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Postal Address: P. O. Box FW 22, Effiduase-Koforidua, Eastern Region, Ghana

Website: http://kadint.net/our-journal.html
E-mail: jacob.sarfo@cherkasgu.press

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## Editorial



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**Editorial**

# User Engagement Trends for a Scholarly Publication Hosted on AJOL: A Case on Journal of Advocacy, Research and Education

Jacob Owusu Sarfo [a, b, c, *]

[a] University of Cape Coast, Cape Coast, Ghana
[b] Centre for Behaviour and Wellness Advocacy, Koforidua, Ghana
[c] Cherkas Global University, Washington, USA

**Abstract**

This editorial briefly analyses user engagement trends for a scholarly publication hosted on African Journals Online (AJOL) between August and November 2024. Using data on abstract views and article downloads, we explore geographical patterns of academic engagement across continents and regions. The analysis revealed that North America, particularly the United States, is the leading download contributor. At the same time, Africa and Asia exhibited significant growth in abstract views based on AJOL's data. The editorial discusses these trends, highlighting the implications for global academic dissemination and suggesting strategies to enhance accessibility, visibility, and impact in underrepresented regions.

**Keywords:** African Journals Online, Hosted, Journal of Advocacy, Research and Education, Scholarly Publication, Trends, User Engagement.

## 1. Introduction

The Journal of Advocacy, Research and Education (JARE) began open-access publishing in 2014 to advance unrestricted dissemination of scholarly research, especially in Africa. After a decade, the JARE was indexed in African Journals Online (AJOL) in 2024. In the contemporary academic landscape, digital platforms like AJOL have become essential and valuable in disseminating scholarly knowledge. These platforms connect researchers, practitioners, and policymakers worldwide, breaking geographical and institutional barriers. Nevertheless, the extent to which this global reach is realised varies across regions, influenced by factors such as the quality of papers, thematic areas of papers, internet access, institutional subscriptions, and cultural engagement with academic literature (Sarfo, 2023a; Sarfo, 2023b).

Previous studies on scholarly engagement have highlighted disparities in access and usage, with regions like North America and Europe often dominating metrics such as downloads (Gurib-Fakim, Signé, 2022; Sarfo, 2019; Tarkang, Bain, 2019). However, emerging African and Asian economies are gradually increasingly engaging with academic content, driven by expanding

* Corresponding author
E-mail addresses: jacob.sarfo@ucc.edu.gh (J.O. Sarfo)
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internet penetration and a growing emphasis on higher education. For example, Africa's contribution to global research output has historically been underrepresented despite its growing academic and research capacity (Gurib-Fakim, Signé, 2022; Tarkang, Bain, 2019). Platforms like AJOL are crucial in amplifying African scholarship, providing visibility for locally relevant studies and fostering international collaborations.

This editorial seeks to contextualise these developments by analysing engagement data, focusing on the distribution of abstract views and downloads across continents and regions. Understanding how users interact with academic content – through abstract views and article downloads – offers a lens into the dissemination and impact of research. This editorial examines engagement data from AJOL over four months in 2024 [following its indexing] to identify trends, challenges, and opportunities for enhancing global academic participation.

## 2. Methods

Engagement data were collected from AJOL for the period August to November 2024. Metrics analysed included:

**1. Abstract Views**: The number of times article abstracts were accessed, reflecting preliminary interest.

**2. Article Downloads**: The number of times full-text articles were downloaded, indicating deeper engagement.

Data were categorised by continent and further divided into regions (e.g., West Africa, Southeast Asia) for a granular analysis. Trends were identified by comparing monthly variations and examining high- and low-performing regions. Key patterns were highlighted to inform targeted strategies for enhancing academic engagement.

## 3. Country-Specific Engagement Metrics

Table 1 summarises a scholarly platform's engagement metrics over four months, focusing on abstract views and article downloads. Abstract views increased steadily from August (130 views) to November (204 views), totalling 680 views over four months. This growth suggests a rising interest in the platform's content. Ghana consistently ranks as a leading contributor to abstract views, with the highest cumulative total (97 views). Also, the Philippines shows significant engagement, especially in November (38 views), leading to a cumulative total of 106 views, the highest overall. Other notable contributors include Nigeria, Kenya, and Iran, indicating diverse regional interests.

**Table 1.** Engagement Metrics for August, September, October, and November 2024

| Metric | August 2024 | September 2024 | October 2024 | November 2024 | Total |
|---|---|---|---|---|---|
| **Abstract Views** | 130 | 151 | 195 | 204 | 680 |
| Top Countries (Abstract Views) | Ghana (26), Nigeria (17), Philippines (15) | Ghana (19), Philippines (26), Kenya (14) | United States (30), Philippines (27), Ghana (20) | Ghana (32), Philippines (38), Iran (19) | Ghana (97), Philippines (106) |
| **Article Downloads** | 553 | 366 | 367 | 781 | 2067 |
| Top Countries (Article Downloads) | United States (313), Ghana (28), Nigeria (16) | United States (93), Nigeria (53), Ghana (17) | United States (93), India (83), Ghana (25) | United States (375), India (66), Ghana (49) | United States (876), Ghana (118), India (232) |

Source: AJOL Stats

Regarding the number of articles downloaded, there is a fluctuating pattern, with a dip in September (366) and October (367) followed by a sharp increase in November (781). The total downloads over the period reached 2,067. This trend suggests varying levels of deeper engagement, where the United States dominates article downloads throughout the period, with a cumulative total of 876 downloads, reflecting its robust academic infrastructure and demand for scholarly

content. India emerges as a significant contributor in October (83 downloads) and November (66), totalling 232 downloads, the second-highest overall.

Concerning abstract views in Africa, West Africa led with 140 views, reflecting strong regional interest, while Southern and East Africa contributed modestly. Also, Southeast Asia (160 views) and South Asia (61 views) showed significant engagement, with Vietnam and the Philippines as key contributors. In North America, the United States accounted for 89 views, consistently maintaining interest in abstracts, while Eastern Europe (35 views) and Western Europe (40 views) demonstrated moderate engagement. Nevertheless, Oceania showed limited engagement, with only a few views from Australia and New Zealand.

Regarding article downloads, North America was the highest contributor, with the United States dominating with 874 downloads, underscoring its position as a primary audience. This is followed by Africa, where West Africa (219 downloads) is the leading sub-region, followed by Southern Africa (31). The next contributor is Asia, where South Asia (190 downloads) outperformed Southeast Asia (120), with India contributing significantly. The remaining contributors to the downloads of articles were Europe, where Eastern Europe (119 downloads) exceeded Western Europe (59) and Oceania, where downloads remained low, with minimal engagement from Australia and New Zealand.

## Conclusion and Implications

The engagement data analysis from August to November 2024 provides valuable insights into the global reach of scholarly publications hosted on AJOL. While North America remains a dominant audience, the growing interest in Africa and Asia signals a shift toward a more inclusive academic landscape. However, the disparity between abstract views and downloads highlights persistent access challenges that must be addressed to ensure equitable dissemination of knowledge.

Generally, the balanced engagement in Europe, where there was a consistent engagement, with Eastern Europe emerging as a significant contributor to downloads, is interesting. Additionally, North America's Dominance, where the United States continues to lead in downloads, reflects its robust academic infrastructure and high demand for scholarly content. Also, the increasing abstract views in West Africa and Southeast Asia highlight the growing interest in academic research, driven by expanding educational initiatives and digital access. These findings underscore the need for region-specific strategies to address access barriers and enhance engagement, particularly in Africa and Asia.

This editorial emphasises the importance of leveraging engagement data to create a more inclusive and impactful academic ecosystem. By addressing the challenges and opportunities highlighted, stakeholders can contribute to a global scholarly community representing diverse perspectives and priorities.

## 6. Declarations

### *Ethics approval and consent to participate*

Not applicable.

### *Consent for publication*

Not applicable.

### *Availability of data and materials*

Data is available via the AJOL Stats Platform and will be available upon reasonable request.

### *Conflict of interest statement*

The author reports no conflicts of interest.

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**Author's ORCID**
Jacob Owusu Sarfo https://orcid.org/0000-0003-2859-7278

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# "How Can a Male Too Want to Do This Work?" Exploring the Challenges Faced by Male Midwives in Ghana's Midwifery Practice

Dina Brenda Boateng Adu [a], Emma Annan [a], Mary Ani-Amponsah [e, *]

[a] University of Ghana, Legon-Accra, Ghana

**Abstract**

Workplace challenges can be daunting and hinder the provision of quality services, especially for a professional such as the male midwife who spends the entirety of his work life in an environment in which he can be termed the minority. Heavy workload, harassment, and intimidation are some documented challenges of the male midwife. The study sought to explore the challenges faced by male midwives in midwifery practice in Ghana. Using the qualitative study design and purposive sampling, data were collected within 30 to 45 minutes for each participant and reached saturation by the 14th participant. Thematic analysis was employed for data analysis. Findings revealed two major themes of current practice and training period challenges from which four sub-themes emerged: the attitude of female midwives, the heavy workload and unfavourable duty schedule, and the clinical supervisors' attitude. In conclusion, male midwives are trained maternal and neonatal health care providers working in various aspects of midwifery to reduce maternal and neonatal morbidities and mortalities; however, the challenges in the workplace pose unbearable barriers which impede the aim of practice.

**Keywords:** Challenges, Ghana, Male Midwives, Midwifery Practice.

## 1. Introduction

The environment in which an individual works can be a motivator or demotivator. The male midwife working in a field where he can be termed as the minority among female colleagues and female clients may raise concerns for both parties. The external environment where most, if not all, of the midwifery life is spent significantly impacts the practice of the male midwife. These experiences may determine whether the male midwife will remain in the profession or not. An environment filled with difficulties, such as a heavy workload, may negatively impact an individual's health and even affect the decision to remain or exit the practice (Rajan, 2018).

The work environment must be conducive enough for the male healthcare provider to develop good coping strategies, as indicated in past studies (Inoue et al., 2006); however, the practice environment is one primary source of burnout among midwives (Thumm, 2022). According to Piddleton (2015), most challenges in the field for male midwives stem from within the profession, especially their female counterparts, as the men are seen as emotionally incapable of handling the care of pregnant women and managing the childbirth process. Some of these challenges can be attributed to the male midwives being the minority in the field of practice, and it

*Corresponding author
E-mail addresses: mani-amponsah@ug.edu.gh (M. Ani-Amponsah)
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has been confirmed in studies that minorities in the workplace are reported to experience bullying and harassment (Fine et al., 2020; Folke, Rickne, 2022).

The education of health care professionals, especially nursing and midwifery, is interspersed with theoretical and practical sessions focused on building a rounded individual who is knowledgeable in both aspects. However, Meyer (2012) reported that male midwives experience external challenges even before the completion of their training. The training sessions and the clinical ward practice sessions are filled with the rejection of service provision by female patients based on culture (Chan et al., 2013), including unfriendly attitudes from clinical supervisors. The lack of supervision during the training periods in the work environment increases the male midwife's frustrations (Mthombeni, Phaladi-Digamela, 2015).

Few studies focus on male minority issues in nursing and midwifery, typically within the African context. Gender roles and biases are noted to compound challenges that male midwives face in the clinical environment, a place that is traditionally female-dominated. Male midwives are often singled out as different and excluded from some clinical activities, mainly based on gender (Ayu, Yasin, 2022; Kantrowitz-Gordon et al., 2014). Other studies report male rejection in clinical care in the Northern part of Ghana, where women were not ready to accept or receive midwifery care from male midwives, and even those who were prepared to receive care from them do so when there is an accompanying female midwife (Nachinab et al., 2022). Similar findings are shared by Bwalya et al. (2015), reporting that most women think it is traditionally wrong for male midwives to provide intimate care to women. Furthermore, additional challenges escalate when there is poor availability of required resources to provide the necessary standard of care.

Just like female midwives, male midwives provide quality maternal and neonatal care to reduce maternal and neonatal mortalities and morbidities, thereby contributing to SDGs 3.1 and 3.2The Gulf of Guinea lies southbound in the region. With a total land area of 9830 $km^2$, the region has the longest coastline (150km) . However, it is particularly challenging, especially in developing countries; these challenges range from a shortage of staff and inadequate infrastructure to logistics issues, including a lack of basic medical logistics (Adatara et al., 2021; Kafulafula et al., 2005). Numerous studies have focused on challenges faced by female midwives in Malawi, Ethiopia, South Africa, and some Asian countries; however, data on the challenges faced by male midwives in Ghana are scarce. It is crucial to explore these challenges and understand the implications on midwifery practice.

## 2. Materials and Methods

### *Study design and setting*

The study utilised a qualitative approach underpinned by the constructivists' worldview (Creswell, 2014) to explore male midwives' experiences of clinical practice in Ghana. This research adopted an exploratory, descriptive design (Cropley 2021) to gain an in-depth understanding of the challenges faced by male midwives in practice in Ghana, considering the gaps in the evidence on male midwives' experiences of practice in Ghana. Due to the limited existing knowledge about the phenomenon under study, a qualitative explorative descriptive was chosen (Creswell, 2014) to explore the factors influencing male midwifery practice in Ghana through an inductive approach to develop rich narratives of the participants' experiences. This approach is considered appropriate as researchers sought a comprehensive understanding of the phenomenon and participants' subjective experiences of it (Grove et al., 2015).

Male midwifery in Ghana is a comparatively recent development and with very limited research data. Historically, male midwives have not been universally accepted. Ghana's efforts to expand maternal/newborn and reproductive health care access required male inclusion in midwifery training as a measure to improve coverage of skilled care delivery. However, male midwives and their acceptance in clinical care have met resistance in practice, culminating in low numbers, though male nurses are relatively common in general nursing practice. In view of the scarce population of male midwives in Ghana, a purposive and snowballing sampling method (Lopez, Whitehead, 2013) was used to recruit male midwives who met the inclusion criteria. The participants were engaged in in-depth interviews until data saturation was reached (Lewis, 2015) by the $14^{th}$ participant, and no new information emerged from the interviews. The collection of data spanned from March to September 2023. Male midwives are few across Ghana, especially at the tertiary level of health care. In this study, we recruited male midwives from two regions of

Ghana, where male midwives are primarily common. Inclusion criteria: male midwives who had a professional licence in good standing with the Nursing and Midwifery Council of Ghana, had practised for at least one year and expressed willingness to be part of the study were included in the study. Male midwives with less than one year of work experience and male student midwives were excluded from the study.

### *Data collection method*

In-person interviews were conducted using a semi-structured interview guide, which was developed based on the evidence from the literature. The tool focused on sections on demographic data and questions related to the study's objectives. The interview guide was pre-tested with two male midwives in the Eastern Region to refine the data collection tool; the data generated from the pre-testing were not included in the analysis for the current study. To gain voluntary informed consent, the study's information sheet, which included the objectives of the study, was shared and explained to eligible participants; questions raised were duly addressed. The principal investigator (DBBA), who is an expert in qualitative studies, conducted the interviews in a quiet environment at a date, time and venue convenient for the study participants. The interview session lasted for about 30-45 minutes for each male midwife, which was audio-recorded. Several probing and follow-up questions were used during the interviews to elicit deeper responses and expantiation of information from the participants. The data were transcribed verbatim.

### *Data analysis*

The data was analysed using thematic analysis following steps outlined by Clarke and Braun (2016). Data collection was concurrent with analysis. The audio recordings of the interviews were transcribed verbatim and validated with the interview transcripts. The transcripts were initially read and re-read to identify similarities in the familiarisation process. Similar concepts are grouped and coded considering key concepts related to the study objectives; the condensed codes were subsequently placed into sub-themes. All researchers reviewed the data, and sub-themes were accurately and collaboratively formed to ensure accurate representations of the data. The researchers then compiled a comprehensive thematic analysis report when a consensus was reached.

### *Ethical consideration*

The research was approved by the Ghana Health Service Ethical Review Committee with number GHS-ERC: 036/01/23. After obtaining consent from the participants, the objectives and benefits of the study were explained, and they were made aware of the right to withdraw from the study at any point. Written and verbal informed consent was obtained from the male midwives before data collection. Confidentiality and anonymity were ensured during data collection by using pseudonyms for each participant.

### *Methodological Rigor*

It was established through credibility, dependability, confirmability, and transferability (Lincoln, Guba, 1985). To ensure credibility, member checking was done by engaging participants in the review of the transcript and confirming the themes derived from the analysis. Triangulation was carried out with support from participants' primary data sources, clinical observations, and field notes. Dependability was attained through the use of the same interview guide along a similar line of questioning used across all participants to ensure uniformity. The research team engaged in peer debriefing sessions during the concurrent data collection and analysis process to discuss data issues, common concepts, and emerging themes to enhance the study's credibility. Confirmability was achieved by maintaining an audit trail and documenting all processes involved in participant selection, data collection, and analysis. In addition, transferability was addressed by providing a comprehensive account of all experiences during data collection, including details about the location and context within which the interview was conducted.

### *Reflexivity*

In qualitative studies, researchers engage in reflexivity to account for their biases and how subjectivity shapes the inquiry and its entire processes, considering this as fundamentally intertwined (Finlay, 2002). In this study, researchers engaged in reflexivity by identifying our

abilities, familiarising with the context, and communicating nuanced decisions in generating real-world data to reflect participants' experiences.

## 3. Results

**Table 1.** Demographic Characteristics of Study Participant

| Pseudonym | Age | Health facility | Number of male midwives |
|---|---|---|---|
| P1 | 36years | Hospital | One |
| P2 | 33years | Health center | One |
| P3 | 42years | Health center | One |
| P4 | 37years | Hospital | Two |
| P5 | 39years | Health center | One |
| P6 | 35years | Health center | One |
| P7 | 35years | Hospital | Two |
| P8 | 34years | Community Health Planning and Services (CHPs) | One |
| P9 | 38years | Health center | One |
| P10 | 35years | Hospital | One |
| P11 | 39years | Hospital | Two |
| P12 | 49years | Hospital | One |
| P13 | 34years | Hospital | One |
| P14 | 41years | Hospital | Two |

### *Themes and subthemes*

Demonstrated in Table 2 are the themes and subthemes developed from the collected data.

**Table 2.** Theme and Sub-Themes

| Themes | Sub-themes |
|---|---|
| 1. Current challenges | a. Attitudes of female midwives |
| | b. Heavy workload |
| | c. Unfavorable duty schedule |
| 2. Training Related challenges | a. Supervisor attitude |

### *Current challenges faced by male midwives in practice.*

This theme relates to the challenges in the participants' work environment and how they impact midwifery practice. It relates to all the physical and tangible surroundings of the participant in which he performs his daily activities as a midwife.

### *Subtheme 1: Attitude of Female Midwives*

Some participants expressed a little challenge with their colleague midwives when explaining the external environment and its effect on their experience as midwives. The participants acknowledged that even though they had excellent relationships with their female colleague midwives, they were not particularly enthused by some of their actions, such as making petty, unwelcoming comments and favouring male doctors over male midwives.

P11 bitterly expressed:

*You know, in the line of work, you come across so many challenges, one or two, but mainly in this one, I am not going to be biased. I am being frank with you, it is our colleagues who make us sometimes feel uncomfortable, our colleagues, as in the female midwives. Some will say that I do not want you to be present when I am in labour, but will allow a male doctor to be present while she is in labour. Some are too lazy and will not do anything immediately after they realise you are on duty with them.* (39 years).

P6 also stated:

*The problem is just our counterparts who are female. Some of them will behave like you are a man, and I do not want you to be there when I deliver with other similar comments* (35 years).

***Sub-theme 2: Heavy workload***

Some participants expressed that they are, more often than not, burdened with the heavy-duty aspect of the practice as compared to their female counterparts, which is a factor in the decision to divert from the profession or move into academia.

P9 said:

*Oh, I am moving into academia, the midwifery training school, because the workload on us, the male midwives in the ward, is hefty*. (34 years).

P1 stated:

*The only challenge I have is from my colleagues. They always think that because I am a male, I have to do all the menial jobs, and then sometimes, when we are for the night, we have to take a small nap in turns. When it's time for them to wake up so that I take my nap, they do not, so I will end up doing everything*. (36 years).

***Subtheme 3: Unfavorable duty schedule***

Some participants, apart from those working in one-man health facilities, stated that sometimes it is a challenge for them when they have to run unfavourable duties.

P11 narrated his experience:

*It's serious because I'm the only male, the way they can use me, the thing is they will draw the duty roster [rota], and someone will get up and say I can't come to work, and when they look around, they will say as for this person (me), he is a man and will be less busy so let's put him there or let's call him. So, I can be sleeping and they will call, or they will call the day I am off and resting saying, we are begging you, this person says she cannot come, and about 4 or 5 females who are supposed to go for that shift have an excuse, so I will have to fill in for her*. (39 years).

P3 added:

*The days are mostly busy, and sometimes, when you leave the workplace and get to the house, someone will come for service, they will call you and you will have to return. That is what makes it difficult*. (42 years).

***Theme 2: Training Period Challenges***

Most participants had significant periods interspersed with minimal setbacks about acceptance during their clinical attachment days. They, therefore, had to put in more effort to prove that they were capable of the work they were being trained.

***Sub-theme 1: Supervisor Attitude***

P10 recounted:

*On Campus was good. But when we went to the field, some directors and supervisors were against it. And some midwives, these old ladies, were against it. Some were not against it, but they were like, oh, this thing, it won't yield good results. It's a pilot program. They will cancel it, those negative thoughts. And you know, as normal human beings, hearing those negative thoughts weighs you down, but when we come back to campus, our tutors encourage us*. (35 years).

P2 stated:

*You know, it was such a challenging moment. Because, you know, people didn't know about male midwifery, people used to tell us that they knew only males who were gynaecologists. So once you go and introduce yourself as a midwife, they are like, mmmm…, how can a male too want to do this work? But you know, it doesn't take one day to change someone. As we started talking with and interacting with them, sometimes, when we can carry out only one procedure on a client, do it very well, and let the clients understand very well, their concern that the male midwives come to look at their vulvas started to change*. (33 years)

## 4. Discussion

Challenges in an individual's career may be within or outside the practice or career environment. For these male midwives, the prominent challenge stemmed from within the practice environment. This study identified that female midwives posed a challenge to male midwives to some extent. Most of the male midwives reported poor recognition from their colleague female midwives, expressing that some of the female midwives underestimated their competence by

refusing care from the male midwives, while others thought they would not be capable of the task as midwives. This is consistent with findings from Piddleton (2015) and Chinkhata and Langley (2018), who reported that most challenges in the field for male midwives stem from within the profession, especially their female counterparts, as they see the men as emotionally incapable of handling the care of pregnant women and childbirth. Again, supporting this is a study by Folke and Rickne (2022), which indicated that gender minorities are at high risk of experiencing harassment in the workplace.

The workload on these male midwives cannot be underestimated. This study identified that heavy workload and unfavourable shift system were challenges the male midwife faced in the field of practice. The male midwives acknowledged the midwifery profession in general to be one that is fraught with stress and heavy workload, and as such, based on their gender as men and seen as the stronger, are put in positions where they carry out all the heavy-duty aspects of the midwifery work, unlike their female counterparts. Furthermore, male midwives are always made to run double or extended shifts when colleague female midwives are on maternity leave or when the female midwife does not report to work or is exhausted from the plights of pregnancy or nursing a child. This aligns with a study that indicates that gender minorities in the workplace may experience some forms of bullying (Fine et al., 2020). Again, Rajan (2018), on the causes and negative impacts of heavy workload, identified long leave of co-workers and co-worker absence.

Another finding of this study is the minor setback related to the periods of training. Participants reported varied challenges from directors and supervisors doubting their competence and intent for practice, which is in tandem with a study that indicates that male midwives experience challenges during training periods even before completion from both clients and supervisors (Chan et al., 2013; Meyer, 2012).

## 5. Conclusion

Male midwives are trained maternal and neonatal health care providers working in various aspects of midwifery to reduce maternal and neonatal morbidities and mortalities, and if the challenges in the workplace become unbearable, then this aim will not be realised. These challenges must, therefore, be addressed to improve work harmony and enhance client outcomes. Again, the clinical session during the training period must be a period of teaching and support to build the confidence of the male midwives even before they graduate and begin working.

## *6. Strengths and Limitations*

The different workstations (health facilities) of the participants provide rich data that enhances the understanding of the challenges experienced by male midwives. The qualitative design and its corresponding sample size may impose on the generalizability of the work.

## 7. Implications

Continuous sensitisation and addressing of these challenges faced by male midwives in practice must be paramount to achieve workplace harmony aimed at improving maternal and newborn infant outcomes. Male midwives must undergo well-planned training with adequate support and clinical preceptorship to enhance the transition. There is also the need to draw policies that enhance awareness creation and visibility of the male midwives. Future research may be conducted to explore the experiences of female midwives working with male midwives.

## 8. Declarations

### *Ethics approval and consent to participate*

The Ghana Health Service Ethical Review Committee granted ethics approval for the study (GHS-ERC: 036/01/23).

### *Consent for publication*

All authors read and approved the final version of the manuscript for publication and agree to be accountable for all aspects of the work, ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

***Availability of data and materials***

The data supporting this study will be made available upon reasonable request to the corresponding author (Mani-amponsah@ug.edu.gh).

***Conflict of interest statement***

The authors do not have any personal or financial interest in this study.

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***Authors' contributions***

DBBA conceptualised the study. DBBA designed the study with input from MAA and EA. DBBA collected data from participants. DBBA analysed and interpreted the data. DBBA drafted the initial manuscript. MAA and EA contributed to the revision and finalisation of the manuscript. All authors read and approved the final version of the manuscript.

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**Authors' ORCID**

Dina Brenda Boateng Adu https://orcid.org/0009-0002-5763-2132
Emma Annan https://orcid.org/0000-0001-9348-7919
Mary Ani-Amponsah https://orcid.org/0000-0002-0480-612X

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# Cognitive and Musical Characteristics as Factors of Creative Development

Marina A. Voytikova [a, *], Elena V. Pugacheva [b], Oleg N. Ryzhov [a]

[a] Sochi State University, Russian Federation
[b] Federal Scientific Center for Psychological and Interdisciplinary Research, Russian Federation

**Abstract**

The study is dedicated to examining cognitive and musical characteristics as factors in the creative development of children in primary school and adolescence. The sample consisted of 126 students of grades 2-3 and 6-7 from comprehensive schools in Moscow and Sochi. The following methods were used: Raven's test, Amthauer's Verbal Scale, Gold-MSI and Torrance test. The results of multiple regression analysis showed that the structure of creative perspective factors changes with age. In primary school, fluid intelligence is the leading factor, whereas active musical involvement comes to the fore in adolescence. A significant interaction effect between fluid intelligence and musical involvement was found. An increase in the role of crystallized intelligence in adolescence was revealed. Emotional responsiveness to music consistently contributes to developing creative potential in both age groups. The results of the study emphasize the importance of an integrated approach to the development of creative potential, taking into account both cognitive and musical factors. Practical implications for education and prospects for further research are discussed.

**Keywords:** Adolescence, Cognitive Characteristics, Creative Development, Crystallized Intelligence, Fluid Intelligence, Musical Characteristics, Musical Involvement, Primary School Age.

## 1. Introduction

Music plays a fundamental role in human development from the earliest stages of life. Research shows that musical sensitivity already manifests in the prenatal period and is closely linked to cognitive and emotional development (Kholikov, 2023). Modern cognitive neuroscience of music studies the relationship between brain activity and mental processes underlying music's perception, performance and composition, demonstrating that musical activity activates multiple brain areas associated with various cognitive functions.

Creativity, a critical factor in the evolution of humanity and socio-cultural systems (Fan, Sarfo, 2023; Fourie, Schlebusch, 2023), is closely related to musical activity (Portin et al., 2018). Neurobiological studies show that creative processes involve complex cerebral mechanisms, including the interaction of various cognitive processes and emotions (Mastnak, 2018). Musical activity significantly impacts neuroplasticity, activating brain areas associated with emotions, personality, sensory integration and executive functions (Groussard et al., 2014). In musical composition, creativity is considered the ability to transform an ill-structured problem into a well-

* Corresponding author
E-mail addresses: marina.voytikova@yandex.ru (M. Voytikova)
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structured task (Wiggins et al., 2001). Essential aspects of creativity in musical composition are the ability to simultaneously represent and process multiple characteristics of a musical piece and the ability to represent musical information hierarchically (Barbot B. et al., 2018). Some researchers believe that learning success is related to intelligence, working memory, and information processing speed (Morosanova et al., 2017).

Research shows that music is an effective tool for developing physical and mental abilities, as well as emotional sensitivity (Sizova, Kislova, 2022). It is important to note that the first six years of a child's life are important for laying the foundations of musical development since, during this period, children have a natural ability to perceive and distinguish musical tones and form an emotional attitude towards music.

Early adolescence is a critical period for identifying and developing various types of giftedness, including intellectual and artistic (Doniy, Shumakova, 2020). In this context, music is considered one of the most effective means of developing creative potential, influencing all aspects of personality (Gilmanov et al., 2010).

Research demonstrates the positive impact of music lessons on the development of verbal memory and intelligence (Ho et al., 2003; Schellenberg et al., 2006). In addition, the home musical environment and the frequency of joint parent-child musical activities at an early age are associated with a higher level of mathematical skills and self-regulation in preschool children (Williams et al., 2015). Self-regulation helps to overcome acute stress due to its high degree of reliability and highly developed processes of action programming (Morosanova et al., 2018). At present, we can talk about the existence of different levels of individual characteristics of the subject, manifested in conscious self-regulation. (Verbitskaya et. al,2020)

Recent studies have identified four key components of children's musicality: musical communication, enthusiasm and motivation, analytical understanding of music, and musical ability itself (Bayanova et al., 2021). This emphasizes the importance of a broad understanding of musical ability that goes beyond traditional tests and includes such aspects as emotional perception of music, as well as expressive and creative abilities.

Thus, cognitive and musical characteristics developed through active interaction with music can serve as important factors in the creative development of the individual. This emphasizes the need to include various forms of musical activity in the educational process to develop the creative potential of students. Despite extensive research into the influence of music on cognitive and emotional development, the question of how exactly cognitive and musical characteristics interact in forming an individual's creative potential remains understudied. In addition, most studies focus on individual aspects of musical influence without considering the complex interaction of various factors.

The purpose of this study is to examine cognitive and musical characteristics as factors of creative development in children of primary school age and adolescents. The study seeks to fill the existing gap in understanding how various aspects of musical experience and cognitive abilities interact in the process of forming creative potential. Our study also aims to identify the structure of factors of creative development in different age groups, which will allow us to understand the dynamics of creative abilities development better. The results of this study may have important practical implications for education, providing a basis for developing more effective strategies for developing the creative potential of children and adolescents through musical activities. In addition, it can contribute to the theoretical understanding of the nature of creativity and the role of music in its development.

## 2. Methods

### *Sample*

The study involved 126 students from comprehensive schools in Moscow and Sochi (68 girls and 58 boys). The study was conducted in two age groups: younger students (2nd-3rd grades, average age 8.5 years, n = 63) and younger adolescents (6th-7th grades, average age 12.7 years, n = 63).

### *Instruments*

1. Fluid intelligence was assessed using the Raven's Progressive Matrices test (short form). It is necessary to identify the logical sequence of elements and select one correct option from the proposed ones. The total score of correctly solved problems was used as an indicator of general intelligence.

2. The verbal scale of the R. Amthauer intelligence structure test was used to diagnose crystallized intelligence, including tasks for general awareness, verbal analogies and generalization.

The total score of correctly solved problems was used as an indicator (adapted by Valuev, Ushakov, 2010) (Gilmanov et al., 2010).

3. Musical characteristics were assessed using the Gold-MSI, v.1.0 method—this tool aimed at measuring various aspects of musical behavior. The Active Involvement and Emotions scales were used (adapted from the Russian version of the method) (Knyazeva, 2018; Knyazeva, 2018).

4. The Torrance Creativity Test (image battery, form A) was used to assess image creativity according to the indicators of fluency, flexibility, originality, and elaboration (Tunik, 1998).

***Data Analysis***

As part of the study of cognitive and musical characteristics as factors of creative development, data were analyzed using the multiple linear regression method with the SPSS 26.0 statistical package. According to the Torrance test, the dependent variable was the originality indicator, which is considered an indicator of creative development. The factors were the indicators of fluid and crystallized intelligence, as well as the scales of musical characteristics: active musical involvement and emotional responsiveness to music. We further conducted the regression analysis with a significance level of $p<0.05$.

## 3. Results

Regression analysis for a group of primary school students (grades 2-3) showed that the model explains 34% of the variance of the dependent variable ($R^2 = 0.34$, $F(4.58) = 7.46$, $p < 0.001$). Statistically significant predictors of originality of thinking were identified: fluid intelligence ($\beta = 0.30$, $t = 2.86$, $p < 0.01$), active musical involvement ($\beta = 0.27$, $t = 2.58$, $p < 0.01$), emotional responsiveness to music ($\beta = 0.21$, $t = 2.01$, $p < 0.05$) and crystallized intelligence ($\beta = 0.18$, $t = 1.72$, $p < 0.05$). Table 1 shows the identified statistically significant predictors of originality of thinking.

**Table 1.** Predictors of originality of thinking (groups of primary school students, grades 2-3)

| **Characteristics** | **β** | **t** | **p** |
|---|---|---|---|
| Fluid intelligence | 0.3 | 2.86 | < 0.01 |
| Crystallized Intelligence | 0.18 | 1.72 | < 0.05 |
| Active musical involvement | 0.27 | 2.58 | < 0.01 |
| Emotional responsiveness to music | 0.21 | 2.01 | < 0.05 |

These results indicate that in primary school age, cognitive and musical characteristics significantly contribute to predicting creative development. Moreover, fluid intelligence has the greatest influence, indicating the importance of general cognitive abilities in developing creative potential at this age stage.

For the group of younger adolescents (grades 6-7), the regression model explains 39% of the variance in the dependent variable ($R^2 = 0.39$, $F(4.58) = 9.28$, $p < 0.001$). The structure of factors changed as follows: active musical involvement ($\beta = 0.33$, $t = 3.15$, $p < 0.01$), crystallized intelligence ($\beta = 0.26$, $t = 2.48$, $p < 0.01$), fluid intelligence ($\beta = 0.24$, $t = 2.29$, $p < 0.05$), and emotional responsiveness to music ($\beta = 0.20$, $t = 1.91$, $p < 0.05$). Table 2 shows statistically significant predictors of originality of thinking.

**Table 2.** Predictors of originality of thinking (groups of younger adolescents, grades 6-7)

| **Characteristics** | **β** | **t** | **p** |
|---|---|---|---|
| Fluid intelligence | 0.24 | 2.29 | < 0.05 |
| Crystallized Intelligence | 0.268 | 2.48 | < 0.01 |
| Active musical involvement | 0.33 | 3.15 | < 0.01 |
| Emotional responsiveness to music | 0.20 | 1.91 | < 0.05 |

Adolescence shows a change in the hierarchy of factors: active musical involvement comes first, which may indicate an increasing role of purposeful creative activity in the development of

originality of thinking. Crystallized intelligence also becomes more significant, which may reflect the increasing role of accumulated knowledge and experience in the development of creative potential.

Additional analysis revealed a statistically significant interaction effect between fluid intelligence and active musical involvement in both age groups (younger group: $\beta = 0.18$, $t = 1.73$, $p < 0.05$; older group: $\beta = 0.22$, $t = 2.10$, $p < 0.05$) which is presented in Table 3.

**Table 3.** Interaction between fluid intelligence and active musical engagement

| Characteristics | β | t | p |
|---|---|---|---|
| Junior group | 0.18 | 1.73 | < 0.05 |
| Senior group | 0.22 | 2.10 | < 0.05 |

This result indicates that a high level of musical involvement enhances the positive effect of intelligence on originality of thinking, which emphasizes the importance of the interaction of cognitive and musical factors in creative development.

Comparative analysis of regression models for the two age groups revealed several significant differences. The explained variance of the dependent variable increased from 34 % in the younger group to 39 % in the older group, which may indicate an increase in the predictive power of the studied characteristics with age (see Figure 1).

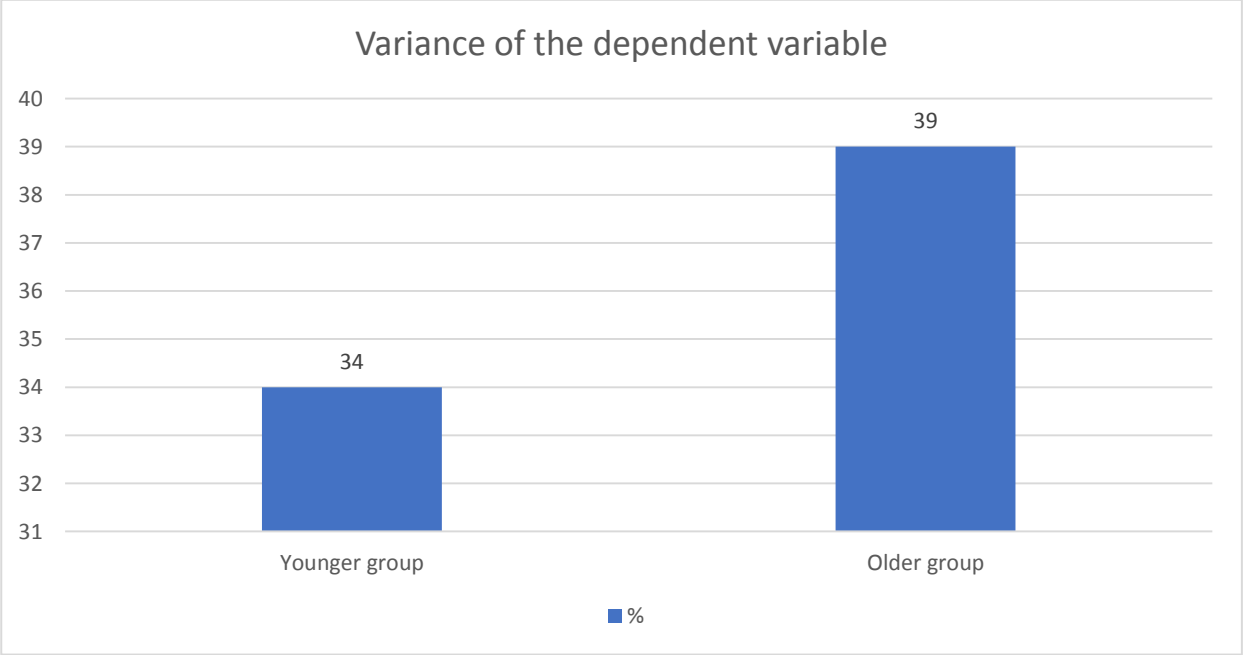


**Fig. 1.** Variance of the dependent variable

The change in the hierarchy of factors from the younger to the older group may reflect a shift in emphasis from general cognitive abilities to specific creative activity in the development process. The increasing role of crystallized intelligence and some decrease in the significance of fluid intelligence in the older group may be associated with the accumulation of knowledge and experience, which begin to play a more significant role in the creative process of adolescents. The strengthening of the effect of interaction between fluid intelligence and active musical involvement in the older group emphasizes the increasing importance of the synergy between cognitive abilities and creative activity in the formation of creative development.

The results indicate the dynamic nature of the relationship between cognitive and musical characteristics and their influence on creative development. They indicate the need to consider age-related characteristics when developing strategies for developing creative potential in children and

adolescents, emphasizing the importance of both intellectual development and active involvement in creative activity.

## 4. Discussion

Dolgikh suggests the existence of a relationship between musical abilities and regulatory function in children, which indicates the special value of music lessons in preschool age (Dolgikh et al., 2022). The conducted study of cognitive and musical characteristics as factors of creative development in children of primary school age and adolescence revealed some important patterns.

Firstly, the results confirm the complex nature of creative potential, which is influenced by both cognitive and musical factors. This is consistent with modern theories of creativity, emphasizing the multifactorial nature of this phenomenon (Lubart, 1996). Shishkina et al. (2020) also say in their work that musical and creative abilities are complex personal characteristics and special abilities necessary for studying music.

The study was devoted to intellectual activity in primary school and adolescence. The network correlation analysis method was used, making it possible to visualize and quantify the relationships between various factors. This made it possible to study in more detail the structure of relationships between intellectual, regulatory and cognitive characteristics measured by the "Creative Field" method. The results are consistent with our conclusions about the importance of both cognitive and musical factors in developing creative potential, emphasizing the complex nature of this phenomenon (Zhukova et al., 2019). The stability of the contribution of emotional responsiveness to music in both age groups confirms the importance of the emotional component in the creative process, which is consistent with studies on the role of emotions in creativity (Sizova, Kislova, 2022).

It is especially interesting to note that the study by Knyazeva also found an important role in musical involvement and emotional responsiveness to music. However, if, in our study, fluid intelligence plays a leading role in primary school age, the author of the study notes the absence of differences in general intelligence between the groups but reveals significant differences in crystallized intelligence. This may indicate age-related features of the development of intellectual abilities and their relationship with musical activity, which requires further study in longitudinal studies (Knyazeva, 2024).

The results obtained have important practical implications for education. They indicate the need for an integrated approach to developing creative potential, including cognitive development and involvement in creative activity. Particular attention should be paid to creating conditions for children's active participation in musical and other types of creative activities, especially in adolescence. Karataeva and Khan (2023), in their works, also paid special attention to the development of the intellectual and creative potential of primary school students, linking their development with children's imagination and creative thinking.

## 5. Conclusion

The conducted study of cognitive and musical characteristics as factors of creative development in children of primary school age and adolescence successfully achieved the set goal and allowed them to solve several important problems.

Firstly, the hypothesis about the complex nature of creative potential, influenced by cognitive and musical factors, was confirmed. The revealed differences in the structure of factors between age groups indicate the dynamic nature of the development of creative abilities, which corresponds to the set objectives of the study.

Secondly, the study showed the increasing role of active musical involvement and crystallized intelligence in adolescence, confirming the hypothesis about the importance of purposeful creative activity and accumulated knowledge in developing originality of thinking.

Thirdly, the discovered interaction effect between fluid intelligence and musical involvement confirms the hypothesis about the significance of the synergy of cognitive abilities and creative activity in forming creative development.

## 6. Limitations and Strengths

Limitations of this study include its cross-sectional nature, which does not allow for unambiguous conclusions about cause-and-effect relationships.

Future longitudinal studies could clarify the dynamics of creative potential development and the factors influencing it. Further research could also consider the influence of other types of creative activity, in addition to musical, on the development of originality of thinking and study the role of social factors and personality characteristics in shaping creative development.

Overall, the obtained results contribute to the understanding of the factors influencing the development of creative potential in childhood and adolescence and emphasize the importance of taking into account age-related characteristics when developing strategies for the development of creativity.

## 7. Implications of the Study

The obtained results can be widely used in various fields. Educators and educational program developers can use these data to create more effective strategies for developing the creative potential of children and adolescents that take into account age-related characteristics and the relationship between cognitive and musical factors. Psychologists and creativity researchers can rely on these results to further study the mechanisms of creative ability formation.

Prospects for further research in this area include several directions. Firstly, it is necessary to conduct longitudinal studies to study in more detail the dynamics of creative potential development and the factors influencing it over a long period. Secondly, the study should be expanded to include other types of creative activity in addition to music in order to determine the general and specific factors influencing the development of creativity. Thirdly, it is important to study the role of social factors and personal characteristics in forming creative development, which will provide a more complete picture of the formation of creativity. Finally, a promising direction is the study of neurophysiological correlates of the interaction of cognitive and musical factors in the process of creative activity.

## 8. Declarations

### *Ethics approval and consent to participate*

The Sochi State University's Ethical Review Committee granted ethics approval for the study.

### *Consent for publication*

All authors read and approved the final version of the manuscript for publication and agree to be accountable for all aspects of the work, ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

### *Availability of data and materials*

The data supporting this study will be made available upon reasonable request to the corresponding author (marina.voytikova@yandex.ru).

### *Conflict of interest statement*

The authors do not have any personal or financial interest in this study.

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### *Authors' contributions*

MAV, EVP, and ONR conceptualized the study. All authors designed the study, collected data from participants, analyzed and interpreted the data, drafted the initial manuscript, contributed to its revision and finalization, and read and approved the final version.

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**Authors' ORCID**

Marina Andreevna Voytikova https://orcid.org/0000-0002-2147-1261
Elena Viktorovna Pugacheva https://orcid.org/0000-0002-0414-3629
Oleg Nikolaevich Ryzhov https://orcid.org/0009-0000-3462-8179

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# Psychosocial Factors Influencing Grade 7 Learners' Performance in Mathematics Classes at Primary Schools in the Northern Cape, South Africa

Fatima Ajimudin [a], Kananga Robert Munkuna [b, *]

[a] Sol Plaatig University, Kimberley, South Africa
[b] University of the Free State, Bloemfontein, South Africa

**Abstract**

This study explores the psychosocial factors influencing Grade 7 learners' performance in mathematics classes at primary schools in the Frances Baard district in the Northern Cape Province of South Africa. The study adopted a qualitative interpretive approach infused with a multiple-case study design. The thematic analysis results show that some learners were not fully engaged in the mathematics classes despite having the necessary resources, including qualified teachers. The study revealed that family and community issues affect learners' academic performance in mathematics classes. It further found that some learners struggle to comprehend mathematical concepts taught in English, their second language. The study recommends that teachers should enhance their pedagogical approaches to fit learners' home languages, locations, and socioeconomic circumstances.

**Keywords:** Academic Performance, Grade 7 Learners, Mathematics Classes, Mathematics Teachers, Primary Schools.

## 1. Introduction

Researchers are increasingly interested in investigating learners' academic performance in mathematics classes. High performance in mathematics is depicted as a fundamental part of human knowledge and a central pillar in the modern technological revolution (Ernest, 2000). Similarly, understanding mathematics is a crucial component of human life, as it effectively builds mental development and encourages logical reasoning and critical thinking skills (López-López et al., 2022). This suggests that mathematics plays a significant role in education and the nation's socioeconomic development. This role explains how education helps individuals enhance their quality of life and improve their living standards (Oginni, 2021). If society does not get the education of the youth right, studying mathematics will remain an unrealistic dream for many.

