

# Pre-entry Attributes and Academic Persistence at the Master's Level in Science and Technology in Burkina Faso: The Mediating Role of University Experience

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Résumé de l'article

*La présente recherche vise à expliquer l'effet de l'expérience universitaire (bourse, redoublement) sur la relation entre les caractéristiques de préadmission (profession du père, genre, lieu de naissance, âge à la première inscription, domaine d'étude, score à l'examen de fin du secondaire, délai d'inscription, réforme universitaire) et la persévérance aux études à la maîtrise en sciences, technologies, ingénierie et mathématiques (STIM) à une université au Burkina Faso. La régression de Cox et l'analyse moderne de médiation sont utilisées sur des données longitudinales de 14 cohortes d'étudiants (n = 13 891). Les résultats indiquent une médiation indirecte uniquement (profession du père [autre], domaine d'étude, âge à la première inscription); une médiation complémentaire (score à l'examen de fin du secondaire); une médiation compétitive (délai d'inscription, réforme universitaire); une absence de médiation (lien direct uniquement) pour le genre; et aucun effet médiateur pour le lieu de naissance et la profession salariée du père. Des programmes de bourses ainsi que des réformes et politiques adéquates visant à réduire le redoublement amélioreraient la persévérance aux études à la maîtrise en STIM.*

## **Pre-entry Attributes and Academic Persistence at the Master's Level in Science and Technology in Burkina Faso: The Mediating Role of University Experience**

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**MOTS CLÉS :** persévérance aux études, expérience universitaire, analyse de survie, analyse de médiation, Burkina Faso

*La présente recherche vise à expliquer l'effet de l'expérience universitaire (bourse, redoublement) sur la relation entre les caractéristiques de préadmission (profession du père, genre, lieu de naissance, âge à la première inscription, domaine d'étude, score à l'examen de fin du secondaire, délai d'inscription, réforme universitaire) et la persévérance aux études à la maîtrise en sciences, technologies, ingénierie et mathématiques (STIM) à une université au Burkina Faso. La régression de Cox et l'analyse moderne de médiation sont utilisées sur des données longitudinales de 14 cohortes d'étudiants ( $n = 13\ 891$ ). Les résultats indiquent une médiation indirecte uniquement (profession du père [autre], domaine d'étude, âge à la première inscription); une médiation complémentaire (score à l'examen de fin du secondaire); une médiation compétitive (délai d'inscription, réforme universitaire); une absence de médiation (lien direct uniquement) pour le genre; et aucun effet médiateur pour le lieu de naissance et la profession salariée du père. Des programmes de bourses ainsi que des réformes et politiques adéquates visant à réduire le redoublement amélioreraient la persévérance aux études à la maîtrise en STIM.*

KEY WORDS: academic persistence, university experience, survival analysis, mediation analysis, Burkina Faso

*The purpose of this research is to analyze the effect of the university experience (scholarship, repetition) on the relationship between pre-entry attributes (father's occupation, gender, place of birth, age at first enrollment, field of study in high school, graduate point average [GPA], university enrollment delay in the university, university reform) and academic persistence in master's degree in science, technology, engineering, and mathematics (STEM) at a university in Burkina Faso. Cox regression and modern mediation analyses are used on longitudinal data from 14 cohorts of freshmen ( $n = 13,891$ ). Findings revealed indirect-only mediation (father's occupation [other], field of study in high school, age at first enrollment), complementary mediation (GPA), competitive mediation (university enrollment delay, university reform), and an absence of mediation (direct-only) for gender. There is no mediating effect for the place of birth and the father's salaried profession. Scholarship programs as well as appropriate reforms and policies aiming to reduce repetition are required to improve academic persistence in master's degree in STEM.*

PALAVRAS-CHAVE: perseverança nos estudos, experiência universitária, análise de sobrevivência, análise de mediação, Burkina Faso

*A presente investigação visa explicar o efeito da experiência universitária (bolsa de estudos, repetição) na relação entre as características de pré-admissão (profissão do pai, gênero, naturalidade, idade da primeira matrícula, área de estudo, classificação no exame final do ensino secundário, prazo de inscrição, reforma universitária) e perseverança nos estudos de mestrado em ciência, tecnologia, engenharia e matemática (STEM) na Universidade Joseph Ki-Zerbo do Burkina Faso. A regressão de Cox e a análise moderna de mediação são usadas em dados longitudinais de 14 coortes de alunos ( $n = 13\ 891$ ). Os resultados indicam apenas uma mediação indireta (profissão do pai [outra], área de estudo, idade na primeira matrícula); uma mediação complementar (classificação no exame final do ensino secundário); uma mediação competitiva (prazo de inscrição, reforma universitária); uma falta de mediação (ligação direta apenas) para gênero; e nenhum efeito mediador para o local de nascimento e a profissão assalariada do pai. A perseverança nos estudos de mestrado em STEM melhoraria com programas de bolsas de estudo e reformas e políticas adequadas destinadas a reduzir a repetição.*

## Introduction

Science, technology, engineering, and mathematics (STEM) disciplines are well known for their ability to contribute to a country's overall development. The knowledge and skills that come from these disciplines are particularly crucial to a country's economic growth (Rottinghaus et al., 2018). According to global projections, many STEM-oriented jobs will be created soon, resulting in an increased need for highly skilled professionals (Bureau of Labor Statistics, 2019). Therefore, training a skilled workforce in these disciplines at the master's and doctoral levels is an important concern both globally and within the Burkinabe context.