Jojo (2019) highlighted that educational reform in South Africa has generally been politically driven. Consequently, the past 20 years have reduced education to serving economic ends, coupled with the conflation of mathematical prowess and problem-solving skills for the knowledge economy (Jojo, 2019). Attempts to redress the situation sought to ensure that all learners are exposed to mathematics at school before completing their matric. Poor academic performance in mathematics has attracted much attention among concerned stakeholders in South Africa. Despite

* Corresponding author
E-mail addresses: mukunakr@ufs.ac.za (K.R. Mukuna)
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many curricula reforms by the South African Department of Basic Education, from the NATED 550 to the Curriculum and Policy Statement (CAPS), most learners still struggle to pass mathematics. South Africa recently adopted the CAPS document as the education policy, which is constructivist, meaning that we are moving away from a theoretical underpinning of teaching mathematics towards a more relevant way of teaching it.

Learners still experience challenges with the subject, especially when transitioning from primary to high school. A study conducted in Zimbabwe examined the causes of poor academic performance in mathematics at a high school in Zimbabwe (Makondo, Makondo, 2020). Other studies have recently focused on factors contributing to poor learner performance in mathematics at selected schools in Mpumalanga Province in South Africa (Michael, 2015; Mabena et al., 2021). Extant literature reveals the negative attitudes embedded in the teaching methods and the negative attitudes of pupils, teachers, and parents towards mathematics and related subjects (Makondo, Makondo, 2020; Chand et al., 2021). Other scholars reported that mathematics teachers' poor experience and inadequate resources were the causes of poor performance in the subject (Suleiman, Hammed, 2019; Makondo, Makondo, 2020). Chand et al. (2021) found an ineffective mathematics curriculum to be the main reason for poor secondary school performance in the subject.

Similarly, Suleiman and Hammed (2019) explored the perceived causes of learners' failure in mathematics at junior secondary schools. The study found that transferring mathematics teachers, learners' poor socioeconomic circumstances or backgrounds, flawed teaching methodology, inappropriate periods allocated for mathematics, and overcrowded classrooms caused poor mathematics performance among learners. Owan (2012) indicated that private primary school pupils perform better in mathematics than public school colleagues. Michael (2015) found poor teaching environments, poorly managed mathematics departments, inadequate self-practice, and learners' poor backgrounds contributed to low grades obtained in mathematics. Literature has shown that learners showed disengagement in the class despite having what they needed in the mathematics classroom (Purdasseea, 2022). A study confirmed that schools must move away from teacher-centred approaches and adopt more learner-centred approaches to teaching (Mackatiani, Komo, 2018). The situation remains the same in various schools in many districts in South Africa. Literature shows that the parents or caregivers of learners must have a good social relationship with schools if learners' academic performance is to improve (Jimmyns, Meyer-Weitz, 2021). Furthermore, positive attitudes and emotions should be fostered among learners in the classroom when teaching and learning mathematics (López-López et al., 2022). Some scholars highlighted that learners' involvement, learner-learner interactions, teacher-learner interaction, satisfaction, task orientation, competition, order and organisation, teacher control, and innovation could be pertinent psychosocial factors that affect the teaching and learning of mathematics in Nigerian schools (Oyenuga, Lopez, 2012).

Poor performance in mathematics in junior high school is not an isolated issue but a far-reaching one worldwide. Some scholars reported that mathematics self-efficacy, mathematics anxiety, motivation, parental influences, adequate teacher support, teachers' competencies, and classroom instruction could influence poor mathematics performance (Kaskens et al., 2020). In South Africa, many studies have focused on factors contributing to poor learner performance in mathematics (Mabena et al., 2021). However, insufficient attention has been paid to psychosocial factors or non-structural problems such as resilience, anxiety, and language barriers, among others. Therefore, this study explores the psychosocial factors influencing Grade 7 learners' academic performance in mathematics classrooms in Frances Baard District in the Northern Cape, South Africa. This will bridge the gap in the existing literature, particularly in the context of South African high schools and the world at large, because the factors vary from one location or institution to another.

## 3. Methods

### *Research design*

This study adopted a qualitative research approach to explore the phenomenon of losing momentum in learning in its natural surroundings (Athanasou et al., 2012). It employed an interpretive paradigm, which helps participants to share their ideas while maintaining integrity (Creswell, Creswell, 2018). A multiple case study design was suitable for this study since it allows the researchers to isolate and define an issue in its actual setting while yielding genuine and

authentic data and allowing for an in-depth interpretation of findings (Karlsson, 2016). The participants in this study were mathematics teachers.

***Participants***

This study's participants were six mathematics teachers in Frances Baard District in Kimberley, Northern Cape Province, South Africa (Sarfo et al., 2021). These teachers came from six schools, three of which were urban, well-resourced, and maintained, with a functioning School Governing Body (SGB). The other schools were moderately maintained and situated in regions of lower socioeconomic status, with SGBs that were not functional. The researchers invited all participants to the boardroom and explained the purpose of participating in this study based on their availability and willingness to participate. It was believed that these participants could provide enough knowledge and experience of the psychological, social, and academic factors that influence Grade 7 learners in mathematics classes. The participants had at least five years of experience teaching mathematics in Grade 7. Their race, gender, highest qualifications, home language, residential area, and teaching subjects were considered in this study. Participants had a mixture of home languages, including Afrikaans and vernacular languages.

***Instrument***

This study used semi-structured interviews with mathematics teachers for data collection. Although time-consuming, semi-structured interviews allowed researchers to elicit valuable data from the participants, with a rich tapestry of information. This instrument comprised open-ended questions about the psychological and social factors influencing Grade 7 learners' performance in mathematics. Some of these factors include learner resilience, learner enthusiasm, disengaged learners, learner confidence, and learners' behaviours influence their learning. The social factors include peer relationships, community issues, and family-related issues. The interview sessions lasted 45 minutes for each participant and were recorded with the participants' permission.

***Data analysis***

Data were analysed using the thematic analysis technique, which helps to organise and give meaning to data (Mills et al., 2012). There is no risk of contaminating the data during this analysis, making it a safe data analysis method (Bryman, 2012). This technique was chosen for its flexibility, allowing researchers to determine the recurring themes that emerged (Hawkins, 2018). The recordings of the interviews were transcribed, and the researchers read the data thoughtfully and insightfully, gaining familiarity with it. The researchers refined the data by recognising the essential themes related to psychological, social, and academic factors that emerged; the recurring themes became the main themes. Regarding the trustworthiness and credibility of the data, all data collected for this study was scrutinised and transcribed by an electronic device. The confirmed data was then protected, providing dependability to the study (Maree, 2020).

***Ethical considerations***

Permission to conduct the study was sought from the Ethics Committee at the University of the Free State. The Department of Basic Education in the Northern Cape Province granted approval to conduct the research at the selected schools (UFS-HSD2021/0315/21). Copies of the consent form, which explained the nature and intended outcomes of the study, were given to all participants. Appointments were made with each of the principals, seeking permission to have their mathematics teachers take part in the study, and all of them provided this permission. The researchers contacted each participant and indicated the purpose of the study before the data collection began. The interviews lasted between 45 minutes and an hour each. The transcriptions of the interviews were stored electronically on a memory stick.

## 4. Results

***Biographic results***

**Table 1.** Biographic results

| Participants | Gender | Age | Subjects taught | Schools |
|---|---|---|---|---|
| Participant 1 | Female | 31 | Mathematics; PE and Technology | City Schools, well-funded. |
| Participant 2 | Female | 53 | Math and Social Sciences | |
| Participant 3 | Female | 55 | Mathematics and Economic Management Sciences | |

| Participants | Gender | Age | Subjects taught | Schools |
|---|---|---|---|---|
| Participant 4 | Male | 56 | Mathematics | Lower economic income schools and less funded schools. |
| Participant 5 | Female | 33 | Mathematics | |
| Participant 6 | Male | 42 | Mathematics, PE, and Technology | |

***Thematic results***

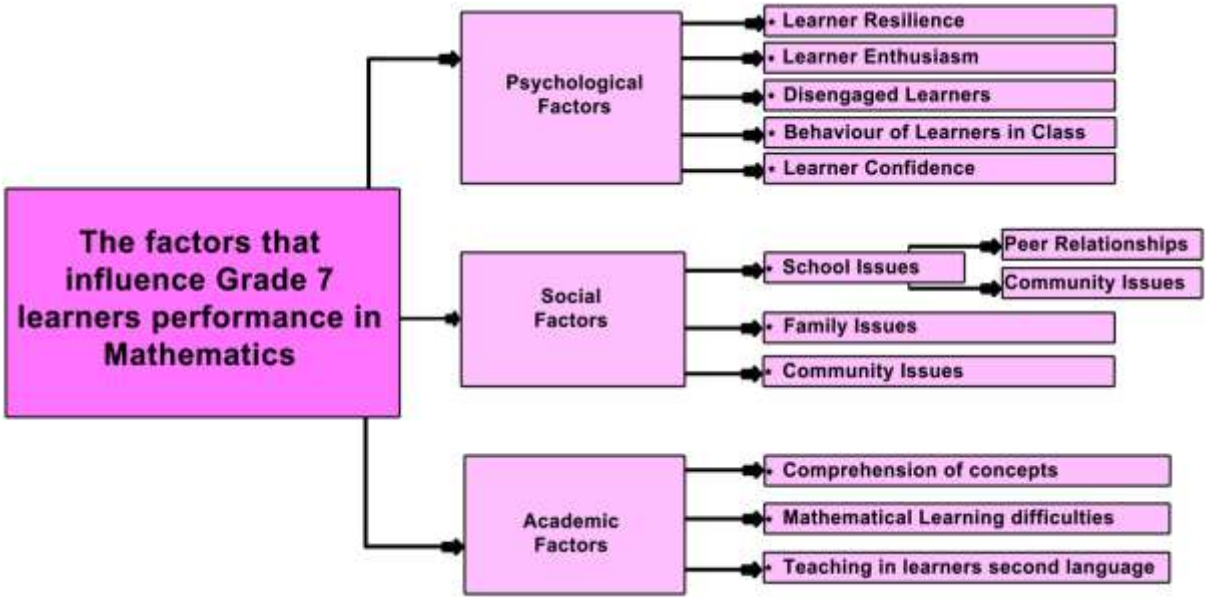


**Fig. 1.** Psychosocial factors influencing Grade 7 learners' academic performance in mathematics classrooms (Ajimudin, 2021)

As illustrated in the framework diagram in Figure 1, it explains factors influencing Grade 7 learners' performance in the mathematics classroom. Three types of factors are involved: psychological, social, and academic. Psychological factors included strong learners despite their difficulties and enthusiasm for mathematics. Some were, however, disengaged despite having what they needed to succeed. Social factors influencing learners' performance included issues like good relationships with teachers and friends, and family and community issues in the immediate environment where learners live, which could affect their performance. Academic factors are related to the teaching and learning issues that Grade 7 learners experience. Some have continuous difficulties with mathematics, meaning they have a learning problem; some must re-learn the basics of mathematics, so they do not perform optimally. Comprehension of concepts refers to learners sometimes missing and not fully understanding the concepts of mathematics when they reach Grade 7.

**Psychological factors**

This study found that resilience, enthusiasm, disengagement, teacher attributes, anxiety, learners' demeanour, and confidence are among the psychological factors influencing the performance of Grade 7 learners at selected primary schools in the Frances Baard District.

***Resilience***

This study found resilience to be a psychological factor influencing the academic performance of Grade 7 learners in mathematics classrooms at the selected primary schools. Some teachers highlighted that learners must cope with negative situations, especially during COVID-19 when schools were on lockdown. They stated that learners exhibit resilience when they persist in their school work. When satisfied in their classroom, they often work hard and accept responsibility for their learning:

*"Resilience occurs when learners persist in a task till they have mastered it"* (Teacher 2).

Learners show resilience by bouncing back and remaining on their feet when faced with a complicated situation. Despite the difficulty that learners experience with mathematics, they can still do their work and be productive individuals. Perhaps adults underestimate learners' resilience,

perceiving them as weak. However, because they are young, they may be able to develop greater resilience in the face of adverse situations. The participants stated as follows:

*"Learners' emotional situations make them either strong or weak"* (Teacher 1).

*"Despite experiencing difficulties, learners still do well"* (Teacher 2).

*"Learners are even more resilient than we give them credit for. We need to come down to their level. The way I teach makes them resilient"* (Teacher 5).

*"Learners have low resilience; however, only odd children persevere through difficulties. Some learners do not even try, and in a class of 40 learners, I reach out to four or five children, 10 % of the learners. That is scary"* (Teacher 6).

Teachers from the selected South African schools expressed various opinions regarding the resilience of their learners. Some learners were reportedly resilient because of their challenging circumstances, while others were said to be struggling; hence, their resilience was still questionable despite the support they received from teachers.

***Enthusiasm***

Enthusiasm could be a psychological factor influencing the academic performance of Grade 7 learners in mathematics classes at the selected primary schools. The teachers interviewed stated that in the mathematics class, the learners' feelings determine the level of their satisfaction and success. Similarly, learners' enjoyment and attention in class signify their happiness. Their willingness to attend school regularly and participate in their lessons indicates their happiness. Learners' level of engagement within the mathematics class signifies learner satisfaction:

*"If a child is working in class, they are comfortable in that space, which makes them prosper"* (Teacher 2).

*"Nothing breeds success like success itself. Mathematical thinkers are good at it, and this breeds enthusiasm"* (Teacher 6).

*"When learners are interested in learning and if they love the subject, they exhibit enthusiasm and progress"* (Teacher 4).

Enthusiasm could be a major psychological factor influencing learners' mathematics success. The successes they experience motivate them to put in the effort needed to attain their ultimate success.

***Disengagement***

Disengagement could be considered one of the psychological factors that influenced Grade 7 learners' academic performance in mathematics classrooms at the selected primary schools. The teachers interviewed mentioned that learners did not openly declare their unhappiness in a class; they reportedly displayed it as disengagement. They exhibit a disruptive and inattentive disposition towards the teachers and adopt a lackadaisical approach to their work. One teacher mentioned that some learners display anger by becoming violent toward others and the environment. Another expressed her concern over learner disengagement, which manifests in their results. Ultimately, the learners' emotional instability manifests in their dissatisfaction with classroom activities:

"*Learners hardly show dissatisfaction; they display disinterest and are not focused. This manifests in their low marks. Sometimes, learners show dissatisfaction by displaying anger* (Teacher 6).

*"They do not show dissatisfaction with our thoughts but act out their dissatisfaction"* (Teacher 5).

*"Learners do not openly show their dissatisfaction in the classroom; however, they display defiance, sometimes not working and not paying attention"* (Teacher 1).

Learners display disengagement from the classroom by showing weakened results. This impedes learners' success.

***Anxiety***

The responses in participants' transcripts demonstrate that Grade 7 learners' anxiety could be a psychological factor influencing their academic performance in mathematics classrooms at the selected primary schools. Teachers stated that Grade 7 learners experience fear in the classroom, and this anxiety precipitates learners' poor performance. The anxiety the learners' experience is usually expressed as fear, as some were reportedly afraid of talking to teachers. One teacher

observed that learners had felt some sort of anxiety during the COVID-19 pandemic, thus causing a decline in their performance in mathematics. In extreme cases anxiety can cause sickness in learners. Friends often exacerbate learners' anxiety, thus pressuring them into certain behaviours. A teacher expressed regret at not having enough opportunity to show concern for the learners' situations. Another said that some learners' anxiety emanated from the nature of the subject:

*"The anxiety and difficulty learners experience emanate from the issues they face daily. Some of them experience anxiety because of COVID-19"* (Teacher 5)

*"Learners experience anxiety. However, this is not obvious as they do not openly show it. They can only show it when they have an opportunity. I have not given them enough opportunity to express their issues"* (Teacher 6).

*"Some of the learners do experience anxiety. One girl constantly faints in class, and this adversely affects her performance, including that of other learners, sometimes"* (Teacher 4).

Learner anxiety often manifests in their behaviours and attitudes toward classroom activities. Some learners present with physical signs of anxiety, such as fainting and being sick when the subject content of geometrical and algebraical mathematics quantity (numbers), structure, space, and change are covered. A group of learners also presented with anxiety emanating from aspects of the subject, which evolved through abstraction and logical reasoning from counting, calculation, measurement, and the systematic study of the shapes and motions of physical objects.

***Misbehaviour***

The participants' responses indicate that the misbehaviour displayed by Grade 7 learners could be considered a psychological factor influencing their academic performance in mathematics classes at school. Teachers said that learners' demeanour determines their poor performance in mathematics classes. Learners who behave well and engage with the teacher perform well in their schoolwork. Teachers expressed that learners' performance signifies their behaviours in class and that a culture of learning in the school positively impacts learners' performance.

*"Learners are just not interested in what we teach them"* (Teacher 5).

"*Some learners sit in the hall, but even those in the classrooms are not well-behaved. More than half are battling concepts*". (Teacher 4)

*"They are given rules right at the beginning, and they know what is expected of them. Learners will only misbehave when the teachers give them the permission to do so*" (Teacher 4).

The learners' classroom behaviours largely depend on the teachers' ability to instill discipline and respect by applying rules and regulations. Teachers who can control learners do not experience these disciplinary issues in their classes and pre-empt misbehaviours by keeping students engaged when learners are not following classroom or school rules. Learners sometimes present with disciplinary issues because they do not listen to the lessons and prevent other learners from learning. Teachers reiterated the need to control the behaviours of the learners:

*"During COVID-19, the classes were made smaller; hence, we should keep a finger on the pulse. The learners will struggle when they all return"* (Teacher 2).

*"I do not experience disciplinary problems in my classes. My learners are generally well-behaved and rarely give me problems"* (Teacher 1).

Learners who experienced COVID-19 conditions in the classroom behaved better as the classes were smaller. However, the general behaviours of learners constitute a significant factor determining learners' success in the mathematics classroom.

***Confidence***

Responses from participants' transcripts indicate that the confidence shown by Grade 7 learners could be considered a psychological factor influencing their academic performance in mathematics at the selected primary schools. Learners display confidence in class when they are sure of themselves and not afraid of making mistakes. They often demonstrate confidence when they receive adequate support from their teachers and parents and have grasped the concepts. When learners' self-esteem is boosted, they feel it is necessary to raise their performance in the mathematics classroom. Learners' success leads to their confidence in the classroom; their confidence will wane if they struggle academically. Learners who understand their work in class will have confidence, enhancing their mathematics performance:

*"Their confidence grows when they succeed academically. They even feel superior about their work"* (Teacher 6).

*"Learners' confidence in mathematics varies according to their ability. When they know the concepts, they exhibit more confidence"* (Teacher 5).

Learners' confidence stems from their knowledge and ability to navigate the subject. The most confident learners are those who succeed in mathematics.

**Social factors**

This study demonstrated that the social factors that influence the performance of Grade 7 mathematics learners in the Frances Baard District seem to replicate themselves in the school, family, and community.

**Social factors in the school**

***Learner-learner relationships***

The responses from participants' transcripts show that learner-learner relationships could be considered a social factor influencing the academic performance of Grade 7 learners in the mathematics classroom. Thus, learners' relationships impact their performance:

*"In our school, interactions are subdued, as the school is very small and there are no major social issues"* (Teacher 4).

*"We have girls that form groups, and some want to be worse than others. Maybe this is hormonal, and such learners are problematic. They agitate each other to be difficult"* (Teacher 5).

*"Learners in a group model and emulate each other; this benefits problematic learners and the rest of the class"* (Teacher 2).

Despite these adverse situations, the learners can still perform well. The groups in mathematics classes motivate each other:

*"They can perform well despite the friendly situation prevailing in the class"* (Teacher 1).

*"The culture in our school ensures that most learners will learn because their groups are competitive and want to compete for the best position"* (Teacher 6).

Learner-learner social interactions determine learners' success in the mathematics classroom. This interaction determines how learners interact with the learning material.

***Learner-teacher relationship***

The responses from participants' transcripts show that learner-teacher relationships could be a social factor influencing Grade 7 learners' academic performance in the mathematics classroom at primary school. The teachers' attributes directly affect how learners cope and perform. If the teacher is too strict, the learners fear expressing themselves and will not be responsive in class. Learners' performance will be raised when teachers know their content and are enthusiastic about teaching. The teacher is the main driving force behind classroom performance, as they are responsible for the atmosphere that prevails in the classroom, which impacts learning. Learners need encouragement because they are young and vulnerable. The teachers believed that if educators presented the lessons enthusiastically, learners would keep up their interest, significantly enhancing the classroom climate. Teachers who use positive reinforcement encourage learners to work hard:

*"I enjoy teaching my learners new concepts, as shown in my presentation"* (Teacher 6).

*"My learners love my lessons, and the videos I use keep them entertained. Effective teaching methods help to maintain discipline. The learners' behaviour depends on the teachers' teaching methodology"* (Teacher 2).

*"Teachers ought to consider the learner's situation. They need to care for the children's needs, looking at the situation from their perspective"* (Teacher 3).

*"The teachers' attitude communicates a lot to the learners; when they are confident, they will capitalise on that and will also be confident"* (Teacher 5).

Teachers' relationship with their learners hugely impacts the learners' attitudes and how they learn. This also adds to the enjoyment they experience in class.

***Family issues***

Responses from participants' transcripts indicate that family issues among the Grade 7 learners could be a social factor influencing their academic performance in the mathematics

classroom at selected primary schools in South Africa. The teachers mentioned that they knew of the family-related social issues their learners experienced, such as living with grandmothers and having parents working away from home. Learners may live with older siblings, which means they do not always have the support of strong family relationships. Some teachers felt that their learners were getting the psychosocial support they needed, and thus, family structural issues should not be a problem. Many teachers attested that their learners remained strong despite these difficulties. The parents' economic situation profoundly affects the learners' social background.

One teacher mentioned that the on-site social worker cares for the learners grappling with adverse social situations the school cannot handle. When learners from poorer homes come to school, they are more likely to be affected by the situation at home than their peers from wealthier families. Teachers lamented situations where parents only take responsibility for their children's physical needs, leaving the rest to the educator. Five teachers declared they witnessed little or no parental involvement in their child's schooling. If parents were perhaps more involved, this would instill accountability among the learners. As three participants noted:

*"The family situation either positively or negatively affects learners"* (Teacher 5).

*"Many learners face social issues at home, often negatively impacting their schooling. Such issues are not always evident but do come up often"* (Teacher 4).

*"Parents feel that once the learner is in school, they cease to be their responsibility. They avoid taking care of their children"* (Teacher 1).

Learners come to school with certain feelings, depending on their origins. This stems from their relationship with their families. Learners residing in the Frances Baard district often live with other family members, which determines how learners feel at school.

### *Community issues*

Responses from participants' transcripts suggest that community issues are a social factor that influences Grade 7 learners' academic performance in mathematics classes at primary school. The school is a microcosm of the larger community, and those social ills that are prevalent in the community permeate into the school system. The participants stated that some difficulties that learners face emanate from their communities, such as bullying of weaker learners. The areas that some learners come from have a stigma attached to them, and learners are often affected by that reality. Most schools provide learners with food; however, this is not the only social issue that learners face. The poverty that the community experiences influences learners' performance in class. One educator mentioned that the different factions learners subscribe to result in learners discriminating against each other despite their minor differences. There were various factions in one of the schools, and these groups came into the school and disturbed its harmonious functioning:

*"My learners are affected by the community they come from; some of them come from very poor communities, a situation that negatively affects them. They come from rough areas"* (Teacher 1).

*"Some learners are indoctrinated into joining gangs early, and this accompanies them to school. This has become a serious problem these days"* (Teacher 3).

Violence has always prevailed in South Africa, as communities are riddled with gangsterism and social ills. This issue hugely impacts learners' performance. Learners from these areas are mentally and emotionally affected by their surroundings.

## Academic factors

The academic factors that influence Grade 7 learners' performance in mathematics classes include the inability to comprehend concepts, mathematical learning difficulties, the language barrier, and the lack of appropriate mathematical resources.

### *Inability to comprehend mathematical concepts*

The responses from participants' transcripts indicate that Grade 7 learners' lack of comprehension of mathematical concepts is an academic factor that negatively influences their academic performance in mathematics classes at primary school. Teachers opined that the inability to comprehend concepts is believed to be the most familiar challenge, as this is the inner nature of mathematics; thus, the retention of facts can always be learned, though learners will get to use a calculator later. Mathematics requires learners to analyse and solve complex problems (Krawitz et al., 2022). Understanding mathematical concepts becomes easy if learners' conceptualisation of the

content is strong. Teachers think that if learners' foundation is not strong, they struggle to grasp mathematical concepts. Mathematical concepts are what learners need to learn in the lower primary grades; if their number of concepts were adequately consolidated, they would not have this problem. If they know the relationship between numbers, their understanding will be enhanced:

*"The retention of facts is problematic to learners, as they hardly apply themselves enough. They can understand everything, though they do not clearly understand the concepts"* (Teacher 1).

*"The retention of facts and concepts is balanced in difficulty, some retention and others concepts. They know what numbers are. It does not have to be difficult"* (Teacher 2).

*"Strong learners understand the concepts and retain the facts. On the contrary, weak learners cannot do any of those things"* (Teacher 3).

Two major factors affect mathematics learners: the retention of facts and understanding of concepts. Learners with these two attributes are less likely to struggle during mathematics classes.

### *Difficulties with learning mathematics*

The responses from participants' transcripts demonstrate that difficulties with learning mathematical concepts is an academic factor influencing the performance of Grade 7 learners at primary school. Educators expressed issues with mathematical difficulties, some of which are prevalent because the learners do not know the basics of mathematics. Some teachers advocated adopting and modifying teaching strategies to overcome this problem. These teachers felt that there were no difficulties in learning mathematics, arguing that everyone was capable and they just had to apply themselves. The curriculum has perhaps rapidly moved on to abstract teaching, and learners often cannot visualise what is being explained. The Grade 7 curriculum vastly differs from the previous grades in that fractions, for example, jump from looking at a fraction wall in Grade 6 to no use of the wall in Grade 7. The teachers mentioned that concrete manipulatives should be used, but consecutive numbers were mentioned as problematic.

Learners struggle to understand specific topics, such as fractions and geometry, which must be concretised to enhance their understanding and mastery of mathematics. In geometry, the learner must be pre-exposed to certain educational games. Some teachers mentioned that geometry is challenging for learners with developmental difficulties. If learners are not at the expected developmental stage, where they can understand how these shapes can be manipulated, they will face difficulty in understanding three-dimensional (3D) shapes. Two teachers said that the teaching strategies that should be used have to be adapted to the learners' level. Learners do not always understand what they are reading, which becomes a problem:

*"When learners are at the right developmental stage, they do not struggle with 3D shapes. Those who struggle with it did not have enough exposure to it"* (Teacher 1).

*"Learners have not been taught well in the earlier years; hence, they struggle"* (Teacher 5).

*"Consecutive numbers are a problem, but when learners eventually get the concept, it will be too late, and the concepts will be difficult at that stage"* (Teacher 4).

One crucial factor that could contribute to learners' success in the mathematics classroom is having a solid foundation of the subject in terms of number concepts and number sense. This is because mathematics is a scaffolded subject, meaning that what is learned early on is essential for learners' later success.

### *Teaching mathematics in the learners' second language*

The participants reported that teaching mathematics in the Grade 7 learners' second language is an academic factor influencing their academic performance in mathematics at primary school. Teachers reported that teaching and learning mathematics is a complex issue, and when learners are taught in their second language, this becomes a barrier. The language of teaching and learning is essential as it enhances understanding of the concepts taught. It is important to note that the language of school instruction differs from the learners' home languages. The vernacular language of learners in the Frances Baard District differs from the medium of instruction, which may negatively impact their teaching and learning. Some teachers expressed the desire to know more about their learners and thought that if they did, they could reach out to more of them:

*"There is a language barrier, as learners do not understand me. Language is a big barrier"* (Teacher 4).

*"Learners are not taught in their home language, which is a huge problem. I am not familiar with their culture. If I knew more about them, I could have reached out to more learners"* (Teacher 6).

*"If we could teach them in their home language, it would be a great advantage for us and the learners"* (Teacher 3).

One educator felt there was no need for culture and considered it an issue that should be excluded from the class.

## 5. Discussion

The findings present the factors that influence the academic performance of Grade 7 learners in mathematics classes. The factors were divided into psychological, social, and academic categories. Psychological factors include learner resilience, learner enthusiasm, learner disengagement, learner anxiety, and learners' behaviours and confidence in the classroom. The social factors included school, family, and community issues. School issues fall into two categories: peer relations and learner-teacher relationships. Academic factors included a lack of comprehension of mathematical concepts, mathematical learning difficulties, and teaching mathematics in the learners' second language.

This study demonstrated resilience as a psychological factor influencing the performance of Grade 7 learners in mathematics at the selected primary schools. They worked hard and accepted responsibility for their learning. Learners were happy in the class and displayed this by doing what was expected of them. Teachers professed that despite learners' difficulties during COVID-19, they remained positive and maintained their psychological balance. Despite harrowing conditions, resilience has been conceptualised as learners' ability to succeed (Hutauruk, Priatna, 2017). A resilient learner can persist through complex mathematical issues (Hafiz, Dahlan, 2017). The teachers who participated in this study said that learners persisted with a problem until they had mastered a particular mathematical concept taught in the classroom.

The enthusiasm the Grade 7 mathematics learners display in the classroom was found to be a psychological factor influencing their performance. The learners' enthusiasm during classroom activities reflects how successful they are. A learner who fully engages in class activities displays enthusiasm. A study in Tanzania established that learners' enthusiasm can be enhanced when they are interested in using technology (Uchidiuno et al., 2019). An Iranian study supports that the classroom environment determines learner enthusiasm (Khajavy et al., 2018).

This study found disengagement to be a psychological factor influencing the performance of Grade 7 learners at primary schools. Sometimes learners are not disengaged, but their results show that they are not working, as they are not at a developmental level where they can clearly express their feelings; thus, they show their feelings by acting out and being disengaged. In this context, disengagement does not mean behaving badly; they are simply disinterested in what they are being told to do. When learners are disengaged from the class, their performance will be seriously hampered (Engels et al., 2019).

Learner anxiety was found to be a psychological factor that tended to influence Grade 7 learners' performance in mathematics at the selected primary schools. Anxiety involves the learners anticipating that something bad will happen to them. The study showed that learners could manifest anxiety due to COVID-19. The teachers expressed that those learners felt anxious, and despite this, they still came to school. It was highlighted that pressure from teachers and parents regarding mathematics could contribute to the learners' anxiety. Segumpan and Tan (2018) reiterated that teachers might be partly responsible for the anxiety learners experience in the classroom. Similarly, Boaler et al. (2019) emphasised that when learners are under pressure and stress, their brain function is not at its best due to anxiety.

This study found that as a psychological factor, the behaviours of Grade 7 learners in the classroom influence their performance in mathematics classes at primary school. They act out by obtaining substandard results. Some learners sit passively throughout the lesson and then ask a friend for help. Such learners seldom misbehave. Thus, teachers should be able to control learners' behaviours (Tran, 2015). One teacher with over 25 years of teaching experience said, "I wish they were as behaved as they seem because their results show that they do not understand the concepts being taught in the class". When learners were exposed to the idea that they 'can' do mathematics,

this positively influenced their performance (Boaler et al., 2019). Teachers in this study mentioned that learners struggled to cope with everyday issues in the class.

Learner confidence was a psychological factor possibly influencing Grade 7 learners' performance in mathematics classrooms at primary school. Learners' confidence is a major factor that impacts their performance. Several factors can be attributed to learners' confidence in the classroom, including academic success, personal history, and individual differences (Wentzel, Miele, 2016). The participants in this study also alluded to this reality, acknowledging that their attitudes and attributes in the class directly affect learners' performance. Learners who showed confidence put more effort into their work, enhancing their performance (Velayutham, Aldridge, 2013). The link between what learners think of themselves and their performance is a factor that highly affects their performance in mathematics. Learner confidence increases when they have adopted the skills needed in the classroom (Bernales, 2016). This study found that learners' mindset distinctly affects their confidence level in the classroom.

This study found peer relationships to be a social factor influencing Grade 7 learners' performance in mathematics at primary school. Peer interaction among learners could impact their learning in mathematics when their friends encourage them to be studious to succeed. However, it may negatively impact learners when their peers influence them to misbehave. It could be positive when it benefits learners by promoting the values of academic and social relationships at school. According to Camerini and Schulz (2018), peer relationships are necessary for developing learners' social well-being at school.

This study also found that teacher-learner relationships might be a social factor influencing the Grade 7 learners' performance in the mathematics classroom at the selected primary schools. These relationships contribute directly to learners' engagement with the content and knowledge of the subject in classrooms (Yuan et al., 2018). The literature demonstrates that teachers' relationships with their learners enhance learners' academic performance and achievement (Sneyers et al., 2018). Teaching new concepts with great enthusiasm and confidence could enhance the learners' preparedness and confidence to work hard and prosper. As the teacher-learner relationship impacts learners' performance, teachers need sufficient support and must acquire the required skills to support their learners (Albright et al., 2017). A teacher's positive attitude makes the atmosphere in the class positive and conducive to teaching and learning.

Family issues were also a social factor that possibly influenced the Grade 7 learners' performance in mathematics at primary school. The family unit is essential, as it shapes the holistic well-being of learners. When the family structure protects a child, it becomes easier for that child to navigate worldly problems. Learners who believe they have their parents' support do better academically as they are supported emotionally and socially (Peteros et al., 2019). Providing social and economic support to families is necessary to enhance learner engagement in the classroom (Asongu et al., 2019). It affords them some sort of security. Parents' working hours do not allow them to interact with their children and give them emotional support. The literature depicts learners with family support as more capable of achieving higher academic scores than those without it (Schulze, Lemmer, 2017).

This study found that community issues are a social factor determining Grade 7 learners' performance in the mathematics classroom at primary school. The social ills that a society experiences spill into the school system because the learners come from the same community. Learners who reside in socially unfavourable conditions struggle at school because they constantly fight for survival (Urbina-Garcia, 2019). They come from poor communities where the members have not been able to secure a better life for their children. A study conducted in Brunei proposes that for a learner to succeed, the focus must be on the communities surrounding the schools (Abdullah et al., 2018). An African study found that interventions are necessary to enhance learners' living standards (Asongu et al., 2019). Learners come from different backgrounds, and these differences culminate in them fighting when they are made to sit together in the same classroom.

The Grade 7 learners' lack of comprehension of concepts was found to be an academic factor influencing their performance in the mathematics classroom at primary school. Learners may be able to learn retention of mathematical facts, but failing to comprehend the concepts means that they cannot understand what is being taught. It would be excellent if teachers tried different strategies to get learners to understand that fractions and geometry are more complicated (Roesslein, Codding, 2019). The conceptual foundation has not been adequately laid down, so the learners struggle with mathematics in this phase.

This study found mathematics-related learning difficulties to be another academic factor that influences Grade 7 learners' performance in the mathematics classroom. Mathematical learning difficulties are prevalent among learners because teachers might use ineffective mathematical teaching strategies. An African study supports the idea that upgrading technology will foster educational enhancement in Africa (Samarakoon et al., 2017). Learning needs to be differentiated, as it gradually becomes abstract, taking advantage of what learners know and introducing what is not known (Fitriani et al., 2018). Teachers must adapt and modify their strategies to match learners' learning needs.

It was also found that teaching mathematics in the Grade 7 learners' second language is an academic factor that could influence their performance in mathematics at primary schools in South Africa. According to Choi et al. (2018), learners should receive intervention in the second language early to enhance their mathematical ability later in their schooling careers. Most of the learners in this study spoke English as their second language.

## 6. Conclusion

Based on the findings from this study, it is recommended that mathematics teachers create a conducive and stimulating atmosphere at their schools, regardless of learners' backgrounds, ethnicities, languages, locations, and gender. Mathematics teachers should consider increasing their interaction with learners who perform poorly in the subject and recommend them for involvement in make-up classes, tutorial classes, or special coaching. Teachers should encourage learners who personally want to enhance their achievements through questioning, better interpersonal relationships, and giving them special attention.

The study has highlighted the psychological issues that rural South African learners face in Mathematics classes. Much emphasis is usually placed on more populated schools; thus, this is an advantage of this study. The need for psychosocial intervention has been brought up to inform authorities. There is also a great need for academic intervention in the schools. The last issue that was raised is that there is a need for teachers to upgrade their teaching strategies.

Limitations of this study include the fact that the researchers collected data from six schools, one of which was private, and five public schools, all of which are under the jurisdiction of the State. Thus, the results cannot be generalised to the entire South African population. The study also focused only on one exit grade, Grade 7, when learners transit from the Intermediate Phase to the Senior Phase, but there are two more: the Foundation Phase (Grade 3) and high school (Grade 9). The study was also only conducted in the Frances Baard District, a rather more rural province than other provinces in South Africa. The study sample was smaller than required in a qualitative approach, limiting the study's results. This study also focused only on one subject, mathematics, and could have benefitted from exploring more subjects.

## 7. Declarations

### *Ethics approval and consent to participate*

Institutional approvals and participants' consent were obtained before the commencement of the study. The authors ensured that the study met the requirements per the Declaration of Helsinki - Ethical Principles for Medical Research Involving Human Subjects, developed by the World Medical Association in 1964.

### *Consent for publication*

All authors read and approved the final version of the manuscript for publication and agree to be accountable for all aspects of the work, ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

### *Availability of data and materials*

Available upon formal request to the corresponding author.

### *Conflict of interest statement*

The authors report no conflicts of interest.

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***Authors' contributions***

All authors contributed equally to this work. They collaboratively developed the concept and design of the study, collected data, and contributed to the analysis and interpretation of the collected data. Additionally, all authors were involved in drafting, revising, and finalising the manuscript.

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**Authors' ORCID**

Fatima Ajimudin https://orcid.org/ 0000-0002-5085-6611
Kananga Robert Mukuna https://orcid.org/0000-0002-1787-4543

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# Socio-Economic Activities and the Sustainability of Fish Smoking in Small Communities: Insights from the Central Region of Ghana

Alexander Tetteh Kwasi Nuer [a, *], Selorm Omega [a], Nazir Kizze-Hayford [a], Jerry Ampofo-Asiama [a], Salifu Seidu-Larry [a], Vivianne Geraldo [a], Isaac Okyere [a], Samuel Bridge Nkansah [a]

[a] University of Cape Coast, Cape Coast, Ghana

**Abstract**

This study explores the impact of fish processing activities on the socio-economic well-being of fish smokers along the coastal regions of Ghana's Central Region, to improve sustainability in fish processing and supply. Using a qualitative phenomenological research design, data was collected through purposive sampling from four fish smokers, each with over 20 years of experience and an average age of 55 years. Thematic analysis was employed to evaluate participants' perspectives on the fish processing industry. The findings revealed that the fish smokers predominantly processed herrings, mackerel, anchovies, and tuna sourced from the sea or cold stores, with smoking primarily done using the Chorkor oven. Despite variations in location or oven type, their operational practices were largely similar. Participants clearly understood their market dynamics, including clientele preferences and pricing strategies. However, key challenges included financial and labour constraints, along with erratic fluctuations in the price of raw fish. The study noted that improving hygienic practices could significantly enhance the shelf life of smoked fish, thereby boosting income and socio-economic prospects for fish processors. The results underscore the importance of addressing operational challenges in the fish processing industry while providing actionable insights for enhancing sustainability. Additionally, the study offers methodological recommendations and highlights strategies to improve smoked fish sales, contributing to a deeper understanding of the socio-economic impact of micro and small-scale fish-smoking enterprises.

**Keywords:** Chorkor and Ahotor Ovens, Central Region, Challenges, Fish Smokers, Ghana, Socio-economic well-being.

## 1. Introduction

Along the coastal regions of Ghana, fish smoking forms an essential socio-economic activity, generating income and creating employment opportunities for several coastal dwellers. Fish smoking is one of the major activities of women in the coastal zones (Sakyi et al., 2019). Due to its delicacy, flavour and aroma, smoked fish is one of Ghana's most consumed processed fish (Antwi, Beran, 2017). In addition to the coastal areas, smoking is also carried out in-land where fish used

*Corresponding author
E-mail addresses: alexander.nuer@ucc.edu.gh (A.T.K. Nuer)
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for smoking can either be obtained frozen from cold stores or fresh from other water bodies (Acosta-Alba et al., 2022). Indeed, fish smoking and its related activities contribute immensely to Ghana's economy, serving as a means of employment, financial gains and improved food security (Acosta-Alba et al., 2022).

Despite its importance, the fish-smoking industry in Ghana is largely unregulated; consequently, different oven types, wood fuels, and processing methods are employed (Avega, Tibu, 2017), leading to variabilities in fish quality. Also, the lack of cooling facilities onboard fishing boats/canoes and landing sites and inadequate know-how in fish post-harvest handling among processors compromise the quality of fish used for smoking. Also, poor processing and packaging techniques and storage facilities have led to the reduced quality of smoked fish from Ghana (Pemberton-Pigott, 2016). Thus, to ensure that the country attains the full economic potential from the fish smoking sector and to help improve the economic status of fish smokers, it is essential that factors that influence the cost of production, profit margins, preferences of consumers and other challenges are brought to the fore. It will even become more pertinent if the fish smokers propose these factors and strategies to mitigate them, as these will enhance adaptability when solutions are proffered.

Factors that are known to influence the cost of production and the profit margin of fish smokers include the source and type of fish, the type of oven used for smoking, and the facilities used to store both fresh and frozen fish (Okorley et al., 2004; Obodai et al., 2009; Sakyi et al., 2019). Within the coastal communities, fresh fish obtained directly from the sea is the major source of fish for smoking. When fresh fish is unavailable, frozen fish from cold-storage facilities are accessed for smoking. The differences in price between these two sources and the cost of transporting fish to the smoking area influence the cost of production (Kwadzo, 2022). Until recently, fishing was allowed all year round, ensuring the continuous availability of fish for smoking. However, since the introduction of the fallow period for fishing in 2016, which spans from July to August each year (Adom et al., 2019), the fishing period in Ghana has been classified as either open (allowed fishing period) or closed seasons (prohibited fishing period). The introduction of the closed season compels smokers to rely mainly on frozen fish for smoking, thus increasing the cost of production since frozen fish are usually sold at higher prices.

Among the ovens used for smoking in Ghana, the most popular is the Chorkor oven, developed more than 50 years ago to overcome the challenges associated with more traditional ovens such as the mud and barrel/drum ovens (Owusu, 2019). Studies, however, have shown that the Chorkor oven has low fuel efficiency and produces excessive amounts of smoke, raising safety concerns for both the users and consumers(Bomfeh et al., 2019; Pemberton-Pigott, 2016). This led to the development of new and improved ovens such as the Ahotor oven. The two ovens are shown in Figure 1 below.

**Fig. 1.** The Chorkor (Bomfeh et al., 2018) and Ahotor (Kubi, 2019) ovens

However, challenges related to low production capacities and installation costs continue to serve as a disincentive to smallholder fish processors (Kwarteng et al., 2017; Owusu, 2019). The lack of storage facilities limits the quantity of fish that can be procured for smoking and how long the smoked fish can be stored before use. In this case, only small quantities of fish can be

smoked at a time since any unsold smoked fish will spoil and lead to waste. Also, due to the limited shelf life of smoked fish, fish smokers are sometimes compelled to sell at much lower prices to prevent waste and losses (Okorley et al., 2004). In addition, there is no standardised system for smoking fish in Ghana. These present wide disparities in the quality of fish among smokers, increased rejection rates at international markets and price variations. Therefore, a procedure for fish smoking must be developed for nationwide adoption that can help enhance the quality of smoked fish. To this end, it is important to study the similarities and differences in the processing activities of fish smokers so that a standard processing method can be developed. Within the fish-smoking communities, associations can be formed among fish smokers to promote well-being and ensure compliance with existing national or traditional regulations (Sharma et al., 2010). In these associations, leaders are chosen to help promote and safeguard the association's activities, with age, years of experience, and sometimes financial status being considered as criteria for selecting the leaders. Hence, by interacting with these leaders, information relating to the fish-smoking activities of a particular community and the challenges faced by the smokers that influence their socio-economic well-being can be obtained. This study contributes knowledge to understanding the effects and potential issues that need to be addressed to improve the sustainability of the fish smoking businesses along the coastal regions, where fishing and fish processing activities are prominent.

## 2. Methods and Materials

### *Research Design*

This study used a qualitative research design to examine the social environment from the viewpoint of individuals (Bryman, 2004). The social world consists of how members perceive and interact with the outside world. Among the different categories employed in qualitative studies, the phenomenological research design, which can be used to ascertain the experience of fish smokers, was employed in this study (Creswell et al., 2007). According to Heidegger (2005), phenomenological research design effectively brings out participants' experiences and perceptions. This design allows for different data collection methods, such as interviews, conversations, observations, focus meetings, and personal texts. According to Opie (2019), phenomenological research suspends a researcher's personal opinion and assumption about an issue and assumes the existence of a universal structure to make sense of people's experiences. This gives the researcher the chance to interpret participants' feelings, perceptions and beliefs in an unbiased manner. Thus, a phenomenological research approach was employed to thoroughly understand how fish smokers evaluate their socio-economic well-being.

### *Study Area*

The Central region, which is one of 16 regions in Ghana, was selected for this study. The region lies to the country's southwest and shares boundaries with the Eastern Region to the northeast, the Ashanti Region to the north, the west with the Western Region, and the Greater Accra Region to the southeast. The Gulf of Guinea lies southbound in the region. With a total land area of 9830 km$^2$, the region has the longest coastline (150km) (Ministry of Food and Agriculture, 2020). The region has an annual temperature range of 24-34 ° C, with a bi-modal rain pattern (April to July being the major season and September to November being the minor rainy season) leading to an average rain of 800-1500 mm.

The Central Region has a population of about 2.9 million, accounting for 8.9 % of Ghana's population (Ghana Statistical Service [GSS], 2022). The average household size of the region is 6.6 %, with 3.2 and 3.4 % being urban and rural residents, respectively. With an average age of 24.4 years, the region is considered to have a youthful population. The major economic activity of the inhabitants of the region is fishing, mining and services (GSS, 2022).

### *Sample size and sampling technique*

Purposive sampling was employed in this study based on the recommendation as the preferred sampling procedure for qualitative research (Palys, 2008). Leaders of fish smokers from Winneba (located in the Efutu Municipal District) and Elmina (situated in the Komenda/Edina/Eguafo/Abirem Municipal District) who form part of the Cerath Development Organization's Power to the Fishers Project (PFP) were selected. PFP is a European Union-funded community project aimed at improving the quality of smoked fish and enhancing livelihood by constructing improved smoking ovens for fish smokers in some selected communities. Participants selected for this study were group leaders of the PFP at both locations. Additionally, participants benefited from various training programs organised by different organisations, had long years of

fish smoking experience, were fairly educated, and were involved in the commercial production of smoked fish. Participants were also up-to-date with knowledge of the fish value chain. Leaders of two fish-smoking communities in Duakor and Savoy (located within the Cape Coast Metropolitan Area) who were not part of the PFP were also compared.

***Data collection instruments and procedures***

The data collection instruments used for the study were observation and an interview guide (face-to-face interviews), which covered questions on socio-economic characteristics, fish processing activities, marketing activities and challenges faced in fish processing. Interviews were audio-recorded and transcribed. Additionally, notes were taken during each audio recording. Prior to the interview, the aims and objectives of the study were verbally explained to each participant. A rapport was developed between the participants and the interviewer to build trust and cooperation through visits to the study locations before the interview. The respondents were given the freedom to decide to participate in the study. All interviews, which lasted from 30 to 45 min, were conducted in a conversational manner to promote dialogue rather than mere responses to questions.

The validity of the instrument was tested to reflect the truthfulness of the findings. For Creswell (2014), validity for qualitative research instruments emerges from the instruments' scores and interpretation. In this research, the internal (credibility) and external (transferability) were checked. The internal validity of the study instrument was checked by assessing the feasibility of replicating the study among other fish smokers. This was achieved through peer review checks of the instrument. The input received from the peer review was used as a guide in correcting the final instrument for grammatical errors and misleading or ambiguous questions.

***Data analytical framework***

The data collected was analysed using thematic analysis with the help of Microsoft Word software for qualitative data analysis. The thematic analysis was conducted following the framework outlined by Braun and Clarke (2006), which involves familiarisation with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report. The data analysis was based on the following themes:

1. Sources and types of fish and oven types used for smoking;
    a. Source of fish for smoking;
    b. Types of fish used for smoking;
    c. Oven types used for smoking;
2. Activities carried out by fish smokers;
3. Marketing activities of micro, small scale fish smokers;
    a. Pricing of smoked fish;
    b. Customer base;
    c. Shelf life of fish;
4. Challenges faced by fish smokers.

## 3. Results

***Socio-demographic characteristics of the participants***

The relevance of age among fish smokers is closely tied to their fish smoking experience and their ability to improvise and adopt different smoking practices. Age also plays a crucial role in determining the level of risk and investment a fish smoker is willing to commit. However, it was observed that many fish smokers either did not know their exact age or were unwilling to disclose it, with participants in this study reporting varying ages, with a miniumum age of 50 years and a maximum age of 67 years.

**Table 1.** Socio-demographic characteristics of the participants

| Participants | Gender | Age | Years of fish smoking Experience (years) |
|---|---|---|---|
| 1 | Female | 62 | 30 |
| 2 | Female | 55 | 30 |
| 3 | Female | 67 | 28 |
| 4 | Female | 50 | 30 |

As fish smokers advance in age, their experience is expected to improve, leading to the adoption of better processing practices, increased income levels, higher adoption rates of new technologies, and greater ease in adjusting to improved methods. In many communities, experience is considered as important as formal training, with most individuals learning fish smoking as a primary occupation through hands-on training provided by relatives or close associates.

For some respondents, fish smoking became an occupation due to a lack of employment opportunities, as they lacked the requisite skills and training to work in the formal sector. Over time, the income generated from fish smoking motivated them to continue as a business, thereby increasing their fish processing experience. In other cases, fish smoking experience arose from migration, driven by the need to support family income and improve livelihoods. For others, however, the experience of fish smoking was entirely accidental, occurring without prior intention but developing into a skill over time.

***Smoking period***

The period allocated for fish smoking within a week differed based on the geographical location. This was ascribed to existing traditional regulations, personal reasons and the demand/supply of smoked fish. In almost all the coastal communities of Ghana, fish smoking activities are low during July to August due to the close season policy implemented by the Ministry of Fisheries and Aquaculture (Apetorgbor, 2018). During this period, fish smokers depend on frozen fish from cold stores, which are mostly imported fish and are considered expensive. Regarding how often fish smoking is carried out, the opinions of participants were;

*"I smoke fish every day except on Tuesdays because I go to the seashore for new stock. I have my own canoes that land on Tuesdays, so I have to go check on them and bring the catch home. It is stressful, so I take Tuesdays off after getting home" [**Participant 1**].*

*"I do all my smoking weekly. I select a day and do all my smoking for the market depending on the availability of fish. During the close season, I smoke fish once a week, but in the open season, sometimes 3 or 4 times" [**Participant 2**].*

*"I do mostly smoke 30 pieces of fish a day. I do this to sell off my smoked fish faster than bearing additional storage costs" [**Participant 3**].*

*"I smoke three times a week. During the remaining days, I use it to sell the smoked fish since I do almost everything by myself" [**Participant 4**].*

Based on the responses, it can be surmised that the factors that influence how often fish is smoked include socio-economic status, the ability to keep the smoked fish from spoilage, and whether the smokers sell the fish directly on the market or hand over the smoked fish to third parties usually women retailers for sale.

**Sources and types of fish and oven types used for smoking**

***Source of fish for smoking***

Fish smokers in Ghana obtain their fish mainly from two main sources, depending on the season/month. During the closed season (July-August), frozen fish is preferred, while fresh fish is obtained directly from canoes and boats during the open season. This view is shared by participants as;

*"My source of fish for smoking is mainly from the sea. I have people who supply me with fish all year round. Sometimes during the close season, they move to other neighbouring counties to fish and supply me" [**Participant 1**].*

*"Because of my customers, I prefer fish directly from the sea. They say fish from the sea taste better and are fresher, so I have no choice but to meet their need. Sometimes the price is high, but they still buy it" [**Participant 3**].*

However, depending on the season, some smokers prefer a combination of both frozen and fresh fish to meet consumer demand. This ensures the availability of smoke fish throughout the year, as shared by a participant;

*"I use a combination of cold stored fish and freshly caught sea fish depending on the time of the year and the demand volumes I have to meet. In some cases, I smoke fish according to customer orders. The reason being that if you don't adjust, you will run out of business" [**Participant 2**].*

***Types of fish smoked***

The choice of fish used for smoking is dependent on the consumers' demand, the cost of obtaining fish, and the consistency of the supply of fish. A similar opinion is shared by a participant as;

*"I smoke mainly Eban (herring) due to its growing demand. Most customers use it for shito (black pepper) and preparation of various local dishes, so there is always demand. However, during the close season, getting it is very difficult. Thank God, herrings have a long shelf life, so I can keep them throughout the close season and sell at a higher price" [**Participant 1**].*

For some fish smokers, however, the preference is to smoke two or more varieties of fish to ensure profit despite the seasonal variations in fish catch and cushion income levels. As reported;

*"I smoke different types of fish like salmon, redfish, tuna and other types of fish. I smoke any kind of fish the fishermen bring as far as it is eaten by consumers. Sometimes, consumers are new to the fish type, but I convince them it is good. If you don't do that, business will suffer" [**Participant 2**].*

***Oven types used for smoking***

The most popular type of oven used for commercial fish smoking in Ghana is the Chorkor oven (Figure 1), which was built to improve over the more traditional metal drum oven. Challenges, however, associated with the use of the Chorkor oven have been reported, especially related to the excessive amount of smoke generated and the exhaustion of large quantities of firewood. This has led to the development of new and improved oven types, the most popular being the Ahotor oven (Figure 1). In congruence with this study's results, the fish smokers' decision to select an oven type depended on customer preference and market demands. This is articulated by a participant as;

*"I tried shifting from the Chorkor to Ahotor oven, but I realised consumers prefer the smoked fish from the Chorkor smoker due to the colour. Therefore, I am giving consumers what they want" [**Participant 2**].*

*"fish smoked with Ahotor smoker are drier and discoloured compared to Chorkor, which is oily and fresh" [**Participant 2**].*

*"I prefer the Chorkor to Ahotor oven because the Chorkor smokes fish faster" [**Participant 3**].*

*"I have both Chorkor and Ahotor ovens, but I mainly used the Chorkor oven for smoking fish, but if I consumer places an order and request that I use the Ahotor oven, then I will use it" [**Participant 3**].*

When the two participants who do not have the Ahotor oven were asked when they intend to procure it, their responses included;

*"I do not have money to buy the Ahotor oven, and I don't know why I should buy it because my customers have not requested that I use it" [**Participant 4**].*

*"Smoking fish using the Ahotor oven takes too long, so I don't have plans to procure one yet" [**Participant 1**].*

**Activities carried out by fish smokers**

The field visits revealed the activities of the participants as shown in Table 1.

The observations depict several similarities in the activities of the smokers from the sample acquisition stage to the packaging of the smoked fish. The fish smokers commonly purchased fish from the cold store facilities within their locality because fish was out of season. Additionally, similarities in the pre-smoking steps, such as the sorting, washing, draining and drying, were observed among the fish smokers. However, it was observed that to achieve a unique flavour for the smoked fish, additional steps, such as using mesh from neem tree leaves, were introduced.

The type of oven mostly used was based on the processing time and the consumers' preferences. The similarities in the activities of the smokers imply that it is possible to develop and implement a smoking process in Ghana that could be acceptable to all fish smokers.

**Table 1.** Activities of the fish smokers during fish processing

| Date | Location | Activities |
|---|---|---|
| March 21, 2022 | Duakor | 1. Frozen fish was obtained from a cold store in the Abura community of Cape Coast, Ghana.<br>2. The price of the frozen fish at the cold store was ¢550.00 per box.<br>3. Fish stocked at the cold store was obtained from Tema and Accra at whole sale prices.<br>4. Transportation of fish to the smoking site was done using a salon car.<br>5. Smoking of fish at the facility began at 3 pm and was completed by 9 pm.<br>6. Smoking was carried out in the participant's own home.<br>7. The Chorkor oven was used for smoking fish.<br>8. Approximately 54 pieces of fish were smoked at a time.<br>9. The participant usually allowed the frozen fish to thaw under ambient conditions, followed by washing with tap water. The washed fish was transferred into plastic baskets to drain after which the fish was arranged on a wooden mesh of appropriately 90 cm x 90 cm for smoking. Firewood was then loaded into the vent of the Chorkor oven. On average, the mesh was turned every hour to allow for even smoking of the fish. After smoking, the mesh and the fish were allowed to cool to room temperature, and the fish were transferred into a woven basket lined with hard, brown paper to keep the smoked fish intact.<br>10. Some challenges that fish smokers encountered during the smoking process included the late start of smoking and difficulty in getting the required quantity and type of fish.<br>11. Round Mackerel fish was the frequently available type used for smoking. |
| 23rd March 2022 | Winneba | 1. Frozen fish was obtained from a cold store in Winneba.<br>2. The price of fish at the cold store was ¢780.00 for two boxes.<br>3. Fish transportation was done using a commercial vehicle (Taxi).<br>6. Frozen fish in the cold store was obtained from Tema and Accra and was sold at retail prices.<br>7. In most cases, the cold store owners preferred to sell to members of the fish smokers associations than to individuals, especially because they could offer sales on credit.<br>8. Both the Chorkor and Ahotor ovens were used for smoking fish.<br>10. Smoking started at 10:10 am for both ovens and was completed by 1:00 pm or 1: 35pm for the Chorkor or Ahotor ovens, respectively.<br>10. Smoking was carried out at the PFP fish processing center.<br>11. A total of 200 pieces of fish were smoked, 100 for each smoking oven.<br>12. Atlantic club mackerel was used for smoking.<br>13. The process of fish smoking was comparable to the previously described process with the following modifications: thawed fish was washed with salted water. A fourth mesh was used to cover the fish during smoking to help retain the heat, which helped to decrease the smoking time. Smoking was faster for the Chorkor oven, requiring a more frequent turning of the mesh than for the Ahotor oven. After smoking, the mesh was placed on the ground to cool. The smoked fish was similarly packaged in plastic baskets lined with brown paper and appropriately labelled.<br>14. Among the observed challenges faced during the smoking process were the late start of smoking, difficulty in getting the required type and quantity of fish, activities of middlemen resulting in increased prices, |

| Date | Location | Activities |
|---|---|---|
| | | and the suboptimal sanitary conditions in the smoking area. |
| March 24 2022 | Elmina | 1. Frozen fish was obtained from a local Elmina district, Central Region, Ghana market.<br>2. The price of fish at the cold store was ¢1200.00 for one and a half boxes of Atlantic Mackerel. The high price was partly due to the low number of cold stores located within the area.<br>3. Fish were transported by commercial vehicle (Taxi).<br>4. Frozen fish was obtained from Tema and Accra at wholesale outlets.<br>5. Both the Chorkor and Ahotor ovens were used for smoking.<br>6. Smoking started at 10 am for both ovens and was completed at 4 pm for Ahotor and 3:00 pm for Chorkor oven.<br>6. Smoking was carried out at the PFP fish processing center.<br>7. A total of 200 fish were smoked, 100 for each smoking oven.<br>8. The smoking process was similar to the previously described process with just a modification: approximately 35 pieces of fish were placed on each mesh.<br>9. Among the observed challenges faced during the smoking process were the late start of smoking and difficulty in getting the required type and quantity of fish. |
| 28th March, 2022 | Savoy | 1. The Round Mackerel was used for the smoking at the participant's residence.<br>2. Apart from fish smoking, the participant sold frozen fish.<br>3. The price of the frozen fish was ¢750.00 per box.<br>4. The smoking process started at 7 am, and completed at 4 pm. The smoked fish was allowed to stay overnight to cool to room temperature.<br>6. The Chorkor oven was used for smoking, and the mesh was prepared from neem trees and broomsticks. According to the participant, the rationale for using neem as mesh is to moderate the effects of heat and smoke on the fish and to impact the aroma. The broomsticks were used to prevent fish from falling into the fire.<br>7. A total of 54 pieces of fish were smoked at a time by the participant.<br>8. The smoking process started with thawing and washing fish, draining using the plastic basket to allow water to seep and laying on neem tree branches as mesh (which were arranged in a circular order of appropriately 90 cm x 90 cm) for smoking. Firewood was placed in the Chorkor oven. On average, the fish was turned every 45 minutes, and some firewood was occasionally removed to control the heat. After the smoking process, the firewood was removed from the oven, and the smoked fish was allowed to cool while on the neem tree.<br>9. The participant indicated some challenges, including the high cost of frozen fish, the unhygienic nature of the smoking environment, and the long distance between the cold store and the smoking area. |

**Marketing activities of fish smokers**

***Pricing of smoked fish***

Several factors, such as the cost of production, transportation, demand and supply, anticipated profits, and even the economic status of the individuals, can influence the cost of smoked fish in the communities in Ghana. According to the participants, the following are taken into consideration in determining the price of smoked fish;

*"Before I determine the price to sell my smoked fish, I consider the cost of labour, cost of fish, cost of firewood and cost of brown paper" [**Participant 4**].*

*"For me, I consider my profit margin and transportation cost" [**Participant 2**].*

*"I consider the type of fish" [**Participant 3**].*

The production cost of smoked fish accrues from the labour, water and electricity, materials such as mesh/net used, cost and quantity of firewood and other consumables such as brown paper

etc. In most instances, the production cost of smoking different types of fish are about the same due to the similarities in the processes employed. Differences can however, occur due to the cost of transportation and expected profit. Price differences can also be driven by the demand for smoked fish. According to the participants, the price charged were indicated as follows;

*"I sell per basket at a rate of ¢550.00. The size of the basket is the medium size. Sometimes when market is slow, I sell in smaller quantities like ¢15.00-200.00 per day" [**Participant 1**].*

*"I sell in small quantities like ¢15.00 and ¢20.00 mostly because people cannot afford the basket. However, for people who can buy the basket, I sell it to them at ¢600.00| [**Participant 2**].*

*"I use to sell in basket but I realise that I was not making much compared to the cost of production, so I started selling 100 pieces for ¢350.00" [**Participant 3**].*

*"I sell 5 pieces for ¢20.00 and above depending on the size of the fish" [**Participant 4**].*

***Clientele base***

For most fish smokers, the local market serves as the clientele base, although others move their products to other locations during the major market days with the aim of achieving higher revenues. In all cases, the clients include regular consumers, retailers or wholesale agents. Most consumers and retailers buy in small quantities while wholesalers buy in bulk, an assertion supported by the participants;

*"I sell mostly to retailers and wholesalers. I have market women friends in various parts of the country. So after smoking, I package and give it to a car to be delivered to them on market days, where they sell, and I give them commission on each basket sold. The left over I sell off to individuals at my local market" [**Participant 1**].*

*"I sell mostly to individuals, local retailers and the market women. But I have the plans to expand to other areas to sell" [**Participant 2**].*

*"I do the production here in Cape Coast and I sell it in Kumasi only. I do not sell here because the market is slow and the price is low, but in Kumasi the market moves faster and the price is like twice for a basket" [**Participant 3**].*

*"I sell to traders in Techiman, Mankessim and Accra. These areas are busy market areas for trading" [**Participant 4**].*

The responses show that the fish smokers have insight into the market dynamics, knowing who and where to sell their products to obtain high revenues. It is possible that such knowledge has been acquired through experience over several years of the fish smoking business. The assertion of bigger markets for fish in Kumasi and Techiman could be due to high population of the towns and their location being further away from the coastal regions.

***Shelf life of smoked fish***

Shelf life is the period after smoking within which the fish remains usable, fit for consumption or saleable. The type of fish spoilage that is mostly detected is caused by the growth of spoliage and pathogenic microorganisms on the surface of the fish. According to the participants, the techniques used to store smoked fish include:

*"After smoking I allow the smoked fish to cool then I cover it with trampoline and ensure its air-tight to take away all moisture" [**Participant 1**].*

*"After smoking I allow it to cool in open air, then I pack it into trays and put it in the freezer" [**Participant 2**].*

*"After smoking, I just put them in a basket and keep it at a cool, dry place" [**Participant 4**].*

In addition, reheating is done to ensure a longer shelf life, depending on the type of fish, as asserted by all participants;

*"My smoked fish can last about 3 months but when it is 2 months, I heat it again and, in that case, it can last for another 3 months" [**Participant 1**].*

**Challenges faced by fish smokers**

In this study, the challenges faced by fish smokers were reported as;

*"Since all my 30 years of fish processing, my major challenge has been the seasons affecting my price, especially during open season I record low sales due to the abundance of smoked fish on the market" [**Participant 1**].*

*"My major problem has to do with labour and financial constraints. At my age, carrying heavy firewood and other materials is hard, and when you hire people, they charge high prices that affect my profit margin" [**Participant 2**].*

However, in addition to the above, the good health and well-being of the operators contribute to the major challenges faced by a smoker. This is due to the direct contact of the eyes to smoke, which has an impact on vision/sight and, in some cases, affects the respiratory health of the operators. For one participant;

*"My major challenge is the smoke that affects my eyes, and also, the cost of transportation" **[Participant 4]**.*

## 4. Discussion

### Socio-demographic characteristics of the participants

Fish-smoking communities in Ghana are considered to be mainly youthful, with active members within the age bracket of 18-50 years (Boohene, Peprah, 2012). It was observed that the leaders of the different fish-smoking communities were much older. This shows that age is considered important when choosing leaders in fishing communities because older people are considered mature, experienced, and able to command respect (Akparep et al., 2019).

The study responses show that people venture into fish smoking for varied reasons, although financial considerations are the major driver that keeps them in the sector. Also, people selected as leaders within the various fishing and smoking communities have considerable years (about 30 years) of experience. In general, however, Okorley et al. (2004) reported that most fish smokers' minimum years of experience was 10 years, which is much lower compared to the 17.5 years reported in Nigeria (Bolorunduro et al., 2005).

Smokers with high socio-economic status can smoke fish often and even select days to rest. Also, taking into consideration that the duration of storage after smoking has an influence on the quality of smoked fish, using appropriate storage facilities is essential. Thus, for smokers who cannot afford storage facilities, selling off smoked fish within the shortest possible time after smoking is essential. Hence, such smokers can prepare new fish for the market only after selling a previous batch, which directly influences the frequency of fish smoking.

### Sources and types of fish and oven types used for smoking

Gordon et al. (2011) and Obodai et al. (2009) acknowledged that frozen fish and fresh fish obtained from the sea are the major sources of fish for smoking. The use of fish from these two sources is influenced mainly by the location of the smokers. A study conducted in northern Ghana showed that fish for smoking was mainly obtained from river bodies (Obodai et al., 2009). Thus, proximity to the sea influences the source of fish used for smoking.

Similar findings were reported by Bomfeh et al. (2019) and Sakyi et al. (2019), who reported that in Ghana, fish species such as tuna, herrings and mackerel are the most smoked fish types due to their availability and shelf life. Gradually, catfish, mostly cultured through freshwater and aquaculture, is gaining recognition among fish smokers, especially in the inland areas (Naylor et al., 2021).

The reports by Avega and Tibu (2017) and Owusu (2019) show that fish smokers continue to use the Chorkor smoker more than the Ahotor oven despite the health benefits of using the Ahotor oven. This shows that despite the benefits of the Ahotor oven in helping to reduce smoke levels, which can pose health hazards to both the smoker and consumer (through the occurrence of polycyclic aromatic hydrocarbons in the smoke fish) as well as reducing the excessive use of firewood in smoking (Avega, Tibu, 2017; Owusu, 2019), the usage of the Ahotor oven among fish smokers is quite low (Bomfeh et al., 2019; Essumang et al., 2013: Kwarteng et al., 2017). Hence, a combined effort of education and legislation by the relevant stakeholders will be required to help promote the usage of the Ahotor oven.

### Marketing activities of fish smokers

Among the factors that influence the shelf life of smoked fish include the type of packaging, level of moisture, and temperature and humidity during storage (Adeyeye, 2018; Kumolu-Johnson, Ndimele, 2011). Storing smoked fish at lower temperatures limits the growth of microorganisms, while regulating humidity using appropriate packaging reduces the availability of moisture/water and air, limiting microbial growth (Adeyeye, 2018; Kumolu-Johnson, Ndimele, 2011). Although rudimentary, the preservation methods used by smokers are based on the general principles of food storage, which include avoiding rehydration, limiting air contact and low temperature (Arvanitoyannis, Kotsanopoulos, 2012). Such knowledge and techniques could have been acquired

through experience and training programs sometimes organised for fish smokers by relevant stakeholders. Thus, it is imperative to give more training on food safety and hygiene, as well as post-harvest handling of fish, to help improve fish smokers' operations and enhance their products' shelf life.

**Challenges faced by fish smokers**

Fish smoking is faced with several challenges, which can be external or internal to the smoking process. The external challenges may include financial constraints, market factors such as demand and supply, as well as post-harvest losses and transportation issues (Antwi, Beran, 2017). Also, the availability of raw materials (fish), firewood, and labour can hinder the productivity and performance of smokers, as well as revenue levels (Sakyi et al., 2019). According to Okorley et al. (2004) and Sakyi et al. (2019), fish smokers face financial resource constraints that limit their ability to sustain their business, leading to inconsistent income and the number of clients they can serve at a time. This issue is compounded by the unavailability of credit or loan facilities for fish smokers, which is mainly attributed to the high level of risk associated with fish smoking as a business.

Sakyi et al. (2019) further argue that fish smokers depend heavily on firewood and are likely to pay high prices to purchase them during rainy seasons. Alternatively, they walk longer distances to purchase firewood for their activity, thus increasing the cost of production and reducing the profit margins. Also, the inability of most fish smokers to own storage facilities limits the purchase and storage of fish in bulk quantities, especially during the open season, leading to the reliance on frozen fish with its associated transportation cost, thus affecting their profit margins (Okorley et al., 2004). Finally, prolonged exposure to smoke can lead to the acquisition of respiratory diseases, which can compromise the health and well-being of smokers (Weyant et al., 2022).

## 5. Conclusion

Examination of the activities of fish smokers along the coastal regions of the Central region and the impact on the socio-economic well-being revealed that fish smokers were mainly women who had little formal education with several years of fish smoking and sales experience as the main source of livelihood. The main types of fish smoked included herring, mackerel, anchovy, and tuna, which were obtained either from the sea or cold storage facilities, depending on the season and cost. Smoking of fish was done 3-4 times per week by mostly using the Chorkor oven because it is faster with fresher and more evenly smoked and flavoured fish than the Ahotor oven. The smoking process for fish was similar among the respondents, with only the use of neem leaves or broomsticks as the minor modifications for the mesh used.

The labour cost, type of fish and cost, firewood and the cost of transportation determined the price of smoked fish. The profits were higher when fish was sold in regions further away from the coast than those closer to the coastal regions. Traditional fish storage methods such as using a trampoline to obtain air-tight and a moisture-free condition, freezers or intermittent heating on smoke to improve the storage quality were used. The major challenges reported include the high cost of fresh fish, especially during the closed season, lack of financial support to expand the operations, and excessive exposure to smoke. Thus, it is imperative to make credit facilities available to fish smokers by the relevant stakeholders while advocating for improved ovens such as the Ahotor oven to help reduce the levels of smoke. In addition, the use of improved processing techniques to enhance the shelf life of smoked fish can help improve the socio-economic well-being of fish smokers.

## 6. Strengths and Limitations

The study provides valuable insights into the socio-economic well-being of fish smokers in the Central Region of Ghana by leveraging an in-depth qualitative phenomenological approach. This methodology allows for a nuanced understanding of the lived experiences, challenges, and opportunities in fish processing, enriched by the participants' extensive knowledge and over 20 years of experience. Additionally, the use of thematic analysis effectively highlights key areas for improvement, such as hygienic practices and market dynamics, offering practical recommendations to enhance the sustainability and profitability of the fish-smoking industry.

The study's small sample size, limited to only four participants selected through purposive sampling, restricts the generalizability of the findings to a broader population of fish smokers.

Furthermore, the focus on qualitative data may have excluded potentially useful quantitative insights, such as production scales or economic metrics, which could provide a more comprehensive understanding of the socio-economic impacts of fish-smoking activities.

## 7. Implications of the Study

The study makes significant contributions to the socio-economic literature by expanding on understanding the fish processing industry's dynamics, particularly in micro and small-scale enterprises. It provides new insights into how traditional practices like fish smoking influence livelihoods, gender roles, and market systems in developing countries. Furthermore, it contributes to sustainability and entrepreneurship theories by highlighting the relationship between resource use, technological adaptation (such as the Chorkor oven), and socio-economic well-being. The study also emphasises the value of qualitative approaches, particularly phenomenological research designs, in capturing lived experiences, offering a framework that can be applied to other informal economic activities in similar contexts.

Furthermore, the study offers actionable recommendations that can inform policy and practice. It identifies key challenges, such as financial and labor constraints, and suggests targeted interventions like financial support, training programs, and infrastructure improvements to address these issues. Improving hygienic practices to extend the shelf life of smoked fish is another important recommendation that can enhance processed fish's quality and marketability. The findings also emphasise the importance of market-driven strategies, as the fish smokers' understanding of their clientele and pricing dynamics can guide the development of business models that optimise sales and ensure fair pricing. Moreover, the study highlights the socio-economic role of fish smoking, particularly among women in coastal communities, and underscores the need for initiatives that empower these individuals through skill development, access to credit, and improved working conditions. By addressing both theoretical gaps and practical challenges, the study bridges academic inquiry with real-world applications, fostering a comprehensive approach to enhancing fish processors' livelihoods and ensuring the industry's sustainability.

## 8. Declaration

### *Consent for publication*

Not applicable

### *Availability of data and materials*

All data and materials used in this study are available upon request.

### *Conflict of interest statement*

The authors declare that they have no competing interests.

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### Authors' ORCID

Alexander Tetteh Kwasi Nuer https://orcid.org/0000-0001-6646-341X
Selorm Omega https://orcid.org/0000-0001-9159-9351
Nazir Kizie-Hayford https://orcid.org/0000-0001-5532-6815
Jerry Ampofo-Asiama https://orcid.org/0000-0002-1704-5796
Salifu Seidu-Larry https://orcid.org/0000- 0002-7414-4264
Vivianne Geraldo https://orcid.org/0009-0002-4135-0034
Isaac Okyere https://orcid.org/0000-0001-8725-1555
Samuel Bridge Nkansah https://orcid.org/0009-0001-0805-5706

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# Levels of Anxiety Towards Mathematics in Elementary School Students

Teresa Zamora-Lobato [a, *], Lizzeth Navarro-Ibarra [b], Rosalba Cabrera Gutiérrez [c]

[a] Tecnológico Nacional de México – Sede ITSM, Veracruz, Mexico
[b] Instituto Tecnológico de Sonora, Ciudad Obregón, Mexico
[c] Centro de Estudios de Posgrado & Universidad Autónoma de Aguascalientes, Mexico

**Abstract**

This study aims to examine the existence of anxiety towards mathematics in elementary school students. For such purpose, it was determined that sixth-grade public school students would be examined. Employing a non-probability, self-selection sampling, an Anxiety Towards Mathematics test, designed by Muñoz-Cantero and Mato-Vázquez, was applied to 183 students. These students stemmed from four different public schools; some attended school in the morning and others in the evening. The reliability of said test showed a Cronbach's Alpha of 0.94, which also meets the function of normality. The Exploratory Factor Analysis was used to obtain the underlying factor solution, which was confirmed subsequently through the Structural Equations Model method. The main findings present the underlying structure of a four-factor model obtained with the Exploratory Factor Analysis validated through the Structural Equations Model method. Regarding gender differences, it was proven that in the dimensions of anxiety towards evaluation, temporality, understanding math problems, and numbers and math operations, there is a difference between males and females, except for anxiety towards mathematical situations in daily life. This last result can be linked to how independent they are in their daily life and not precisely inside a classroom.

**Keywords:** Anxiety Towards Mathematics, Evaluation, Gender, Teacher's Performance.

## 1. Introduction

Nowadays, the topic of learning and teaching mathematics does not go unnoticed in educational institutions, especially when the student's performance is consistently deficient (Sarfo et al., 2020). An interesting fact that stands out is the most recent report made from the 2024 Programme for International Students Assessment (PISA) test, which indicates a significant decrease in the level of mathematical competence since only 34% reached level 2, a percentage below the average (69 %) of all Organization for Economic Co-operation and Development (OECD) members. The result obtained between 2018 and 2022 displays a setback in mathematics and sciences in relation to what was observed from 2003 to 2009. Specifically for mathematics, the students' scores decreased, and even those who reached a high performance decreased by a greater percentage than those who got a lesser performance (OECD, 2022).

*Corresponding author
E-mail addresses: mtjzamora@itsm.edu.mx (T. Zamora-Lobato)
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Thus, the score appearing in the OECD (2022) places Mexico at a low level in mathematics. This is related to the results of the study conducted by Larracilla-Salazar et al. (2019). Firstly, the results exhibited an ongoing concern regarding the students enrolled in Economics, Business Administration and related fields, who could be deemed as having a more solid background in mathematics. Secondly, it also allows for the possibility of considering the teachers' education as an element that likely affects the students' performance. When the performance is low, it is associated with the levels of anxiety caused by the process of learning mathematics. These facts are alarming since mathematics is essential to our education, regardless of our profession. A low score in mathematical skills negatively affects our professional development as well as our everyday activities. For instance, the study conducted by Suri et al. (2013) indicates how certain consumers cannot calculate the prices accurately. If there are items on sale whose price is easy to calculate but the consumers cannot, they would overlook them.

The low performance of a student in mathematics can obey different situations, among which we could reference the teaching strategies or the complexity of developing equations. However, some studies have cited that the main reasons could be related to the characteristics of the mathematical discipline, the performance and how prepared the educational staff is for teaching mathematics, the assessments and, most importantly, the students' traits (Sepúlveda-Obreque et al., 2019). Considering these arguments makes it interesting to question whether the process of learning mathematics causes anxiety in a student. In this regard, anxiety towards mathematics has been an ongoing topic in literature where several scales that assess this phenomenon can be identified, such as the pioneering works of Richardson and Suinn (1972), Fennema and Sherman (1976, 1978), Alexander and Martray (1989), McLeod (1992, 1999), Larracilla-Salazar et al. (2019), among others.

However, how can anxiety be defined? Szucs and Mammarella (2020) developed a study on anxiety towards mathematics sponsored by the United Nations Educational, Scientific and Cultural Organization (UNESCO), a specialized organism from the United Nations. This research references that anxiety towards mathematics is presented in the students' fear or discomfort towards the subject of mathematics, which can also occur towards making calculations or solving mathematical problems. In addition, it is worth mentioning that both perception and attitude also have an influence on this topic (McLeod, 1994).

Other predictors associated with mathematics and on which the studies have focused are the numeric system, comparison of symbolic numbers, verbal and spatially short-term memory ability, and job performance. In their study, Caviola et al. (2020) proved that, on the one hand, homework was not adequately set up for the development of mathematical skills in school-age students; on the other hand, this did not occur with the rest of the predictors in which a very significant correlation was observed.

Furthermore, there is no doubt that anxiety towards mathematics is a phenomenon that affects people throughout their school careers from an early age, since it is linked to how worried students feel about said subject (Fernández-Blanco et al., 2023). On this matter, it is worth emphasizing that neither the students' knowledge nor their ability influences it, given that some existing studies have been designed to measure this phenomenon, such as the Mathematics Anxiety Rating Scale (MARS) made by Richardson and Suinn (1972); the Abbreviated Math Anxiety Scale (AMAS) designed by Hopko et al. (2003), whose results have shown that there are different causes and even symptoms regardless of how solid the set of skills the students possess.

Negative experiences and even beliefs can produce anxiety towards mathematics. In relation to this, Soni and Kumari (2017) studied the background and its consequences on anxiety and attitude towards mathematics in 595 native children from India from schools in the southeast of Punjab, and their ages ranged from 10 to 15 years old. For such purpose, the parent or tutor participated in the test by using a shortened version of the Mathematics Anxiety Scale. The results indicated that parents' anxiety and attitude towards mathematics acted as precursors to the students' own anxiety and attitude towards mathematics. Also, Evangelopoulou et al. (2023) influenced even more in their children's mathematical performance.

While there are several strategies to address anxiety towards mathematics inside and outside of the classroom, it is necessary to identify the causes of anxiety in each specific group since it could vary from one population to another depending on the students' traits. Based on this, Evangelopoulou et al. (2023) mention that anxiety will have a significant emotional impact on the

students who experience it by affecting their performance in mathematics. In their recommendations, they emphasize the need for all school personnel to implement some activities as a means to reduce anxiety levels from an early age.

The following question emerges: what is the anxiety level towards mathematics in sixth grade children currently enrolled in public schools in the region of Xalapa, Veracruz, Mexico? In addition, what is the underlying structure that explains mathematics anxiety in students? As a result, this study aims to measure the anxiety level towards mathematics in sixth-grade students currently enrolled in public schools in the region of Xalapa, Veracruz, Mexico. Finally, to determine the underlying structure which explains mathematics anxiety in students.

Therefore, the hypotheses are as follows:

$H0_1$ = The level of anxiety in sixth-grade students is high.

$Hi_1$ = The level of anxiety in sixth-grade students is low.

$H0_2$ = There are no variables that explain anxiety towards mathematics expressed in sixth-grade public school students from Xalapa, Veracruz.

$Hi_2$ = The set of variables explains the anxiety about mathematics expressed by sixth-grade public school students from Xalapa, Veracruz.

## 2. Literature review

Anxiety towards mathematics has been analyzed for a while now. One of the pioneering works was made by Taylor (1952), who designed the Manifest Anxiety Scale to measure cognitive task performance. Likewise, another work was conducted by Gough (1954), to whom the term mathemaphobia is attributed, which is defined as a sort of anxiety towards numbers. Several studies followed this work, such as those by Dreger and Aiken (1957), who tried to identify the origin of the condition. To better understand the feelings of tension and anxiety presented by students, which certainly affect the comprehension and the skill to solve algebraic problems, the study of Richardson and Suinn (1972) took place.

Furthermore, the topic of mathematical anxiety is addressed in several studies focusing on different aspects such as mathematical performance (Hembree, 1990; Ashcraft, 2002), the existence of negative emotions like fear, panic and mathemaphobia (Gough, 1954), and how disorders and mathematical anxiety are conditions that affect performance (Hembree 1990; Iglesias, 1972; Lazarus, 1974; Tobias, 1976; Tobias, 1978).

Moreover, anxiety towards mathematics is not related to the student's intelligence but rather the emotions caused by this subject, like fear or dread (Moreno-García et al., 2022; García-Santillán et al., 2022). New tests were created to measure this phenomenon alongside the interest in studying this topic. For example, Richardson and Suinn (1972) designed the Mathematics Anxiety Rating Scale (MARS) scale, which contains 98 items on a five-level Likert scale, where the subject considers how much anxiety they feel towards mathematics. This scale contributed to the creation of several more, such as the scale by Alexander and Martray (1989), Plake and Parker (1982), and Hopko et al. (2003), who only took twenty-five items, all focused on the level of anxiety. In addition, Dreger and Aiken (1957) posited a hypothesis which allowed for the conceptualization of anxiety towards mathematics vs general anxiety. Consequently, Spielberger (1977), in his Anxiety Inventory Test, exhibited the existing relation between these two types of anxiety.

Other studies, such as Dew et al. (1983), used several instruments to measure anxiety during mathematics tests. In the same line, Hunsley (1978) shows the similarities and differences in mathematics anxiety during tests. Similarly, LeFevre et al. (1992) pointed out that students perceive this subject as terrifying. Therefore, they will likely avoid it as much as possible and look for careers in which mathematics is not an essential requirement (Ashcraft, Krause, 2007). In fact, the Organization for Economic Co-operation and Development (OECD, 2015) denotes in its report on anxiety towards mathematics that 59 % of 15-year-old students consider mathematics class challenging, 33 % tend to feel stressed while solving mathematics homework, and 30 % indicate fear of obtaining low grades in mathematics.

Nowadays, the state of the art regarding anxiety towards mathematics is constantly evolving and dynamic (Chang, Beilock, 2016). Suppose we also add the permanent results provided by the PISA test, where one of the indicators assessed is mathematics performance in each country. In that case, this fact triggers the ongoing interest that researchers have in explaining the low scores in mathematics. From these results, Radišić et al. (2015) conducted a study in Serbia, which

reports that over 50 % of Serbian students tend to worry due to the difficulties experienced in mathematics class, while also getting low grades, which in turn leads to high levels of anxiety.

Different studies that use an approach based on emotions towards learning and mathematical performance have noted that emotions tend to be negative, resulting in anxiety towards mathematics. Based on a positive approach, Villavicencio and Bernardo (2016) made a study on Filipino college students who were enrolled in trigonometry courses. The Academic Emotions Questionnaire-Mathematics test was applied, and scales were used to assess self-efficacy and self-regulation in trigonometry. This study concluded that if positive emotions are looked for while learning mathematics, they can contribute towards achieving a more balanced picture regarding the role of affective states in mathematics learning.

Anxiety has been studied depending on school level and beliefs, and the results have proven a negative effect on the high level of anxiety caused by homework, even higher when parents or tutors want to help (Szczygieł, 2020). On the contrary, if a student can answer any assessment, it is because the teacher is interested in the student's learning, which reduces anxiety, as Visscher and White (2020) pointed out. Their study analyzes the validation of fifteen items from the Revised Mathematics Anxiety Scale (RMARS), a standardized test that measures students' anxiety based on their responses to calculations and assessments. What is important to emphasize is that when the level of anxiety towards mathematics is low, the student's performance improves in any domain, whether in assessments or in doing homework, whereas a high level of anxiety deeply affects said performance.

As a result, from the referred arguments, to respond to the questions and achieve the objectives proposed, after testing the hypothesis, the method employed will be defined below.

## 3. Method

### *Research Design and Sample*

The study was conducted by using a hypothetic-deductive approach. Through a non-probabilistic self-selection sampling, a scale was applied to 183 students of sixth grade, 44 % male (n = 80) and 56 % female (n = 103), enrolled in public schools from a middle-class background in the city of Xalapa, Veracruz, Mexico. The ages of all participants ranged from 11 to 12 years old.

### *Instrument*

To gather the data, the test designed by Muñoz-Cantero and Mato-Vázquez (2007), called "Anxiety Towards Mathematics" was used. Which consists of 24 items grouped into five factors or dimensions: the factor "Anxiety towards evaluation", which contains 11 items; "Anxiety towards temporality" with 4 items; "Anxiety towards the understanding of math problems" with 3 items; and "Anxiety towards a mathematical situation in daily life" also comprising 3 items. (See Table 1 and Appendix)

**Table 1.** Dimensions of the scale

| Dimension | Code | Items |
|---|---|---|
| Anxiety towards evaluation | ATE | 1, 2, 8, 10, 11, 14, 15, 18, 20, 22, 23 |
| Anxiety towards temporality | ATT | 4, 6, 7, 12 |
| Anxiety towards the understanding of math problems | ATUMP | 5, 17, 19 |
| Anxiety towards numbers and math operations | ATNMO | 3, 13, 16 |
| Anxiety towards mathematical situation in daily life | ATMSDL | 9, 21, 24 |

Source: based on the test by Muñoz-Cantero, Mato-Vázquez, 2007

### *Statistical procedure*

To validate the data obtained from the test, first, the internal consistency of the items is assessed by using Cronbach's Alpha (CA) and Omega coefficient. The AC is a reliability indicator of psychometric scales used in social sciences. Theoretically, if the internal consistency of all the items on a scale is high, we can infer that said scale is consistent and it can measure the construct that we are analyzing. Therefore, if we use the variances to calculate the CA, the equation is as follows:

$$\alpha = \frac{K}{K-1}\left(\frac{\sum_{i}^{K} = 1\sigma^2 Yi}{\sigma_X^2}\right.$$

Where:
K = Number of items in the scale
$\sigma^2 Yi$ = variance of item i
$\sigma^2 X$ = variance of all the individuals' observed scores.

As a way of calculating omega coefficient, factorial loadings are employed to obtain a more stable coefficient of reliability (Gerbing, Anderson, 1988) by using the following equation:

$$\omega = \frac{\left[\sum_{i=1}^{i} \lambda\right]^2}{\left[\sum_{i=1}^{i} \lambda\right]^2 + \left[\sum_{i=1}^{i} 1 - \lambda_1^2\right]}$$

Where:
ω = omega coefficient
ʎi = standardized factorial loading of i

Since the absence of normality could be a possibility, the employment of a polychoric correlation matrix is suggested for carrying out an exploratory factor analysis (Richaud, 2005; Ogasawara, 2011). The exploratory factor analysis (EFA) calculates Bartlett's test of sphericity, which is complemented by Kaiser-Meyer-Olkin's test (KMO), the value of Chi-square with *n* degrees of freedom and the p-value, as well as the measures obtained by a Measurement system analysis (MSA). Therefore, the null hypothesis (H0) will be rejected if the value of the Chi-square calculated is higher than the critical value shown in the tables. It is essential to identify that the value of the determinant approaches zero (d = from 0 to 1), which is a key indicator for the validity of the analysis and will assist in verifying whether it corresponds to an identity matrix or not. After the EFA, with the factor solution obtained, the measurement model is validated using a Structural Equation Modeling (SEM) method. This method validates the model's adjustment, structural adjustment, and parsimony (Ho, 2006; Schreiber et al., 2006; Hooper et al., 2008; Hair et al., 1999). For designing the diagrams and the SEM calculations, the software IBM SPSS AMOS v23 was used.

The assessed indicators are: $\chi^2$ (Chi-square), Goodness-of-Fit Index (GFI), Adjusted Goodness-of-Fit Index (AGFI), Root Mean Squared Error of Approximation (RMSEA), Root Mean Squared Residuals (RMR), Tucker Lewis Index (TLI), and Comparative Fit Index (CFI).

***Analysis***

The values of Cronbach's alpha and Omega coefficient are presented in Table 2, Table 2b and Table 3, as well as the values if the element was deleted for both cases.