To foster greater expertise in STEM, Burkina Faso, through its educational policy, has been looking to develop STEM skills by increasing educational opportunities in mathematics, physics, chemistry, biology, biochemistry, and geology. The establishment of science schools in each of the country's 13 regions and the awarding of prizes to the top-performing students are examples of initiatives implemented in 2016 to provide better access conditions in STEM and higher education. By adopting this approach, the government aims to ensure equal access to quality education and lifelong learning opportunities.

Although progress has been made in education in general, inequalities remain between and within countries (World Bank, 2020). In Burkina Faso, the number of graduates in STEM is among the lowest of the various university study programs (Kobiané & Pilon, 2013). For the 2008-2009 academic year, the dropout rate among first-year students was 43.2% in the department of fundamental and applied sciences (mathematics, physics, and technology) and 31.2% in the department of life and earth sciences (biology, chemistry, biochemistry, and geology). The overall dropout rate for the first three years of university was around 43%—it reached 70.1% in the former department and 47.5% in the latter in 2006-2007 (Kobiané & Pilon, 2013). These dropout rates can be seen as losses of human capital that may represent obstacles to the country's economic development.

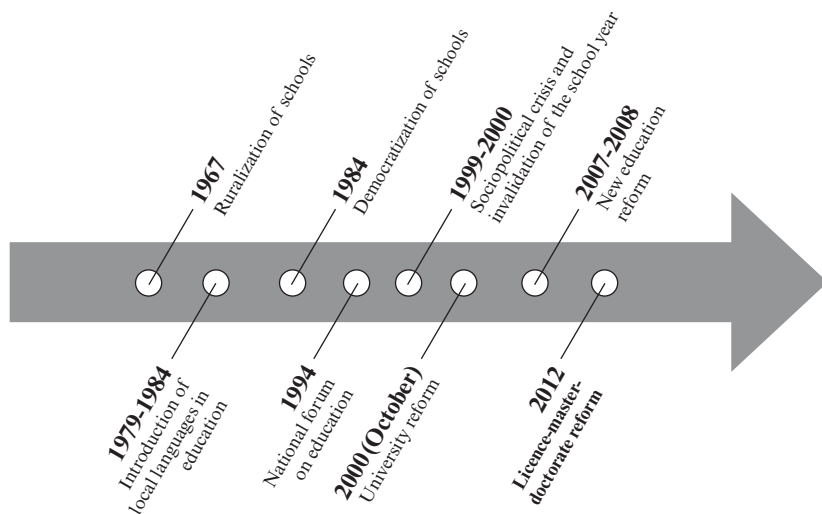
Although access to higher education has improved in Burkina Faso, graduating, or persistence in higher education remains a challenge (Zagré, 2007). The present research focused on the effect of university experience (scholarship and repetition) on the relationship between pre-entry attributes and academic persistence. In this study, enrollment in a STEM master's level at a university in Burkina Faso was used as a measure of academic persistence. Improving persistence at the master's level in STEM could be a powerful way to improve the lives of Burkinabè, notably by training professionals capable of addressing the country's sociosanitary issues (e.g., malaria, waterborne diseases, hunger, etc.).

Building on Tinto's (1997) work on student persistence, a better understanding of the variables affecting academic persistence will help guide educational policy, improve persistence in the STEM master's degree, and mitigate inequalities and differences in pre-entry attributes that are most likely to impact persistence. The efforts made to improve persistence in STEM studies should be based on an understanding of why students either drop out or persist (Ehrenberg, 2010). This research examined longitudinal data from 14 student cohorts using Cox regression and modern mediation analysis (Zhao et al., 2010).

### ***Burkina Faso and the Education System***

Burkina Faso is a landlocked country in sub-Saharan Africa with limited economic capacity and natural resources. Most of its economy is based on agricultural activities, which make up nearly 80% of the working population. The country is particularly vulnerable to weather events and rainfall fluctuations. Periods of low rainfall have a financial impact on farmers whose incomes depend on their crops, which in turn reduces their ability to afford higher education for their children<sup>1</sup>.

The education system in Burkina Faso has undergone several reforms since the country's independence in 1960 (see Figure 1). In 1984, the democratization of the school system allowed for a significant increase in student enrollment in higher education. All high school graduates were free to pursue university studies and were granted scholarships to do so. However, the 1987 coup d'état and structural adjustment policies in the 1990s led to a drastic reduction in funding streams towards education, which reduced the financial aid available to students.



*Figure 1.* Education System Reforms in Burkina Faso.

Subsequently, in 1999, a sociopolitical crisis led to a new university reform that came into effect in October 2000. This reform was the culmination of several campus protests (boycotts, vandalism, and student strikes) that had affected the course of the academic year and activities. As a result of these events, the government issued a failing grade (invalidated academic year) to all university students. Students were forced to repeat courses the following year, and many lost their scholarships as a result. Faculties were dissolved to make way for training and research units. This reform, known as *refondation* (restructuring), aimed among other things to improve governance by making the university a public institution of a scientific, cultural, and technical nature.

Prior to 2012, university education included a two-year general academic studies degree (DEUG), a licence (one year after the DEUG), a master's degree (one year after the licence), and a doctorate (five years after the master's degree). After the 2012 reform, the structure of higher education curricula was changed to the following: licence (three years), master's degree (two years), and doctorate (three years). Today, Burkina Faso has four large public universities (over 10,000 students), three medium-sized

public universities (under 10,000 students), and more than 20 private universities and colleges. In 2017, as in previous years, the high school graduation rate (a requirement for enrolling in university) was under 40% (MESRSI, 2019). Also, 31% of students who graduated from high school decided to pursue a university education. Of all the students at Joseph Ki-Zerbo University in 2016, 34.5% were enrolled in STEM studies as first-year students (MESRSI, 2019) and the overall dropout rate for the first three years of study was at least 43%.

## Conceptual Framework

### *Academic Persistence*

In scientific literature, academic persistence refers to:

- 1) engagement in academic work (Miller et al., 1996; Robbins et al., 2004);
- 2) persistence when faced with difficult problems in the class (Miller et al., 1996);
- 3) the conscious choice to pursue a learning activity cognitively, metacognitively and affectively, despite obstacles and difficulties (Pintrich & Schunk, 2002);
- 4) tenacity—despite obstacles and difficulties, the learner shows determination and continues to devote time to the learning activity (Viau, 2009);
- 5) the idea of persevering despite obstacles (Multon et al., 1991);
- 6) resilience (Miller & Tatum, 2008).

The convergence point of these definitions is that academic persistence is a longitudinal process involving a multitude of behaviors (De Clercq et al., 2014) that can be captured by a variety of measures:

- 1) length of time during which a student remains enrolled in the institution (Houme, 2009; Pritchard & Wilson, 2003; Robbins et al., 2004);
- 2) obtainment of a diploma (DeRemer, 2002; Kamanzi et al., 2010);
- 3) student effort in learning activities during the year (Neuville et al., 2007);

- 4) continuous enrollment from one semester to the next in a program of study (St. John et al., 1991), including students who have taken a break.

Researchers have also measured academic persistence by one's intention to continue with their program (DaDeppo, 2009; Schmitz et al., 2010), which represents more of a motivational approach (Roland et al., 2015). In this research, enrollment in the STEM master's program is used as a measure of academic persistence.

### ***Pre-entry Attributes***

Differences in pre-entry attributes have been found to influence academic persistence regardless of whether the theories were psychological, social, economic, organizational, or interactionist (Cabrera et al., 1993; Eccles & Wigfield, 2002; Tinto, 1975, 1997). In his 1997 model, considered the most robust model by Braxton and Hirschy (2005), Tinto grouped family background, individual attributes, and prior school experience into the broader category of pre-entry attributes.

#### ***Family Background***

First, family background focuses on the socioeconomic status of the family (family income, capital, parental occupation, and education, etc.). Murdoch et al. (2012) understood family background through the level of education of the parents, ethnocultural background (ethnicity, province of residence, etc.), and social background (parents' socioprofessional category and income).

#### ***Individual Attributes***

Building on Tinto's (1997) approach, individual attributes refer to gender, age, place of birth, motivation, personality, and social, intellectual, and political preferences.

#### ***Prior School Experience***

Finally, Tinto (1997) regrouped under prior school experience the student's performance in high school and the type of school attended (private, public, class size, etc.). As for Kamanzi et al. (2010), they operationalized prior school experience through high school GPA, time spent on homework, dropout episodes, interruption of studies prior to university entry, and type of high school attended (private or public).



According to the literature, math grades, high school GPA, high school rank, and grades in the first semester of university were predictors of persistence in STEM studies (Gayles & Ampaw, 2011; Green & Sanderson, 2018; Heilbronner, 2011; Thompson & Bolin, 2011). Early enrollment in STEM was also an important factor in academic persistence (Green & Sanderson, 2018). Age at the time of enrollment should also be considered. Finally, earlier and sustained exposure to STEM fields has been found to be beneficial to students who chose to pursue graduate studies in these fields (Kokkelenberg & Sinha, 2010).

### ***University Experience***

University experience refers to the pedagogical environment; the experience of the classroom, laboratory, and practical work; the social environment (interaction with peers and professors); and the university resources (Tinto, 1997).

First, the student's academic performance (success, failure, repetition, interruption, etc.) is a result of their adaptation to the pedagogical and social environment (Tinto, 1997). Thus, repeating or retaking a course is a factor that can influence the classroom experience and the student's decision to persevere or drop out (Kobiané & Pilon, 2013).

Regarding academic resources, several studies have examined the influence of financial aid on academic persistence (Chen, 2008). Chen and Desjardins (2010) found that subsidized loans on average had a positive effect on academic persistence, whereas unsubsidized loans had no significant influence. Financial aid was also found to have a positive effect on academic persistence (Astin, 1976) and a negative effect on dropout (Desjardins et al., 1999). However, other studies found no effect (Moline, 1987; Peng & Fetters, 1978).