**Table 2.** Reliability statistics

| Valid N | % | Cronbach's alpha | McDonald's Omega |
|---|---|---|---|
| 183 | 100 | .940 | .939 |
| Excluded [a] 0 | 0 | N elements 24 | N elements 24 |
| [a]. The elimination for each list is based on all the variables from the procedure. | | | |

**Table 2b.** Statistics for each item if the element is deleted (Cronbach's alpha)

| Items | Mean of scale if the element is deleted | Variance of scale if the element is deleted | Corrected total correlation of elements | Cronbach's alpha if the element is deleted |
|---|---|---|---|---|
| Gender | 77.8525 | 467.907 | -.271 | .935 |
| Mood | 76.3443 | 461.293 | .006 | .934 |
| Age | 77.6721 | 462.815 | -.035 | .933 |

| Items | Mean of scale if the element is deleted | Variance of scale if the element is deleted | Corrected total correlation of elements | Cronbach's alpha if the element is deleted |
|---|---|---|---|---|
| V1 | 77.0273 | 428.104 | .596 | .928 |
| V2 | 76.6776 | 430.516 | .555 | .929 |
| V3 | 76.5464 | 423.733 | .615 | .928 |
| V4 | 76.9016 | 431.309 | .584 | .929 |
| V5 | 76.3552 | 422.186 | .654 | .927 |
| V6 | 75.7978 | 422.041 | .681 | .927 |
| V7 | 76.2568 | 424.445 | .650 | .928 |
| V8 | 76.1421 | 424.848 | .548 | .929 |
| V9 | 75.5574 | 434.270 | .483 | .930 |
| V10 | 76.0273 | 424.906 | .616 | .928 |
| V11 | 76.6448 | 423.945 | .644 | .928 |
| V12 | 76.6831 | 425.020 | .583 | .929 |
| V13 | 75.9945 | 423.709 | .634 | .928 |
| V14 | 77.0328 | 421.076 | .694 | .927 |
| V15 | 76.9727 | 427.060 | .585 | .928 |
| V16 | 76.1858 | 421.767 | .712 | .927 |
| V17 | 76.1475 | 419.192 | .684 | .927 |
| V18 | 76.3169 | 423.525 | .617 | .928 |
| V19 | 75.7541 | 424.879 | .621 | .928 |
| V20 | 77.0984 | 432.474 | .489 | .930 |
| V21 | 75.8907 | 430.933 | .506 | .930 |
| V22 | 76.4317 | 418.840 | .645 | .928 |
| V23 | 76.9344 | 426.985 | .580 | .929 |
| V24 | 75.5519 | 428.227 | .605 | .928 |

**Table 3.** Statistics for each item if the element is deleted (Omega coefficient)

| | Mean of scale if the element is deleted | Variance of scale if the element is deleted | Corrected total correlation of elements | Squared multiple correlation | Cronbach's alpha if the element is deleted | McDonald's omega if the element is deleted |
|---|---|---|---|---|---|---|
| V1 | 70.6503 | 432.404 | .606 | .542 | .937 | .936 |
| V2 | 70.3005 | 435.200 | .557 | .544 | .938 | .937 |
| V3 | 70.1694 | 428.680 | .612 | .513 | .937 | .936 |
| V4 | 70.5246 | 436.053 | .586 | .466 | .938 | .936 |
| V5 | 69.9781 | 426.835 | .657 | .622 | .937 | .935 |
| V6 | 69.4208 | 426.531 | .686 | .606 | .936 | .935 |
| V7 | 69.8798 | 428.942 | .655 | .621 | .937 | .935 |
| V8 | 69.7650 | 429.719 | .547 | .384 | .938 | .937 |
| V9 | 69.1803 | 439.171 | .482 | .420 | .939 | .938 |
| V10 | 69.6503 | 429.723 | .615 | .538 | .937 | .936 |
| V11 | 70.2678 | 428.714 | .645 | .620 | .937 | .936 |
| V12 | 70.3060 | 429.697 | .585 | .448 | .938 | .936 |
| V13 | 69.6175 | 428.655 | .632 | .534 | .937 | .936 |
| V14 | 70.6557 | 425.963 | .692 | .638 | .936 | .935 |
| V15 | 70.5956 | 431.770 | .586 | .565 | .938 | .937 |
| V16 | 69.8087 | 426.441 | .714 | .590 | .936 | .934 |
| V17 | 69.7705 | 423.760 | .688 | .602 | .936 | .935 |
| V18 | 69.9399 | 428.299 | .618 | .477 | .937 | .936 |
| V19 | 69.3770 | 429.786 | .619 | .595 | .937 | .936 |
| V20 | 70.7213 | 437.257 | .491 | .482 | .939 | .938 |

| | Mean of scale if the element is deleted | Variance of scale if the element is deleted | Corrected total correlation of elements | Squared multiple correlation | Cronbach's alpha if the element is deleted | McDonald's omega if the element is deleted |
|---|---|---|---|---|---|---|
| V21 | 69.5137 | 435.801 | .505 | .415 | .939 | .938 |
| V22 | 70.0546 | 423.579 | .645 | .589 | .937 | .936 |
| V23 | 70.5574 | 431.896 | .578 | .479 | .938 | .936 |
| V24 | 69.1749 | 432.903 | .607 | .579 | .937 | .936 |

In both Cronbach's alpha and Omega coefficient tests, the scale proves internal consistency and reliability in the items, which in turn makes the database reliable for the corresponding analysis. To verify the hypothesis of normality, we established the following: Ho: data must have a normal distribution; Ha: data has no normal distribution. Therefore, if Ho <0.05, Ho is then rejected and Ha accepted; whereas if Ho >0.05, there is no evidence to reject Ho.

## 4. Results

To verify the normality of the data, the Kolmogorov-Smirnov test (KS-1) was applied since the sample consists of 183 subjects, thus n >50, and the cases are assessed with the items grouped for each dimension. The result of the KS-1 test shows an absence of normality in the data (Table 4). As a result, it is suggested that an exploratory factor analysis is applied to identify underlying variables, which explains the structure of correlations in the set of observed variables. Therefore, the EFA was used to obtain the factor solution by extracting the main components and applying the Varimax rotation (Ogasawara, 2011; Timmerman, Lorenzo-Seva, 2011).

**Table 4.** Kolmogorov-Smirnov test of normality for one sample

| | | | ATE | ATT | ATUMP | ATNMO | ATMSDL |
|---|---|---|---|---|---|---|---|
| N | | | 183 | 183 | 183 | 183 | 183 |
| Normal parameters [a,b] | Mean | | 30.26 | 12.021 | 9.989 | 9.519 | 11.245 |
| | Standard deviation | | 10.511 | 4.1043 | 3.3083 | 3.3803 | 3.1378 |
| Most extreme differences | Absolute | | .082 | .087 | .095 | .085 | .127 |
| | Positive | | .082 | .087 | .074 | .080 | .116 |
| | Negative | | -.041 | -.073 | -.095 | -.085 | -.127 |
| Test statistic | | | .082 | .087 | .095 | .085 | .127 |
| Asymp. Sig. (two-tailed) [c] | | | .004 | .002 | <.001 | .002 | <.001 |
| Monte Carlo Sig. (two-tailed) [d] | Sig. | | .005 | .003 | <.001 | .003 | <.001 |
| | Confidence interval on 99% | Lower Limit | .003 | .001 | .000 | .002 | .000 |
| | | Upper limit | .007 | .004 | .001 | .005 | .000 |

[a] Test distribution is normal. [b] Calculated from data. [c] Correction of Lilliefors significance test. [d] Lilliefors method based on the samples of 10000 Monte Carlo with an initial seed of 2000000.

### Exploratory factorial analysis

Both Bartlett's test of sphericity and the KMO test obtained adequate values, the latter with a sampling adequacy of .930, a Chi-square of 2317.419 with 276 degrees of freedom and p-value <.001, which suggests an adequate set of data for analysis. Furthermore, the correlation matrices present moderate correlations which are appropriate for grouping factors, and since the determinant's value is close to zero, this demonstrates that the correlation matrix is adequate. There was no multicollinearity observed, and the usage of an exploratory factor analysis is justified to reduce the group of data into an underlying structure that better explains the variance (see Table 5 and Table 5b).

**Table 5.** Correlations matrix and MSA

| | V1 | V2 | V3 | V4 | V5 | V6 | V7 | V8 | V9 | V10 | V11 | V12 | MSA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| V1 | 1.000 | | | | | | | | | | | | .918[a] |
| V2 | 0.474 | 1.000 | | | | | | | | | | | .897[a] |
| V3 | 0.484 | 0.447 | 1.000 | | | | | | | | | | .945[a] |
| V4 | 0.478 | 0.485 | 0.392 | 1.000 | | | | | | | | | .953[a] |
| V5 | 0.529 | 0.373 | 0.568 | 0.434 | 1.000 | | | | | | | | .905[a] |
| V6 | 0.441 | 0.424 | 0.507 | 0.358 | 0.542 | 1.000 | | | | | | | .941[a] |
| V7 | 0.455 | 0.498 | 0.534 | 0.536 | 0.659 | 0.469 | 1.000 | | | | | | .911[a] |
| V8 | 0.343 | 0.247 | 0.293 | 0.260 | 0.357 | 0.384 | 0.365 | 1.000 | | | | | .954[a] |
| V9 | 0.195 | 0.116 | 0.316 | 0.218 | 0.348 | 0.483 | 0.218 | 0.235 | 1.000 | | | | .926[a] |
| V10 | 0.282 | 0.245 | 0.418 | 0.309 | 0.487 | 0.573 | 0.364 | 0.374 | 0.492 | 1.000 | | | .930[a] |
| V11 | 0.505 | 0.589 | 0.444 | 0.504 | 0.483 | 0.416 | 0.568 | 0.344 | 0.174 | 0.435 | 1.000 | | .932[a] |
| V12 | 0.365 | 0.322 | 0.384 | 0.392 | 0.429 | 0.424 | 0.437 | 0.371 | 0.318 | 0.338 | 0.420 | 1.000 | .951[a] |

[a.]Determinant = 1.542E-6

**Table 5b.** Correlations matrix and MSA

| | V13 | V14 | V15 | V16 | V17 | V18 | V19 | V20 | V21 | V22 | V23 | V24 | MSA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| V13 | 1.000 | | | | | | | | | | | | .944a |
| V14 | 0.401 | 1.000 | | | | | | | | | | | .923a |
| V15 | 0.297 | 0.625 | 1.000 | | | | | | | | | | .912a |
| V16 | 0.494 | 0.560 | 0.400 | 1.000 | | | | | | | | | .953a |
| V17 | 0.391 | 0.463 | 0.379 | 0.579 | 1.000 | | | | | | | | .935a |
| V18 | 0.361 | 0.487 | 0.429 | 0.550 | 0.411 | 1.000 | | | | | | | .956a |
| V19 | 0.544 | 0.372 | 0.334 | 0.567 | 0.496 | 0.414 | 1.000 | | | | | | .923a |
| V20 | 0.230 | 0.506 | 0.516 | 0.355 | 0.425 | 0.255 | 0.183 | 1.000 | | | | | .892a |
| V21 | 0.448 | 0.310 | 0.197 | 0.384 | 0.480 | 0.289 | 0.456 | 0.164 | 1.000 | | | | .939a |
| V22 | 0.496 | 0.394 | 0.351 | 0.467 | 0.537 | 0.335 | 0.508 | 0.378 | 0.475 | 1.000 | | | .921a |
| V23 | 0.295 | 0.606 | 0.454 | 0.442 | 0.448 | 0.388 | 0.380 | 0.411 | 0.317 | 0.421 | 1.000 | | .935a |
| V24 | 0.449 | 0.349 | 0.313 | 0.501 | 0.550 | 0.447 | 0.649 | 0.197 | 0.493 | 0.503 | 0.298 | 1.000 | .922a |

[a.]Determinant = 1.542E-6

After verifying the correlation matrix, which does not constitute an identity matrix, it contains values that surpass the 0.5 threshold in the Measurement System Analysis (MSA) as well as in Bartlett's test of sphericity with KMO. Table 6 describes the total variance and Table 7 the rotated factor matrix. The extraction of four components under the criterion of eigenvalues higher than one provides 52.979% of accumulated variance before rotating the original variables of the phenomenon studied. Table 7 displays the rotated factor matrix with Varimax, where only four factors with >.5 loadings were extracted, the same factor solution with which the initial measurement model is confirmed.

**Table 6.** Total variance explained

| Factor | Sum of squared loadings from the rotation | | |
|---|---|---|---|
| | Total | Variance % | Accumulated % |
| 1 | 4.499 | 18.745 | 18.745 |
| 2 | 3.792 | 15.799 | 34.544 |
| 3 | 3.297 | 13.737 | 48.282 |
| 4 | 1.127 | 4.697 | 52.979 |
| Extraction method: maximum likelihood. | | | |

Items that were excluded from the rotated factor matrix for <.5 loadings

| |
|---|
| V18. I feel nervous when I solve a mathematics assessment test |
| V8. I get nervous when someone looks at me while I do my math homework |
| V4. I feel nervous when I think about the math test, one hour before the start of it |
| V1. I get nervous when I think about the math test the day before |

**Table 7.** Rotated factor matrix [a]

| Indicators | F11 | F2 | F3 | F4 |
|---|---|---|---|---|
| V19. I feel nervous when I see / hear my teacher explain a math problem | .713 | | | |
| V24. I feel nervous when I start working on my homework | .708 | | | |
| V10. I feel nervous when I start studying for a math test | .615 | | | |
| V6. I get nervous when I realize that next year I will still have math classes | .609 | | | |
| V21. I feel nervous when I try to find out the change after purchasing something in a store | .577 | | | |
| V9. I feel nervous when I check the purchase ticket after paying for something | .572 | | | |
| V16. I feel nervous when I am assigned a list of math problems | .558 | | | |
| V17. I feel nervous when I try to understand a classmate who is explaining a math problem | .556 | | | |
| V13. Math operations make me nervous | .521 | | | |
| V15. I get nervous when I take the final math test | | .695 | | |
| V14. I feel nervous when I need to explain a math problem to the teacher | | .679 | | |
| V20. I am nervous when I receive the math test final grades | | .643 | | |
| V11. Math tests make me nervous | | .590 | | |
| V23. I feel nervous when I need to explain a problem in math class | | .576 | | |
| V2. I feel nervous when I receive the questions from the math test | | .508 | | |
| V5. I feel nervous when I hear other classmates solving a math problem | | | .677 | |
| V7. I feel nervous when I think about next week's math test | | | .676 | |
| V3. I get nervous when I open the math book and find a page full of problems | | | .621 | |

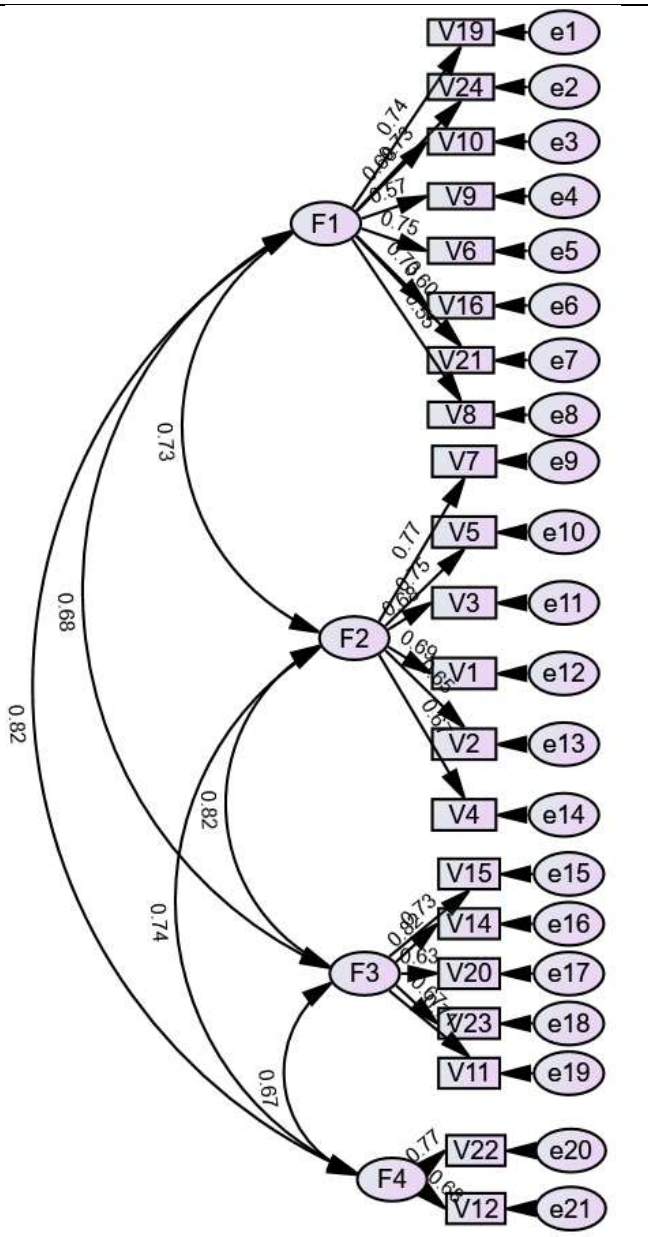


**Fig 1.** Initial measurement model
(Chi-square = 378.766; Degrees of freedom = 183; Probability level = .000)

| Indicators | F11 | F2 | F3 | F4 | Initial measurement model |
|---|---|---|---|---|---|
| V22. I feel nervous when a math problem is assigned, and I hear that a classmate solves it before me | | | | .726 | |
| V12. I feel nervous when I am assigned difficult math problems for homework and I have to bring them solved for next class | | | | .651 | |

Extraction method: maximum likelihood. Rotation method: Varimax with Kaiser Normalization. a. The rotation has converged in 7 iterations.

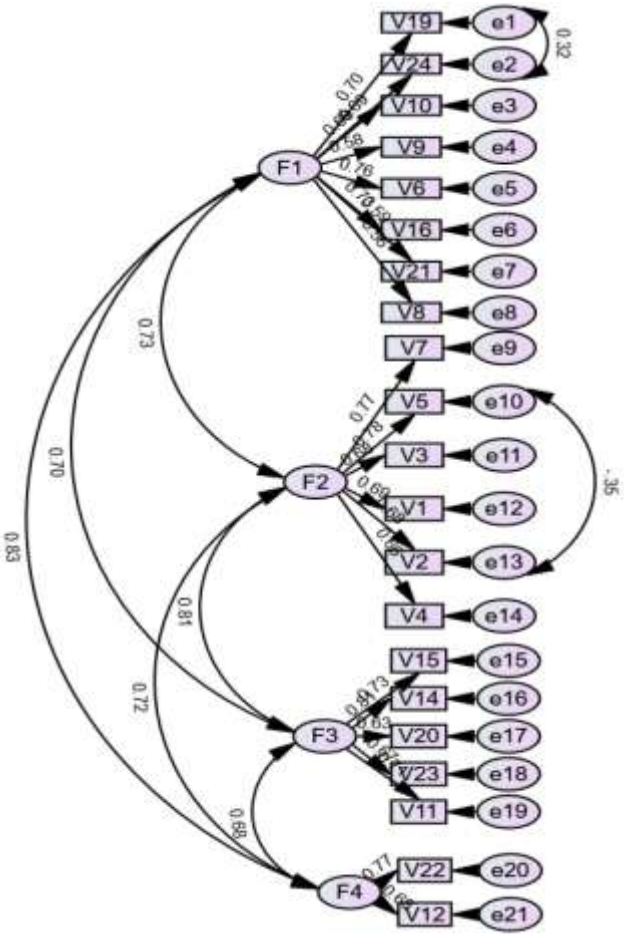


**Fig. 2.** Measure model
(Chi-square = 349.429; Degrees of freedom = 181; Probability level = .000)

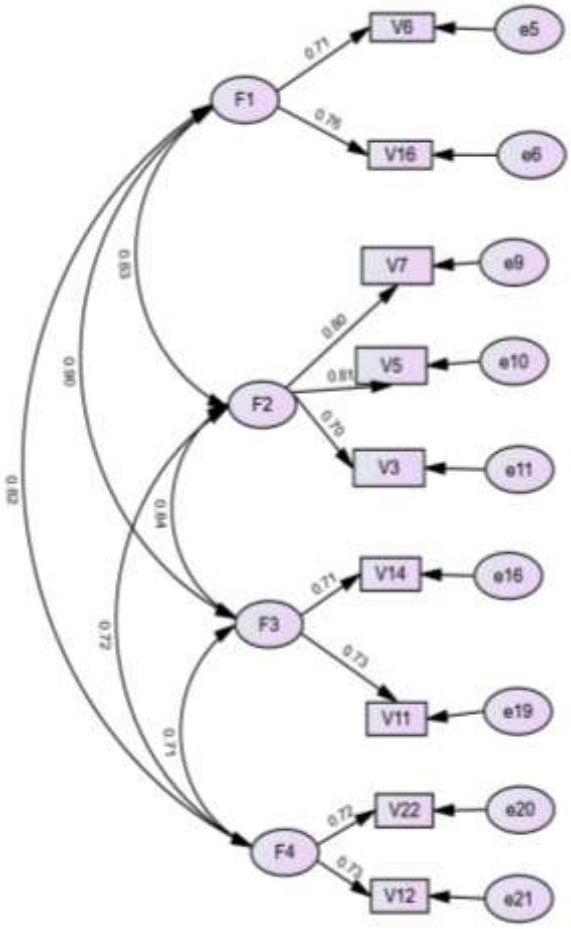


**Fig. 3.** Measure model
(Chi-square = 35.649; Degrees of freedom = 21; Probability level = .024)

After excluding the indicators below .60 in the initial measurement model (diagram 1), diagram 2 shows the model that contained the best adjustment. Table 8 displays the acceptable values in CMIN/DF (1.698), CFI (.968), GFI (.957), TLI (.962), RMSEA (.062) indicators, among others.

**Table 8.** Models obtained

| | RMSEA | CMIN/DF | RMR | GFI | AGFI | PGFI | TLI | CFI | PRATIO | PNFI | PCFI |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Model 1 | .077 | 2.070 | .123 | .834 | .791 | .661 | .876 | .892 | .871 | .708 | .777 |
| Model 2 | .072 | 1.931 | .119 | .846 | .804 | .663 | .892 | .907 | .862 | .712 | .782 |
| Model 3 | .062 | 1.698 | .070 | .957 | .908 | .447 | .962 | .968 | .583 | .554 | .570 |

## 5. Discussion

The four-factor model obtained by the confirmatory factor analysis allows us to discuss the results in the following terms: the structure presented in Muñoz-Cantero and Mato-Vázquez (2007) test could not be confirmed in this sample since the component matrix is obtained from a Varimax orthogonal rotation. Subsequently, during the validation of the factor solution model, an adjustment was needed, which caused the exclusion of some indicators.

The four factors better aligned with the purpose of this study regarding the level of anxiety of elementary school students are explained as follows. In factor number one, students feel nervous when realizing that they will keep having math classes next school year and are assigned a list of math problems for them to solve. As for factor two, they get nervous just by thinking about next week's math test, as well as when they listen to their classmates who are solving the math problems, and finally feel nervous just by opening a math book and seeing pages full of problems that need to be solved. This corresponds to what Sepúlveda-Obreque et al. (2019) exposed, who argue that the student's low performance is linked, among other situations, to how complex the equations and the assessments are and, of course, each student's traits.

Regarding factor three, nervousness appears in the students when they need to explain a math problem to the teacher, but generally, they get nervous due to the math test. Lastly, factor four occurs when the students realize that a classmate finished solving a math problem before them, as well as due to the math problems assigned for homework that need to be already solved for the next day's class.

The results provided by these four factors allow us to understand that anxiety towards mathematics among students is not necessarily linked to their abilities or intelligence since the items are more associated with nervousness and fear produced by mathematics, as Gough (1954) pointed out in his pioneering studies. Moreover, the students' nervousness is what provokes that anxiety and affects their performance, just as several authors have emphasized, such as the pioneering studies in this field made by Iglesias (1972), Lazarus (1974), Tobias (1976, 1978), and Hembree (1990); and more recently, Larracilla-Salazar et al. (2019), Moreno-García et al. (2022), and García-Santillán et al. (2022).

The student's low performance in mathematics can arise from several situations, among which we could cite the teaching strategy or the complexity of developing equations. However, some studies have referenced that the main causes are related to the characteristics of the mathematical discipline, the preparation and the performance of the math-teaching staff, the assessment, and, above all, the students' own traits (Sepúlveda-Obreque et al., 2019).

## 6. Limitations and suggestions for future research

### *Limitations*

This study presents several limitations that should be considered when interpreting its results. Firstly, one of the main limiting factors was the lack of financial resources, which restricted the possibility of conducting a more extensive study and having a more diverse and representative sample. The shortage of resources also prevented the implementation of additional measures, such as qualitative interviews or direct observation, which could have provided a deeper understanding of students' mathematical anxiety experiences. Moreover, the limited time available to carry out the survey was another significant limitation. Due to the short period during which the questionnaires were administered, it was not possible to conduct long-term follow-up or explore the impact of mathematical anxiety on academic performance over time. This time limitation may also have affected the quality of participants' responses, as many students may have felt pressured to complete the survey quickly, potentially influencing the accuracy of their answers.

### *Recommended future studies*

To better understand mathematical anxiety and its impact on academic performance, future studies could adopt longitudinal approaches to track how anxiety evolves over time and how various factors (such as pedagogical interventions, emotional support, and individual student characteristics) influence the experience of mathematical anxiety. Such studies would provide a more comprehensive and dynamic perspective on how students manage anxiety as they progress through their education.

Additionally, it would be valuable to expand the sample to include different educational contexts, such as public and private schools, and explore whether mathematical anxiety varies based on social

and cultural contexts. Including students of various ages and educational levels would also allow for a more accurate understanding of how anxiety manifests in different student groups.

## 7. Conclusion and implications

### Conclusion

This research consisted of a review on the topic of anxiety towards mathematics, specifically among sixth-grade public school students from the city of Xalapa, Veracruz, Mexico and the variables that appeared. A correlation analysis confirms that students show levels of mathematical anxiety, just as indicated by the scientific papers referenced in this work. Said works are being produced internationally since this topic is continuously developing, even in the field of teaching mathematics.

As for the determining variables regarding anxiety towards mathematics, the results from the regression analysis suggest that students present this anxiety while facing assessment situations or an activity that includes some mathematical skill. To conclude, mathematics anxiety creates a problem among students, which is a relevant and yet ignored fact despite all the studies conducted to this day. It is also worth noting that the consequences of mathematics anxiety have been proved on an educational performance level. Thus, students with a high level of anxiety tend to evade all sorts of education and professions related to mathematics. The results obtained propose that the mathematics anxiety phenomenon is essentially associated with both a negative perception towards its field and the lack of mathematical skills. It is considered that these factors can contribute to the teaching curriculum and even to the creation of strategies while planning for classes which could help the students overcome mathematics anxiety.

### Theoretical implications

The results of this study have significant theoretical implications for the fields of educational psychology and mathematics education. First, the study reinforces the idea that mathematical anxiety is not exclusively related to students' cognitive abilities or intelligence, but also involves emotional factors such as nervousness and fear. This finding aligns with Gough's (1954) pioneering work, which emphasized the emotional dimension of mathematical anxiety. Based on the four factors identified in this study, it can be argued that anxiety towards mathematics should be conceptualized as a complex phenomenon that affects students regardless of their level of ability in the subject. This perspective suggests that existing theoretical models of learning and performance in mathematics should incorporate the emotional dimension of anxiety as a crucial component that influences the acquisition of mathematical skills.

Furthermore, the results suggest the need to expand theoretical models of academic anxiety by integrating the idea that nervousness and fear related to specific mathematical situations (such as exams, interaction with peers, or simply the visualization of problems) are key factors in the experience of anxiety. This model of mathematical anxiety, based on specific factors such as exams, social comparison, and task assignments, offers a more nuanced perspective on how students perceive and experience mathematics. Future studies could explore how these factors interact and contribute to academic performance in mathematics, considering not only the negative effects of anxiety but also possible strategies for mitigating it.

### Practical Implications

From a practical standpoint, the findings of this study have several implications for improving the teaching and learning of mathematics in the classroom. First, it becomes clear that mathematical anxiety must be addressed comprehensively in the classroom, as it directly affects student performance. Teachers could adopt pedagogical approaches that foster a more relaxed and less threatening learning environment. This could include implementing activities that reduce stress, such as math games, group dynamics, or relaxation techniques before assessments. Furthermore, promoting a school culture that values effort and the learning process, rather than focusing solely on outcomes, could help alleviate the pressure generated by mathematical anxiety.

Another key implication is the need for continuous professional development for teachers. Educators should be trained to recognize signs of anxiety in their students and to apply strategies that help manage it. Incorporating modules on emotional management and techniques for reducing anxiety into teacher training programs could be an important step. Teachers should also receive guidance on how to structure assessments in a way that does not exacerbate anxiety, using

formative assessments or more frequent evaluations that provide continuous feedback, rather than relying solely on final exams that induce high levels of stress.

Finally, the results suggest that mathematical assessments should be designed with consideration for the emotional impact they have on students. Rather than administering strict or competitive exams, more flexible and collaborative approaches could be adopted to allow students to approach mathematics with greater confidence and less anxiety. Assessments that include constructive feedback, as well as group tasks or collaborative projects, could help reduce pressure and improve students' attitudes toward mathematics.

## 8. Declarations

### *Ethics approval and consent to participate*

This study is carried out in accordance with the recommendations of the Code of Ethics of the National Technology of Mexico. The Research Ethics Committee of the Division of Graduate Studies and Research approved the protocol. In accordance with the Declaration of Helsinki, all participants gave their consent to participate in the study.

### *Consent for publication*

Not applicable.

### *Availability of data and materials*

Data and materials associated with this study are available upon request.

### *Conflict of interest statement*

The author's declares no conflict of interest.

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### *Authors' contributions*

This document is the authors' work, as an intellectual contribution of their academic work, which they approved for publication. Conceptualization: TZL, LNI and RCG, methodology, data curation, data analysis: TZL and LNI, writing—original draft preparation, writing: TZL, LNI and RCG; writing—review and editing: RCG, and TZL; writing—supervision: TZL AND LNI; funding – TZL and RCG. All authors have read and agreed to the final version of the manuscript for publication.

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**Authors' ORCID**

Teresa Zamora-Lobato https://orcid.org/0000-0001-5564-3976
Lizzeth Navarro-Ibarra https://orcid.org/0000-0003-4537-9248
Rosalba Cabrera Gutiérrez https://orcid.org/0009-0006-5119-7175

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**Appendix 1.** Instrument

| | SA | A | N | D | SD |
|---|---|---|---|---|---|
| 1. Do I get nervous (a) when I think of the mathematics exam the day before? | | | | | |
| 2. Do I feel nervous when they give me the questions for the mathematics exam? | | | | | |
| 3. Do I get nervous when I open the mathematics book and I find a page full of problems? | | | | | |
| 4. Do I feel nervous when I think of the mathematics exam when there is an hour before doing it? | | | | | |
| 5. Do I feel nervous when I listen how other co-students solve a mathematics problem? | | | | | |
| 6. Do I get nervous when I realize that the next year I will still have a mathematics course? | | | | | |
| 7. Do I feel nervous when I think of the mathematics exam that I will take the next week? | | | | | |
| 8. Do I get nervous when somebody looks at me when I am doing the mathematics homework? | | | | | |
| 9. Do I feel nervous when I review the purchase receipt after having paid? | | | | | |
| 10. Do I feel nervous when I get to study for a mathematics exam? | | | | | |
| 11. Do mathematics exams get me nervous? | | | | | |
| 12. Do I feel nervous when they assign me difficult problems to do at home and that I have to deliver done for the next session? | | | | | |
| 13. Me pone nervioso hacer operaciones matemáticas calculations? | | | | | |
| 14. Do I feel nervous when I have to explain a mathematics problem to the teacher? | | | | | |
| 15. Do I get nervous when I am doing the final mathematics exam? | | | | | |
| 16. Do I feel nervous when they give me a list of mathematics exercises? | | | | | |
| 17. Do I feel nervous when I try to understand another costudent who is explaining a mathematics problem? | | | | | |
| 18. Do I feel nervous when doing an mathematics evaluation exam? | | | | | |
| 19. Do I feel nervous when I see/ listen my teacher explaining a mathematics problem? | | | | | |
| 20. Do I feel nervous when I get the final grades of the mathematics exam? | | | | | |
| 21. Do I feel nervous when I want to find out the change at the grocery store? | | | | | |
| 22. Do I feel nervous when they give us a math problem and a co-student finishes it before me? | | | | | |
| 23. Do I feel nervous when I have to explain a problem at the mathematics class? | | | | | |
| 24. Do I feel nervous when I begin doing my homework? | | | | | |

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# Role of Job Satisfaction in Turnover Intentions in a Private Security Company

Aylin del Rosario Lagunes-Hernández [a, *], Miriam Flores-Bañuelos [b], Rubén Edel-Navarro [c]

[a] UCC Business School, Cristóbal Colón University, Veracruz, México
[b] Universidad Veracruzana, Veracruz, México

**Abstract**

Employee turnover is a significant challenge for many companies, and understanding the causes and consequences of this phenomenon is crucial for ensuring long-term organizational stability and success. In this context, a study was conducted to explore the relationship between job satisfaction and employees' intention to leave in a private security company. To address this issue, an empirical study was carried out with a non-experimental design, using a comprehensive approach that included descriptive, correlational, exploratory, and confirmatory analyses, all framed within the hypothetical-deductive paradigm and applying Structural Equation Modeling (SEM) methodology. The study sample consisted of 620 workers from Duxon, a private security company located in the Boca del Río metropolitan area, Veracruz, México. The research findings revealed that job satisfaction has a negative relationship with the intention to resign from the job. In this case, it was observed that employees report being satisfied with the variety of tasks they perform at work and feel comfortable and secure in their work environment. As a result, this variable does not significantly impact their intention to leave.

**Keywords:** Employee Retention, Organization, Productivity, Satisfaction, Turnover.

## 1. Introduction

Employee turnover is a global challenge influenced by factors such as salary, professional development, recognition, and innovation. Understanding the underlying causes of turnover is crucial for addressing internal issues like organizational culture and team dynamics, as well as for implementing effective strategies to retain talent. Employee turnover has been linked to job satisfaction and organizational justice. Addai et al. (2018) found that turnover intentions were negatively correlated with job satisfaction and organizational justice, with salary and distributive and procedural justice being the key factors. Interestingly, gender had no significant effect on turnover intentions. Despite poor working conditions, many employees remain in their positions. According to Adusei et al. (2016), intrinsic motivation affects job performance, but extrinsic factors – such as reduced stress and increased autonomy – are more crucial for teacher retention. In this context, "Duxon Seguridad", a nationally established company, faces the challenge of understanding the factors contributing to its high employee turnover rate, ranging between 60 % and 70 % monthly over the past five years. Therefore, the purpose of this study is to identify the underlying causes of employees' intention to leave, with the aim of providing practical

*Corresponding author
E-mail addresses: aylin_lagunes@hotmail.com (A.R. Lagunes-Hernández)
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recommendations that could help the company reduce this high turnover rate and improve workforce stability. Nagpaul et al. (2022) propose that when individuals are dissatisfied with their working conditions, they are more likely to consider leaving their jobs. This is because people typically seek optimal consistency and balance between their personal and professional lives. In this sense, a lack of job satisfaction can significantly increase the likelihood of turnover. Due to the attitudinal nature of job satisfaction, individuals tend to stay in jobs they find satisfactory and leave those they consider unsatisfactory (Basińska, Rozkwitalska, 2020). Consequently, ensuring high job satisfaction becomes essential for retaining talent and optimizing business outcomes. Evaluating job satisfaction and other influencing factors is crucial, as Lee et al. (2022) highlight that satisfaction significantly impacts employees' intention to leave.

Various authors have explored job dissatisfaction as a factor contributing to turnover. Nurtjahjono et al. (2023) found that job satisfaction positively and significantly impacts employees' intention to leave, based on a quantitative study of 113 employees at PT. Bank Pembangunan Daerah Jawa Timur in Malang. The study concluded that a higher level of job satisfaction is associated with a decreased intention to leave the company. On the other hand, Gómez and Jiménez (2022) demonstrated a correlation between motivation, decision-making, and teamwork, emphasizing that promoting optimal working conditions to enhance job satisfaction is crucial for increasing productivity. When employees do not find purpose in their work, they are more likely to seek opportunities elsewhere due to job dissatisfaction.

According to Charles-Leija et al. (2023), having a meaningful job and feeling valued by colleagues are crucial factors for job satisfaction. Their research, which examined the relationship between job significance and turnover intentions, concluded that activities contributing to long-term goals and enjoyment of daily tasks are important predictors of job happiness. This satisfaction, in turn, directly impacts employees' intention to leave.

In this context, a key question arises for the present research: Is job satisfaction associated with the intention to leave? To address this, the study aims to test the following main hypothesis: H1 – Job satisfaction negatively influences the intention to leave. Therefore, the research's objective is to explore the relationship between job satisfaction and the intention to leave.

## 2. Literature Review

Employee turnover is a global challenge driven by factors such as salary, professional development, recognition, and innovation. Understanding the underlying causes of turnover is crucial for addressing internal issues such as organizational culture and team dynamics, as well as for implementing effective talent retention strategies. Below, a review of the specialized literature on the topic is presented, with the aim of grounding the research question and establishing a point of comparison between existing theory and the findings of this study. This will contribute to the existing body of evidence on the factors that influence employees' turnover intentions.

In this regard, Guilding et al. (2014) highlight that the causes of employee turnover have profound economic implications for companies, including the significant costs associated with hiring and training new staff, which represent a substantial financial burden for organizations across all sectors (Bryant, 2018). In addition to these direct costs, voluntary employee turnover has consequences that affect individuals and organizations, as Aranibar et al. (2017) demonstrated. Furthermore, Chakraborty et al. (2021) argue that employee turnover is one of the most significant challenges in human resources. Organizations often invest considerable time and money in recruiting and retaining staff with the expectation of gaining added value. However, when an employee leaves, opportunity costs arise for the organization, including the time needed to recruit and select a replacement.

Al-Suraihi et al. (2021) identify several factors driving employee turnover, including work stress, job satisfaction and security, work environment, motivation, and compensation. Employee turnover significantly impacts organizations, as associated costs can deteriorate productivity, sustainability, competitiveness, and profitability. Therefore, it is crucial for companies to understand their employees' needs to implement strategies that optimize performance and minimize turnover. To achieve success, organizations must focus on their employees' needs and adopt effective retention strategies. Various theories have been developed to understand employee turnover and job satisfaction. Domínguez Olaya (2015) provides empirical evidence showing that employee turnover is closely linked to factors such as salary, growth opportunities, recognition,

innovation, and interdepartmental cooperation. Voluntary employee departures often occur when employees evaluate their relationship with the company for personal or professional reasons.

On the other hand, Sabarete et al. (2018) apply Herzberg's theory to identify a direct relationship between employees' job satisfaction and their working conditions, such as sector, organizational structure, and type of contract. Their data indicate that job satisfaction is high based on intrinsic factors, although promotion opportunities are a notable exception. Significant variables leading to dissatisfaction and turnover were not identified, as most external factors, except for salaries, are close to a high average. Workers particularly value assigned responsibility, the opportunity to use interpersonal skills, and job stability. Djoemadi et al. (2019) argue that job satisfaction directly influences employees' commitment to their work.

Factors such as job security, the comfort of the work environment, stress levels, working hours, and management policies are fundamental to ensuring that employees feel satisfied and, consequently, committed to the organization. Navarro and Quijano (2003) present a theory of work motivation that integrates three key variables in the scientific literature: motives, self-efficacy, and perceptions of instrumentality. This theory also examines how workers' knowledge and skills, as well as their perception of fairness, influence individual motivation within the work environment, directly affecting their level of satisfaction. This theoretical approach helps understand how job satisfaction, derived from optimal working conditions and recognition of employee capabilities, can reduce turnover and improve organizational commitment.

Job satisfaction is the degree to which employees are content with various aspects of their job, including salary, company policies, work environment, development opportunities, and sense of achievement. This satisfaction is deeply linked to a perception of security and financial stability, which is generally associated with positive motivational and hygiene factors in the work environment (Nagpaul et al., 2022). High levels of job satisfaction tend to decrease employees' intention to leave, as they are less inclined to leave the company when they are satisfied with their work.

In a study by Gan et al. (2020), the impact of job satisfaction and organizational commitment on the relationship between public service motivation (PSM) and turnover intention among public employees was investigated. Using Structural Equation Modeling (SEM) in AMOS 24, the researchers found that PSM did not directly affect turnover intention when job satisfaction and organizational commitment were considered together. The authors suggested that future research should focus on how individual changes in PSM might affect turnover intention and other work behaviors to provide a more comprehensive understanding of these phenomena. Romeo et al. (2020) conducted research on the impact of job satisfaction on the turnover intention of employees with disabilities. Using descriptive analysis and bivariate correlations with SPSS software, they found that fostering a work environment with positive interpersonal relationships between employees and managers could reduce turnover intention. The authors recommended that future research expand the sample to include employees with disabilities in common companies to obtain more comprehensive and representative results.

Salleh et al. (2020) studied the effect of career planning and job satisfaction on turnover intention in Jordan. Using SmartPLS software to analyze data from 412 employees in 25 banks, they found that both career planning and job satisfaction negatively affect turnover intention. The researchers suggested that future studies should extend this model to include additional variables related to organizational behaviors for a complete view of the phenomenon. Nguyen et al. (2020) indicated that both burnout and job satisfaction have a significant relationship with turnover intention. Their research focused on determining the influence of job demands, burnout, and job satisfaction on turnover intention among public administration employees in Vietnam. To enrich the findings, they recommended that future research consider a wider variety of cultural contexts, countries, and sample sizes.

### 2.1. Related Studies and Discussion

#### *Turnover Intention*

The role of work is essential for the development of companies, leading numerous researchers to explore the causes contributing to increased employee turnover. Flores (2021) examined the relationship between employee turnover and its underlying factors in a maquiladora company in Reynosa, Tamaulipas, where the weekly fluctuation of nearly 400 workers was significant. The research revealed that approximately 90 % of employees choose to terminate their

employment with the company. Using regression models and Probit binary response models, it was found that women have a higher turnover rate, mainly due to personal issues or circumstances. In line with other studies, it was suggested that to reduce turnover, it is crucial to define job evaluations to set appropriate salaries and compensations, conduct performance and environmental impact assessments, clarify promotion and demotion processes, and foster a harmonious organizational environment to improve job satisfaction.

Félix-Cabada (2022) conducted a descriptive, deductive, and non-experimental study aimed at identifying factors contributing to employee attrition and turnover in private higher education institutions (HEIs) in Tabasco. The research covered academic, administrative, and operational staff of HEIs in the 6 South region of the National Association of Accounting and Administration Faculties and Schools (ANFECA). The study used a 20-item survey with a 6-point Likert scale. The results revealed that 54 % of respondents were dissatisfied with their salary, which negatively affected their performance and caused job dissatisfaction. The study suggests that companies and organizations should prioritize employee job satisfaction, as dissatisfaction directly impacts institutional performance and productivity.

Various studies have shown that job satisfaction is crucial to employees' turnover intentions. Álvarez et al. (2023) conducted research focusing on job satisfaction levels in small and medium-sized enterprises (SMEs) in Tuxpan, Veracruz, Mexico. The study revealed that factors such as gender, age, job position, contract type, department, and job category significantly influence employees' satisfaction levels. The quality of hygiene factors in the work environment is crucial; a lack of satisfaction can cause problems in any organization, negatively impacting productivity and performance and increasing turnover intentions.

Organizational climate also plays a vital role in employees' decisions to leave their workplace. Villalobos et al. (2020) demonstrated in a government agency in Coatzacoalcos, Veracruz that a good organizational climate and high staff satisfaction are associated with a low turnover rate. In contrast, the study by Reyes et al. (2021) conducted at the Crowne Plaza Hotel Tuxpan, Veracruz, identified that unmet expectations and employee dissatisfaction are significant causes of turnover. These findings underline the importance of creating a work environment that promotes satisfaction and a positive organizational climate to reduce turnover and improve employee retention.

### *Job Satisfaction*

Job satisfaction is essential for employee performance in a company, as it is closely linked to both organizational commitment and turnover intention. Nurtjahjono et al. (2023) emphasize that a high level of job satisfaction improves employee performance and decreases the likelihood of employees considering leaving the company. In contrast, high turnover, often due to job dissatisfaction, can have significant adverse effects on organizations. Nagpaul et al. (2022) highlight that job satisfaction is key to creating a positive work experience and reducing turnover. This underscores the importance of maintaining high satisfaction levels to minimize turnover-related costs and enhance organizational stability and performance.

Job satisfaction refers to employees' overall attitude towards their work, which can be either positive or negative. This attitude reflects how employees perceive both their tasks and the work environment in general. According to Londa and Permatasari (2021), when job satisfaction levels are high, companies have a greater capacity to retain their employees, who, in turn, contribute to organizational success through positive performance. Job satisfaction is crucial for managing employees' turnover intentions. Various studies have explored its definition and impact. Agustian and Rachmawati (2021) highlight that job satisfaction is crucial in managing turnover intentions. Fisher (2010, cited by Basińska and Rozkwitalska, 2020) defines job satisfaction as pleasurable judgments that include positive attitudes, emotions, and states of flow.

Employee commitment is fundamental for providing a competitive advantage to the organization, and this commitment is achieved mainly through job satisfaction. Satisfied employees tend to show loyalty and dedication, while those who feel disrespected or demotivated may experience decreased productivity and efficiency. If this dissatisfaction persists, such employees are likely to develop intentions to leave the organization, potentially leading to high turnover. Therefore, maintaining high levels of job satisfaction is vital to ensuring a committed workforce and reducing turnover. Suleman et al. (2022), from the perspective of Herzberg's two-

factor theory, state that organizations focusing on improving both motivating (intrinsic) factors and hygiene (extrinsic) factors will increase job satisfaction and reduce turnover intention. According to this theory, it is crucial for companies not only to ensure a suitable work environment (hygiene factors) but also to provide growth and recognition opportunities (motivating factors) to keep employees engaged and satisfied.

Complementarily, Lee and Lee (2022) highlight that job satisfaction is essential for employee retention. They argue that to increase employee retention, it is crucial to enhance the value and meaning of work, as well as to improve employees' ability to adapt to the work environment. This approach suggests that creating a positive work environment and fostering a sense of purpose and adaptability are key to reducing turnover and improving employee retention. To achieve high levels of job satisfaction, it is essential to provide employees with resources that act as motivators. According to Herzberg's theory (1987), these motivating resources include aspects such as effort, confidence, and growth opportunities, which are fundamental for fostering satisfaction.