### ***Pre-entry Attributes and Academic Persistence***

#### ***Family Background***

First, regarding family background, Kamanzi et al. (2010) found ( $n = 10,882$ ) that in Canada, students whose fathers held managerial or professional positions were not only more likely to access university education, but also more likely to persist further than those whose fathers did not hold such positions. In the United States, Chen (2008) found that in the 1995-1996 school year, 56% of students ( $n = 6,733$ ) from wealthy families earned a bachelor's degree, compared to only 26% of students from

modest-income families. At the University of Johannesburg, South Africa, Van Zyl (2016) found that students ( $n = 21,037$ ) from disadvantaged backgrounds or modest-income families were less likely to persist compared to those from wealthier families. In Burkina Faso, Kobiané and Pilon (2013) noted that students ( $n = 78,018$ ) whose fathers had a salaried profession (substantial and stable income) were less likely to persist after one year, compared to students whose fathers were farmers (modest income).

### *Individual Attributes*

Regarding individual attributes, St. John et al. (1991) found that in the United States ( $n = 6,075$ ), based on an analysis of financial aid variables, prior school experience and gender were significantly correlated with student retention. Kamanzi et al. (2010) found that graduation rates were higher for women than for men in Canada. Graduation rates were also higher for 26-year-old students than for younger students. In addition, rural residents faced significant challenges when attempting to pursue higher education (Kamanzi et al., 2010).

### *Prior School Experience*

Regarding prior school experience, Engstrom and Tinto (2008) showed that underprepared students—students who did not perform well in school—were less likely to persist in university than those who performed well and those who had been prepared to university studies. Kamanzi et al. (2010) found that among Canadians aged 18 to 20 in 1999, obtaining a bachelor's degree was positively correlated with prior school experience. Students with a higher high school GPA score spent generally more time on homework and were more likely to graduate in four years. Lastly, Murtaugh et al. (1999) found that in the United States ( $n = 8,867$ ), prior school performance was the variable with the largest effect.

### *Pre-entry Attributes and University Experience*

Loye et al. (2017) noted the paucity of studies on the relationship between pre-entry attributes and university experience. Nonetheless, Allen and Bir (2012) showed ( $n = 2,433$ ) that prior school experience—measured by a student's high school GPA—was significantly correlated with their university GPA. Nicpon et al. (2006), on the other hand, found ( $n = 40$ ) that social support through family and friends had no effect on student academic performance. However, race and cultural identity did influence student engagement in their program (Veal et al., 2012).

### ***University System Experiences and Academic Persistence***

Regarding university experience, failing, repeating a course or an academic year, or dropping a course or program of study were related in part to the relevance of the learning activities for the students (Heilbrun, 1965; Tinto, 1997), but also to study strategies (Murdoch et al., 2012) and teaching strategies (Engstrom & Tinto, 2008), and had an effect on academic persistence. Ishitani (2016) found ( $n = 7,571$ ) that a one-point increase in first-year score decreased the risk of dropping out in the second year of college. In turn, Wood (2014) showed that students ( $n = 16,100$ ) who retook a course to improve their grade were more likely to persist than those who did not.

Regarding university resources (scholarships, loans, and grants), studies are mixed as to whether financial aid has a positive impact on academic persistence (St. John et al., 1991). For Hansen (1983), financial aid provided to students is seen as a cash transfer program that does not improve access to higher education. Astin (1976) found a negative relationship between academic persistence and loans for men, but a positive one for women between the first and second years of college. Terkla (1985) showed that receiving financial aid had a positive effect on academic persistence. Breier's (2010) research on reconceptualizing the role of financial aid in higher education suggested that many students in developing countries dropped out of school for financial reasons. Furthermore, according to Dowd (2004), merit-based rather than need-based financial aid may exacerbate inequalities among students.

### ***Mediation Analysis***

In a mediation model (see Figure 2), the effect of an independent variable  $X$  on a dependent variable  $Y$  is carried through a third variable  $M$ , called a mediator (MacKinnon, 2008). These relationships are captured in the following three equations:

There have been significant advances in the development of mediation analysis methods over the past 10 years. Building on the work of Baron and Kenny (1986), Zhao et al. (2010) proposed a modern approach where:

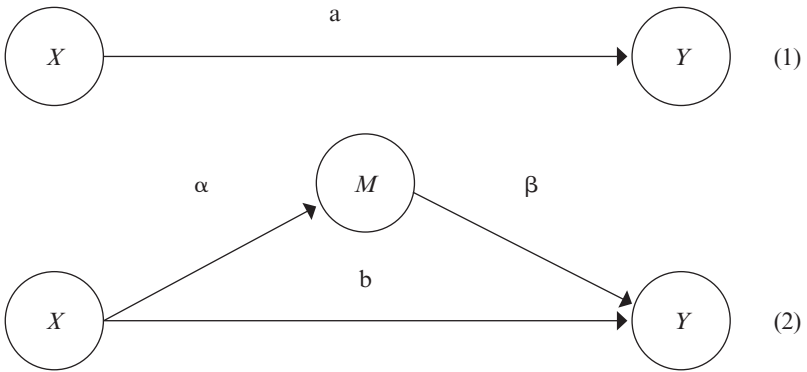
- 1) The strength of a mediation is measured by the importance or size of the indirect effect, rather than the lack of a direct effect. The presence of a direct effect may suggest the presence of other mediating variables not considered in the analysis.

*Equations 1, 2, 3*

$$Y = i_1 + aX + e_1 \quad (1)$$

$$M = i_2 + \alpha X + e_2 \quad (2)$$

$$Y = i_3 + bX + \beta M + e_3 \quad (3)$$



**Figure 2.** Mediating Effect of a Variable, Based on Mackinnon (2008)

2) There need not be a significant effect between the dependent variable  $Y$  and the independent variable  $X$ . A significant indirect effect ( $\alpha \times \beta$ ) could be sufficient, because the total effect is given by  $a = (\alpha \times \beta) + b$ . When  $b$  and  $(\alpha \times \beta)$  are of the same sign, then  $a$  is also of the corresponding sign. If  $(\alpha \times \beta)$  and  $b$  are of opposite signs, the value of  $a$  could be close to 0 and the total effect may turn out to be insignificant.

3) Bootstrapping is used as a robust approach to determine the significance level of the effects (Preacher & Hayes, 2004).

There are five possible outcomes of a mediation:

- 1) *Complementary mediation*: The mediated effect and the direct effect are significant and of the same sign.
- 2) *Competitive mediation*: The mediated effect ( $\alpha \times \beta$ ) and the direct effect  $b$  are significant and of opposite signs.

- 3) *Indirect-only mediation*: The mediated effect ( $\alpha \times \beta$ ) is significant, but the direct effect  $b$  is not significant.
- 4) *Absence of mediation with direct effect*: The direct effect is significant, but the indirect effect is not significant.
- 5) *Absence of mediation*: Neither the direct effect  $b$  nor the indirect effect ( $\alpha \times \beta$ ) is significant.

Based on the nature of the dependent and mediating variables, various linear regression models (Hayes, 2013), logistic models (Nguyen et al., 2015; VanderWeele & Vansteelandt, 2010), survival analysis models (Lange & Hansen, 2011), as well as direct and indirect effects decomposition methods have been developed. These models are applicable to longitudinal data and survival analysis models (Gelfand et al., 2016; Lapointe-Shaw et al., 2018).

In the case of a survival analysis, to determine the mediated proportion as a percentage, VanderWeele and Vansteelandt (2010) suggest using the following formula:

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$$\% = \frac{OR^{NDE}(OR^{NIE}-1)}{(OR^{NDE} \times OR^{NIE}-1)} \times 100;$$


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where<sup>2</sup>  $NDE$  = direct effect;  $NIE$  = indirect effect; and  $OR$  = odds ratio. This formula is suitable for the analysis of survival data using accelerated failure time models and proportional hazard models (VanderWeele, 2016).

In the presence of several mediating variables, the percentage mediated by each variable can be estimated by entering each mediating variable in a separate model. The mediated effect percentage is then given for each of the mediating variables. The sum of these percentages can be greater than 100% in three cases (VanderWeele, 2015): 1) the existence of mediating variables with negative mediated proportions; 2) at least one of the mediating variables having an effect on the other mediating variables; and 3) interaction between the mediating variables. To address this, Nguyen et al. (2015) proposed a method using inverse odds ratio weighting. This method can be applied in cases where the mediating variables interact, which is a

step forward for the estimation of mediated effect proportions. The significance of the effects is determined by using the bootstrap method, which is a robust approach (VanderWeele, 2015; Zhao et al., 2010).

### **Purpose of the Study**

In a systematic review of scientific literature published in peer-reviewed journals using several databases (ERIC, PsycINFO, MEDLINE, Ariane, Érudit, and Cairn) on the relationships between the pre-entry attributes, university experience, and academic persistence variables, Loye et al. (2017) found no research addressing all three variables in the African context. Nine articles examined the relationships between these three variables, 62 examined the relationship between pre-entry attributes and academic persistence, 12 examined the relationship between pre-entry attributes and university experience, and 51 examined the relationship between university experience and academic persistence. Only two papers focused on STEM education. Further research is therefore needed to examine the mediating role of university experience on the relationship between pre-entry attributes and academic persistence.

Several studies on persistence in STEM have found that once academic preparation is accounted for, some of the gender difference in academic persistence is eliminated (Griffith, 2010; Price, 2010). Students who attended STEM classes in high school and maintained a higher GPA in high school were found to be more likely to persist in academic STEM studies (Kokkelenberg & Sinha, 2010; Price, 2010), although these factors were only weak predictors of academic persistence when university grades were analyzed (Ost, 2010; Rask, 2010). This latter finding does not mean that these factors are unimportant, but rather that their effects are primarily mediated through student performance in university courses (Ehrenberg, 2010).

This research aimed to shed light on how these mechanisms operate in the STEM fields at the university level in Burkina Faso. This study sought to answer the following research question: Does university experience mediate the relationship between pre-entry attributes and academic persistence (as measured by enrollment in a master's program) in STEM in Burkina Faso?