On the other hand, personal dissatisfactions are linked to hygiene factors, which include interpersonal relationships, job conditions, and the work environment. Motivational factors are elements that drive personal development, potential, and commitment to work, directly contributing to satisfaction and a sense of accomplishment. In contrast, hygiene factors, such as the quality of communication between leaders and employees, prevention of workplace harassment, and the adequacy of the work environment, are more focused on preventing dissatisfaction. Thus, while motivational factors are crucial for improving satisfaction and employee commitment, hygiene factors are equally important for preventing dissatisfaction and, consequently, turnover.

## 3. Methods

### *Methodological design*

This research employed a quantitative and descriptive methodological design, as it did not aim to manipulate the independent variables (X) to alter their effects on the dependent variables (Y). Instead, it used the Structural Equation Modeling (SEM) methodology, which facilitated the identification of relationships between variables and determined which ones acted as dependent or independent (Portillo et al., 2016). This methodology allowed for inferring the relationships between the studied variables and drawing conclusions about the impact of each factor on employee turnover intention.

### *Population and sample*

This study will analyze turnover intention among employees of Duxon Seguridad, a company operating in the metropolitan area of Boca del Río, Veracruz. The sample includes participants with varying educational levels, from elementary to doctoral degrees, and encompasses both genders. Age ranges from 18 years to over 65 years. The sample also consists of employees in different administrative and operational positions, with various salaries based on their professional level within the company. Employee tenure is not considered, providing a comprehensive view of turnover intention across different segments within the organization.

### *Instrument*

The instrument used in the research consists of 67 items derived from the scales developed by Akosile and Ekemen (2022) and Wilson and Holmvall (2013). This instrument is part of the doctoral research and is composed of the following sections: I. Demographic Data, including employment status, job position, and salary (5 items); II. Motivational and Hygienic Factors (18 items) from Akosile and Ekemen (2022); III. Salary and Compensation (4 items) from Akosile and Ekemen (2022); IV. Managerial Support (13 items) from Akosile and Ekemen (2022); V. Job Satisfaction (3 items) from Akosile and Ekemen (2022); VI. Turnover Intention (3 items) from Akosile and Ekemen (2022); VII. Customer Incivility (21 items) from Wilson and Holmvall (2013). For this work, the items corresponding to the sociodemographic data of the participants were used, and for hypothesis testing, items X36 to X41 were selected. The instrument was designed in electronic format and distributed via Google Forms.

## 4. Data Analysis

### *Reliability analysis*

In the study, the reliability of the scales was assessed using Cronbach's alpha coefficient, yielding a value of 0.718 for the employee turnover intention scale. This value is considered

acceptable, as Cheung et al. (2023) state that the reliability of a scale should not be lower than 0.7. This indicates that the construct used has an adequate level of reliability. Furthermore, it must be ensured that the total error variance does not exceed 30% of the latent variable variance to maintain measurement accuracy. Descriptive statistics for the sociodemographic profile variables were then calculated to obtain a detailed view of the participants' characteristics in the study.

***Description of the Sociodemographic Profile of the Study Population***

The frequencies of the sociodemographic profile items of the participating workers in the private security company are described below based on the data obtained from the instrument's application.

**Table 1** provides details on the distribution of the study participants. It is observed that 57.1 % (n = 354) of the participants are men, while 42.9 % (n = 266) are women. In terms of age range, the majority fall into the 35-44 years group (31.1 %, n = 193), followed by the 18-34 years group (28.7 %, n = 178). Regarding seniority, the largest group has 1-3 years of tenure (n = 257), followed by those with less than 1 year of tenure (n = 235). Additionally, participants primarily identified with the ASIPOALT assignments (18.9 %, n = 117) and ASIPOVER assignments (16.8 %, n = 104).

**Table 1.** Frequencies of profile indicators

| **Demographics** | **Frequency** | **%** |
|---|---|---|
| Gender | | |
| *Female* | 266 | 42.9 |
| *Male* | 354 | 57.1 |
| Age | | |
| *18 - 34* | 178 | 28.7 |
| *35 - 44* | 193 | 31.1 |
| *45 - 54* | 158 | 25.5 |
| *55 - 64* | 79 | 12.7 |
| *65+* | 12 | 1.9 |
| Tenure | | |
| *Less 1 year* | 235 | 37.9 |
| *Between 1 – 3 years* | 257 | 41.5 |
| *Between 3 – 6 years* | 101 | 16.3 |
| *> 6 years* | 27 | 4.4 |
| Educational level | | |
| *Primary School* | 13 | 2.1 |
| *Middle School* | 171 | 27.6 |
| *High School* | 272 | 43.9 |
| *Bachelor's degree* | 161 | 26.0 |
| *Master's degree/Doctorate or PhD* | 3 | .5 |
| Work location | | |
| *DG* | 10 | 1.6 |
| *CPT* | 12 | 1.9 |
| *AF* | 13 | 2.1 |
| *CT* | 18 | 2.9 |
| *CH* | 39 | 6.3 |
| *NOM* | 10 | 1.6 |
| *OP* | 40 | 6.5 |
| *GCC* | 7 | 1.1 |
| *REC* | 4 | .6 |
| *BUUK* | 19 | 3.1 |
| *TRANSF* | 6 | 1.0 |
| *ANAM* | 6 | 1.0 |
| *INDEP* | 10 | 1.6 |
| *ASIPOEN* | 6 | 1.0 |
| *ASIPOALT* | 117 | 18.9 |

| Demographics | Frequency | % |
|---|---|---|
| *ASIPOVER* | 104 | 16.8 |
| *ASIPODB* | 4 | .6 |
| *ASA* | 2 | .3 |
| *ASIPODBCTV* | 8 | 1.3 |
| *BANOBRAS* | 2 | .3 |
| *ASIPOVALL* | 40 | 6.5 |
| *CFE* | 6 | 1.0 |
| *ASIPOTAMP* | 7 | 1.1 |
| *ASIPOPRG* | 12 | 1.9 |
| *CIIT* | 12 | 1.9 |
| *KIEWIT* | 9 | 1.5 |
| *ICX* | 18 | 2.9 |
| *FYPA* | 4 | .6 |
| *GNIETO* | 6 | 1.0 |
| *JDM* | 7 | 1.1 |
| *BKS* | 9 | 1.5 |
| *PGS* | 21 | 3.4 |
| *PHOME* | 14 | 2.3 |
| *BRD* | 18 | 2.9 |

Notes: For confidentiality reasons, the job assignments of the participants have been abbreviated.

**Factorial analysis**

For the exploratory factorial analysis, SPSS version 29 for Windows was used. The factorial structure of the questionnaire was assessed using the principal components method with Varimax rotation. Table 2 shows the polychoric correlation matrix for the 6 items of the scale used. Table 3 shows the results of Bartlett's test of sphericity along with the KMO index and the Chi-squared goodness-of-fit test with df and p-value, which evaluate the statistical significance of the data.

**Table 2.** Polychoric Correlation Matrix

| | X36 | X37 | X38 | X39 | X40 | X41 | Measure Sampling Adequacy |
|---|---|---|---|---|---|---|---|
| X36 | 1.000 | 0.250 | 0.356 | 0.384 | -0.230 | -0.221 | .823a |
| X37 | | 1.000 | 0.361 | 0.511 | -0.311 | -0.345 | .819a |
| X38 | | | 1.000 | 0.410 | -0.244 | -0.192 | .797a |
| X39 | | | | 1.000 | -0.472 | -0.487 | .796a |
| X40 | | | | | 1.000 | 0.604 | .746a |
| X41 | | | | | | 1.000 | .730a |

**Table 3.** KMO and Bartlett's Test

| | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | .959 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 19861.552 |
| | *df* | 1891 |
| | P-value | .000 |

As shown in Table 2, the polychoric correlation matrix shows acceptable correlations, indicating that it is not an identity matrix. The correlation values display significant variability among the items, and the determinant value close to zero provides significant evidence that the matrix is an acceptable correlation matrix according to theoretical criteria (Bartlett, 1950; Kaiser, 1974). Similarly, in Table 3, the obtained KMO value of 0.959 is acceptable, and the Chi-squared value of 19861.552 with 190 degrees of freedom (which is higher than the critical value in tables) and the statistical significance value of 0.00 supports the use of factor analysis (Timmerman, Lorenzo-Seva, 2011). This technique allows for the generation of theoretical model structures and the formulation of hypotheses that can be empirically tested (Portillo et al., 2016).

Therefore, this result allows us to reject the null hypothesis (H0), which asserts that the data matrix is an identity matrix with no correlation. On the contrary, it has been demonstrated to be a matrix with acceptable correlations, indicating that it is not an identity matrix. Once this requirement is met, it is possible to proceed with the factorial analysis. Table X shows the explained variance matrix, which displays two factors that account for the percentage of total variance, and Table Y shows the rotated factor matrix with the components that make up the obtained factorial solution, which is subsequently confirmed using the SEM methodology.

**Table 4.** Total explained variance

| Component | Initial eigenvalues | | | Sum of squared charges of the extraction | | |
|---|---|---|---|---|---|---|
| | Total | % variance | % accumulated | Total | % variance | % accumulated |
| 1 | 2.825 | 47.075 | 47.075 | 2.825 | 47.075 | 47.075 |
| 2 | 1.030 | 17.162 | 64.237 | 1.030 | 17.162 | 64.237 |

**Table 5.** Rotated component matrix[a]

| Items on Job Satisfaction vs. Turnover Intention | Component | |
|---|---|---|
| | Turnover intention 1 | Job satisfaction 2 |
| X41 | .875 | |
| X40 | .846 | |
| X39 | -.584 | .574 |
| X38 | | .803 |
| X36 | | .731 |
| X37 | | .562 |
| Composite Reliability (CR) | 0.523 | 0.766 |
| Average Variance Extracted (AVE) | 0.608 | 0.456 |
| Extraction method: principal component analysis. Rotation method: Varimax with Kaiser normalization. [a.] The rotation has converged in 3 iterations.<br>*A composite reliability of 0.70 is recommender (Hair, 1999), Fornel and Larcker (1981) recommended a CR value of 0.60 or more. Fornell and Larcker (1981) recommended and AVE greater than 0.50 | | |

To verify the hypothesis: Job satisfaction is related to employee turnover intention, the software AMOS v29 is used to evaluate the factorial solution through model fit, structural fit, and parsimony, as follows: Fit indices**:** These indices are used to assess the quality of the model in comparison to the observed data. This group of indices include measures such as Chi-square, RMSEA (Root Mean Square Error of Approximation), CFI (Comparative Fit Index), and TLI (Tucker-Lewis Index). A good fit is indicated by values close to 1 for CFI and TLI, and low values for RMSEA.

Structural fit: This reflects the model's ability to represent the relationships between variables. It is assessed by comparing different models to ensure that theoretical relationships align with empirical data. A strong structural fit indicates that the model is both valid and reliable. In addition, the Parsimony of this concept refers to the model's simplicity in relation to its capacity to explain the data. A parsimonious model achieves a good fit with the fewest parameters possible, thereby avoiding overfitting. It is evaluated based on the balance between the model's complexity and its fit. A parsimonious model is preferred because it is easier to interpret and apply.

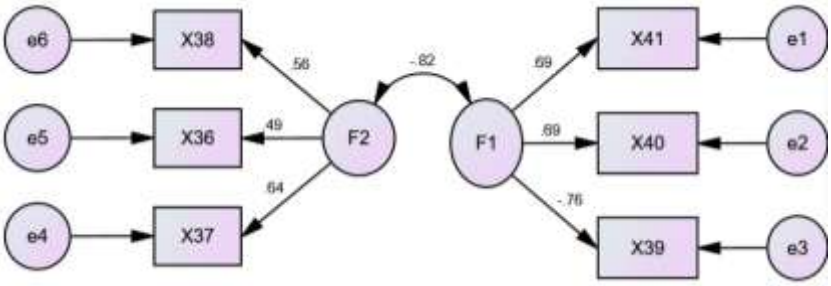


**Fig. 1.** Initial model of job satisfaction vs. turnover intention

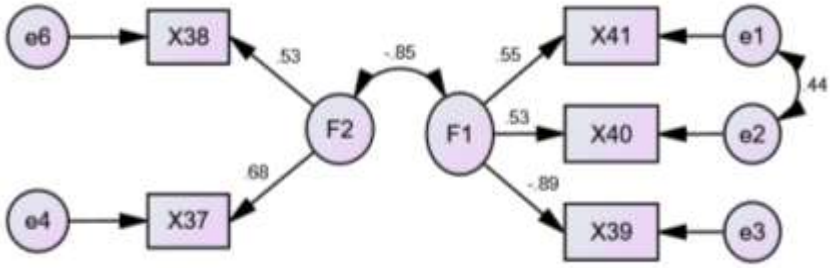


**Fig. 2.** Adjusted model of job satisfaction vs turnover intention

**Table 6.** Summary of fit indices, structural fit, and parsimony

| Model | RMSEA | | CMIN/DF | | RMR | GFI | AGFI |
|---|---|---|---|---|---|---|---|
| Figure 1 | .151 | | 15.046 | | .059 | .935 | .829 |
| Figure 2 | .045 | | 2.263 | | .015 | .996 | .978 |
| Model | PGFI | TLI | CFI | PRATIO | PNFI | PCFI | |
| Figure 1 | .356 | .778 | .882 | .533 | .467 | .470 | |
| Figure 2 | .199 | .985 | .995 | .300 | .298 | .299 | |

## 5. Discussion

The study addressed the research question, "Is job satisfaction associated with employee turnover intention?" by testing the hypothesis: "Job satisfaction is related to employee turnover intention". As shown in Figure 2, the relationship between the factor labeled "job satisfaction" and the factor labeled "employee turnover intention" is negative (r = -0.85). This suggests that job satisfaction does not significantly influence employees' intention to resign. Furthermore, the model fit, including both structural fit and parsimony, meets the established theoretical criteria. Fit indices such as the maximum likelihood ratio CMIN/DF (2.263) and the RMSEA (0.045) indicate a good fit for the model, as detailed in Table 6.

The data analysis reveals that job satisfaction exhibits a negative relationship with employees' turnover intentions. This suggests that, within the context of the studied company, the high job satisfaction experienced by employees does not significantly affect their desire to leave the organization. Employees report feeling comfortable with the variety of their tasks and believe that safety conditions align well with their functions. As a result, job satisfaction does not appear to be a driving factor for turnover intentions among the employees of this company. This finding contrasts with the perspective presented by Nagpaul et al. (2022), who found that dissatisfaction with working conditions might lead employees to consider leaving their positions. In the case of the company under study, the positive perception of the work environment and the conditions offered seem to act as a mitigating factor regarding turnover. On the other hand, this result aligns with the studies by Salleh et al. (2020), who argue that high job satisfaction has a negative effect on turnover intentions; that is, as employees become more satisfied, their inclination to leave the company decreases. This consensus reinforces the notion that improving working conditions and ensuring a positive work environment may be crucial for employee retention.

This analysis underscores the importance of addressing the objective conditions of work and employees' general satisfaction with their roles and work environment. Although job satisfaction may not be a decisive factor in turnover in this particular case, it remains essential for maintaining a committed and motivated workforce. Organizations must continue to pay attention to these factors to sustain the balance between satisfaction and personnel retention, adapting strategies that align with their employees' specific perceptions and needs.

## 6. Conclusion

As a final remark, the study's results indicate that, within the context of the analyzed company, job satisfaction does not significantly influence employees' turnover intention. With a correlation coefficient of -0.85, a negative relationship is established between job satisfaction and the intention to leave employment, suggesting that a high level of satisfaction does not correlate with an increased intent to remain. This contrasts with previous studies linking dissatisfaction with working conditions to a greater propensity to leave the position, highlighting the uniqueness of the company's work environment.

Furthermore, the model fit indices indicate good adequacy, supporting the validity of the findings. Although job satisfaction does not appear to be a decisive factor for employee turnover in this case, its relevance for maintaining a positive and motivating work environment is underscored. Therefore, organizations should continue to pay attention to employee satisfaction, adapting their strategies to their workforce's specific perceptions and needs to promote long-term retention and commitment. Improving working conditions and attending to the overall well-being of employees is fundamental to achieving a balance between satisfaction and employee retention.

## 7. Limitations and Strengths

At the beginning of the research, the number of surveys collected was very limited, making it difficult to obtain a representative and reliable sample. In response to this challenge, considerable efforts were made to increase the number of surveys, persistently encouraging participants to complete the data collection instrument. Throughout the process, continuous efforts were made to overcome barriers such as participants' distrust of the questionnaires, due to concerns about confidentiality or a lack of clarity regarding the study's purpose. Additionally, financial constraints hindered the ability to hire extra personnel or acquire necessary materials, further complicating the study's execution. The limited time available also affected the survey distribution, restricting the amount of data that could be collected within the given timeframe. However, once a more significant number of surveys were obtained, the research was strengthened by improving the representativeness of the sample, leading to more accurate and generalizable results. The increased volume of responses provided a more robust foundation for conducting detailed analyses and identifying patterns or trends, enriching the conclusions and offering a deeper understanding of the phenomenon being studied.

## 8. Implications for Future Research

Future studies could explore various aspects related to job satisfaction and turnover intention. For example, it would be useful to examine moderating factors such as leadership style and organizational culture, as they may significantly influence the relationship between job satisfaction and turnover. Leadership styles, particularly those focused on transformational or supportive leadership, could either enhance job satisfaction or mitigate turnover intention by fostering a positive and motivating work environment. Similarly, organizational culture, whether collaborative, hierarchical, or innovative, may shape employees' perceptions of their work experience, thereby affecting their likelihood to stay or leave. Additionally, conducting comparative studies across different sectors would help understand whether the effects of job satisfaction on turnover intention vary by industry. Different sectors often have unique characteristics, such as work demands, job roles, or economic pressures, that could influence how satisfaction impacts employees' decisions to stay or leave.

Specific working conditions, such as schedule flexibility and the physical work environment, could also be key factors to investigate. Flexible work hours or the option for remote work have become increasingly relevant in today's work environment and could significantly influence employee satisfaction and turnover rates. On the other hand, the physical work environment –

such as office layout, safety, or access to resources—can affect an employee's comfort and overall job satisfaction, thereby impacting their intention to stay with or leave an organization. A longitudinal study would be particularly valuable, allowing researchers to observe how changes in job satisfaction over time correlate with shifts in turnover intention. This type of study would enable a deeper understanding of the dynamic nature of job satisfaction and how fluctuations in this area might influence decisions regarding turnover in the long term.

Furthermore, qualitative analyses could provide rich insights into employees' lived experiences, offering an opportunity to identify the underlying reasons for their satisfaction or dissatisfaction. By gathering direct feedback through interviews or open-ended surveys, researchers could uncover nuanced factors, such as personal values, career aspirations, or interpersonal relationships, which quantitative studies might overlook. Evaluating organizational interventions, such as employee engagement programs, professional development opportunities, or wellness initiatives, would also be valuable. Understanding how these interventions impact job satisfaction and retention could offer actionable insights for organizations looking to reduce turnover and improve employee engagement.

Finally, exploring how job satisfaction is linked to job performance would be interesting. Satisfied employees are often more motivated, productive, and committed to their roles, so investigating this relationship could help organizations understand the broader effects of satisfaction on overall performance. Additionally, studying the effect of remote work on turnover intention could provide insights into how flexibility in work arrangements impacts employees' loyalty to their organizations. Lastly, the impact of diversity and inclusion initiatives in the workplace on satisfaction and retention should not be overlooked, as fostering an inclusive and supportive environment could be a crucial factor in reducing turnover and ensuring that employees feel valued and motivated to stay. By expanding research into these areas, organizations can better address the complex factors that contribute to job satisfaction and turnover, ultimately leading to improved retention rates and a more engaged workforce.

## 8. Declarations

### *Ethics approval and consent to participate*

This study is carried out under the recommendations of the Code of Ethics of the UCC Business School at Cristóbal Colón University, which approved the protocol. Following the Declaration of Helsinki, all 620 Duxom workers consented to participate in the study.

### *Consent for publication*

Not applicable.

### *Availability of data and materials*

Data and materials associated with this study are available upon request.

### *Conflict of interest statement*

The authors declare no conflict of interest.

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### *Authors' contributions*

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### Authors' ORCID

Aylin del Rosario Lagunes-Hernández https://orcid.org/0000-0003-3623-8777
Miriam Flores-Bañuelos https://orcid.org/0000-0002-3703-0591

Rubén Edel-Navarro https://orcid.org/0000-0002-7066-4369

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# Strategies for Sustainable Development in Organic Farming: A Topic Modeling Approach Using Latent Dirichlet Allocation

Sumana Chiangnangam [a], Paiboon Manorom [a, b], Wirapong Chansanam [a, *]

[a] Khon Kaen University, Khon Kaen, Thailand
[b] Bansomdejchaopraya Rajabhat University, Bangkok, Thailand

**Abstract**

Organic farming products have gained popularity among health-conscious consumers as a sustainable alternative. Agricultural entrepreneurs focusing on organic agriculture aim to create value through sustainable development, leveraging networks across production, processing, and marketing. Despite its growth, organic agriculture development requires further research to identify effective approaches and methods across various dimensions. This study aims to investigate strategies and methodologies for organic farming by analyzing topic models related to organic agriculture and entrepreneurship using bibliographic information. A dataset of 4,327 article abstracts published between 1946 and 2023 in the Scopus database was analyzed using the Latent Dirichlet Allocation (LDA) topic modeling method. The analysis identified five primary topics: (1) Soil for organic agriculture, (2) Environment and organic agriculture, (3) Agricultural business, (4) Organic production, and (5) The use of organic substances. The topic modeling approach yielded a connection value of 0.419, indicating an effective and appropriate grouping of topics. The findings provide valuable insights for farmers, enabling them to understand historical trends and strategies in organic farming and entrepreneurship. Additionally, the study offers researchers a foundation for applying topic modeling to explore future research directions in organic agriculture and related fields.

**Keywords:** Agricultural entrepreneurs, Latent Dirichlet Allocation, Organic agriculture, Topic Modeling.

## 1. Introduction

Agriculture in Thailand continuously evolves through technology and has adapted innovation to transform into the era of Agriculture 4.0, which emphasizes high-quality agriculture to increase production productivity in the quantity and value of agricultural products (Office of the Small and Medium Enterprises, 2020). Furthermore, the government sector also expects farmers to practice sustainable agriculture in three dimensions, i.e., the economy, the society, and the environment, to create growth based on an environmentally friendly (Office of the Small and Medium Enterprises, 2021) through promoting agricultural products and processed agricultural products to create high value, which is environmentally friendly and build

*Corresponding author
E-mail addresses: wirach@kku.ac.th (W. Chansanam)
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an image of Thailand to be tourism destination that emphasizes value and sustainability (National Organic Agriculture Development Committee, 2017).

Organic farming is considered a sustainable agricultural system, which gained the attention of farmers and consumers (Asamoah et al., 2023). This system resulted in the increase of organic agricultural products along with the project for promotion and support for farmer groups to enter organic farming. It also strengthened farmer groups by connecting production, processing, and marketing networks. Notably, in the National Economic and Social Development Plan No. 13 (2023–2027), was mentioned the objectives related to the development of organic agriculture as follows: 1) A high-value economy with a friendly environment and to be a leading country in agricultural products and agricultural processing that create high value and build Thailand to be a tourism destination that emphasizes value and sustainability, 2) Society of opportunity and equality for strong SMEs with high potential and high competitiveness, 3) Sustainable lifestyles for a circular economy and a low-carbon society to reduce risks and impacts from natural disasters and, 4) Factors Driving Development for a highly capable workforce for future development and needs (Announcement on the National Economic and Social Development Plan No. 13., 2022). In addition, the government has urgent policies to lay the foundations of the country's economic system for the future of technology development along with developing the skills of small and medium-sized entrepreneurs (SMEs) and communities as well as urgent policies for developing public services systems to develop the government's data collection and disclosure system to establish a central organic agricultural database for the entire organic agricultural supply chain and support research and development to create systematic knowledge and innovation in a concrete way (Agricultural Research Development Agency, 2018; Office of the Small and Medium Enterprises, 2020).

Before engaging with an entrepreneur, it is essential to gain an in-depth understanding of various critical aspects that can serve as guidelines to drive the growth of entrepreneurial groups. These aspects include information on production systems, production factors, market intelligence, technology, innovation, and other relevant areas. The collection of organic agricultural information should be categorized consistently and rely on updated resources, including information, knowledge, and skills (Blake, Wijetilaka, 2015). Researchers from various fields have been actively studying organic farming and entrepreneurship, with several studies already catalogued in the database. However, finding useful information or additional information about organic agriculture and entrepreneurs makes it difficult to retrieve information in the public sector (Joo et al., 2016). Furthermore, analyzing large amounts of data also requires tools to help in aspect processing information, e.g., natural language processing, which analyzes huge amounts of text from social media data, including topic modeling techniques (Jelodar et al., 2019).

Topic modeling is a data distribution model for categorization and contains ideas from various documents, resulting in a huge amount of data and a collection of topics. Each topic has a probability of words occurring in that topic (Maneewong et al., 2024). Thus, the topic modeling is creating a data distribution model that was used to group data based on the idea that a document is a combination of huge resources. Consequently, the topics might have a probability distribution of many words occurring in each topic based on the concept of the Latent Dirichlet Allocation: LDA, which was created with the idea that a document would consist of topics together randomly in the form of word groups. In the search, LDA is used to find topics or word groups that need to be extracted from the document by calculating the probability value (probabilistic) from words appearing in documents as a latent topic, which cannot be observed. Then, the LDA program will analyze the probability of each word in the latent topic and estimate the proportion of hidden topics in a document. The LDA is the most commonly used, as it is a flexible method and is changeable for creating topic models to separate essential points of the message. To create a topic model, the question can be answered: which topics are discussed most frequently? Therefore, topic modeling will provide more insight into relevant topics within that topic by creating content relevance by selecting semantically relevant keywords. Meanwhile, the content is then analyzed to determine whether it is applicable, which is widely used in various fields of study such as Linguistic science, Political science, Medical and Biomedical Science, Geography, etc. (Jelodar et al., 2019). Hence, this study is an analysis of research on organic agriculture and entrepreneurs in the relevant context and citation, which relevant topics are discussed the most in the field of study.

## 2. Methods and Materials

This study has employed a quantitative analysis of bibliographic research articles through the text analysis method from research abstracts intending to understand organic agriculture, entrepreneurship, and knowledge pedagogy research trends. Nonetheless, the application of this technique uses the concept of text analysis with a topic model to analyze topic model creation. Then, the researcher considered the prominent words of each issue and grouped them together for the important issues that correspond to the others. The research methodology was comprised of four stages, as were as follows:

### *Data collection*

In this study, the researcher has searched for documents related to organic agriculture and entrepreneurs in the Scopus database by specifying keywords used in the search. To identify the keywords, we then analyzed the main issues regarding organic agriculture and agricultural entrepreneurs in the heading or title of the various sources, such as documents, books, articles, and related research. After that, proceed with the obtained words in the search using advanced search techniques with AND to connect the words to get the results in which both words appear. Besides, the OR was used to connect words to get the results in which either word appears (Prabpala et al., 2023). Therefore, the research technique would be "(organic AND agriculture) OR (organic AND farming) OR (organic AND business) OR (organic AND startup) OR (organic AND entrepreneur)". The method has selected relevant documents for organic agriculture, entrepreneurs, and businesses. The index organizes the resulting document into several academic and professional fields, including Social Sciences, Business Management and Accounting, Economics/Econometrics and Finance, Multidisciplinary studies, and Arts and Humanities. This classification helps researchers and readers identify the document's relevance to their area of interest. Additionally, publishers have made the document available exclusively in English, ensuring accessibility to English-speaking audiences. The publication timeline spans from 1946 to 2023, reflecting its long-standing contribution to knowledge in these disciplines. The data in this study was downloaded on April 11, 2023, and found that 6,730 results were obtained. Then, the researcher checked for duplication, anonymous author, and abstract absence to be excluded from this study. The final results were about 4,327 in total and were saved in the file in CSV format for data analysis.

### *Data preparation and data cleaning with Natural Language Processing (NLP)*

For the data preparation and cleaning, the data was imported into English through Natural Language Processing (NLP) at the pre-processing step to clean the data, accelerating computers to understand human language. The NLP would assist in categorizing, summarizing, and creating text, which converts the data with reliable tools as open source and available to run on Python. The text at the pre-processing stage proceeded to PyCaret (Ali, 2020). These steps involved deleting commonly used but insignificant words, which would help to delete the marks, punctuation, numbers, and unnecessary words to extract representative keywords from articles.

### Topic Modeling with Latent Dirichlet Allocation

The topic modeling is a tool to help the researcher discover hidden knowledge structures in document datasets. This allows the researcher to make informed decisions and gain insights into complex topics (Blei et al., 2003). However, choosing the right model would be challenging since the various models have different strengths and weaknesses (Jelodar et al., 2019). For example, LDA is well-known for learning descriptive topics, whereas LSA is well-known for generating visual representations of semantics in datasets (Stevens et al., 2012). After completing the pre-processing step, the TF-IDF as weighting method, which is a pre-filtering step for a statistical measure used to rate the importance of words in the content of a document set based on the occurrence of each word, then the relevant keywords in the corpus would be investigated through a bi-gram algorithm to select common phrase together with the TF-IDF algorithm to extract keywords from the abstract (Grun, Hornik, 2011; Wattanasiri et al., 2024).

### *Data visualization*

The data visualization was designed based on group categorizations derived from each topic identified by the Latent Dirichlet Allocation (LDA) model. Graphs and diagrams illustrate the datasets and highlight the relationships within each dimension, providing a clear and structured view of the underlying data patterns.

***Data Collection***

From collecting and selecting the document lists regarding organic agriculture and entrepreneurs in the Scopus database, the bibliographic information of the articles in each context was recorded, as well as the name of the author, title, year of publication, name of the journal, and issue. The year, the number of citations and the abstract were then downloaded as CSV files, which can be opened in Excel to check and select duplicate data or data without an author. There were no published years. It was found that there were 4,327 articles from 1946 to 2023 (Figure 1). After that, files were prepared for import and analysis, including the name of the author, title, year of publication, and abstract. We added the context for each article in the CSV file format.

## 3. Results

***Published research articles***

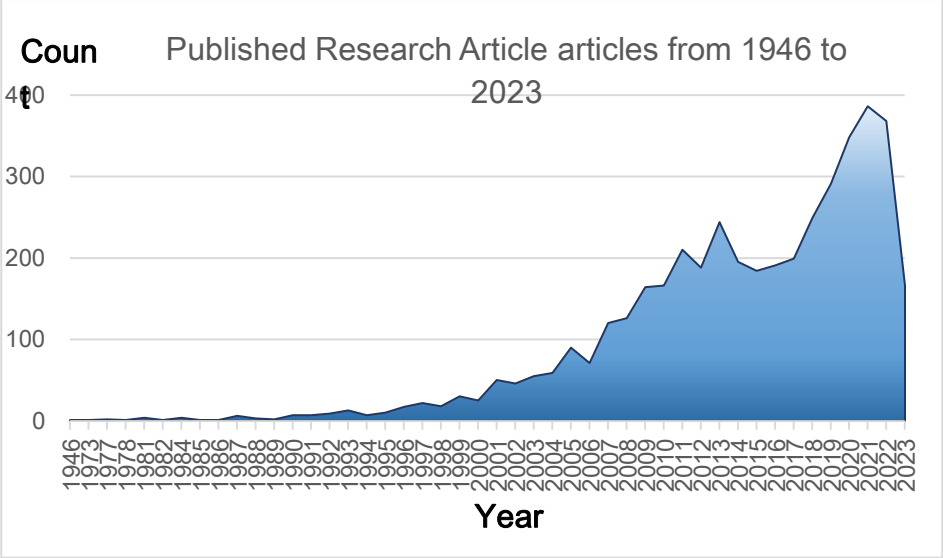


**Fig. 1.** Published articles from 1976 to 2023

The data reveals that Social Sciences has the highest article concentration, with approximately 1600-1800 publications. This is followed by Business, Management, and Accounting, which show roughly 1000 articles. Arts and Humanities and Economics, Econometrics, and Finance demonstrate similar levels of publication output, each with approximately 600-800 articles. Health Sciences and Multidisciplinary categories show the lowest number of publications, each containing fewer than 400 articles (Figure 2).

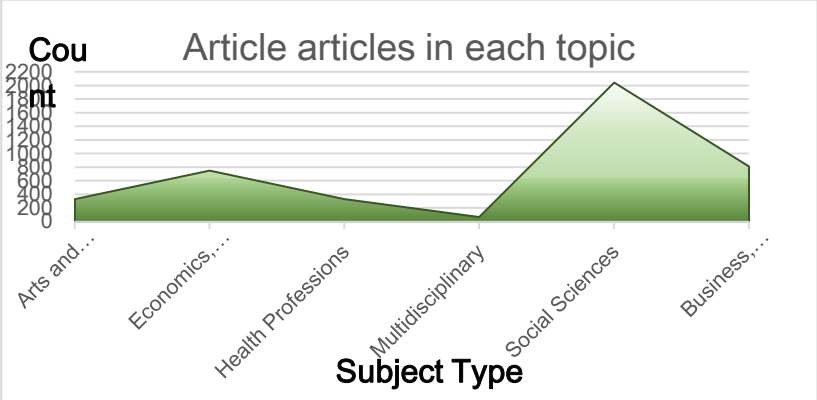


**Fig. 2.** Article articles on each topic

**Data Preparation and Data Cleaning Result**

***Indicate Data Categorization for Analysis***

In this study, we have chosen to analyze the content of the abstract section because the abstract contains an overall summary and contains important information for each article collected by preparing the data and cleaning the data, importing the .CSV file from which the data was collected into the Python program (Figure 3) and examining the data in the abstract section. The results indicated that there were 7,239 session data from 4,327 documents with 19,939 words (Figure 4)

display(dataset)

| | Authors | Title | Year | Cited by | Abstract | Sbj. A. |
|---|---|---|---|---|---|---|
| 0 | A.V V.B.; Banesel J.P.; Weedon O.; Finckh M.R. | Effects of ten years organic and conventional ... | 2019 | 13 | Early vigour traits of wheat composite cross p... | 0 |
| 1 | Asiaz N.; Bin Ibrahim M.D.; Bin Ahmed G. | Green consumers: A growing market for SME'S an... | 2010 | 1 | This study attempts to gain knowledge about th... | 3 |
| 2 | Aarnink A.J.A.; Hol J.M.G.; Beurskens A.G.C. | Ammonia emission and nutrient load in outdoor ... | 2006 | 16 | Ammonia emission and nutrient load in outdoor ... | 4 |
| 3 | Aarts H.F.M.; Conijn J.G.; Corré W.J. | Nitrogen fluxes in the plant component of the ... | 2001 | 14 | Sandy areas in th... | 4 |
| 4 | Abbas A.; Sajid M.B.; Sajid J.; Ahmed N. | Forecasting environmental and social benefits ... | 2023 | 1 | Embodied carbon of new buildings can be effect... | 4 |
| ... | ... | ... | ... | ... | ... | ... |
| 4322 | Zrakić M.; Jež Rogelj M.; Grgić I. | Organic agricultural production on family farm... | 2017 | 7 | The Croatian organic products market is not de... | 4 |
| 4323 | Zuba-Ciszewska M.; Kowalska A.; Manning L.; Bi... | Organic milk supply in Poland: market and poli... | 2019 | 10 | Purpose: Global demand for organic milk produc... | 1 |
| 4324 | Zubizarreta-Gerendiain A.; Pukkala T.; Peltola H. | Effects of wood harvesting and utilisation pol... | 2016 | 30 | We studied the effects of different wood harve... | 4 |
| 4325 | Zuo X.X.; Li H.Y. | Carbon sequestration within millet phytoliths ... | 2011 | 91 | Phytoliths are noncrystalline minerals that fo... | 0 |
| 4326 | Zuorro A.; Moreno-Sader K.A.; González-Delgado... | Evaluating the feasibility of a pilot scale sh... | 2021 | 6 | The foreseen increase in the demand of chitin,... | 1 |

4327 rows × 6 columns

**Fig. 3.** Data from Imported File .CSV format

```
my_nlp_experiment = nlp.setup(data=dataset, target='Abstract')
```

| Description | Value |
|---|---|
| session_Id | 7239 |
| Documents | 4327 |
| Vocab Size | 19939 |

**Fig. 4**. Document Computation and Appeared Words

***Data Processing***

(1) First, for a suitable format analysis, cleaning data by eliminating unnecessary data, such as numbers, punctuation marks, symbol marks, and unnecessary words space between words.

(2) After that, the abstract was prepared and imported into the model to analyze topics, which is called topic modeling. We employed Latent Dirichlet Allocation (LDA) to define the topics. Finally, the obtained results from the LDA model showed the measurement values for evaluating topics in Abstract Topic 0 – Topic 4, which is the most valuable topic in the abstract. This was considered the main topic mentioned in the abstract (Figure 5).

(3) In the topic distribution, Figure 3 shows that topic 3 was the most common (Figure 6). Each topic was represented by a group of keywords of the topic in the visualized text in WordCloud format, which is a visual representation of text that highlights keywords in the given content. In this study, we created a word cloud from the WordCloud library in Python to present the main research content and each topic (Figure 7; Cho et al., 2018).

Figure 7 shows a set of word clouds representing different topic clusters related to organic farming and agricultural research.

Topic 0: Centered around “soil” and “use,” with prominent terms like “high” and “crop,” suggesting a focus on soil management and crop cultivation practices.

Topic 1: It prominently features “organic” and “production,” with terms like “cost” and “emission,” indicating research on organic production systems and their environmental/economic impacts.

Topic 2 Emphasizes “use,” “production,” and “environmental,” with “organic” and “system” also prominent. It suggests research on the environmental aspects of organic farming systems.

Topic 3: Dominated by “farmer” and “use,” with “organic” and “farming” also prominent, indicating a focus on farmer practices and adoption of organic farming methods.

Topic 4: It highlights “use,” “study,” and “organic,” with “method” also visible, suggesting a more research-methodology-oriented cluster focusing on organic farming studies.

| | Authors | Title | Year | Cited by | Abstract | Sbj. A. | Topic_0 | Topic_1 | Topic_2 | Topic_3 | Topic_4 | Dominant_Topic | Perc_Dominant_Topic |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | A.V V.B.; Baresel J.P.; Weedon O.; Finckh M.R. | Effects of ten years organic and conventional ... | 2019 | 13 | early vigour trait wheat composite cross popul... | 0 | 0.708468 | 0.119149 | 0.095792 | 0.012793 | 0.063799 | Topic 0 | 0.71 |
| 1 | Asijaz N.; Bin Ibrahim M.D.; Bin Ahmed G. | Green consumers: A growing market for SME'S an... | 2010 | 1 | study attempt gain knowledge consumer organic ... | 3 | 0.011254 | 0.085088 | 0.183898 | 0.718953 | 0.000807 | Topic 3 | 0.72 |
| 2 | Aarnink A.J.A.; Hol J.M.G.; Beurskens A.G.C. | Ammonia emission and nutrient load in outdoor ... | 2006 | 16 | ammonia emission load outdoor run lay hen meas... | 4 | 0.546840 | 0.379436 | 0.043079 | 0.028813 | 0.001831 | Topic 0 | 0.55 |
| 3 | Aarts H.F.M.; Conijn J.G.; Corré W.J. | Nitrogen fluxes in the plant component of the ... | 2001 | 14 | sandy area mainly use intensive dairy farming ... | 4 | 0.558460 | 0.342258 | 0.014455 | 0.083324 | 0.001503 | Topic 0 | 0.56 |
| 4 | Abbas A.; Sajid M.B.; Sajid J.; Ahmed N. | Forecasting environmental and social benefits ... | 2023 | 1 | embody carbon new building effectively reduce ... | 4 | 0.115941 | 0.587271 | 0.112740 | 0.131617 | 0.052432 | Topic 1 | 0.59 |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 4322 | Zrakić M.; Jež Rogelj M.; Grgić I. | Organic agricultural production on family farm... | 2017 | 7 | croatian organic product market develop econom... | 4 | 0.008134 | 0.032815 | 0.121155 | 0.835245 | 0.002650 | Topic 3 | 0.84 |
| 4323 | Zuba-Ciszewska M.; Kowalska A.; Manning L.; Br... | Organic milk supply in Poland: market and poli... | 2019 | 10 | purpose global demand organic milk product gh... | 1 | 0.003496 | 0.172735 | 0.130970 | 0.648461 | 0.044338 | Topic 3 | 0.65 |
| 4324 | Zubizarreta-Gerendiain A.; Pukkala T.; Peltola H. | Effects of wood harvesting and utilisation pol... | 2016 | 30 | study effect different wood harvesting utilisa... | 4 | 0.623315 | 0.245907 | 0.006514 | 0.114429 | 0.009834 | Topic 0 | 0.62 |
| 4325 | Zuo X.X.; Lü H.Y. | Carbon sequestration within millet phytoliths ... | 2011 | 91 | phytolith noncrystalline mineral form inside c... | 0 | 0.806932 | 0.013072 | 0.109274 | 0.016638 | 0.054084 | Topic 0 | 0.81 |
| 4326 | Zuorro A.; Moreno-Sader K.A.; González-Delgado... | Evaluating the feasibility of a pilot-scale sh... | 2021 | 6 | foresee increase demand chitin reveal business... | 1 | 0.060316 | 0.874597 | 0.027210 | 0.018608 | 0.019268 | Topic 1 | 0.87 |

4327 rows × 13 columns

**Fig. 5.** The Results from LDA Model Analysis

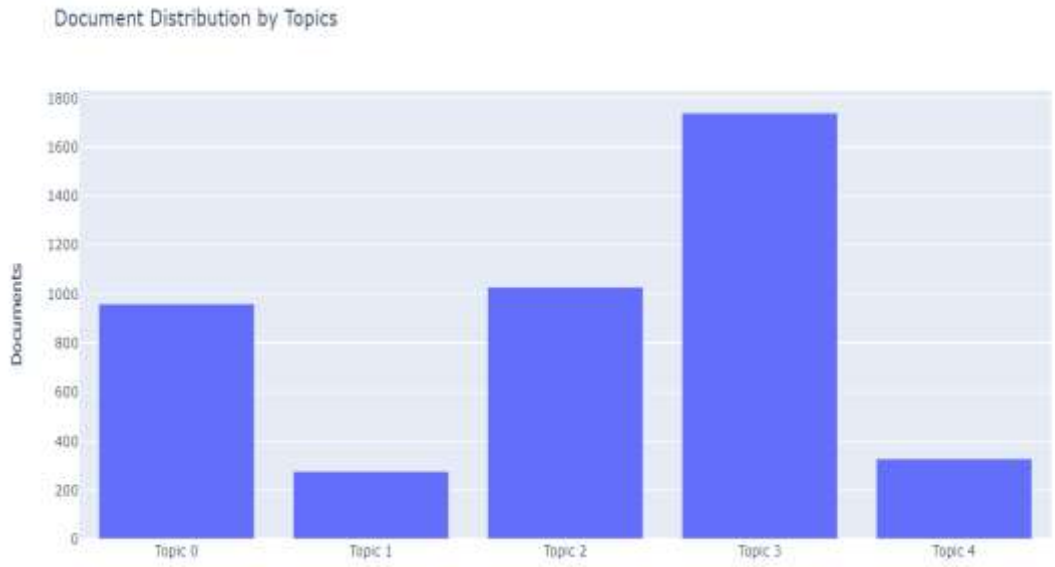


**Fig. 6.** The Topic Distribution

Common threads across all topics include 1. Consistent appearance of “use” and “organic” across multiple clusters, 2. Environmental and production-related terminology and 3. A mix of practical farming terms and research-oriented language

This WordCloud suggests that these topics represent different aspects of organic farming research, from soil management to farmer practices to production systems. There is some overlap in terminology but distinct thematic focuses.


**Fig. 7.** WordCloud Format from Library

***Topic Modeling Results***

Topic modeling is a tool for exploratory analysis of large volumes of documents (Koltsova, Koltcov, 2013; Elgesem et al., 2015), showing the overall interpretability of topics and used to assess topic quality. The Coherence Metrics technique was used to calculate statistical values and probabilities extracted from a reference library, especially focusing on the context of words to score the coherence of topics. From the probability distribution, the model can determine which topics are in a given document and which words are in the given topic by considering the distribution of words on various topics and the distribution of topics in documents. When considering the consistency of topics across topics from 0 to 6, topic 5 (Figure 8) is the optimal number of topics for this model to maximize topic coherence. This corresponds to the 5 topics specified in the pre-processing evaluation.

```
from gensim.models import CoherenceModel
# instantiate topic coherence model
cm = CoherenceModel(model=lda_model, corpus=bow_corpus, texts=corpus, coherence='c_v')
# get topic coherence score
coherence_lda = cm.get_coherence()
print(coherence_lda)
```

```
0.41970792415122304
```

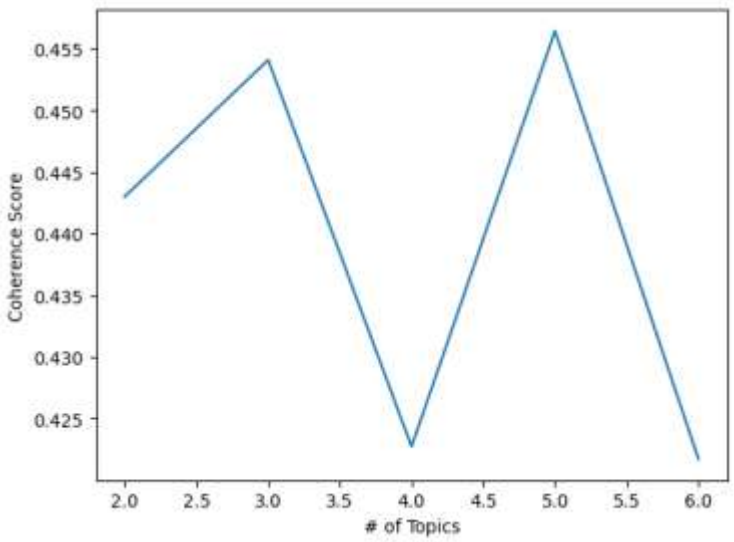


**Fig. 8.** The Appropriate Topic Computation Results

**The Topic Naming and Topic Detail**

The researcher has employed the bigram's properties to predict the most common words in each topic, which the bigram feature performs better for prediction than the unigram and trigram features with overlapping structural relationships in the bibliometric analysis study on the dataset. Among the 100 most common word clusters, five topics were divided according to topic from Topic 0 – Topic 4 (Figures 9–13).