Key variables found in the literature has been examined: place of birth, field of study in high school, university enrollment delay, and university reform.

In this study, place of birth was a dichotomized variable (urban/rural) used to capture whether students attended primary school in an urban or rural area. In Burkina Faso, as in many African countries, high schools and universities are generally located in urban areas (Schewel & Fransen, 2018), which makes it easier for students born in cities to continue their education.

Students who pursue a university degree in STEM in Burkina Faso are mainly students who attended these programs in high school. However, graduates from other high school programs (accounting, humanities, etc.) may also enroll in STEM at the university level as part of the school and university counseling process. Given that this counseling process may have an impact on academic persistence, we have included a field of study in high school variable in the analysis.

The university enrollment delay variable captured the amount of time between high school graduation and first enrollment in university. Taking a longer or shorter break after high school prior to university could influence academic persistence in STEM. Thus, understanding the effect of university enrollment delay could help inform initiatives aimed at improving academic persistence.

Finally, a reform variable has been analyzed to capture the effects that reforms, such as the 2000 higher education reform in Burkina Faso, may have on academic persistence. A better understanding of these effects could help define the role of reforms in reducing disparities in academic persistence.

## **Methodology**

### ***Data Collection Process***

The data used in this study were collected as part of Kobiané and Pilon's (2013) study on the valorization of higher education data in Burkina Faso. Information from university administrative forms that were filled out by students when they enrolled in university was compiled into a database of 14 student cohorts (1995 to 2008). The cohorts were tracked

only up to 2011. All cohorts were tracked for a minimum of four years and up to more than 10 years for the older cohorts. The home university ethics committee approved the use of the data.

### ***Sample***

The sample consisted of 13,891 students, 20.6% of whom enrolled in the master's degree program in science and technology (see Table 1). This enrollment rate varied by cohort, depending on the number of years of tracking (from four to over 10 years). The 1995, 2006, 2007, and 2008 cohorts (0.2% to 17.1%) had the lowest rate, followed by the 1996, 1997, 1998, and 2005 cohorts (20.7% to 26.7%), and the 1999 to 2004 cohorts (31.1% to 35.9%).

Regarding pre-entry attributes, students' fathers were primarily farmers, and more men were enrolled in science and technology than women.

Regarding individual attributes, 92.8% of students were under 25 years old when they first enrolled in university.

Regarding prior school experience, there were slightly more students born in urban areas. 10.4% of the students performed well on the high school exit exam—students who scored 12 or more out of 20 were performing well. The field of study in high school was mainly science (94.9%). Before the 2000 reform, 25.0% of students were enrolled in science and technology. Only 6.1% of students enrolled in university at least one year after high school graduation.

Finally, regarding university experience, 6.7% of students received a scholarship and 59.8% had at least one repetition in their education.

### ***Variables***

Enrollment (or not) in the master's program was used as a measurement of academic persistence and served as the dependent variable for the analysis. The independent variables were the different pre-entry attributes of the students, and the mediating variables were the elements related to university experience.

The education reform variable had two possible values, namely *before* or *after* the 2000 reform. The age at first university enrollment variable was dichotomized (*under* or *over* 25 years old) to reflect whether students had followed the standard curriculum—age at entry into primary school (six to eight years old), plus the length of the study cycles (six years for



Table 1  
*Definition of variables and sample*

<b>Variables</b>	<b>Definition</b>	<b>N°</b>	<b>%</b>
<b>Academic persistence</b>	<i>Master's degree enrollment</i>		
	1 = Yes	2,861	20.6
	0 = No	11,030	79.4
<b>Pre-entry attributes</b>			
Family background	<i>Father's occupation</i>		
	0 = Farmer	6,087	43.8
	1 = Salaried	3,354	24.2
	2 = Other	4,450	32.0
Individual attributes	<i>Gender</i>		
	1 = Female	1,780	12.8
	0 = Male	12,112	87.2
	<i>Age at first university enrollment</i>		
	0 = ≥ 25 years old	1,002	7.2
	1 = < 25 years old	12,889	92.8
	<i>Place of birth</i>		
	0 = Urban	7,000	50.4
	1 = Rural	6,891	49.6
Prior school experience	<i>High school exit exam score</i>		
	0 = 10-12	12,447	89.6
	1 = 12-20	1,444	10.4
	<i>Field of study in high school</i>		
	0 = Literature/technical	710	5.1
	1 = Sciences	13,181	94.9
	<i>University reform</i>		
	0 = Before reform	3,467	25.0
	1 = After reform	10,424	75.0
	<i>University enrollment delay</i>		
0 = > 1 year	844	6.1	
1 = ≤ 1 year	13,047	93.9	
<b>University experience</b>	<i>Receipt of a scholarship</i>		
	0 = No	12,965	93.3
	1 = Yes	926	6.7
	<i>Repetition</i>		
	0 = No	5,588	40.2
	1 = Yes	8,303	59.8

primary school, seven years for high school with two possible repetitions per cycle). The score on the departmental high school exit exam (covering all subjects) was a dichotomized variable (10-12 or 12-20) reflecting the level of performance.

### ***Analysis***

Cox's (1972) regression model can be used to analyze academic persistence as a longitudinal process (Tinto, 1997). It is by far the most widely used model for the analysis of longitudinal data (Cleves, 2008).

Cox's regression model addresses issues related to censoring and truncation, which cannot be resolved with cross-sectional data (Kamanzi et al., 2016). In this model, a delay variable was created reflecting the length of time between the date of initial enrollment in the university and enrollment in the master's program. Odds ratios (OR) were used to interpret the results by comparing the groups to the reference group for each variable. When  $OR > 1$ , the group was 1 - OR times more likely to persist than the reference group for that variable. When  $OR \leq 1$ , the reference group was 1 - OR times less likely to persist than the one considered for comparison. Goodness of fit was estimated using Cox and Snell's (1968) residuals: if the cumulative hazard is close to the 45° straight line (Cleves, 2008), then the data is consistent with the model.

This study drew on recent advances in modern models of mediation analysis (Nguyen et al., 2015; VanderWeele, 2015; Zhao et al., 2010). Four models were examined:

- 1) Model 1 estimates the effect of pre-entry attributes on academic persistence.
- 2) Model 2 introduces the scholarship mediator in Model 1 to observe changes in the odds ratios.
- 3) Model 3 introduces the repetition mediator in Model 1 to observe changes in the odds ratios.
- 4) Model 4 introduces both mediators simultaneously in Model 1.

The likelihood ratio test was used to assess the added value of the variables in the models (Crichton, 2002). The bootstrap method was used to perform 1000 replications to determine the significance level of the direct and indirect effects. The mediated effect proportion was only calculated for indirect-only mediations and complementary mediations, because it does not apply to competitive mediations (VanderWeele, 2015).

## Results

### *Model 1: Effects of Pre-entry Attributes on Academic Persistence*

Goodness of fit was estimated using the Cox and Snell (1968) residuals. The  $\beta_2$  estimate showed no significant difference, and the residuals plot indicated that the data fit the Cox regression model. The results showed that father's occupation (other), gender, age at first university enrollment, high school exit exam score, university enrollment delay, and university reform were predictive of academic persistence at the master's level in STEM in Burkina Faso (see Table 2). The place of birth and field of study in high school variables had no significant effect.

No significant difference was observed between students whose fathers were salaried and those whose fathers were farmers. Students whose fathers worked in other sectors (e.g., commerce) were 11% less likely to persist to the master's program than students whose fathers were farmers. Women were 15% less likely to persist to a master's degree than men. Students under 25 years of age when first enrolling at the university were 35% more likely to persist to the master's program than those 25 years of age and older. In addition, students who scored 12 or higher on the high school exit exam were 28% more likely to persist to a master's degree than those with lower scores. Students who enrolled for the first time more than a year after passing the high school exit exam were 20% less likely to persist to the master's program than those who did not. Finally, students who enrolled after the university reform in 2000 were twice as likely to continue to the master's degree as those who enrolled before the reform.

### *Model 2: Mediation Analysis Involving the Scholarship Mediator*

The Cox regression results showed several similarities to those of Model 1. The effect of father's occupation (other), gender, age at first enrollment, and enrollment delay remained essentially unchanged<sup>3</sup>. However, a slight decrease (6%) was observed in the effect of high school exit exam score, along with a small increase (3%) in the effect of reform. For the university experience variable, students with scholarships were 25% more likely to persist to the master's degree than students without scholarships.

The results presented in Table 3 show an absence of mediation (direct and indirect effects were not significant) between the father's occupation variable (salaried profession and other), the place of birth variable

Table 2  
*Effects of University Experience on the Relationship Between Pre-entry Attributes and Academic Persistence: Cox Regression*

Variables	Model 1	Model 2	Model 3	Model 4
<b>Pre-entry attributes</b>				
Family background				
<i>Father's occupation</i>				
Farmer (ref.)				
Salaried	0.97	0.98	0.95	0.95
Other	0.89**	0.89**	0.94	0.94
Individual attributes				
<i>Gender</i>				
Male (ref.)				
Female	0.85**	0.85*	0.94	0.94
<i>Age at first university enrollment</i>				
≥ 25 years old (ref.)				
< 25 years old	1.35**	1.35*	1.09	1.09
<i>Place of birth</i>				
Urban				
Rural	0.95	0.95	0.99	0.98
Prior school experience				
<i>Field of study in high school</i>				
Literature/technical Sciences	1.12	1.12	1.09	1.09
<i>High school exit exam score</i>				
10-12 (ref.)				
12-20	1.28***	1.22***	1.20***	1.15*
<i>University enrollment delay</i>				
> 1 year				
≤ 1 year	0.80*	0.80*	0.79*	0.79*
<i>University reform</i>				
Before the reform (ref.)				
After the reform	2.00**	2.03***	1.74***	1.77***
<b>University experience</b>				
<i>Receipt of a scholarship</i>				
No (ref.)				
Yes		1.25***		1.23***
<i>Repetition</i>				
No (ref.)				
Yes			0.22***	0.22***
Pseudo- $R^2$	0.7%	0.7%	3.3%	3.3%
Likelihood-ratio test	298.39***	310.99***	1409.89***	1420.84***

Note. ref. = reference category; \* =  $p < 0.05$ ; \*\* =  $p < 0.01$ ; \*\*\* =  $p < 0.001$ .

and the scholarship mediator. An absence of mediation with direct effect (significant direct effect and insignificant indirect effect) was observed between the scholarship mediator and the gender, age at enrollment, field of study in high school, and high school exit exam score variables. For the university enrollment delay and university reform variables, there was an indirect-only mediation relationship (direct effect was not significant and indirect effect was significant) with the scholarship mediator.