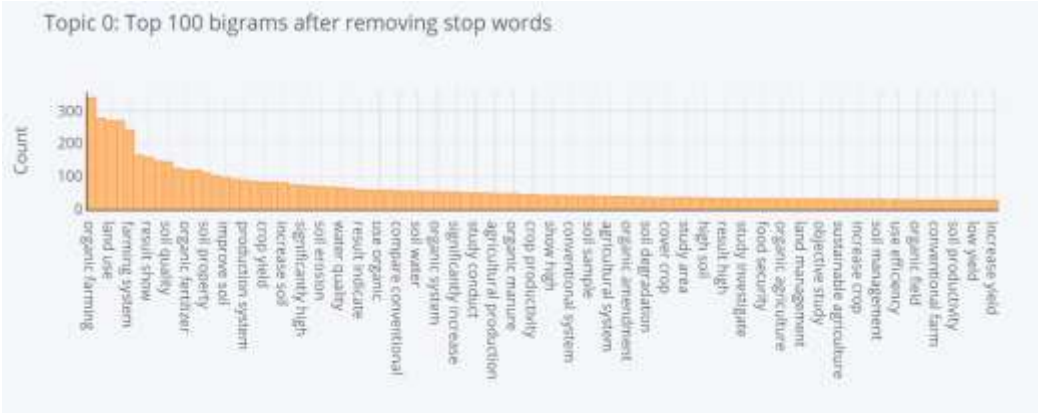


**Fig. 9.** Word Cluster from Bigram Algorithm in Topic 0

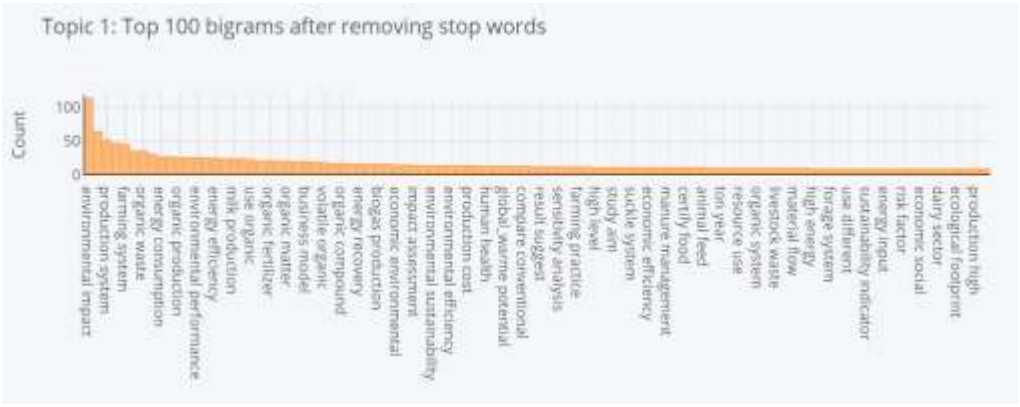


**Fig. 10.** Word Cluster from Bigram Algorithm in Topic 1


**Fig. 11.** Word Cluster from Bigram Algorithm in Topic 2

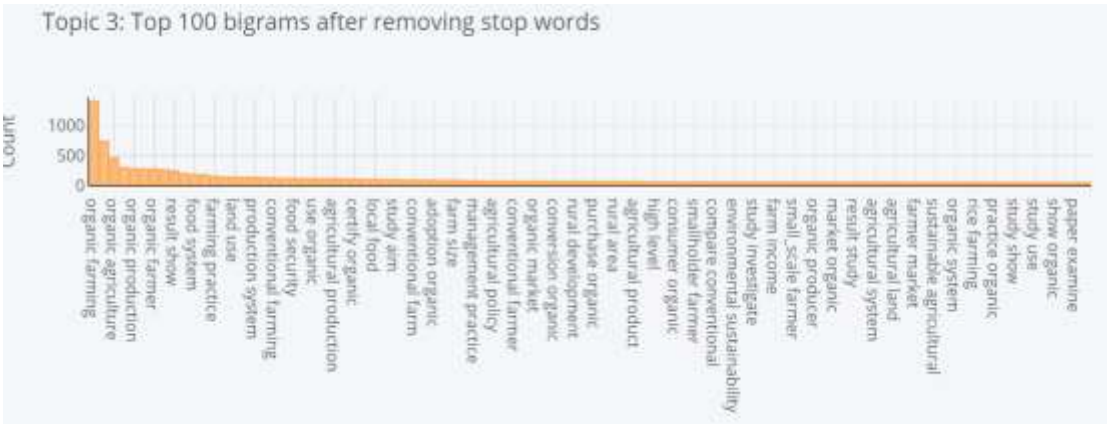


**Fig. 12.** Word Cluster from Bigram Algorithm in Topic 3

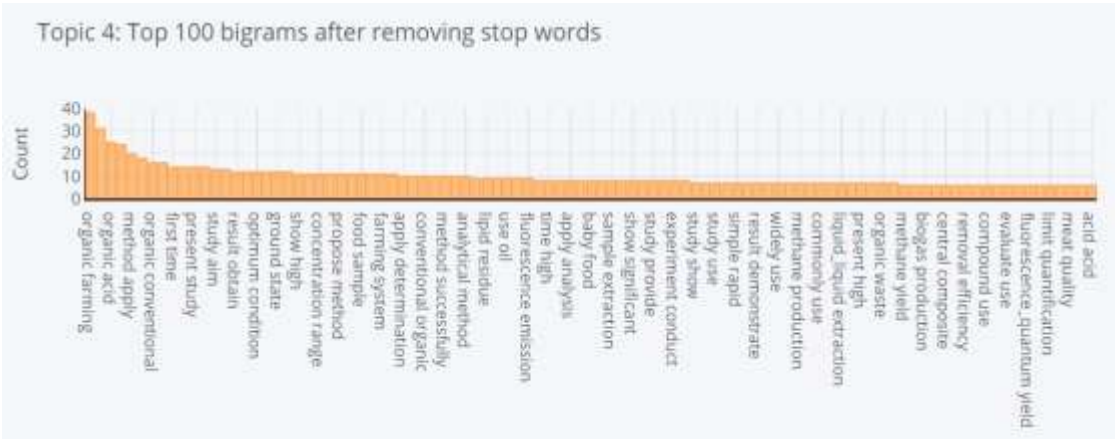


**Fig. 13.** Word Cluster from Bigram Algorithm in Topic 4

**Table 1.** The Topic Modeling from the Representative Topic

| Topic No. | The Representative Topic (bigrams) | Topic Name | Description |
|---|---|---|---|
| 0 | Organic farming, organic matter, land use, soil organic, farming system, organic carbon, result show, organic conventional, soil quality, soil fertility, organic fertilizer, cropping system, soil property, farming practice, improve soil, management practice, production system, crop production, crop yield, conventional farming | Soil for Organic Agriculture | The study of organic agriculture requires studying soil in areas related to organic agriculture, such as land use, soil quality, and soil properties. soil improvement adding nutrients to the soil, soil management, etc. |
| 1 | Environmental impact, organic farming, production system, result show, farming system, land use, organic waste, case study, energy consumption, management system, organic production, waste management, environmental performance, dairy farm, energy efficiency, energy use, milk production, conventional organic, use organic, organic conventional | Environment and Organics | The origins of organic farming were intended to preserve the environment and reduce its impact on the environment, namely, agriculture using chemicals. This resulted in more than chemical residues in the soil mixed in water and air, continuously affecting consumers' health directly and indirectly. A study of the article shows that this group of liquor information has emerged to have more knowledge and understanding of organic farming. |
| 2 | Organic farming, case study, organic agriculture, organic food, food system, organic growth, sustainable development, business model, organic farmer, small business, organic farm, purpose paper, food production, organic production, development | Organic Agriculture Business | Organic farming relates to the business sector. Currently, there are many forms of organic farming business, according to the results of the topic analysis in the article, related to management, production, development, inspection, and strategy, were business systems that classify small businesses, kitchen businesses, new business, including |

| Topic No. | The Representative Topic (bigrams) | Topic Name | Description |
|---|---|---|---|
| | organic, organic product, organic sector, result show, business environment, social movement | | presentation of business results. |
| 3 | Organic farming, organic food, organic agriculture, organic product, organic production, organic farm, organic farmer, farming system, result show, organic conventional, food system, case study, farming practice, food product, land use, food production, production system, conventional organic, conventional farming, sustainable agriculture | Organic production | Organic farming consists of many factors to get quality organic products. It maintains organic conditions regarding organic agriculture, organic products, producers, safe food production, food systems, products, organic certification, and agricultural policy. |
| 4 | Organic farming, organic solvent, organic acid, result show, method apply, organic conventional extraction method, first time, the result indicated, the present study, volatile organic, study aim, method use, result obtain, organic residue, optimum condition, high quality, ground state successfully apply | Organic use | Having organic farming knowledge about agriculture might not be enough. There is a need to know organic substances so that various compounds can be used correctly, which does not violate the principles of organic farming. The article, therefore, studies and publishes content about organic substances usage and methods for extracting organic compounds, residues, on-organic and organic substances to provide those interested in studying organic agriculture with guidelines for further study. |

Topic 0, named “Soil for Organic Agriculture,” was a concept structure that shows the relationship between soil and organic agriculture, which shows the importance of soil used in organic farming is useful in studying. This indicates that studying organic agriculture requires studying soil in areas related to organic agriculture, such as land use, soil quality and properties, soil improvement, adding nutrients to the soil, soil management, etc.

Topic 1, named “Environment and Organics”, was a concept structure that shows the relationship between the environment and organic agriculture, which shows that the origins of organic farming are intended to preserve the environment to reduce the impact on the environment, namely agriculture using chemicals. This resulted in an excess of chemical residues in the soil mixed with water and air, continuously affecting the health of consumers both directly and indirectly. A study of the article shows that this group of liquor information has emerged to have more knowledge and understanding of organic farming.

Topic 2, named “Organic Agriculture Business”, was a concept structure that shows the relationship between business and organic agriculture to manifest how organic farming relates to the business sector. Currently, there are many forms of organic farming businesses, according to the results of the topic analysis in the article, related to management, production, development, inspection, and strategy, which are business systems that classify small businesses, kitchen businesses, new business, including presentation of business results.

Topic 3 is named “Organic production”, a conceptual construct representing organic production. The collected articles revealed that most of the word groups found in this topic cover a

lot of content. Whether it is a farming system, a food system, a production system, an agricultural system, an organic system, an inspection system, organic certification, or sustainable development,

Topic 4, named “Organic use” is a concept structure that expresses the relationship between organic use and methods, which shows content related to inorganic and organic substances, chemical residue, volatile organic, compounds organic solvents, organic acids, compound use, and concentration rate which benefits from this topic and can be used as a guideline for further studies regarding organic agriculture apart from agriculture or farming.

**Data Visualization**

Interactive diagramming is a highly effective way to present the results of topic models. In this regard, the pyLDAVis package (Sievert, Shirley, 2014) created interactive diagrams showing the most representative topics and terms. (Figure 14). The size of each circle in the diagram indicates the relevance of the topic in the corpus, and topics that are close together are more similar. One of the main advantages of the pyLDAvis visualization method is that users can adjust the relevance of words in a topic using a slider (Chuang et al., 2012; Sievert, Shirley, 2014). This tool offers clear and intuitive visualization and can show the relationships and strengths of each topic by displaying the words that make up each topic in a circle and horizontal bar chart.

The circles on the left panel show the model’s overall view, allowing users to easily understand the relationship between topics and their related strengths. Meanwhile, the horizontal bar chart on the right panel shows the terms that make up each topic, which gives the user a detailed understanding of the topics.

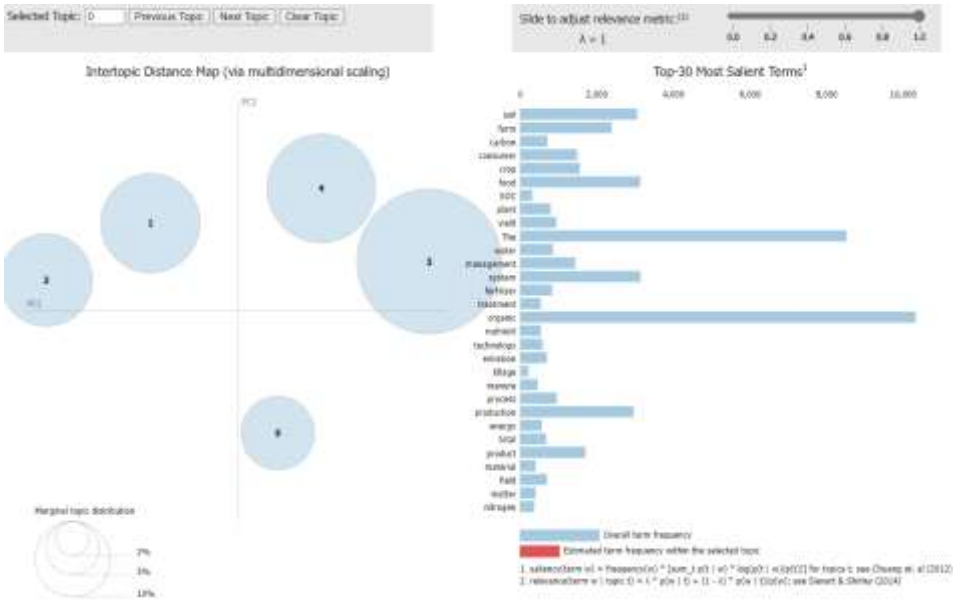


**Fig. 14.** Show pyDAVis topic model results.
Source: Ischool

In this study, it can be clearly seen that the five topics identified were different and belonged to different research areas. When clicking on each topic circle, the tool creates a bar graph showing the top 30 for the most relevant terms for that topic. This feature allows users to quickly and concisely summarize topic relevance through the most important keywords by analyzing the words of these keywords to make it possible to categorize all five topics.

The categories covered by these topics were highly relevant to current research topics. This can be seen from the keywords related to each topic by plotting document classifications using t-SNE (t-distributed Stochastic Neighbor Embedding). In this method, each group was represented as a probability distribution, which was a normal distribution to measure the distance between groups. This technique was used for 3D projections to visualize the similarity between multidimensional vectors and plot groups of similar documents (Figure 15).

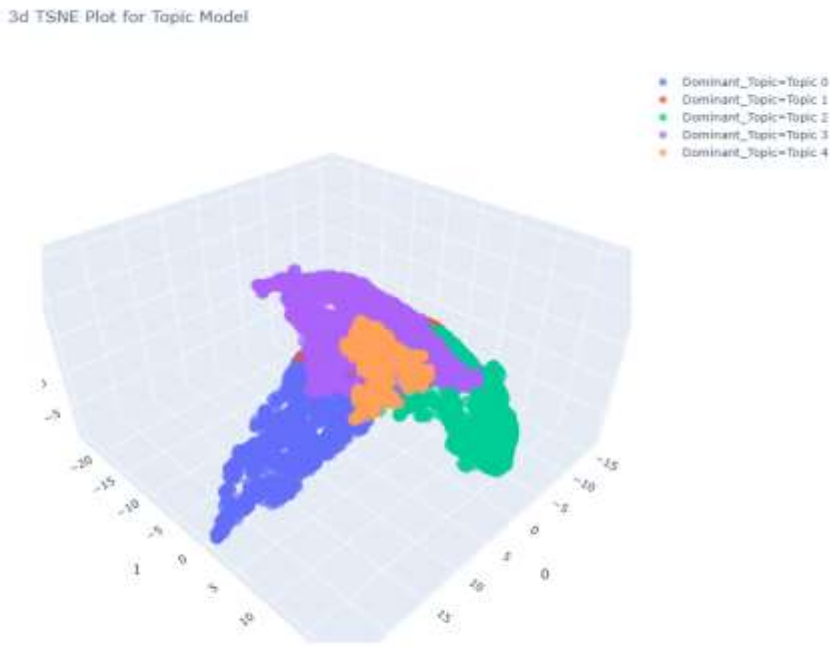


**Fig. 15.** The Topic Distribution representing in 3-Dimensions

## 4. Discussion

This study offers a detailed examination of organic agriculture and entrepreneurship by analyzing bibliographic data from 4,327 articles published between 1946 and 2023, sourced from the Scopus database. By employing the Latent Dirichlet Allocation (LDA) method, the research identified five significant topics that provide essential insights into the multifaceted nature of organic agriculture and its connection with environmental sustainability, economic development, and technological innovation. These topics include soil management for organic agriculture, the interplay between organic farming and environmental conservation, the integration of organic farming into business models, organic production systems, and the effective use of organic substances.

The findings highlight the importance of soil as the foundation for sustainable organic farming, emphasizing soil quality, management practices, and nutrient enhancement. This perspective aligns with existing literature, such as that of Blake and Wijetilaka (2015), which underscores the critical role of soil in organic systems. Furthermore, research focused on reducing chemical residues and promoting environmental sustainability through organic farming resonates with the priorities outlined in the National Organic Agriculture Development Strategy (2017-2021). This strategy emphasizes environmentally friendly agricultural practices as a cornerstone of organic farming.

The study also illuminates the relationship between organic farming and the business sector, illustrating how organic agriculture has been integrated into small enterprises and supply chain networks. These findings support the goals of the National Economic and Social Development Plan No. 13 (2023–2027), which stresses economic growth and entrepreneurship in sustainable agriculture. Similarly, the results underscore the necessity for quality assurance, organic certification, and sustainable food systems, aligning with global trends emphasized by the Research Institute of Organic Agriculture (2021). In addition to exploring soil, environment, and business aspects, the study identifies the methods and standards for using organic compounds effectively and safely. As Joo et al. (2016) noted, this focus aligns with modern agricultural innovations, ensuring adherence to organic farming principles while promoting sustainable practices.

The study's findings validate and expand upon the claims presented in the introduction. It reinforces the evolving nature of organic agriculture, particularly its significance in achieving sustainable development and economic progress. The introduction highlighted Thailand's Agriculture 4.0 initiative, which integrates technology, innovation, and sustainability into agricultural practices (Office of the Small..., 2020). This research offers empirical support for these

objectives, demonstrating how advanced topic modeling and visualization tools such as pyLDAVis can structure diverse research findings into coherent topics (Chansanam, Tuamsuk, 2020). Moreover, the study addresses the challenges noted in the introduction, such as the difficulty in retrieving organized information about organic farming and entrepreneurship (Joo et al., 2016), by providing a systematic and accessible framework.

This study's implications are far-reaching, as it bridges the gap between theoretical research and practical applications. By visualizing trends in organic agriculture, the research offers a clear roadmap for farmers, policymakers, and researchers, enabling them to identify key areas for focus and development. For example, insights into soil management practices and the use of organic substances directly benefit farmers, while understanding business models for organic agriculture informs policymakers and entrepreneurs. Despite its strengths, the study has limitations. Its reliance on abstract data may overlook detailed findings in full-text articles, and its focus on English-language publications may exclude significant contributions in other languages. Future research should expand to include broader datasets and explore additional scientific fields to create a more comprehensive understanding of organic agriculture.

In conclusion, this study enhances the understanding of organic agriculture and entrepreneurship by systematically categorizing a diverse body of research. The insights gained lay a solid foundation for future investigations and practical applications, significantly contributing to the global sustainable development of organic farming practices.

## 5. Conclusion

The analysis of research on organic agriculture and entrepreneurs from the barometric data was done using the text analysis technique with the PyCaret library in Python, and a group of words related to organic agriculture and agricultural producers were obtained. The results have expanded to reveal more knowledge, which is useful for further study in the parts that are not yet complete to be able to use it to structure knowledge more comprehensively. Especially, issues regarding the content and important concepts of organic agriculture and entrepreneurs. There were issues that farmers or entrepreneurs must study, from organic farming, production systems, development, management, and marketing to knowledge about the environment and essential organic substances to be able to do organic farming correctly according to standards and have sufficient knowledge in doing organic farming business.

This study analyzed the bibliographic data using text analysis and topic modeling techniques on abstracts from 4,327 articles collected from the Scopus database, analyzing five different aspects. The Python was employed to perform topic modeling and evaluate each topic's performance. The model and present figure of the results clearly show the information, emphasizing insights and important trends from the analysis.

In the aspect of limitations in this study, this study reflected in the analysis section that the researcher had to choose stable programs and software that were able to analyze and process accurately and precisely, and that could be recorded and stored appropriately. In addition, the results of this study were a collection of information in the context related to organic agriculture and entrepreneurs, which was analyzed from the abstract. There might be some limits to reading research results that might not cover all of agricultural science. Therefore, future research should explore additional fields of science to get more comprehensive results.

## 6. Strengths and Limitations

A major strength of the study is its robust methodology and use of advanced tools like LDA and pyLDAVis. These tools effectively categorize and visualize complex data, making it accessible to farmers, policymakers, and researchers. The study aligns well with global and national strategies, such as Thailand's Agriculture 4.0, emphasizing its practical relevance.

However, its reliance on abstracts may overlook deeper insights in full texts, and its focus on English-language articles may exclude significant regional contributions. Additionally, while topics are well-defined, their interrelations are not fully explored. Despite these limitations, the study provides a strong foundation for future research and practical applications in sustainable organic farming.

## 7. Implications of the Study

The findings of this study have significant implications for the development of organic agriculture and entrepreneurship. By identifying five core topics – soil management, environmental impacts, organic business models, production systems, and organic substance usage – the study provides a structured framework to guide stakeholders in addressing key challenges in sustainable farming. Farmers can leverage insights on soil quality and sustainable practices to enhance productivity while adhering to organic standards. Policymakers can use the findings to design targeted strategies that promote organic agriculture, aligning with broader goals such as environmental sustainability and economic growth, as seen in initiatives like Thailand's Agriculture 4.0.

The study offers a methodological blueprint for researchers, showcasing the utility of advanced tools like LDA in extracting meaningful insights from large datasets. This facilitates the exploration of emerging trends and gaps in organic farming research. Overall, the study bridges theoretical knowledge with practical applications, fostering innovation and sustainable practices in organic agriculture.

## 8. Declarations

### *Ethics approval and consent to participate*

This study did not involve human participants, animals, or any sensitive personal data and therefore did not require approval from an Institutional Review Board (IRB) or ethics committee. The research was conducted using publicly available bibliographic data from the Scopus database, adhering to all applicable guidelines for ethical research. No consent to participate was required as the study relied solely on secondary data sources without the direct involvement of individuals or organizations.

### *Consent for publication*

All authors have reviewed and approved the final manuscript for submission. They consent to the publication of this work and confirm that it has not been submitted elsewhere for publication. Each author agrees to be accountable for all aspects of the work, ensuring the integrity and accuracy of the study.

### *Availability of data and materials*

Available upon formal request to the corresponding author.

### *Conflict of interest statement*

The authors report no conflicts of interest.

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### *Authors' contributions*

All authors (S.C., P.M., and W.C.) contributed equally to this work. They collaboratively developed the concept and design of the study, collected data, and contributed to the analysis and interpretation of the collected data. Additionally, all authors were involved in drafting, revising, and finalizing the manuscript.

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### Authors' ORCID

Sumana Chiangnangam https://orcid.org/0009-0003-3516-681X
Paiboon Manorom https://orcid.org/0009-0002-2165-1120
Wirapong Chansanam https://orcid.org/0000-0001-5546-8485

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# Review on the Application of Universal Design for Learning in Classroom Instruction

Yaqin Fan [a, *]

[a] Office of Academic Affairs, North China Electric Power University, Beijing, China

**Abstract**

To comprehensively understand the application of Universal Design for Learning (UDL) in classroom instruction and to pinpoint existing challenges, an extensive literature review was undertaken, utilizing renowned databases such as ERIC, PsycInfo, Social Sciences Index, and Science Direct. This review yielded over 80 peer-reviewed articles encompassing empirical research studies, covering a wide range of educational stages from primary schools to universities. The 62 selected pieces of literature offered a wealth of information, enabling a detailed examination of the application of UDL in real-world classroom contexts. The findings from this review were meticulously organized and subjected to a thorough analytical process, focusing on three key dimensions: the general application of UDL principles, the specific strategies employed for implementation, and the evaluations of these strategies' effectiveness. The analysis revealed a landscape where the adoption of UDL principles is marked by a lack of systematic approaches and a shortage of clearly defined, tailored strategies. This has led to a varied picture in terms of outcomes, with some instances showing promising results while others falling short of expectations. The heterogeneity in the application and the inconclusive nature of the effectiveness underscore the need for further research and the development of more precise, contextually relevant UDL strategies to ensure that the principles of UDL are effectively translated into practice for the benefit of all learners.

**Keywords:** Universal Design for Learning, Classroom Instruction, Application Review, Special Education, Inclusive Education.

## 1. Introduction

The collective teaching system was widely promoted and developed in the industrial era in order to rapidly and massively cultivate talents at a considerable level to meet the needs of the industrial society. Undoubtedly, the form of collective teaching has absolute advantages and status in meeting daily teaching needs. However, this "assembly line" training method cannot better focus on students' learning differences and needs (Cui et al., 2019; Fan, 2023). Every individual is different, and this difference and diversity must exist (Commey, 2024; Kojana, Mukuna, 2024). This also predicts and calls for diversity in education. Moreover, an American educator, John Dewey, also mentioned that the traditional teaching form was designed to serve teachers' rapid and efficient work, rather than students' individual development and growth (Dewey, Dewey, 1915). In the current information age, when material and spiritual resources are greatly abundant, it has

* Corresponding author
E-mail addresses: fanyq127@126.com
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become an inevitable trend for the development of education and teaching to focus on each student's individual learning needs and characteristics.

Universal Design for Learning (UDL) is considered as an appropriate framework for designing courses in increasingly diversified classrooms, aimed at helping educators improve the learning process (CAST, 2018). Instead of adjusting and modifying the course content and framework during the course management process, UDL focuses on actively building support for course objectives, course resources, teaching practices, and assessments from the very beginning of course design. It emphasizes providing options that can meet the needs of various learners by building flexibility in the curriculum and instruction.

However, issues such as how to apply and evaluate UDL are still under further research and exploration. This study focuses on the following three aspects to systematically sort out and analyze the application of UDL in teaching, aiming to discover patterns and problems, and provide references and suggestions for the application of Universal Design for Learning in classroom teaching in China.

1. Who are the target groups for the application of UDL, and what impact will it have on teachers' teaching?
2. What are the application strategies of UDL? And how do they reflect the principles of UDL?
3. Is there a significant effect of UDL in teaching practice?

## 2. Methods

### *Search Strategy*

The literature search was conducted using the databases ERIC, PsycInfo, Social Sciences Index, and ScienceDirect. The primary keywords utilized in the search included "universal design for learning," "universal instructional design," "universal design of instruction," and "universal design." Additionally, the secondary keywords "post-secondary," "college," "university," "higher education," "elementary," "middle," "high," and "secondary" were included in all searches. The search scope covered literature published within the last 15 years, resulting in the identification of 89 relevant articles. Through skimming, 62 closely related articles were selected and utilized as the primary sources for this study. The inclusion criterion for these 62 articles is that they have utilized at least one UDL principle in their teaching practices.

### *Data Analysis*

The selected 62 articles were categorized and summarized based on various headings such as research objectives, research methods, research findings and implications, descriptions of research applications, application strategies, and rationales for strategy selection. This systematic categorization aimed to uncover patterns and trends in the application of Universal Design for Learning (UDL) in educational practice. The analysis adheres to academic publication norms and standards.

## 3. Results

### The Connotation and Basic Principles of Universal Design for Learning

UDL was first proposed by CAST in the United States in 1998 (Orkwis, McLane, 1998). It has successfully gone through two models, Universal Design of Instruction and Universal Design for Instruction (Schelly et al., 2011), and undergone multiple revisions and improvements in concepts and principles (CAST, 2018). The latest version defines it as follows: "Universal Design for Learning is a framework to improve and optimize teaching and learning for all people based on scientific insights into how humans learn" (CAST, 2018). The principle of Universal Design for Learning emphasizes that teaching should precede learning. This approach aims to eliminate obstacles, lags, struggles, and remedial efforts encountered by students during their learning process. To achieve this, teaching must be deliberately designed to offer tailored support in the form of environments, resources, and tools that cater to the diverse needs of students right from the outset of their learning journey. By doing so, it becomes unnecessary to constantly modify or adjust the curriculum or learning environment after its creation to accommodate different learners. This approach ensures that all learners benefit from an optimized and inclusive learning experience (Capp, 2017; Rose, 2000; Skaggs, McMullin, 2024).

In fact, UDL is proposed based on Universal Design and incorporates knowledge from fields such as education, psychology, and neuroscience, focusing on the three learning networks of the

human brain: the Affective Network, Recognition Network, and Strategic Network, as shown in Figure 1.

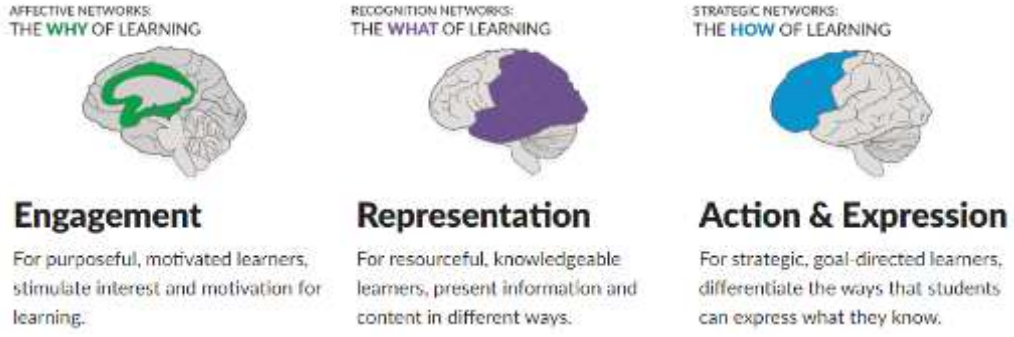


**Fig. 1.** The Three Learning Networks of UDL (CAST, 2018)

CAST proposed three fundamental principles based on the three learning networks of UDL (CAST, 2018):

***Principle 1: Multiple means of engagement***

Different learners engage in learning in various ways and are motivated by different factors. Some individuals are naturally active and highly engaged in learning, while others prefer a more quiet and even introverted approach. Some thrive on adventure and challenge, while others prefer to follow a structured approach taught by teachers and learn step by step. In addition to externally increasing student engagement, intrinsic learning motivation is also necessary for students to cope with future life and work. Besides the subject matter taught in school, self-discipline is equally important for students with different emotions and attitudes (CAST, 2018).

***Principle 2: Multiple means of representation***

Principle 2 corresponds to the Recognition Network, indicating that different learners perceive or understand information in diverse ways. For example, individuals with hearing or visual impairments, aphasia, or intellectual disabilities may need to rely on audio, visual, or other forms of materials to learn. For the majority of the general population, differences mainly manifest in language, cognitive strategies, culture, and history. They require different forms of content representation to deepen their understanding of knowledge. There is no single way of presenting information that suits all students. Therefore, a diverse and rich approach to content presentation and access is crucial. Additionally, the way information is processed, including discovering, creating, using, and organizing information, is also important. As a result, this principle emphasizes teaching methods and technological applications that highlight key information, emphasize important ideas, connect information, and simulate inquiry, ensuring that all students can capture the information (CAST, 2018).

***Principle 3: Multiple means of expression***

Principle 3 corresponds to the Strategic Network, indicating that different learners express themselves in different ways. Some excel at speaking, while others prefer writing. Some like to present their ideas through multimedia, and even their preferences for types of multimedia vary, such as drawing tools or video editing. Beyond that, a rich array of learning supports that help students express themselves is also necessary, such as pre-project reviews, feedback, and revisions, as well as alternative learning materials tailored to learners of different levels. These supports gradually withdraw as learners' abilities continue to improve (CAST, 2018).

## 4. Application Status of UDL in Classroom Instruction

### Application overview

#### *Target groups*

UDL was initially proposed and gradually applied in the development of inclusive education, aiming to enable students with special education needs to receive quality and equal educational services and better adapt to the general educational environment (Ma, 2024). Therefore, its primary target group was initially students with special educational needs. Of course, students in general education will also benefit from it. With the widespread development of UDL, this framework has gradually been applied to general education teaching. Therefore, from a broader perspective, UDL is targeted at students with special educational needs and general education students.

***Teachers' role in UDL***

In the collected literature on the application of UDL, the number of teachers involved in classroom application of UDL is generally larger than that in the general educational environment. Typically, this includes a main lecturer, a special education teacher, and several teaching assistants (Basham et al., 2010; Browder et al., 2008; Coyne et al., 2012; Kelly, Zakrajsek, 2023). This suggests that while the application of UDL in the classroom can bring numerous benefits to students, it also poses a certain workload for teachers during the initial stages of implementation. Therefore, it is necessary to establish a community of teachers to assist in the application of UDL.

***Terminology determination***

As mentioned earlier, UD (universal design) principles are being applied in educational settings. This has led to the use of various related terms in the literature to describe this application. Some of the most prominent terms are Universal Design for Learning (UDL), Universal Design of Instruction (UDI), Universal Instructional Design (UID), and Learning Universal Design (LUD). We used all of these terms during our literature search. Although different terms refer to the application of UD principles in educational settings, to avoid confusion, this study uses the term Universal Design for Learning (UDL). The inconsistent use of terminology hinders research on the application and effectiveness of UD educational models (Rao et al., 2014).

**Application strategies**

Generally speaking, the application of UDL in teaching is initiated based on its three principles: multiple means of representation, multiple means of expression, and multiple means of engagement. Researchers aim to accommodate the diversity and differences of students from these three dimensions. However, the application strategies guided by these principles mainly involve supplementary learning materials, task-based learning, online teaching platforms, and mobile learning tools (Garrad, Nolan, 2023; Rao, Tanners, 2011). In other words, the implementation of UDL is addressed through three aspects: learning materials, learning methods, and the application of technological tools. Nevertheless, it is rarely mentioned in UDL-related practical articles whether these strategies correspond to the UDL principles, how they reflect the UDL philosophy, and how they are designed based on the UDL principles. Although all researchers indicate that their application strategies are rooted in the UDL philosophy, there are significant differences in the detailed descriptions of how the components of the application strategies are associated with specific principles (Ok et al., 2016; Thomas et al., 2023). Moreover, no established guidelines specify how guiding principles should correspond to application strategies (Rao et al., 2014). Worse still, some UDL application cases lack specific descriptions of the application strategies, further reducing their referential value (Piticari, 2023; Sokal, Katz, 2015; Watchorn et al., 2013).

Regarding the three principles, more attention has been paid to the first principle. The second principle, which emphasizes that there are multiple ways to present knowledge to students beyond the sole textual form, mainly covers perception, language and symbols, and comprehension methods. Most application strategies targeting this principle involve video games and supplementary materials (Basham et al., 2010; Coyne et al., 2012). These materials provide students with multiple representations and opportunities for repeated practice, resulting in higher levels of student engagement compared to traditional course materials (Dickinson, 2018; Kumar, Wideman, 2014).

The second principle, which focuses on teachers' ability to engage students in learning through various means, addresses emotional factors such as motivation and interest in learning. In other words, it explores the reasons for learning, including emotional motivation for entering learning, beliefs in sustained learning, self-management and self-regulation during learning. There is insufficient recognition and attention to this concept in traditional classroom teaching and UDL application strategies. Many teachers believe learning is a natural obligation for students, but questions such as "Why learn?" "What is the meaning of learning?" "How do you deal with distractions while learning?" "How to persevere in learning for a long time?" and "What to do when encountering problems during learning?" demonstrate the importance of paying attention to students' emotional attitudes. Emotions and beliefs are the driving forces for learning, serving as the starting point and the source of sustained learning efforts (Kumar, Wideman, 2014; Metcalf et al., 2009). Therefore, they deserve teachers' focused attention.

There is a noticeable lack of applications targeting the third principle compared to the second. The third principle is related to action and expression, emphasizing that students can demonstrate their understanding and knowledge through various means, including physical

actions, communication, and execution planning. Compared to teachers' use of multiple means to present knowledge, there are fewer studies focusing on students' ability to express their behaviors and understanding through multiple means (Abell et al., 2011; Kennedy et al., 2014; Marino, 2009). However, acquiring knowledge does not necessarily equate to learning. While the second principle aims to provide students with multiple ways of presenting knowledge, the third principle seeks to provide them with multiple means of "manipulating" knowledge. If the second principle prepares students better for "input" in learning, then the third principle offers multiple paths and means for "output" in learning. Future research should focus more on students' behaviors and expressions related to learning outcomes to demonstrate the effectiveness of UDL in teaching.

**Application effect**

The application effects of UDL in teaching are mixed. On the one hand, most teaching practice cases of UDL indicate that UDL can improve students' participation in learning, promote learning communication and interaction between teacher-student, and student-student, serving as a teaching method that optimizes students' learning process (Rao et al., 2014; Garrad, Nolan, 2023). On the other hand, some studies have pointed out that while it can optimize students' learning experience, it does not necessarily lead to substantial improvement in academic achievement (Capp, 2017; Hitchcock et al., 2016; Mavrou et al., 2013).

Moreover, some research suggests that the effectiveness of UDL-based teaching varies greatly in many practical cases, with different scopes and degrees of impact (Ok et al., 2016). For instance, when comparing the teaching effects of online and offline courses that have implemented UDL, there are certain differences in teaching effects between special education students and regular education students. Specifically, online courses tend to have better teaching effects than offline courses, and in offline courses, regular education students often outperform special education students (Hall et al., 2015).

UDL is an exciting conceptual approach that appears theoretically sound but lacks a solid empirical research foundation (Capp, 2017; Roberts et al., 2011). In the future, it is necessary to conduct more extensive applications of UDL in teaching beyond its basic concepts and theoretical frameworks in order to examine the objective impact of UDL on students' learning outcomes.

## 5. Implications and Suggestions

Based on the comprehensive review and understanding of UDL's application in classroom teaching discussed above, the following implications and suggestions are proposed to promote the effective implementation of UDL, optimize students' learning process, and bring positive learning experiences to students.

***Clarify the characteristics of target learners to provide basic conditions for effective application of UDL***

The initial concept of UDL aims to meet the learning needs of every individual student as much as possible. Therefore, collecting and organizing students' learning needs and characteristics is the first step in implementing UDL and serves as fundamental information for others to draw lessons from excellent cases of UDL application. Additionally, a comprehensive description and organization of the characteristics of the target learners are not only necessary to examine the effectiveness of UDL's application in specific groups but also crucial for analyzing and understanding the differences in application effects among different groups, thereby identifying the optimal target groups for UDL and determining which UDL interventions are suitable for which types of students, providing basic information for the widespread application of UDL.

Moreover, as mentioned earlier, the target audience of UDL is not limited to students with special education needs but also includes those in general education. However, compared to students with special education needs, the differences and needs among students in general education are less pronounced. Furthermore, studies have shown that the benefits of UDL-based teaching vary among students in general and special education (Ok et al., 2016). Therefore, it is reasonable to raise the question of whether there are significant differences in the application effects of UDL among students with special education needs and those in general education.

***Develop operational UDL application strategies and actively explore their use in teaching***

UDL is both a framework for teaching design and an ideal state that cannot be fully achieved. The key to its implementation lies in designing and developing corresponding application

strategies. Currently, the development of UDL application strategies is still in its initial stage, with most strategies being developed individually by teachers based on the learning needs of their specific classes. This approach results in strategies that are not systematic, specific, or easily adaptable for others to learn from. Additionally, developing UDL application strategies can be a significant workload for individual teachers, especially during the initial stages. As mentioned earlier, current applications of UDL often involve multiple teachers working together. Therefore, regarding the future development of UDL application strategies, it is recommended that (1) a community of teachers be established and relevant departments such as educational institutions and enterprises be invited to assist in the strategy development; (2) based on the characteristics of the target learners, developed application strategies should be systematically organized and categorized to enhance the replicability of successful UDL application cases; (3) the relationship between the application strategies and the three principles of UDL should be clearly described, which will not only facilitate further research on UDL applications but also aid other teachers in drawing lessons and references; (4) application strategies should be made as specific as possible, which will not only facilitate their implementation in the classroom and enhance their replicability and reference value but also provide starting points for evaluating the effectiveness of UDL applications.

Moreover, regarding the overall application of UDL, the low popularity of its current applications is due to the lack of excellent and complete UDL application cases for reference. Undeniably, the success of an excellent UDL application case depends not only on the development and application of strategies but also on various factors such as teachers' teaching abilities, students' learning abilities, and interpersonal relationships. Therefore, a complete description of an excellent UDL application case will facilitate the further implementation of UDL in teaching.

***Strengthen the evaluation of UDL application effects to promote high-quality implementation in teaching***

As mentioned earlier, the effects of UDL's application in teaching are mixed, and not all applications lead to improved student learning outcomes. Therefore, further investigation and analysis are needed to assess the effectiveness of UDL applications. Currently, most UDL application cases focus only on strategy development and application, neglecting the evaluation of their effectiveness in the later stages. Therefore, it is recommended that (1) attention be paid to whether UDL has significant application effects on both students' learning processes and outcomes; (2) investigate in which aspects and under what conditions UDL can improve students' learning experiences; (3) determine whether the application of UDL can facilitate teaching and bring better teaching experiences to teachers.

The purpose of evaluating the effectiveness of UDL applications is not only to assess their educational value but also to obtain feedback that can be used to improve the methods and approaches of UDL implementation, thereby promoting its high-quality development.

## 6. Conclusion and Prospect

Although UDL has extensive applications abroad, issues such as inconsistent terminology, unsystematic application strategies, and the inability to align application strategies with principles have hindered its further development. Future research should focus on addressing these issues individually. The concept of UDL is based on the acknowledgment of differences among students, but the current application of UDL in teaching lacks a deep understanding of this concept. This is a crucial aspect of the effective application of UDL. In the future, educational researchers and frontline teachers need to change their understanding of teaching conceptually and implement UDL in practice to provide students with a better learning experience.

## Declarations

***Ethics approval and consent to participate***

Not applicable.

***Consent for publication***

Not applicable.

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***Conflict of interest statement***

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**Author's ORCID**

Yaqin Fan https://orcid.org/0000-0001-7536-8908

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# Management and Public Procedures for Providing Higher Legal Education

Tetiana Bilous-Osin [a, *], Mykola Yurchenko [b], Mykhailo Goncharenko [c], Natalia Sukhytska [d], Pavlo Gorinov [d]

[a] National University "Odesa Law Academy", Odesa, Ukraine
[b] Odesa State University of Internal Affairs, Odesa, Ukraine
[c] Interregional Academy of Personnel Management, Kyiv, Ukraine
[d] Mykhailo Drahomanov Ukrainian State University, Kyiv, Ukraine

**Abstract**

The provision of higher legal education is formed from a set of material and institutional measures that have the appropriate procedural form of implementation. Public management procedures are integral elements of this provision. Higher legal education is defined as a complex system of knowledge, skills, expertise, legal-related ways of reasoning, qualities, and competencies acquired during training in a higher education institution according to a standardized educational program; the completion of this program is the ground for awarding a higher education degree. The purpose of the article is to determine the managerial and procedural aspects of providing higher legal education. The findings substantiate the need to improve legislation in the field of higher legal education by developing and adopting special legislation. The study's methodological framework involved general and special scientific approaches, such as methods of philosophical argument, system analysis, deductive reasoning, structural-functional, and empirical methods. The authors present an argument for special features determining the provision of higher legal education. The findings can be of avail to legislators and law enforcement bodies to regulate relations in higher legal education.

**Keywords:** Accreditation, Administrative Procedure, Educational Program, Higher Legal Education, International Law, Law, Licensing.

## 1. Introduction

Article 53 of the Constitution of Ukraine enshrines the right of a person to free and unimpeded access to education (Verkhovna Rada of Ukraine, 1996). If necessary, a person can exercise the right to get an education in the language of national minorities. This right applies to all levels and forms of education, including pre-higher, higher, adult, and vocational education (Verkhovna Rada of Ukraine, 2017a). In order to guarantee this right, the state provides a supportive environment for accessing educational services by funding various educational, research, and socio-economic initiatives and programs. Given the above, authorized bodies of the state are obliged to take all necessary actions to provide access to higher education under any conditions.

* Corresponding author
E-mail addresses: tetiana_bilous@sci-academy.cc (T. Bilous-Osin)
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European integration affects all social life spheres, subject to legal ordering. This is especially true for the activities of public institutions in all their forms and external manifestations. A positive step in this direction was the adoption of legislation on administrative procedures, which allowed law enforcement activities of all subjects entitled by law to execute public administration functions and shift toward a new paradigm. This shift aligns with the principle of upholding the rule of law in a democratic state governed by the rule of law (Verkhovna Rada of Ukraine, 2022). Even though the scope of the provisions of the legislation on the administrative procedure is quite obvious, there is a need to examine how certain public procedures can be applied as administrative ones in the field of legal higher education.

Law has always been one of the most in-demand professions as highly qualified lawyers need to make sure that the state is improving its efforts to uphold the rule of law, promote human and civil rights and freedoms as the most important societal values, and bolster national security (Dunn et al., 2023; Economides, 2015; Flood, 2011). One of the challenges facing the rule of law is the lack of normative consolidation of the notion of "higher legal education", and specific legislation governing its provision results in gaps in this field and a generalization of the fundamental principles that affect the protection of the right to education. The existing research scope on higher legal education is limited to the issues of its definition and educational program specifications. In comparison, the administrative aspect of relationships for the provision of higher legal education is still overlooked. This article fundamentally raises the issue of the formal application of management tools in higher legal education by outlining its subject boundaries, determining public procedures for its provision, and analyzing the legal nature of licensing and accreditation as procedures for managing educational activities.

## 2. Materials and Methods

The modeling method was the primary method used for the first stage of the study. This method helped to build a theoretical model of higher legal education by analyzing existing doctrinal works, which was the first stage of this research. These works were a kind of research materials for examining existing approaches to improving the field of legal education (Latkovska et al., 2019; Lucky et al., 2019; Muilenburg, Berge, 2005; Wu, 2015).

The second stage of this research was the search for new modifications and interpretations of established regulatory approaches to management procedures in higher legal education. As a method of analysis, comparison, classification, and systematization were used during this research stage. The current regulatory framework for higher education was examined with the help of a method of analysis. We used the comparative method to determine the differences between the current and desired states of legal regulation of public relations in the discussed field.

Furthermore, it can be noted as per our methods that no doctrinal works on public management aspects of higher legal education had been developed yet. Studies that discuss the areas for improving legal education formed the theoretical basis of the research. These studies highlighted the following important issues: the implementation of new national educational programs in higher legal education in Ukraine and the use of open education forms as a condition for sustainable development (Kivalov, Bila-Tiunova, 2020); intensification of the practice of digital education and digitalization of law learning process (Boon, Webb, 2008); determination of the essence of licensing in the education and administrative procedures.

Licensing of educational activities of a higher education institution was interpreted through the dogmatic method. Accordingly, it was interpreted as the basis of the mechanism for regulating the activities of the institution and the higher education quality assurance system in Ukraine (Sysoiev, 2019; Sytnyk et al., 2022). A praxeological method helped to identify, based on statistical analysis, the purpose of the licensing procedure; it is a guarantee of higher education quality ensured by using the potential and effectiveness of higher education institutions in providing educational services (Kovalova et al., 2019; Svizhevska, 2012).

The analysis, synthesis, and modeling methods were used during the third stage of this research, which concerned regulatory approval. At this stage, changes and recommendations that should be introduced into the legislation to improve management procedures in the field of higher legal education were identified. The fourth stage of this research concerned the practical approbation of the findings. The presence of a dialectical correlation between the studied phenomena and the suggested theoretical and regulatory concepts would be worthless without

putting it into practice. In this case, the empirical method was applied in combination with the methods of analysis and deduction. As a result, the research substantiated the importance of standardizing educational programs in higher legal education and updating their structure.

## Results

### *Scope of higher legal education*

The draft law "On Legal Education and Legal Profession" (Verkhovna Rada of Ukraine, 2017b) was the first certified attempt to specialize in higher legal education in Ukraine. The draft law defined legal education as higher education majoring in Law or International Law obtained in Ukraine or foreign countries, provided that it is recognized in Ukraine by the procedure established by law. Even though the draft law was rejected in 2019, its attempt to formally distinguish higher legal education as a separate field of education and introduce a single qualification exam provided a basis for further improvement of this sphere of public life.

According to the list of fields of knowledge and majors for which higher education students are trained, persons who graduated with Bachelor's and Master's degrees in Law or International Law may hold positions or carry out activities, the qualification requirements for which provide for the availability of full higher or higher legal education (Cabinet of Ministers of Ukraine, 2015c; Yuldashev et al., 2022).

In order to define higher legal education, majors such as Law or International Law, which are equivalent for this purpose, should be used as the basis. In accordance with the standards of higher education, the subject boundaries of the educational program majoring in law encompass learning laws, their sources, legal doctrines, values, and principles that are based on fundamental rights and freedoms. The learning objectives presuppose that students become able to address complex legal problems and acquire a comprehensive understanding of their essence and content.

Methods of understanding legal phenomena of general and special nature are fundamental for all legal techniques or technologies. These methods include ways to assess the behavior or actions of individuals and social groups within the framework of the law, as well as techniques for identifying legal issues and problems (Pavliuchenko, Savchuk, 2021; Ministry of Education and Science of Ukraine, 2022). In contrast, students majoring in International Law study legal relations arising in the field of foreign policy and foreign economic activity of public authorities and local self-government. International Law as a major also involves examining legal relations with a foreign element between public authorities and local self-government of different states, natural and legal persons of different nationalities and jurisdictions (Ministry of Education..., 2017). Regardless of the chosen major (Law or International Law), students must confirm their Master's degree by passing the Unified State Qualification Examination (Ministry of Education..., 2021).

It is advisable to adopt specialized legislation, which will enshrine the notion of higher legal education and the features of its provision. This is argued by the importance of legal education, the acquisition of which is the basis for engaging in professional legal activities, such as the profession of a judge, lawyer, prosecutor, etc. The importance of the justice sector in a developed democratic state should be confirmed by the proper provision of education for future lawyers.

### *Public management procedures for the provision of higher legal education*

It should be noted that the draft Concept for the Development of Higher Legal Education provides for the following areas of the provision of higher legal education (Ministry of Education..., 2019b):

– Activities of centers for quality assurance of higher education in law schools;

– Annual assessment of higher education students and academic staff of law schools;

– Advanced training of academic staff;

– Accessibility to the resources required for managing the educational process, including students' self-study;

– Accessibility to the information systems for organizing the educational process; involvement of legal practitioners in lecturing or teaching individual courses for future lawyers;

– Transparency in disseminating information about educational program and qualifications; compliance with the principles of academic integrity for academic staff and students by establishing an efficient plagiarism detection and prevention system;

– Development of an efficient system to hold individuals accountable for violating academic integrity standards;

– Access for students to educational resources, including recognized academic databases, international information, research-to-practice, library, and other resources;

– Combined training of students with practice in legal clinics, internships, etc.

The National Agency for Higher Education Quality Assurance is the key entity obliged to provide higher education, including legal education. Given this, there is a need to examine the types of activities of this body, which include the following:

– Well-worked educational program that are essential for maintaining a high quality of the provided educational services and are ensured by implementing an accreditation procedure and complying with rigorous standards for both the Agency and higher education institutions;

– The guidance, information provision, and local quality system benchmarking to promote internal quality assurance systems; approval of principles and establishment of requirements for ensuring the quality of higher education based on best international and national experiences;

– The acknowledgment of research outcomes (raising awareness about research integrity policies, implementing transparent and efficient procedures, and exhibiting zero tolerance towards pseudoscientific tendencies);

– The implementation of academic staff certification procedures in accordance with the foremost European standards; supervision of the activities of specialized academic councils based on the designed regulations;

– The exercise of control in higher education (education quality maintenance through academic staff accreditation and certification procedures; efficient interaction between all stakeholders for higher education quality assurance through ensuring transparency in communication and mutual respect);

– The encouragement of higher education institutions in Ukraine to participate in international research rankings according to the designed qualitative criteria, etc. (National Agency..., 2022).

Thus, the procedural format of higher education quality assurance is limited to academic staff accreditation and certification (Sukhonos, 2021). However, little attention is devoted to educational activity licensing carried out by the Ministry of Education and Science of Ukraine. By the provisions of the Law of Ukraine "On Higher Education" (Verkhovna Rada of Ukraine, 2014), educational activities can be carried out exclusively by those institutions of higher education or professional pre-higher scientific institutions that have received a license from the central executive body in the field of education and science.

### *The legal nature of licensing and accreditation as management procedures in higher legal education*

Educational program accreditation constitutes a public management procedure that determines whether the quality of such a program and its educational activities comply with higher education standards. This evaluation seeks to ascertain its capability to achieve the designated learning outcomes, all based on predetermined criteria for assessing study program quality (Ministry of Education..., 2019a).

The Ministry of Education and Science of Ukraine is responsible for approving standards of higher legal education; it establishes whether a higher educational institution is eligible to provide educational services, the result of which will be a student's qualification as a lawyer. Educational activity licensing in the field of higher legal education is a public management procedure when a higher education institution exercises its right to provide educational activities. Viktorov (2006) notes that licensing is a form of public administration associated with granting permission to educational institutions to conduct a particular type of educational activity. Safonova (2005) identified the following stages in the periodization of the formation and development of educational activity licensing: formal resolution on reforming the higher education system and granting specific levels of accreditation to higher education institutions; drafting documents that establish licensing principles; development and enhancement of the licensing and accreditation procedures. Thus, it can be assumed that accreditation and licensing procedures are administrative ones by their legal nature. Analysis of the Law of Ukraine "On Administrative Procedure" indicates the following features of the procedures, which will be hereinafter referred to as administrative:

1) this is the procedure for consideration and resolution of the case enshrined by law;

2) the specified case should concern public relations to ensure the exercise of the rights, freedoms, or legitimate interests of persons and (or) the fulfillment of their obligations provided by law, the protection of their rights, freedoms, or legitimate interests, which are considered by an administrative body;

3) the administrative body will be authorities of the Autonomous Republic of Crimea, local self-government or executive bodies, their officials, or other entities authorized by law to perform the functions of public administration;

4) a result of the administrative procedure is an administrative act drawn by an administrative body to resolve a particular case and ensure a person's rights and (or) obligations, etc. (Verkhovna Rada of Ukraine, 2022).

Thus, the procedure for accreditation and licensing of educational activities in higher legal education as a type of administrative procedure will be characterized by the following features: a) will be carried out by the procedure established by the legislation on higher education; b) will relate to public relations to ensure the exercise of the rights, freedoms, or legitimate interests of persons in the field of education; c) will be decided with the participation of an administrative body (the Ministry of Education and Science of Ukraine) or a collegial body (the National Agency for Higher Education Quality Assurance); d) as a result of these administrative procedures, an administrative act will be passed in the form of a license or accreditation certificate, etc. (Cabinet of Ministers of Ukraine, 2015b). The summarized findings are provided in Table 1.

**Table 1.** Correlation of findings with the designed methodology

| No. | Procedural components of research methodology | Correlation of findings |
|---|---|---|
| 1 | Suggested theoretical model | Interpretation of the concept of "higher legal education", which is the sphere of implementation of special managerial administrative procedures with the corresponding justification of the legal nature of the latter |
| 2 | Suggested modifications and interpretations | Specification of higher legal education rather than its equalization with higher education. This thesis mediates the need for the management apparatus to adhere not to quantitative but qualitative indicators |
| 3 | Regulatory approval | Adoption of the Law of Ukraine "On Higher Legal Education"<br>Adoption of the Resolution of the Cabinet of Ministers of Ukraine "On the Features of Licensing Educational Activities in the Field of Higher Legal Education" |
| 4 | Law-enforcement approval | Development of standards for higher legal education, filling in the components of educational program profiles, improving the skills of the management staff involved in the accreditation and licensing of higher legal education institutions |

## 4. Discussion

### *Scope of higher legal education: definition of subject boundaries*

The findings establish the following key characteristics of higher legal education:

1) It comprises a set of systemized knowledge, competencies, skills, ways of reasoning, professional qualities, ideological and civil values, moral and ethical principles, and other aspects relevant to the fields of law and international law.

2) Legal education acquired within higher education institutions that are individual legal entities governed by either private or public law. These institutions are authorized to conduct educational activities at various levels of higher education and engage in innovative, technical, research, or methodological activities. Under the issued license, higher education institutions are entitled to facilitate educational processes, their organization, and the attainment of higher or

postgraduate education by individuals, taking into account their interests, vocations, and capabilities (Verkhovna Rada of Ukraine, 2014).

3) It is an education in a specific field of knowledge in law, which may include related legal majors.

4) Higher legal education will be considered obtained, regardless of its degree (junior specialist, bachelor, master, doctor of philosophy), provided that a person completed the educational program as a basis for awarding the appropriate degree of higher education.

5) The successful completion of a single qualification exam is an obligatory condition for getting a Master's degree in law.

6) Higher legal education is based on the standards of education in this field of knowledge, etc.

Thus, higher legal education is defined as a complex system of knowledge, skills, expertise, legal-related ways of reasoning, qualities, and competencies acquired during training in a higher education institution according to a standardized educational program, and the completion of this program is the ground for awarding a higher education degree.

***Public management procedures for provision of higher legal education***

Regulations governing the licensing of educational activities ought to be categorized according to several factors. However, this article uses the regulation's subject as a main factor in order to fulfill the objectives of this research, even though it is not a popular approach in the scientific community. Thus, the following regulations are distinguished:

1) those that regulate the static characteristics of educational activity licensing;

2) those that regulate the dynamic characteristics of educational activity licensing.

Apart from the Law of Ukraine "On Higher Education," the second group includes those regulations that determine licensing principles. These are the provisions of the Law of Ukraine "On Licensing of Certain Types of Economic Activity" (Verkhovna Rada of Ukraine, 2015). On the one hand, it establishes the extension of the main provisions to the field of education (paragraph 6 of Part 1 of Article 7). On the other hand, it determines the general principles of licensing (type, licensing principles, and the definition of terms of licensing activities, such as licensee, license, issuance of a license, etc.).

Regulations governing the static characteristics of educational activity licensing include those that are subordinate. First of all, this applies to the following:

1) Resolution of the Cabinet of Ministers of Ukraine No. 630 regarding the attribution of licensing powers to the powers of this central executive body (paragraph 44 of Part 4 of Art. 1 provides that the powers of the Ministry of Education and Science include "licensing of educational activities in the fields of higher, postgraduate, professional pre-higher and professional (vocational) education") (Cabinet of Ministers of Ukraine, 2014);

2) Resolution of the Cabinet of Ministers of Ukraine No. 1187, which outlines both educational areas requiring licensing and licensing conditions that depend on the level of higher education or educational programs, where the last ones provide awarding qualifications in fields subject to additional regulation at specific higher education levels (Cabinet of Ministers of Ukraine, 2015a);

3) Order of the Ministry of Education and Science of Ukraine No. 620, which refers to a single electronic database containing information about the licensing conditions of a particular educational institution, etc. (Ministry of Education..., 2018).

The laws of Ukraine, "On Higher Education" and "On Administrative Procedure", are the regulations that govern the licensing procedure. However, the current legislation does not provide for a special licensing procedure. Therefore, the Resolution of the Cabinet of Ministers of Ukraine should be adopted to approve the procedure for educational activity licensing. Consequently, the public management procedures for providing higher legal education are formally related to higher education, but their content should be based on the verification of compliance with the requirements for the provision of knowledge in the field of law.

Yakovliev (2016) defined the essence of administrative procedures, their participants, and the final decisions. The researcher noted that the procedural form is of great instrumental importance; it ensures the observance of citizen's rights and freedoms in public administration, the comprehensiveness, objectivity, completeness, and due time of consideration of administrative cases. Furthermore, the procedural form provides for the validity of law enforcement acts issued by authorized bodies and the legality of their power influence on public relations. In turn, the absence of

predictable procedures in the law has negative consequences for both the application of the substantive rule of law and the implementation of legal prescriptions (Korniienko et al., 2020; Golovin et al., 2022).

### *The legal nature of licensing and accreditation: Definition and classifications*

Accreditation and licensing procedures for educational activities should be classified as administrative procedures of a certain type in order to determine their qualitative features. Shkolyk (2021) singled out a general administrative procedure (uniform for all areas of public administration) and a special one (variable for certain areas of public administration). According to the level of legal regulation, these procedures can be divided into the following: 1) complete or complex, determining all aspects of the procedure for the activities of public administration entities in a certain area; 2) partial or fragmentary, containing separate elements of regulation of such an order of activities (Shkolyk, 2021; Smokov et al., 2022). Thus, the procedures for licensing and accrediting educational programs represent an example of a particularized partial administrative procedure.

It is possible to classify administrative procedures depending on their impact on social relations. Consequently, the procedures for licensing and accreditation of educational activities are a type of law enforcement administrative procedures carried out directly when applied by public administration entities that carry out public administration in the field of education. Depending on the presence or absence of a dispute between the subject of public administration and a private person, jurisdictional (disputed, conflict) and non-jurisdictional (organizational, indisputable, non-conflict) administrative procedures are distinguished. Therefore, the procedures in question are classified as non-jurisdictional procedures.

According to the direction of activity, there are internal (internal organizational) and external (external organizational) administrative procedures. The licensing and accreditation procedures are external, as they relate to the rights and interests of individuals. According to the subject of legislative initiative, there are application and interventional administrative procedures. An initiator of claim administrative procedure is an individual, and interventional administrative procedures are initiated by subjects of public administration in cases established by law (Shkolyk, 2021). Therefore, licensing and accreditation procedures for educational activities are administrative application procedures. According to the classification criteria, the licensing and accreditation procedure for educational activities is a kind of the following: 1) special partial; 2) law enforcement; 3) non-jurisdictional; 4) external; 5) application administrative procedure.

The features of the license as an administrative act of the Ministry of Education and Science of Ukraine are associated with its classification as an act of individual action. The qualifying feature of administrative acts is not the form of their adoption but their relation to the exercise of public authority and focus on the rights, freedoms, and obligations of particular persons. The concept of an administrative act is defined in the Law of Ukraine "On Administrative Procedure" as a decision or a legally binding action of an individual nature taken (committed) by an administrative body to resolve a specific case and designed to acquire, change, terminate, or exercise the rights and (or) obligations of the individual(s) (Verkhovna Rada of Ukraine, 2022).

Having compared the concepts provided in the administrative legislation and the legislation on education, the license can be defined as an individual decision taken by the executive body authorized to perform the functions of public administration to resolve a specific case for the acquisition, change, termination, or implementation of rights and (or) obligations in the field of education.

It should be noted that the license to conduct educational activities in higher legal education is granted by the decision of the licensing body to grant the business entity the right to perform educational functions within the licensed scope or to conduct educational activities under the educational program of the standardized sample "Law" or "International Law." These programs are designed to confer professional qualifications in regulated professions, extending beyond the authorized scope at the respective level.

## 5. Strengths and Limitations

The methodology applied to examine the established socio-legal phenomena and the findings constitute the scientific novelty of this study. A new approach to public administration in the field of legal education is developed based on the dialectical relationship between the standardization and establishment of public management procedures for higher legal education. The standardization of public management procedures involves determining the specifics of legal

education and verifying the compliance of educational programs with Law and International Law majors. This approach can become the basis for improving the regulatory framework and developing initial programs within higher educational institutions that train lawyers in Ukraine. As a result, more rigorous and balanced steps to standardize higher legal education will enhance the training of professional personnel in the legal field. Given the European integration, many standards from various branches of law must be implemented and adapted in Ukraine, while a significant part of the existing ones must be reformed. Accordingly, the state will need professional lawyers who can put the declared European values into practice.

The findings of this research may interest theorists in higher education management and improvement and practitioners who directly perform public administrative functions in higher legal education. In addition, scientifically grounded conclusions are the basis for legislative and law enforcement activities in accordance with the proposed innovations.

## 6. Conclusions and Implications

In the course of the study, it is proposed to interpret the concept of higher legal education as a complex system of knowledge, skills, expertise, legal-related ways of reasoning, qualities, and competencies acquired during training in a higher education institution according to a standardized educational program. Completing this program is the ground for awarding a higher education degree.

The study substantiates the expediency of adopting specialized legislation to enshrine the concept of higher legal education and its features. The study also advocates the need to adopt the Resolution of the Cabinet of Ministers of Ukraine, which will approve the procedure for licensing educational activities. It is noted that public management procedures for providing higher legal education are formally related to higher education in general. However, they should be based on the verification of compliance with the requirements for the provision of knowledge in the field of law.

Accreditation and licensing procedures in the field of higher legal education are analyzed. The standards of higher legal education are defined as those that determine whether a higher educational institution is eligible to provide educational services, the result of which will be a student's qualification as a lawyer. Accreditation and licensing procedures are defined as administrative procedures by their legal nature. According to the classification criteria, licensing and accreditation procedures for educational activities are a kind of the following: 1) special partial; 2) law enforcement; 3) non-jurisdictional; 4) external; and 5) application administrative procedure.

This study is limited in the analysis of curricula used in legal education institutions in Ukraine. Further research should involve identifying the common and distinctive components of curricula, comparing them with international and European standards, and developing recommendations regarding the content of legal education in Ukraine, its internal structure, and its mandatory and optional courses.

## 9. Declarations

### *Ethics approval and consent to participate*

This article does not contain any studies with human participants or animals performed by any of the authors for which ethical approval is required.

### *Consent for publication*

All authors have reviewed and approved the final version of the manuscript for publication. They also affirm their accountability for all aspects of the work and commit to addressing and resolving any issues related to the accuracy or integrity of any component of the manuscript.

### *Availability of data and materials*

Data will be made available upon request

### *Conflict of interest statement*

The authors declare that they have no personal or financial conflicts of interest related to this study.

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***Authors' contributions***
Tetiana Bilous-Osin – Writing – Review & Editing; Visualization; Formal analysis
Mykola Yurchenko – Project administration; Writing – Original Draft; Methodology
Mykhailo Goncharenko – Conceptualization; Software; Validation
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Pavlo Gorinov – Supervision; Data Curation
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**Authors' ORCID**
Tetiana Bilous-Osin https://orcid.org/0000-0001-5343-3756
Mykola Yurchenko https://orcid.org/0000-0002-2910-7042
Mykhailo Goncharenko https://orcid.org/0000-0002-9193-9202
Natalia Sukhytska https://orcid.org/0000-0002-6830-3708
Pavlo Gorinov https://orcid.org/0000-0002-8294-2784

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# Mathematical Skills Applied in Finance and their Relationship with Academic And Personal Variables: Empirical Study in College Students

Liduvina Valencia-Márquez [a, *], Sergio Hernández-Mejía [b], Daniel Martínez-Navarrete [c]

[a] Tecnológico Nacional de México – Sede ITSH, Veracruz, México
[b] Instituto Tecnológico Superior de Alvarado, Veracruz, México
[c] Tecnológico Nacional de México, Veracruz, México

**Abstract**

This research aims to determine the relationship between mathematical skills applied in finance and the academic and personal variables of college students. The results of the ordered Probit regression model show the mathematical competencies of the students according to their professional area of study, gender and employment condition. It is more likely that students in the "economic-administrative" area, compared to students in the engineering area, have mathematical skills to perform basic numerical operations, ratios and proportions, as well as apply formulas that involve financial concepts. The sample was 309 university students who were studying in the last semester of their bachelor's program. The sample is made up of students enrolled in public and private universities, belonging to the Municipality of Veracruz, Mexico. The questionnaire was structured in two sections. The first section includes questions about the student's personal and academic characteristics. The second section includes 23 questions, with multiple-choice answers, with only one answer being true. To explain the behavior of the dependent variable, as well as mathematical skills, with ordered response options, the ordered Probit response model is used. The results show the role of the students' employment status in relation to mathematical skills to perform basic arithmetic operations related to spending, personal budget and calculations of variation of quantities and amounts. The results of the research suggest strengthening the mathematical competencies of university students in personal finance topics, which allows them to promote informed financial decision-making.

**Keywords:** Mathematical Skills, Mexico, Ordered Probit, University Students.

## 1. Introduction

Several studies indicate that mathematical competence has gained significant attention in recent years (Adusei, Sarfo, 2020; Balbás, 2008; Figueroa-Rodríguez, 2017; Granados-Ramos et al., 2018; Ministerio de Educación, 2013; Muyo, Valdari, 2020; Nwosu et al., 2020; Sarfo et al., 2020). The challenges in financial economics are becoming increasingly complex, requiring the use of mathematical procedures. This has been evident in areas such as financial problem-solving, asset valuation, investment selection, asset management risks, and risk measurement, all of which are characterized by the application of mathematical methods (Balbás, 2008).

* Corresponding author
E-mail addresses: masterliduvale@gmail.com (L. Valencia-Márquez)
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Today, people are immersed in daily activities that require basic or more advanced mathematical-financial calculations. These activities demand knowledge of calculus and, in some cases, more specialized skills, including algebra, probability, statistics, etc. In the educational context, both mathematical competencies and didactic strategies are necessary to help students develop sound judgment and make reasoned decisions when faced with mathematical problems in their everyday lives (Íñiguez, 2015). Therefore, students need more knowledge, particularly in science, but most importantly, in mathematics and finance. This foundational knowledge is essential for navigating various situations within their context, while also contributing to the overall educational development of the country. Such skills are crucial in daily life, aiding individuals in managing their finances and assets, including budgeting (Muyo, Valdari, 2020). The National Research Council (2001) emphasizes that all young people must learn to think mathematically and use this thinking to learn effectively.

In addition to the above, mathematics must be taught from a practical perspective, relevant to real-life situations, and not just abstract problems where processes are unclear. From a consumer standpoint, mathematics must be applied daily, for instance, in calculating interest rates, taxes, etc. These are areas where the mathematics learned in school will be directly applicable (Muyo, Valdari, 2020).

The National Research Council (2001) highlights the importance of young people understanding mathematics and adopting these skills to apply them effectively in their professional environments, through tools like computer graphics or in personal settings, such as using spreadsheets. Given market trends, there is an increasing need for agility in handling data tables, graphs, and formulas, which leads to clearer, more efficient, and effective decision-making.

Thus, mathematical and financial competencies must be integrated into the training of university students, who should recognize the importance of acquiring this knowledge (Muyo, Valdari, 2020). Additionally, Jayaraman, Saigeetha, and Kenneth (2018) note that the level of financial literacy among young people worldwide remains low. These gaps in financial education have significant implications for both the broader economy and the financial well-being of individuals.

***Question Research***

From the above, the research question emerges: Is there a relationship between the mathematical skills that the university student has, to perform operations and calculations in finance, with academic and personal variables? Therefore, the following objective is established: determine the relationship between the mathematical skills applied in finance by university students, with academic and personal variables.

From the arguments presented, the following hypotheses emerge:

***Hypotheses***

H1. The basic arithmetic mathematical skills that college students have, for personal spending and budget operations, are related to academic and personal variables.

H2. The basic arithmetic mathematical skills that college students have, for financial charge operations of loans and investments, are related to academic and personal variables.

H3. The mathematical skills of sequences and algebraic operations that college students have, to calculate the return on an investment, are related to academic and personal variables.

H4. The mathematical skills of fractions and percentages that college students have, for calculating commissions of financial variables, are related to academic and personal variables.

H5. The mathematical skills of the concept of variation that college students have, for calculating variations of percentages or quantities, are related to academic and personal variables.

H6. The mathematical skills of the concept of ratio and proportion that college students have, to formulate and calculate proportions, are related to academic and personal variables.

H7. The mathematical skills of the concept of financial function that college students have Organization for Economic Co-operation and Development to make financial decisions that involve the interest rate are related to academic and personal variables.

## 2. Literature review

The mathematical skills of the population and its relationship with financial decision-making have gained relevance in recent years (Jayaraman et al., 2018; OECD, 2020; OECD, 2017). The results reported in several studies highlight a strong correlation between students' performance in financial topics and their mathematical skills (Liang et al., 2022; OECD, 2020;

Villagómez, Hidalgo, 2017). Financial decisions involve the use of money, which is why mathematical knowledge is required (OECD, 2019).

Mathematical competence is the ability of people to know and understand the role that mathematics plays in the world. In the same way, help to satisfy their needs regarding their personal life or, as responsible, constructive and reflective citizens, they transmit informed judgments using and relating mathematics (OECD, 2003).

Mathematics has been a crucial element for the development of several fundamental topics of financial economics; some topics are those related to financial markets, for example, the topic of investments, risk, among others (Balbás, 2008). In this regard, Liang et al. (2022) report that students' financial performance is positively related to mathematical skills (arithmetic, algebra, problem-solving process).

Knowledge in science and technology has always been an integral part of mathematics, therefore the instrumental and social role of mathematical competence has allowed it to be a key tool to interpret, understand and provide solutions to the problems of our environment (Ministerio de Educación, 2013). Consequently, numerical information revolves around people's daily lives (Granados-Ramos et al., 2018). In their work, Muyo and Valdari (2020) analyze mathematics and finance together, they suggest that to improve mathematical competence, it is essential to find where, when and how students should use the knowledge acquired to use it outside of school.

In the development of daily activities such as calculating the time to move from one point to another, the amount of money that must be paid for a certain product, etc., knowledge of mathematics is required. This knowledge is learned from early stages through their interaction and classification of objects with which they interact in their environment. This knowledge is strengthened and increased when entering school and learning to solve problems in their daily lives using numbers through; addition, subtraction, multiplication and division (Granados-Ramos et al., 2018).

Mathematical competence must be characterized by being applied in real or simulated contexts of the student's life (Rico, 2006; Alsina, 2009). Hence, the student who constantly has contact with mathematics in real life requires solving problems through mathematical modeling. To develop people's level of financial education, it is essential to know about financial problems that lead to making financial decisions and through this achieve appropriate financial behavior (Muyo, Valdari, 2020).

Lacking mathematical reasoning is synonymous with being excluded from the various areas and activities of the human being. Lack of mathematical skills limits their opportunities to be competent in everyday tasks (National Research Council, 2001). Regarding the relevance of mathematical skills applied in finance, Jayaraman et al. (2018) consider that there is a strong relationship between financial knowledge and arithmetic knowledge, therefore, the effective increase in arithmetic skills can help increase financial education.

For their part, Erner et al. (2016) point out that mathematical competency are related to basic financial education. In people's daily activities, it is essential to keep adequate control of their daily expenses, as well as planning future expenses in accordance with their monthly income received, by incurring basic purchases such as their expenses in cash or with bank cards, among others. If the person has mathematical and financial skills, this can contribute to appropriate behavior in terms of expense planning based on their income level (Muyo, Valdari, 2020).

Regarding the academic and personal variables, García (2016) states that the origins of the differences between genders may be due to the qualities, behaviors and identities that arise through the socialization process. These inequalities arise due to power relations, such as access to decisions and resources. The different positions of women with respect to men, are related by historical, economic, cultural and educational realities. In this idea, Indrahadi and Wardana (2020) reported the significant impact of sociodemographic, personal and academic variables on the academic performance of students; among their findings, they identified that those students belonging to public schools obtained better performance compared to those belonging to private schools.

Females have lower participation in the stock market and obtain lower scores in financial education than men (Almenberg, Dreber, 2012). Lemaster and Strough (2014) and Almenberg and Dreber (2012) agree that women are less intolerant of risk than men are, and the male sex takes greater risks. For their part, Liang et al. (2022) identify that male students obtain higher scores in problem-solving; likewise, students who have taken a calculus course at university obtain higher scores on mathematics tests compared to those who have not taken it.

## 3. Methods and Materials

### *Research Design*

The objective of this research is to determine the relationship between mathematical skills applied in finance by university students, with academic and personal variables. The study is descriptive, correlational, and non-experimental. The sample was 3,098 university students who are studying the last semester of their bachelor's program during the semester January to June 2022. The sample is made up of students enrolled in public and private universities, belonging to the Municipality of Veracruz, Mexico.

### *Sample*

The type of sampling is non-probabilistic due to self-determination. Data collection is carried out through the application of a questionnaire applied online, through the Google Forms tool. Information gathering is carried out during the months of May to November 2022.

### *Instrument*

To obtain the data, a hybrid instrument is designed based on the scales proposed by Mandell and Kline (2009); Lusardi and Mitchell (2008, 2011); CFI Official Global Provider of the Financial Modeling and Valuation Analyst (FMVA)™; Certification Program (2015); Tecnológico de Costa Rica (TEC) (2017); and LearningExpress (2017).

The questionnaire was structured in two sections. The first section includes questions about the student's personal and academic characteristics (sex, age, family life, employment status, type of university where they study, and area of their profession). The second section includes 23 questions, with multiple choice answers, with only one answer being true. The questions allow us to identify the mathematical skills that the student has to perform calculations and operations in financial matters.

Table 1 presents the operationalization of the primary variable of this research, mathematical skills applied to finance topics.

**Table 1**. Operationalization of mathematical skills applied to finance topics

| Mathematical knowledge | Kind of mathematical calculus | Ability | Applied to finance topics |
|---|---|---|---|
| Arithmetic basic | Basic numerical operations | Do addition and subtraction | 3 questions related to the personal spending and income budget. |
| Arithmetic basic | Basic numerical operations | Solve arithmetic problems based on basic arithmetic | 2 questions related to financial charges for loans and investments |
| Sequences and algebraic operations | Operations with sequences and obtaining the general term | Apply the concept of geometric sequences and perform algebraic operations | 4 questions related to the performance of an investment |
| Fractions and percentage | Mathematical calculus with decimals and proportions | Calculate the percentage of a given amount in conjunction with arithmetic operations | 3 questions related to the calculation of commissions |
| Variation | Basic numerical operations with decimals and proportions | Calculate the percentage and absolute variation of a quantity | 3 questions related to the variation of percentages or amounts |
| Ratio and proportion | Ratio and proportion operations | Formulate expressions that involve the of ratio concept | 3 questions related to the ratio and proportion of monetary quantities and amounts |
| Function | Apply pre-established financial functions | Apply financial functions for decision making | 5 questions related to financial decision making that involves the interest rate |

***Analyzing of Data***

For each mathematical knowledge, an indicator or unit of measurement is constructed, which is obtained from the sum of correct answers to questions on financial topics. The indicator can take the value 0,1,2,3,4,5 depending on the number of questions that make it up. (For example, the basic arithmetic indicator regarding basic numerical operations can take the value of 0, 1, 2 or 3).

***Statistical procedure***

According to the values that the indicator can take, the ordered Probit model is used, according to the proposal of Villagómez and Hidalgo (2017). The independent variables are categorical and are coded as follows: the sex variable takes the value of 1 if the respondent is a man and 0 if the respondent is a woman. The variable called family coexistence is made up of three categories (lives alone, lives with his parents, lives with his partner), for which a dichotomous variable is designed per category. The employment condition variable takes a value of 1 if the respondent studies and works, and a value of 0 if they only studies.

The dichotomous variable type of university takes the value of 1 if the respondent studies at a public university, and a value of 0 if the respondent studies at a private university. The professional area variable takes the value of 1 if the respondent studies a degree in the economic-administrative area and 0 if the respondent studies an engineering degree. Table 2 show the numerical characteristics of the sample.

**Table 2.** Numerical characteristics of the student sample

| Variable | Category | Total cases | % |
|---|---|---|---|
| **All** | | **294** | **100** |
| X1: gender | Female | 177 | 60.2 |
| | Male | 117 | 39.8 |
| X2: family coexistence | Live alone | 35 | 11.9 |
| | Live with parents | 234 | 79.6 |
| | Live with | 25 | 8.5 |
| X3: labor status | Only study | 137 | 46.6 |
| | Study and work | 157 | 53.4 |
| X4: University where study | Private University | 182 | 61.9 |
| | Public University | 112 | 38.1 |
| X5: Professional profile | Engineering | 82 | 27.9 |
| | Economic-Administrative | 212 | 72.1 |

To explain the behavior of the dependent variable (y), as well as mathematical skills, with ordered response options, the ordered Probit response model is used (Wooldridge, 2010).

The observed variable takes integer values 0,1,2,3,4,...,J; $y^*$ is a latent variable that is continuous, determined by the equation, $y^* = X\beta + e$ ; $\beta$ is a vector size ($Kx$ 1), X which denote the characteristics of the surveyed, $e \sim N(0,1)$, which is a stochastic term and $N$ is the cumulative normal distribution function. Therefore, α_1<α_2<⋯<α_J, be cut-off points (threshold parameters) whose values are unknown. The relationship between the observed variable and the estimated variable is given as follows:

$$y = 0 \ \ if \ \ y^* \leq \alpha_1; \ \ y = 1 \ if \ \ \alpha_1 < y^* \leq \alpha_2 \ ; \ y = J \quad if \ \ y^* > \alpha_J.$$

The parameters $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ are estimated by the maximum likelihood method. For each knowledge of mathematical skills, a model is estimated ($y_i$):

Model ($y_1$): math skills for spending and budgeting operations
Model ($y_2$): mathematical skills to calculate financial charges for loans and investments
Model ($y_3$): mathematical skills to calculate the return on an investment
Model ($y_4$): mathematical skills for calculating commissions
Model ($y_5$): mathematical skills to calculate variations expressed in percentages
Model ($y_6$): mathematical skills for calculating proportions

Model ($y_7$): mathematical skills for calculating financial interest

The independents variables are: X1: gender, X2: family coexistence, X3: labor status, X4: type of university, X5: professional profile.

Table 3 shows the descriptive statistics of mathematical skills. For each mathematical skill, the value of the mean of correct answers, median, standard deviation, minimum and maximum value is presented.

**Table 3.** Descriptive statistics of mathematical skills applied to finance topics

| Variable | Mean | Median | Std Dev. | Mínimum | Maximum |
|---|---|---|---|---|---|
| $y_1$ | 2.37 | 3.00 | 0.798 | 0.000 | 3.00 |
| $y_2$ | 0.459 | 0.000 | 0.587 | 0.000 | 2.00 |
| $y_3$ | 2.40 | 3.00 | 1.15 | 0.000 | 4.00 |
| $y_4$ | 1.79 | 2.00 | 0.761 | 0.000 | 3.00 |
| $y_5$ | 1.73 | 2.00 | 0.846 | 0.000 | 3.00 |
| $y_6$ | 1.44 | 1.00 | 0.909 | 0.000 | 3.00 |
| $y_7$ | 2.46 | 2.00 | 1.13 | 0.000 | 5.00 |

Table 4 shows the results of the estimation of the ordered Logit regression model for each of the mathematical skills related to the characteristics of the students. The results of each of the models are described below, emphasizing those significant variables. From model 1, it is found that students in the work condition "study and work", compared to students who only study, is less likely to ($\beta = -0.61, p < 0.01$) who have the mathematical skills to perform basic arithmetic operations related to personal spending and budget. While that the students in the economic-administrative professional area, compared to those students who study engineering, are more likely ($\beta = 0.64, p < 0.05$) that they do have these skills. The previous results support hypothesis 1, regarding the relationship of basic arithmetic mathematical skills with the student's employment status and their professional profile.

From model 2, it is found that male students, compared to female students, are more likely to have basic arithmetic mathematical skills to calculate financial charges for loans and investments($\beta = 0.51, p < 0.05$). In addition, students in the "economic-administrative" professional profile, compared to those students who study engineering, are more likely to have these skills. The result supports hypothesis 2, regarding the relationship between the basic arithmetic mathematical skills that the student has and its relationship with the student's gender and professional profile($\beta = 0.69, p < 0.05$). Regarding model 3, evidence was obtained that students in the economic-administrative professional profile, compared to students in the engineering area, are more likely to have mathematical skills. This math skill allow them to perform operations with geometric sequences and apply formulas to make algebraic calculations that involve financial concepts as simple and compound interest rate on a bank deposit or loan and inflation and its effect on the time value of money ($\beta = 0.73, p < 0.05$). The result supports hypothesis 3, regarding the relationship between the mathematical skills of succession and application of formulas that the student has and its relationship with the professional profile.

Regarding model 4, evidence was obtained that students belonging to the "study and work" employment condition, compared to students who only study, are less likely to have mathematical skills to perform operations with fractions and calculation of percentages of commissions on costs, profits, prices and sales of goods ($\beta$ = -0.49, $p<0.05$). The result supports hypothesis 4, regarding the relationship between the mathematical skills of operations with fractions and percentages that the student has and its relationship with employment status.

Regarding the model 5, it was possible to verify that the group of men, compared to female students, is more likely ($\beta = 0.47$, $p < 0.05$) to have mathematical skills to calculate the variation of an absolute quantity and that expressed in percentage terms. The result supports hypothesis 5, regarding the relationship between the mathematical skills for calculating variations that the student has and its relationship with gender.

Finally in model 6, evidence was obtained that students in the family coexistence condition, live with a partner, compared to students who live alone, are less likely to have mathematical skills

to perform calculations that involve the concept of ratio and proportions in buying and selling activities (β = -1.22, p<0.05). While, students in the economic-administrative professional profile, compared to those students who study engineering, are more likely to have these skills (β=0.71, p < 0.05). The result supports hypothesis 6, regarding the relationship of mathematical skills to formulate expressions that involve the concept of ratio and proportions that the student has and its relationship with the condition of family coexistence and the professional area. In model 7, there is no significant differences by groups, regarding the mathematical skills to apply financial functions for making savings and investment decisions.

**Table 4.** Ordered Logit estimates: dependent variable (mathematical skill)

| **Independent variables** | **Model ($y_1$)** | **Model ($y_2$):** | **Model ($y_3$):** | **Model ($y_4$):** | **Model ($y_5$):** | **Model ($y_6$):** | **Model ($y_7$):** |
|---|---|---|---|---|---|---|---|
| X1: Gender (REF=Female ) | | | | | | | |
| Male | −0.25 (0.24) | 0.51** (0.25) | 0.33 (0.22) | 0.09 (0.24) | 0.47** (0.23) | -0.15 (0.22) | 0.18 (0.22) |
| X2: Family coexistence (REF= live alone, live with his parents | 0.41 (0.35) | 0.42 (0.40) | -0.29 (0.31) | 0.43 (0.35) | -0.07 (0.35) | -0.06 (0.32) | 0.27 (0.35) |
| lives with his partner | 0.10 (0.51) | 0.84 (0.55) | -0.80 (0.49) | -0.11 (0.49) | 0.10 (0.51) | -1.22** (0.50) | 0.13 (0.50) |
| X3: labor status (REF= only study) | | | | | | | |
| Study and work | −0.61*** (0.23) | -0.20 (0.24) | -0.17 (0.21) | -0.49** (0.23) | -0.05 (0.22) | -0.26 (0.21) | 0.10 (0.21) |
| X4: University | | | | | | | |
| (REF=private, public | −0.05 (0.27) | 0.35 (0.28) | -0.28 (0.25) | 0.08 (0.26) | -0.002 (0.25) | 0.04 (0.25) | 0.03 (0.25) |
| X5: professional profile | | | | | | | |
| (REF= engineering; economic-administrative) | 0.64** (0.30) | 0.69** (0.32) | 0.73** (0.28) | 0.38 (0.30) | 0.52* (0.29) | 0.71** (0.28) | 0.46* (0.27) |
| Mean of the dependent variable | 2.37 | 0.45 | 2.39 | 1.78 | 1.73 | 1.78 | 2.46 |
| number of cases correctly predicted | 164 (55.8%) | 175 (59.5%) | 98 (33.3%) | 171 (58.2%) | 144 (49.0 %) | 171 (58.2%) | 98 (33.3%) |
| Likelihood ratio test: Chi-square (d.f.) | Chi-squared (6)= 65.11 [0.0000] | Chi-squared (6)=48.95 [0.000] | Chi-squared (6) = 84.48 [0.000] | Chi-squared (6) = 83.16 [0.000] | Chi-squared (6) = 72.66 [0.000] | Chi-squared (6) = 83.16 [0.000] | Chi-squared (6) = 98.80 [0.000] |

Notes: *,**;***: statistical significance at 10%, 5%, 1% respectively. Standard errors in parentheses. REF=reference categories.

## 4. Discussion

The relationship between the mathematical skills of university students and academic and personal variables has gained increasing relevance from both a theoretical and empirical perspective. Various studies report a significant correlation between students' mathematical competencies and their performance in financial matters (Jayaraman et al., 2018; OECD, 2020; Liang et al., 2022). Arithmetic skills, such as the ability to perform basic budgeting calculations and compute simple and compound interest, are essential for making informed decisions in both personal and professional finance (OECD, 2017; OECD, 2020).

The econometric analysis in this study reveals several factors that affect mathematical skills applied to finance, with gender differences standing out. The results show that men are more likely to possess the mathematical skills needed to perform financial calculations, such as those related to loans and investments. This finding is consistent with the OECD (2020), which identifies a gender gap in financial literacy, favoring men. In this regard, Al-Bahrani et al. (2020) suggest that the gender knowledge gap develops early in university before individuals have had the opportunity to acquire practical skills through experience or role-related activities.

Regarding professional profiles, the results indicate that students from the "economic-administrative" field are more likely to develop mathematical skills related to financial decision-making, such as interest calculations and asset valuation. Liang et al. (2022) report that students in the economics and finance field score higher in mathematical skills, associated with prior knowledge in calculus and statistical methods. Similarly, Muyo and Valdari (2020) suggest that integrating mathematics and finance into curricula can enhance student performance in financial topics.

On the other hand, it was found that students' employment conditions negatively affect their ability to solve operations related to spending and budgeting, as well as calculations involving fractions and percentages. This result contrasts with Tejada-Peña et al. (2023), who report a positive effect of the student's work-study condition on their mathematical ability in percentage variations (such as inflation and investment returns). This discrepancy may be explained by differences in students' socioeconomic contexts or the level of educational support they receive.

The results also show that the type of university (private or public) does not significantly impact students' mathematical skills, which contrasts with the findings of Indrahadi and Wardana (2020), who report that students from public institutions performed better compared to those from private schools.

Regarding gender, the findings of this study align with previous research showing that men are more likely to possess better mathematical skills in financial contexts, which is also related to a greater willingness to take financial risks (Almenberg, Dreber, 2012; Liang et al., 2022; Jayaraman et al., 2018). In this sense, students from economic-administrative fields are more likely to possess mathematical skills applied to concepts such as compound interest and the time value of money, which supports the hypothesis that academic training positively influences financial competencies. Regarding cohabitation factors, a relevant finding is that students living with a partner are less likely to possess mathematical skills related to calculations of proportions and ratios in purchases and sales. This result differs from existing literature, which has not sufficiently addressed the influence of cohabitation conditions on mathematical skills, suggesting that factors such as family support or household structure may influence the development of these skills.

In summary, the findings of this study reinforce the idea that mathematical skills have a significant impact on financial decision-making. Gender differences and professional profiles are key factors explaining variations in students' mathematical competencies, while employment and cohabitation conditions yield unexpected results, opening new avenues for future research.

## 5. Conclusion

The results of this research confirm the existence of a significant relationship between mathematical skills and the financial decisions of university students, particularly in areas related to economics and business administration. Additionally, gender differences and students' professional profiles align with findings from previous studies (Almenberg, Dreber, 2012; Liang et al., 2022), highlighting that men and students from economic-administrative fields are more likely to possess better mathematical skills applied to finance. However, notable discrepancies were identified concerning employment status and living conditions, suggesting that factors such as stress levels or family responsibilities may influence the development of mathematical skills in

practical contexts. These differences should be considered in future research to provide a more comprehensive understanding of how mathematical skills are developed and applied in financial decision-making across various contexts.

In this regard, the primary objective of this study was to determine the relationship between mathematical skills applied to finance by university students and their academic and personal variables. The results provide evidence of a relationship between the mathematical skills necessary to perform basic arithmetic operations related to personal spending and budgeting, and the student's employment status as well as their professional profile, which supports hypothesis H1. Additionally, evidence of a gender difference in favor of men regarding basic arithmetic skills required to calculate financial charges for loans and investments was found, which supports hypothesis H2.

Furthermore, a positive relationship was found between students' mathematical skills in sequences and formula application and their professional training in economic-administrative fields, which supports hypothesis H3. A relationship was also identified between students' mathematical skills in operations with fractions and percentages and their employment status, which supports hypothesis H4. Regarding gender, a relationship between students' skills in calculating variations and their gender was found, which supports hypothesis H5. Lastly, a relationship between students' skills in formulating expressions related to ratios and proportions and their family living conditions and professional field was observed, which supports hypothesis H6.

Finally, the results of the model did not support the relationship between mathematical skills needed to apply financial functions in decision-making, savings, investment, and the students' individual characteristics. These findings highlight the importance of strengthening the mathematical competencies of university students, particularly in personal finance, to promote more informed and responsible financial decision-making.

## 6. Implications of the Study

Regarding the theoretical implications, this study provides evidence supporting the relationship between mathematical skills and financial decision-making. The theory behind this relationship is based on the idea that mathematical competencies allow individuals to make informed and responsible financial decisions using mathematical tools such as interest calculations and understanding the time value of money. The connection between these skills and financial performance is crucial to understanding how mathematical education can influence individuals' economic management in different personal and professional contexts. Moreover, it is confirmed that students in economic-administrative fields, who typically receive more mathematical training, have better skills in performing complex financial calculations. This reinforces the theory that specialized mathematical education can enhance competence in both personal and professional finance.

From a practical perspective, the evidence obtained in this study suggests that greater integration of financial mathematics into curricula could improve students' financial performance, particularly those preparing for careers in economics and administration. The ability to handle mathematical concepts such as percentage calculations, interest rates, and financial planning is essential for effective resource management, both personally and professionally. On the other hand, observed differences based on gender and work experience suggest that some groups, such as men and students not working, may have advantages in developing these skills. Therefore, educational programs should consider inclusive strategies to mitigate disadvantages observed in other groups, such as women or students balancing work and study.

Based on the results obtained regarding mathematical skills and financial decision-making, as well as the limitations and discrepancies found, several suggestions for future studies can be made: A longitudinal study on the impact of the work-study balance on the development of mathematical skills would be valuable. This type of research could explore how different types of employment (part-time work, field jobs, jobs related to the economic field, etc.) influence the development of mathematical skills over time. It would be helpful to investigate how work experience and practical contexts either support or hinder learning and applying mathematical concepts in financial decisions.

Comparative studies between groups with different work and educational conditions could provide deeper insights. A more in-depth comparison of students who work versus those who do not, controlling for factors like job type, educational level, and family responsibilities, could shed light on how the work environment influences mathematical and financial skills. Further studies on

the gender gap in mathematical skills and financial decision-making are also important. Although a difference in mathematical skills between men and women has already been identified, it is essential to understand the underlying causes of this gap. This could involve exploring cultural, educational, and psychological factors influencing attitudes toward mathematics and finance in each gender. Additionally, examining how gender roles affect personal and professional financial decisions would be insightful. To address the gender gap, it would be valuable to explore how different educational approaches can empower women in mathematics and finance, through inclusive teaching strategies or awareness programs.

Given that marital status was part of the participants' profile, it could be relevant to study the impact of living arrangements on the development of mathematical skills. Research on how living conditions (e.g., living with a partner or family) affect mathematical skills in financial contexts could be an interesting avenue to explore. This study could consider factors like family support, household responsibilities, or even stress associated with family dynamics as elements influencing the learning and application of mathematics in financial decision-making.

## 7. Study Limitations

Regarding the limitations, the study faces several factors that may affect the validity of its results and the generalization of its findings. One of the key limitations is the limited resources available for the study, which led to a relatively small sample size due to financial and material constraints. This could limit the ability to generalize the results to a broader population. This limitation is particularly relevant when considering the relationship between mathematical skills and financial decision-making in different contexts. Another important factor is time: the study's duration may have influenced the depth with which certain variables were explored. A longer period would have allowed for a better observation of the development of mathematical skills over time, particularly in work and social contexts.

It is also important to note that the study does not address all socioeconomic factors that could influence mathematical skills. Therefore, the discrepancy observed between students with work experience and those without it could be influenced by contextual factors, such as stress or additional responsibilities, which were not fully controlled in the study. Additionally, selection bias in the sample may have affected the results, especially if not all demographic and socioeconomic groups were considered. This could influence findings related to gender and work context. These limitations should be considered when interpreting the results, and addressing them in future research would provide a broader and more accurate understanding of the link between mathematical skills and financial decision-making.

## 8. Declarations

### *Ethics approval and consent to participate*

This study is carried out in accordance with the recommendations of the Code of Ethics of the National Technology of Mexico. The Research Ethics Committee of the Division of Graduate Studies and Research approved the protocol. In accordance with the Declaration of Helsinki, all workers gave their consent for participation in the study.

### *Consent for publication*

Not applicable.

### *Availability of data and materials*

Data and materials associated with this study are available upon request.

### *Conflict of interest statement*

The author declares no conflict of interest.

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### *Author contributions*

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**Authors' ORCID**

Liduvina, Valencia-Márquez https://orcid.org/0000-0003-1431-031X
Sergio, Hernández-Mejía https://orcid.org/0000-0002-5477-666X
Daniel, Martínez-Navarrete https://orcid.org/0000-0003-2072-9598

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# Improving Student Engagement in Co-curricular Programmes: The Role of Monitoring and Incentive Structures

Keren Naa Abeka Arthur [a, *], Esther Afoley Laryea [b]

[a] University of Cape Coast, Ghana
[b] Ashesi University, Ghana

**Abstract**

Management educators are becoming increasingly interested in preparing their students for managerial and leadership roles in the job market, and soft skills have been touted as useful in this transition. Nevertheless, soft skills in public universities are difficult to develop in large class sizes, making co-curricular skills development training a good alternative. This paper is an instructional innovation piece that reports on the results of experimenting with different combined incentive and monitoring structures to understand their role in improving student engagement in a design thinking course aimed at developing soft skills in the extra-curricular setting. In this study, we analyzed quantitative and qualitative data from administrative records and interviews using descriptive, t-test and thematic analysis techniques to understand the effect of the combined mechanisms on engagement. Our findings indicate a significant difference between the control and treatment groups with regard to all engagement variables except for efforts to work harder. However, the mechanisms are more important in promoting behavioural engagement than cognitive and affective engagement. We recommend that management educators tailor incentives to specific engagement variables that drive desired outcomes rather than tying them to programme-level outcomes. Additionally, we suggest a need to understand the communication culture of students to shape decisions regarding monitoring mechanisms.

**Keywords:** Co-curricular Activity, Experiential Learning, Incentives and Monitoring, Public Universities, Student Engagement, Twenty-first Century Skills.

## 1. Introduction

In the context of the current dynamism of our business world, employee skill set requirements are changing. Soft skills are becoming paramount for the 21st-century workforce (Dean, 2017), especially for business leaders, managers and administrators. Therefore, management educators are becoming more interested in how they can better prepare their students for careers in management and leadership (Schmidt-Wilk, Lovelace, 2017). Critical thinking, problem-solving, negotiation, communication and information sharing constitute soft skills crucial to developing effective managers and leaders (Delise, Mello, 2017; Stepanovich et al., 2017). However, employers bemoan the gap between their expectations of the soft-skill performance of management graduates and their actual performance on the job (Gunarathne et al., 2021; Ofoegbu et al., 2018). Thus, calls have been made for

*Corresponding author
E-mail addresses: keren.arthur@ucc.edu.gh (K. Arthur)
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changes in management education to help close this gap (Ginting et al., 2020; Ofoegbu et al., 2018; Gunarathne et al., 2021). To this end, there is consensus that management educators need to shift from curriculums that highlight "what students need to know" to curriculums that emphasize "what students need to be able to do" (Schmidt-Wilk, Lovelace, 2017).

To meet the demands of the job market, management educators need to be intentional about soft skill development in the design of their curriculum (Ritter, 2018). Real learning is more likely to occur when students are involved in what they are being taught (Schmidt-Wilk, Lovelace, 2017); thus emphasizing the importance of student engagement in achieving desirable learning outcomes (Carini et al., 2006). This suggests that soft skill acquisition requires consistent and active engagement of learners. Nevertheless, high enrollment rates coupled with limited classroom infrastructure restrict the ability of faculty in public universities to deploy experiential learning strategies (Delise, Mello, 2017; Stepanovich et al., 2017), which have been touted as effective in soft skill training (Stalp, Hill, 2019). Public universities in Africa are not exempt from this challenge. Chikoko (2017) describes current pedagogies in African higher education as teacher-centred, leading to rote memorization and surface learning. Therefore, McCowan et al. (2022) recommend a shift towards learner-centered education; a change that would require institutional and individual-level adjustments (McCowan et al., 2022). Barriers such as limited resources, weak governance and poor pedagogical culture inhibit this transition towards a learner-centered teaching and learning approach (McCowan, 2018).

In the face of the challenges mentioned above, co-curricular activities present an opportunity for soft skill development (Afzali, 2023). Co-curricular activities are flexible and offer participants multiple training session options, which helps circumvent challenges with large class sizes and limited infrastructure. Additionally, organizers of co-curricular activities have greater training design autonomy, facilitating smaller group sizes that support experiential learning. Suskie (2015) mentions that the use of out-of-class experiences can improve students' learning, growth, and development. Several researchers (Lourens, 2014; Turrentine et al., 2012), also argue that programmatic involvement in extra-curricular activities is linked to a variety of favourable outcomes, including increased self-efficacy, satisfaction, feelings of support, retention, academic success and intellectual engagement and improved interpersonal understanding. Additionally, Millunchick and Zhou (2020) found that engineering students' participation in co-curricular activities in a large public university contributed positively to academic, social and professional outcomes.

Ankoma (2024) also argues that extra-curricular activities are particularly useful for international students in promoting inclusivity and connectivity and career development opportunities that balance theory with practices to help make international student experience positive. However, anecdotal evidence from the researchers' practice shows that students sometimes perceive a negative relationship between engagement in co-curricular activities and academic outcomes because it is not considered in computing Grade Point Averages (GPAs). While Mansi (2023) found a positive relationship between extra-curricular activities and graduate employability, a 2019 Job outlook survey confirmed that about 73 % of employers use GPAs in screening job candidates (Tai, 2020). Thus, making it more attractive for students to focus on activities that have a direct relationship with their GPA, while ignoring those that do not. Donald et al. (2018), recommend that facilitators offer rewards to encourage students' participation in co-curricular activities. Additionally, monitoring structures could help facilitators gauge the level of commitment students have made to the learning process, so that the necessary support can be offered to them. Despite this, literature on the subject of monitoring and incentive structures for promoting student engagement in co-curricular soft skills development is scarce to date.

This study experiments with monitoring and incentive structures to understand their role in fostering student engagement in a co-curricular design-thinking training programme aimed at developing management-relevant soft skills in a large public university in Ghana. In the paragraphs that follow, we lay out the theoretical underpinnings of the study, after which we describe the methods employed. Next, we describe the structure of the proposed co-curricular program, present the results of our experiment and discuss the findings and their implications for management education.

## 2. Literature review

### *Theoretical background*

Two theoretical frameworks and one model underpin this study; Kolb's Experiential Learning Theory (1976), Vroom's Expectancy Theory (1964) and the threshold model for explaining the

impact of student participation in co-curricular activities on student academic performance. Based on Kolb's Experiential Learning Theory, we argue that skills development involves the continuous discovery, assimilation and accommodation of knowledge from experience (Piaget, 1999). Skill acquisition comes from understanding and understanding in turn comes from exposure to cognitive and affective behaviors embedded in the four components of the learning cycle (Kolb, 1984). Findings from Babu et al. (2020) and Mayombe (2022) show that experiential learning theories facilitate skill acquisition but require learner commitment for success.

We infer from Vroom's Expectancy Theory (1964) that the extent to which learners commit to participating in experiential learning will depend on their expectations about the likely outcomes and their attractiveness to them. Therefore, student commitment to participate in co-curricular skills development training programs could be low considering the absence of direct linkages with overall student performance measures like the GPA. This necessitates the use of strategies such as incentives and monitoring mechanisms to alter the attractiveness of outcomes.

Our study encourages student participation in co-curricular activities because it contributes positively to the acquisition of industry relevant competencies. Nevertheless, we argue from the threshold model perspective (Seow, Pan, 2014) that there are trade-offs between participation in extra-curricular activities and academic performance beyond a threshold point where time and cognitive capacity requirements could become a burden (Seow, Pan, 2014). Therefore, there is a need for proper design of co-curricular activities and support mechanisms for students in their pursuit of co-curricular activities.

### *Relevant soft skills for management education*

Ingols and Shapiro (2014) and Ritter (2018) describe soft skills as intra and interpersonal skills that enhances an individual's contribution to an organization and chance of professional success. Literature emphasizes generic soft skills more than sector-specific soft skills (Oppong, Segbenya, 2023). Joie-La Marle et al. (2022) identified seven soft skills including problem-solving, interpersonal and comfort with uncertainty that are generic and apply to managerial and administrative roles. Gutterman (2023) highlights that relevant soft skills can vary based on a manager's scope of work (e.g. general or functional) and place in the organizational hierarchy. Whereas top managers need more interpersonal skills, middle and first-line managers stand to benefit more from technical and diagnostic skills (Anzengruber et al, 2017; Laud et al., 2016).

Maduko and Puche (2020) found that communication, strategic influencing, problem-solving and interpersonal skills had a positive effect on front-line managers' innovativeness. Further, Oppong and Segbenya (2023) observed that communication, leadership and teamwork were the topmost managerial skills in a study focused on six Ghanaian sectors. These findings show the relevance of conceptual and human skills for would-be managers and administrators. The importance of these skills in organizations today guided the selection of targeted skills for our study.

### *Pedagogies for improving student engagement*

As previously argued, improving student engagement is pivotal to soft-skill development in co-curricular learning environments. Student engagement has been conceptualized as having three dimensions: behavioural engagement, affective engagement, and cognitive engagement (Fredricks et al., 2004; Eccles, 2016; Kelly et al., 2022). Thus, developing the conceptual and human skills of managers would require a focus on achieving these engagement outcomes; namely behavioural, cognitive and affective. Behavioral outcomes relate to learner engagement in learning activities and signify a positive attitude towards course completion (Wei et al., 2021). Cognitive outcomes concern learner knowledge and skill acquisition while affective outcomes encompass learner perception of the course, learning experiences and benefits (Wei et al., 2021). Various researchers have established the important role of cognitive and affective learning in management education (Bagley et al., 2020; Decker et al., 2015; Montiel et al., 2018).

Calhoun et al. (2009) call for an investigation into pedagogies that facilitate behavioral and cognitive engagement in business education. Studies like Quibrantar and Ezezika (2023) and Li et al. (2019) emphasize the importance of experiential learning approaches in the improvement of student engagement. Ritter (2018) also proposes experiential learning pedagogical tools like video and written case reviews, role plays, debates, discussions and team projects as useful in developing soft skills in management education. Additionally, Delise and Mello (2017) and Stepanovich et al.

(2017) suggest various in-class experiential learning exercises that can be useful in developing specific soft skills. These resources leverage case study analysis, group discussion, and project-based learning all of which were considered in the design of the intervention. We argue that experiential learning approaches play a two-pronged role of improving student engagement while facilitating skill acquisition.

### *Operationalizing student engagement*

Engagement can be used as a proxy for learning (Carini, 2012). Kuh (2009) defines engagement from two perspectives as time and effort invested in learning activities and activities conducted by educators to induce participation. Although learning requires more than engagement, Perry (2022) argues that learning cannot occur without student engagement; thus, making engagement an assessment indicator that can contribute positively to outcomes. Kuh (2003) suggests that level of engagement can be explored from three dimensions: cognitive, affective, and behavioural. Cognitive engagement describes the mental processes students use to participate in learning (Walker et al., 2006). Behavioural engagement involves making an effort, being persistent, and taking part in learning activities while affective engagement relates to how students feel about their education and their institution (Lam et al., 2014). Pickering (2017) found that cognitive engagement is a more reliable proxy for measuring learning although all three levels of engagement work together with other factors to deliver intended outcomes.

Mandernach (2015) developed assessment indicators to gauge cognitive, affective and behavioural dimensions of engagement. Assessment indicators for the cognitive dimensions included (1) proportion of coursework emphasizing higher-order thinking strategies, (2) time spent on projects requiring integration and synthesis of ideas, and (3) the amount of coursework requiring practical application of knowledge or skills. For behavioural engagement indicators consisted of (1) frequency of asking questions in class, (2) frequency of group projects or collaborative work, (3) frequency of tutoring others and (4) frequency of attending events related to course material. Finally, Mandernach (2015) measured affective engagement using (1) student effort to work harder to meet the instructor's expectation, (2) investment to better understand someone else's perspective, (3) time invested in studying, (4) tendency to be prepared for class and (4) frequency of discussing course material outside of class time. Data collection using these indicators can be self-reported or directly observed (Kerr, 2018). These assessment indicators guided the design of data collection instruments.

### *Incentive and monitoring structures for improving engagement*

Incentives represent a key success factor for co-curricular programmes. Donald et al. (2018) assert that teachers ought to offer rewards to encourage students to take part in co-curricular activities. Using incentives can help attract and retain students by promoting programme attendance and making them feel invested in programmes. According to Collins et al. (2008), incentives not only promote programme attendance; they also foster a sense of belonging to a programme while spurring academic achievement. Deci et al. (1999) explain that students' response to incentives meant to promote engagement can be influenced by multiple factors including level of intrinsic motivation, student goals and student perception of likely success.

Incentives can be monetary (cash, checks, gift cards), non-monetary (certificates, recognition, praise etc.), tangible or intangible; and their effectiveness depends on frequency and duration of the incentive as well as what is rewarded (Pavetti, Stanley, 2016). Additionally, incentive size and stressful conditions like poverty can alter the effectiveness of incentives in changing behaviour (Pavetti, Stanley, 2016). Although, both tangible and intangible rewards have been found to play a pivotal role in improving student engagement and performance, tangible rewards have been found to have a greater significant effect as compared to intangible rewards (Xiao, 2023).

Shaker, Brignell and Pugh (2023) found that incentivization through mark allocation increased student engagement in pre-class reading. Incentives like financial resources, food, and prize recognition have also been found to be effective in encouraging participation in out-of-school programmes (Collins et al., 2008). Angrist (2009) observed a positive effect of financial incentives on student engagement in comparison to other incentives like peer advising and organized study groups.

While programme incentives can indeed encourage participation and help maximize programme benefits, research suggests that incentives should not be used excessively (Collins et al, 2008).

Kuh (2003) emphasizes the reciprocal responsibilities of both the institution and the students to create engagement. This nexus between the responsibilities of students and institutional agents reiterates the need for monitoring and incentive structures to achieve increased student engagement. Schrock, Iqbal and Masood (2022) proffer email notifications, reflexive teacher evaluations and badge achievement awards as mechanisms for monitoring student engagement in virtual learning environments. Mandernach (2015) asserts that using student self-assessment reports as a monitoring tool is a good way to gauge how engaged students are in the learning process. Self-assessments can take the form of questionnaire completion, focus group discussions, and reflective journaling (Mandernach, 2015). Students can also be monitored using administrative records. According to Mandernach et al. (2011), indicators of student engagement can be found in administrative data such as attendance, assignment submissions, adherence to assignment rules, and involvement in supplementary activities. These monitoring structures will help teachers to know the level of commitment students have made to the learning process.

## 3. Methods

A pragmatist research paradigm guides this study. We adopt a mixed method approach, specifically the explanatory sequential, where a quantitative approach is followed by a qualitative approach. Kroll and Neri (2009) suggest that the mixed method approach is appropriate in instances when researchers want to gain a deeper understanding of quantitative results using qualitative data. In this study, we used qualitative data to better understand the factors driving the different levels of engagement observed quantitatively.

### *Quantitative study*

Our quantitative study employed a quasi-experimental research design involving the exposure of a treatment group to different incentive schemes and monitoring structures in each project cycle to understand their effect on participants' engagement. This design is considered appropriate in educational settings where randomization of participants can be difficult (Harris et al., 2006). We also observed a control group to allow for comparison. The population for our qunaititative study comprised a total of 540 students in the needy but brilliant students' database of the students' financial support office of the university.

### *Sampling*

First, we placed out a call for expression of interest to the population. Second, we screened applications purposively using motivation and academic performance as criteria for selecting 40 participants as our sample (see Table 1 for demographics), jointly shortlisted by the head of the students' financial support office and the research team. Then, we randomly split the 40 participants into two using the lottery approach and labelled them as control or treatment. Sampled participants included male and female students between the ages of 18 and 30. Participants came from different academic levels and areas of study. However, this short course was offered to them in cognizance of the importance of management skills regardless of the area of study and this aligned the university wide vision of providing all students with some basic form of management education.

### *Data collection and analysis*

Our study was designed to use multiple data types: system-generated, observational and self-reported data. System-generated data comprised attendance statistics and assignment submission reports from the university's learning management system. Observational data consisted of notes taken while reviewing recordings of Zoom meetings and evidence submitted by participants to show real-life engagement. During these observations, we focused our attention on highlighting relevant information, like the number of students asking questions in the class and the relevance of the evidence submitted. Self-reported data also included student evaluation of their group activity using the group engagement log.

We consulted varied sources for data collection for this study. Our quantitative data collection sources included: (1) Participants' engagement activity reports from the university's LMS, (2) Participants' engagement activity reports from Zoom and Physical Meetings, (3) Participants' entries in reflection journals, and (4) Participants' submission of evidence for real-

life engagement in ethnographic research. Quantitative data was analyzed using descriptive statistics and t-test analysis.

**Table 1.** Participant's demographics

| Variables | Treatment Group | Control Group |
|---|---|---|
| **Gender** | | |
| – Female | 5 | 10 |
| – Male | 15 | 10 |
| **Level of study** | | |
| – 1st Year | 9 | 13 |
| – 2nd Year | 11 | 7 |
| Age Range | 18-25 | 18-25 |
| **Area of study** | | |
| – Agriculture and natural sciences | 9 | 2 |
| – Humanities and legal studies | 10 | 11 |
| – Educational studies | 1 | 7 |

***Qualitative study***

The qualitative aspect of the study adopted an exploratory research design (Swedberg, 2020) aimed at gaining insights into a new area of study.

***Sampling***

We used a sample of 10 participants randomly selected from the pool of 40 participants earlier sampled using purposive techniques for the quantitative study. In line with arguments by Sarfo et al. (2021), our focus was not necessarily on the numbers but in ensuring a good fit between our research goal of gaining deeper insights, our sampling approach and the principles of data saturation.

***Data collection and analysis***

The study employed interviews for data collection being guided by a semi-structured interview guide. According to Cresswell (2014), interviews create room for deeper insights into a studied phenonomenon making it suitable for the qualititative aspect of this study. Two rounds of interviews were conducted, the second being a follow-up meant to fill in the gaps identified during the analysis. Each interview lasted an average of 30 minutes and was audio recorded after permissions were sought. Audio recordings were then transcribed verbatim and analyzed thematically (Cresswell, 2014) by reducing the data through open and axial coding, displaying the data using tables to identify emerging themes and drawing of conclusions (Schutt, 2011).

***Intervention design***

Table 2 summarises the content, structure, and learning activities in the training programme curriculum. Participants attended ten physical meetings either aimed at exposing them to knowledge on the design thinking process or providing opportunities to apply knowledge to real-life projects. Students worked in static self-selected teams throughout the duration of the programme. Students were required to complete six (6) assignments; namely, challenge framing, sense making, ethnographic research, ideation, prototyping, and reflection assignments. While the first five assignments were team-based, the last was individual-based. One instructor facilitated Training sessions separately for the control and treatment groups, which two volunteers supported. Different monitoring mechanisms were introduced in each project cycle for participants in the treatment group, as shown in Table 3 below. The study also experimented with three different financial and non-financial incentives, as shown in Table 3. Participants in the control group were neither monitored nor received any incentive across the duration of the training. A monitoring and evaluation (M&E) role was created and mandated to 1) remind participants in the treatment group of upcoming/past deadlines and offer support if needed and 2) take feedback on each team's progress with their project.

**Table 2.** Training Programme Overview

| Description | Details |
|---|---|
| Course descriptions | Introduce participants The programme was designed as a co-curricular design thinking training for students in a public higher education institution. |
| Learning objectives | The aim of the programme was to enable participants to develop management-relevant soft skills. |
| Skills targeted | ICT literacy, critical thinking, communication, collaboration, creativity, leadership, and perseverance skills. |
| Number of sessions | Nine (9) sessions |
| Length of sessions | 1 – 4 hours |

**Table 3.** Monitoring and Incentive Mechanisms

| Project Cycle | Monitoring Structure | Incentive |
|---|---|---|
| Project cycle 1 | **Email notifications**<br>Before deadlines: The M&E officer sent each team an email two days before each deadline.<br>After deadlines: The M&E officer sent emails to teams that were yet to submit their assignment on the LMS prior to the arranged meeting. | **Internship opportunity**<br>Internship award was conditioned on a perfect attendance score by attending the two project meetings in the cycle and submitting all assignments related to Project cycle 1 |
| Project cycle 2 | **Telephone calls**<br>Before deadlines: The M&E officer called each team lead two days before each deadline.<br>After deadlines: The M&E officer called teams that were yet to submit their assignment on the LMS prior to the session. | **Perks: Airtime and lunch**<br>Project cycle 2 offered airtime and lunch to every participant who showed up for a project cycle meeting. |
| Project cycle 3 | **Coaching via WhatsApp**<br>Before and after deadlines: The M&E officer joined the WhatsApp group of each team in the treatment group.<br>The M&E officer provided reminders on upcoming deadlines, answered questions, asked for feedback on projects, and initiated discussions among team members | **Cash prize**<br>A cash prize to the best performing team. The best performing team was selected on the basis of attendance, submission of tasks and innovativeness of solution. |

## 4. Results

### *Descriptive Analysis*

Quantitative data on engagement was organized in line with Mandernach's (2015) engagement measurement model under three headings; namely: behavioural, affective, and cognitive. A review of the data collected revealed that some participants failed to input data on some of the indicators under behavioural and affective engagement since it was self-recorded.

Behavioural engagement was measured using frequency of tutoring others, frequency of asking questions and frequency of attendance. Figure 1 below represents the level of behavioural engagement for participants in the treatment group. The chart indicates that 17 participants attended at least one of the 10 sessions. Individual attendance was encouraging with one person attending all 10 sessions and four other participants making it to 9, 8 and 7 sessions respectively. The rest of the participants attended less than 5 sessions. Overall, 8 out of the 17 participants asked

questions in the sessions but only 3 made an effort to tutor others by answering questions and making comments.

Findings from the study shows the behavioural engagement levels for the 11 out of 20 participants in the control group who engaged with the training on a behavioural level. Individual attendance was recorded at a minimum of 1 and a maximum of 7. This means there was no individual who attended all 10 sessions. Additionally, over the course of the training only 7 out of these 11 participants asked questions in class while 3 made an effort to tutor others by answering questions or making comments. Behaviourally, most participants engaged mainly through attendance. Additionally, we observe that participants engaged a lot more by asking questions than supporting their peers in learning.


**Fig. 1.** Level of behavioural engagement of participants in the treatment group

Attendance for the treatment and control groups as shown in Figure 2 indicates a higher attendance rate for the treatment group in comparison to the control group at the start of the training. However, attendance levels increased for both groups over a short period and then dropped for a number of sessions. While this decreases continued steadily for participants in the control group, the graph shows that attendance level picked up again for the treatment group.

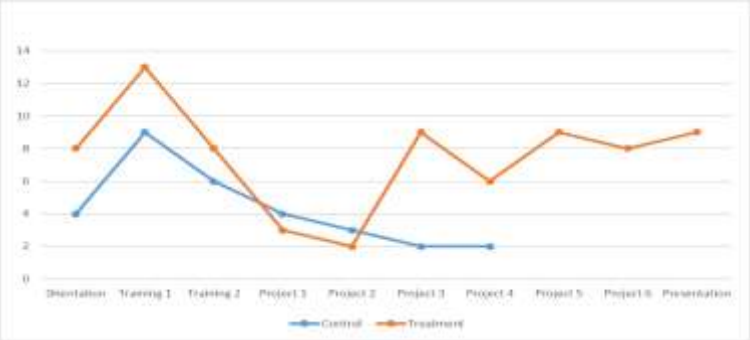

**Fig. 2.** Comparison of behavioural engagement in control and treatment groups

Figure 3 below shows an illustration of the level of cognitive engagement that treatment group participants displayed. According to the chart, all 11 respondents submitted assignments on higher order thinking skills. However, only 2 of the respondents submitted several reflection assignments. For instance, participant S submitted 11 higher order thinking skills assignments while participant A submitted only 1. Efforts made by most participants for the practical assignment submission were generally below average, with the highest being 5 submissions considering that a total of 12 practical assignments were given throughout the training. For the control group, cognitive engagement was observed for 6 participants, but this was relatively lower than the treatment group.

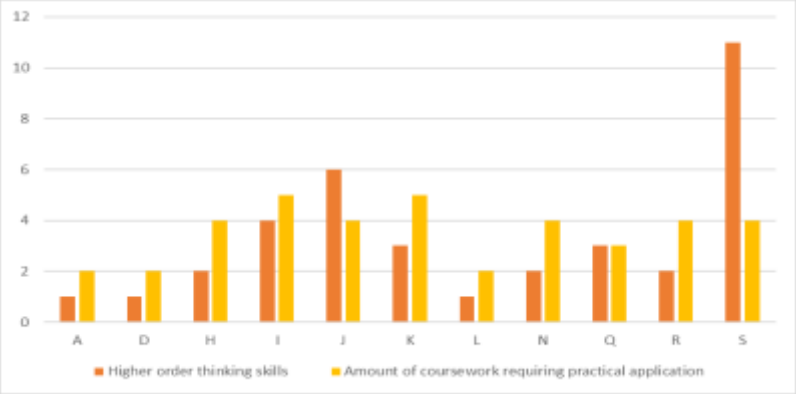


**Fig. 3.** Comparison of behavioural engagement in control and treatment groups

Findings from the study show that six out of the seventeen participants in the treatment group demonstrated affective engagement by giving more than 20 hours of their time to the training. Additionally, in terms of participants' commitment to work harder, measured by the amount of evidence submitted to support the completion of the real-life engagement assignment and the number of requirements in the reflection guide they addressed, we found mixed results. Although the percentage of participants who demonstrated effort to work harder to meet instructor expectations was higher than that of the control, the level of effort made by the few participants in the control group was greater than that of those in the treatment group.

***T-test Analysis***

To validate the observations above on the dynamics of the effect of different monitoring and incentive structures on engagement, we conducted a t-test analysis. The results of the t-test, as shown in Table 4, indicate a significant difference between the control and treatment group regarding all engagement variables ($p < 0.05$) tested except for efforts made by students to meet instructor expectations where the p-value was greater than 0.05. This shows that overall, the incentives that were put in place made a significant difference in attaining the project objective of greater engagement measured by all variables of interest except for the effort that both groups made to meet instructor expectations.

This finding could be because this engagement variable required participants to engage in activities which were relatively more tasking than the other activities. The task required students to engage with real-life to provide real-life evidence in support of the activity. This engagement variable required participants to leverage a wide range of skills, including interpersonal, questioning, and cognitive skills. Additionally, it generally required a higher time commitment in comparison to the other tasks. We also considered it important to further break down the data into sub samples to enable us to better understand the effect of each intervention on engagement for both the control and treatment groups, with the results shown in Table 5.

**Table 4.** Paired T-test results-Complete Project Data

| Variables | Control Group | | Treatment Group | | |
|---|---|---|---|---|---|
| | Mean | Std. Error | Mean | Std. Error | P Values |
| Attendance | 0.433 | 0.135 | 0.967 | 0.141 | 0.0072 |
| Tutoring Others | 0.183 | 0.115 | 1.217 | 0.295 | 0.0017 |
| Asking Questions | 0.2 | 0.1422 | 0.152 | 0.304 | 0.0002 |
| Number of HoTS | 0.1 | 0.0391 | 0.6 | 0.1526 | 0.0023 |
| Practical Assignments | 0.267 | 0.134 | 0.933 | 0.174 | 0.0031 |
| Time Invested | 1.733 | 0.541 | 4.667 | 0.687 | 0.0011 |
| Effort to meet Expectation | 0.3 | 0.210 | 0.57 | 0.175 | 0.3321 |

**Table 5.** Paired T-test results by Project Cycle

| Variable | Treatement (Mean) | Control (Mean) | diff | St. Err | t-value | p-value |
|---|---|---|---|---|---|---|
| **Project Cycle 1** | | | | | | |
| Attendance | 1.3 | 1.1 | 0.2 | 0.447 | 0.45 | 0.657 |
| Tutoring Others | 1.5 | 0.55 | 0.95 | 0.726 | 1.3 | 0.201 |
| Asking Questions | 2.15 | 0.6 | 1.55 | 0.81 | 1.9 | 0.065 |
| Number of HoTS | 0.8 | 0.3 | 0.5 | 0.346 | 1.45 | 0.162 |
| Practical Assignments | 1.2 | 0.5 | 0.7 | 0.482 | 1.45 | 0.154 |
| Time Invested | 5.2 | 4.4 | 0.8 | 1.789 | 0.45 | 0.657 |
| Efforts to meet Expectations | 0.3 | 0.9 | -0.6 | 0.64 | -0.95 | 0.359 |
| **Project Cycle 2** | | | | | | |
| Attendance | 0.75 | 0.2 | 0.55 | 0.246 | 2.2 | 0.032 |
| Tutoring Others | 0.85 | 0 | 0.85 | 0.365 | 2.3 | 0.031 |
| Asking Questions | 1.55 | 0 | 1.55 | 0.505 | 3.07 | 0.006 |
| Number of HoTS | 0.79 | 0 | 0.79 | 0.30 | 2.62 | 0.0175 |
| Practical Assignments | 1.2 | 0.3 | 0.9 | 0.395 | 2.28 | 0.03 |
| Time Invested | 3.82 | 0.8 | 3 | 1.23 | 2.43 | 0.022 |
| Effort to meet Expectation | 1.4 | 0 | 1.4 | 0.45 | 3.11 | 0.0057 |
| **Project Cycle 3** | | | | | | |
| Attendance | 0.85 | 0 | 0.85 | 0.221 | 3.8 | 0.0011 |
| Tutoring Others | 1.3 | 0 | 1.3 | 0.503 | 2.58 | 0.0182 |
| Asking Questions | 0.85 | 0 | 0.85 | 0.28 | 3.0 | 0.0074 |
| Number of HoTS | 0.25 | 0 | 0.25 | 0.123 | 2.03 | 0.0563 |
| Practical Assignments | 0.4 | 0 | 0.4 | 0.184 | 2.18 | 0.154 |
| Time Invested | 5 | 0 | 5 | 1.33 | 3.77 | 0.0013 |
| Effort to meet Expectation | - | - | - | - | - | - |

In Project Cycle 1 there was no significant difference in the levels of engagement between the treatment and control groups measured at a significance level of $p<0.05$. This finding could be because at the onset of the project, participants in both the treatment and control group were running on their internal motivation and willing to fully engage and benefit from the training. In this event, we surmise that at the start of the project, the effect of the intrinsic motivation outweighed the effect of the incentives/monitoring tool put in place because participants perceived specific benefits they will derive like skills development, experiential learning, and networking opportunities.

Additionally, it appears from findings in the qualitative aspect of the study (as explained below) that the implementation of project cycle 1 occurred at a time in the semester when academic demands in the form of quizzes, practical work and assignments were less. This presents very useful feedback about the timing of incentives and monitoring activities. We observe that in Project Cycle two, across all engagement variables, there is a drop in the level of engagement for both the treatment and control group. However, we also observe a significant difference between engagement in the treatment group in comparison to the control group for Project cycle 2; contrary to what was observed for Project cycle 1 where there was generally no significant difference in levels of engagement of the two groups.

Specifically, there was a significant difference in attendance ($p = 0.032$) between the two groups, indicating that a significantly higher number of participants attended sessions in the treatment group than in the control group. This trend runs across all variables tested, and we infer that at this stage in the training programme, the phone calls placed, the internet data, and the lunch coupons provided significantly altered engagement across both groups. Although incentives

were not very effective at the start of the project, they were more effective as the training progressed. As the project advanced and external pressures from academic work increased, the internal motivation waned, and extrinsic motivation in the form of incentives and monitoring activities became effective. Similar patterns were observed in project cycle three; an observation of the means across the engagement variable in project cycle 3 showed that engagement from the control group dropped even further to a point where it could be described as non-existent.

We also find a mixed pattern in the level of engagement for the treatment group across the project cycles. While in project cycle 2, there was a clear drop in engagement across all variables for the treatment group, we observe that in the third project cycle, there were mixed patterns in levels of engagement when compared to project cycle 2. The mean values for attendance, tutoring and time invested increased when compared with the mean values for the same variables in project cycle 2. Thus, we infer that the use of incentives and monitoring mechanisms proved effective in sustaining and even improving engagement in the treatment group as the training progressed.

***Qualitative Evidence***

All the participants interviewed acknowledged facing some challenges in the course of the training. All participants faced challenges with timing. In most cases, the training time clashed with academic activities which sometimes involved courses that were considered very important by students to their academic progression; thus, leading to a decision to skip the training session. In one instance, a participant explained having to make intermittent trade-offs between the training and his maths class. He explains:

*"Sometimes I had to sacrifice class for the training and the training for class."*

Due to these clashes, some of the participants reached out to the training team to either ask for permission or request for rescheduling of training. For one respondent, the reason for his unavailability was personal as he engaged in other co-curricular activities. Another respondent also explained that it was difficult meeting the time needs of everyone due to programme specialization and academic level diversity. A few students who chose to miss sessions due to clashes with academic work tried to catch up through discussions with their peers.

Some participants also raised the issue of communication gaps. They were unable to participate because they did not read email communications. Further, monitoring mechanisms like phone calls were reported by one of the respondents to have been a trigger for re-engagement after a period of dormancy. Regarding incentives, findings from the study indicated that most participants appreciated the airtime and lunch incentives introduced in the second project cycle. Specifically, these participants expressed their concern about the long hours they spent at the training which caused them to skip lunch because they mostly had back-to-back lectures. One respondent explained:

*"I mostly skipped lunch because I had to rush to the training venue from my last lecture for the day and didn't want to run late for the training."*

Another respondent also appreciated that serving lunch at the training made her save money for some pressing needs. Respondents also purported that the provision of airtime for internet data bundles helped them get access to the internet at their convenience. The incentive that featured second was the cash prize for the best-performing team during the final presentation. Participants asserted that they put much effort into working on the last presentation because of the prize that was attached to winning. One respondent recalled:

*"I enjoyed the last project because the cash prize boosted my efforts to push hard."*

Another respondent exclaimed:

*"The cash prize motivated me to work hard, and I wished my team won."*

Lastly, the opportunity for the best-engaged participants to join the junior consultancy programme was considered the least appreciated incentive. Only one respondent mentioned that she *"put in much effort because she wanted to be associated with the junior consultancy programme."*

Regarding monitoring, it was evident from the study that participants considered WhatsApp monitoring to be the most preferred. Participants mentioned that information from the monitoring officer was swift as compared to the other monitoring mechanisms. One respondent emphasized:

*"Information always came on time and there were no challenges receiving the information."*

Participants established that on the WhatsApp platform, all the issues they brought up were addressed. Participants also indicated that they never missed information on the WhatsApp platform since it will always be there for their reference. Next on the monitoring mechanisms were the phone calls. Participants who appreciated phone calls asserted that the phone calls served as a wake-up call to attend the next training. Only one participant highlighted that the email reminders worked for him because he frequently checked his mail.

## 5. Discussion

Our findings show that incentivization enhanced student engagement with the course in line with findings observed in the literature (Collins et al., 2008; Angrist, 2009; Shaker et al., 2023). Nevertheless, the study observes higher levels of behavioural engagement in comparison to affective and cognitive engagement. Additionally, increased engagement as a result of incentives occurred mainly at the behavioural level rather than at cognitive and affective levels. We also identify the important role of timing in incentivization effectiveness. Like Pavetti and Stanley (2016), we found that stressful conditions in the form of pressure from academic work and timetable clashes that call for trade-offs between academic work and co-curricular activities significantly altered the effectiveness of our incentives.

The result of our study also shows that tangible incentives like cash, food, and airtime were more effective in comparison to the intangible reward of an internship opportunity in improving student engagement; thus, suggesting that students prefer tangible rewards and incentives over intangible ones (Xiao, 2023). Moreover, given the socio-economic background of the pool of applicants, we could argue that tangible incentives were more relevant to them. In this vein, Pavetti and Stanley (2016) emphasize the need for incentives to be right-sized for effectiveness.

Our findings contradict arguments made by Schrock et al. (2022) on the usefulness of email notifications for monitoring in virtual learning environments. This may be due to the limited use of email communication in the culture of the studied institution's culture and internet challenges. Therefore, we argue that it is important for management educators to understand the communication culture of students and their institution and use that to shape communication and monitoring mechanisms selected. On the other hand, the results of our study emphasized the important role of technology for monitoring as interviewed participants highlighted real-time benefits that made it easier to keep track of all activities and reminders.

## 6. Implications for Management Education

Based on the findings of our study, we argue that a training module might require higher or lower levels of behavioural, cognitive, or affective engagement depending on the intended outcomes. Therefore, considering the important role that cognitive and affective learning play in management education (Decker et al., 2015), management educators may benefit from tailoring incentives to specific engagement variables like cognitive and affective learning activities rather than tying them to programme level outcomes.

Additionally, the important role of timing identified in our results brings up the question of what activities to put where and when in the design of a management-relevant skills development course to be implemented in co-curricular settings. Based on our findings, we recommend that cognitive activities that require more effort may be better placed at the beginning of the course for our context when the demands on students from regular academic work are minimal. Alternatively, management educators could implement such training programmes around off-peak periods on

the academic calendar, although this might require intensive interactions over shorter periods to achieve the desired outcomes. Incentive duration could also be tied to periods when students face intense pressure from regular academic work (E.g. quiz writing, revision period and examination writing weeks).

Finally, the results of our study imply that management educators must consider the backgrounds of students in determining the mix of incentives to be used. It is important to note that these tangible incentives come at a cost. In the context of public universities in Ghana, where resources are limited, management educators need to consider their funding options.

## 7. Conclusion

In this study, we sought to understand how monitoring and incentive mechanisms shape student engagement in a co-curricular design thinking training program. Based on our findings, we conclude that co-curricular activities tend to compete with regular academic work; incentives and monitoring structures could be useful for encouraging engagement. However, the effectiveness of these mechanisms will depend on several other factors, such as timing, participants' backgrounds, and participants' communication culture. Additionally, educators should pay attention to the type of engagement required, i.e., whether behavioural, cognitive or affective and tie incentives intentionally to relevant activities for optimal outcomes.

## 8. Strengths and Limitations

While this study has many strengths, it is limited in terms of scope and methodology. First, the study focused only on students with a financial support need and an averagely strong cumulative grade point average in their regular academic work. The absence of these two factors could affect how tangible versus intangible incentives played out and the willingness to sacrifice time for co-curricular activities even in times when academic pressure is low; thus, necessitating future studies on students with other backgrounds. Regarding methodology, the use of experimentation allowed for useful comparisons, but controlling for other variables, such as the program studied, could also have been beneficial considering the different demands that different programs make on students.

## 8. Declarations

### *Ethics approval and consent to participate*

The Internal Review Board of Ashesi University Ghana granted ethics approval for this study under protocol number 52022, All participants provided informed consent.

### *Consent for publication*

Participants consented to the publication of any results arising from their participation in the research.

### *Availability of data and materials*

All data are available in a password-protected file maintained by the researcher.

### *Conflict of interest statement*

The manuscript's authors declare no conflicts of interest and confirm that all consulted literature is duly credited in the text and reference list.

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### Authors' contribution

Both authors contributed equally to the designing of the study, data analysis and writing of the manuscript. The first author also took responsibility for data collection.

### Authors' ORCID

Keren Naa Abeka Arthur https://orcid.org/0000-0002-9904-4323

Esther Afoley Laryea https://orcid.org/0000-0001-7177-0027

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