### ***Model 3: Mediation Analysis Involving the Repetition Mediator***

The results of the Cox regression are rather mixed compared to the two previous models. There were nonsignificant effects for father's occupation (salaried and other), gender, age at first university enrollment, place of birth, and field of study in high school. A decrease in the effect of high school exit exam score (8%), university enrollment delay (1%), and university reform (26%) was observed. With respect to university experience, students who repeated a year were 78% more likely to drop out before enrolling for a master's degree.

The results presented in Table 3 show an absence of mediation from the repetition mediator for the father's occupation (salaried), place of birth, and enrollment delay variables. There was an absence of mediation with direct effect for the gender and field of study in high school variables. An indirect-only mediation from the repetition mediator was observed for the father's occupation (other), age at enrollment, and high school exit exam score variables. Finally, concerning the university reform variable, there were significant indirect and direct effects of opposite signs, suggesting competitive mediation.

### ***Model 4: Mediation Analysis Involving Both Mediators***

Model 4, which considers both mediators simultaneously, has similar Cox regression results to Model 3—nonsignificant effect for father's occupation (salaried and other), gender, age at first university enrollment, place of birth, and field of study in high school. However, a 13% drop in the odds ratio was observed for high school exit exam score, 1% for university enrollment delay, and 23% for university reform. Regarding university experience, students who had repeated a year were 78% more likely to drop out before the master's degree, and those with a scholarship were 23% more likely to persist to the master's degree.

Table 3  
*Decomposition of the Effects of the Variables*

Variables	Receipt of a scholarship			Repetition			Both mediators			Types of mediation		
	Value	%	p	Value	%*	p	Value	%	p	Receipt of a scholarship	Repetition	Both mediators
<i>Father's occupation: salaried</i>										AM	AM	AM
Indirect effect	-0.009	10.6	0.76	-0.058	70.6	0.08	-0.058	70.2	0.08			
Direct effect	-0.072	89.4	0.19	-0.023	29.4	0.66	-0.023	29.8	0.66			
Total effect	-0.081	100.0	0.07	-0.081	100.0	0.07	-0.081	100.00	0.07			
<i>Father's occupation: other</i>										AM	Indirect-only mediation	Indirect-only mediation
Indirect effect	-0.008	29.9	0.35	-0.053	68.0	0.00	-0.053	68.0	0.00			
Direct effect	-0.019	70.1	0.63	0.026	32.0	0.48	0.026	32.0	0.48			
Total effect	-0.027	100.0	0.48	-0.027	100.0	0.48	-0.027	100.00	0.48			
<i>Gender</i>										AM: direct effect only	AM: direct effect only	AM: direct effect only
Indirect effect	0.000	0.0	0.98	-0.002	1.3	0.92	-0.011	8.5	0.54			
Direct effect	-0.121	100.0	0.02	-0.119	98.7	0.02	-0.107	91.5	0.03			
Total effect	-0.121	100.0	0.02	-0.121	100.0	0.02	-0.117	100.00	0.03			
<i>Age at enrollment</i>										AM: direct effect only	Indirect-only mediation	Indirect-only mediation
Indirect effect	0.021	5.1	0.19	0.396	78.8	0.00	0.499	94.7	0.00			
Direct effect	0.515	94.9	0.00	0.140	21.2	0.16	0.037	5.3	0.71			
Total effect	0.536	100.0	0.00	0.536	100.0	0.00	0.536	100.00	0.00			
<i>Field of study in high school</i>										AM: direct effect only	AM: direct effect only	Indirect-only mediation
Indirect effect	-0.001	0.0	0.93	-0.001	0.0	0.95	0.402	68.0	0.00			

Variables	Receipt of a scholarship			Repetition			Both mediators			Types of mediation		
	Value	%	p	Value	%*	p	Value	%	p	Receipt of a scholarship	Repetition	Both mediators
Direct effect	0.667	100.0	0.00	0.667	100.0	0.00	0.265	32.0	0.05			
Total effect	0.666	100.0	0.00	0.666	100.0	0.00	0.666	100.00	0.00			
<i>Place of birth</i>										AM	AM	AM
Indirect effect	-0.003	8.0	0.86	-0.003	8.0	0.86	-0.006	15.3	0.78			
Direct effect	-0.037	92.0	0.39	-0.037	92.0	0.39	-0.034	84.7	0.41			
Total effect	-0.040	100.0	0.29	-0.040	100.0	0.29	-0.040	100.00	0.29			
<i>High school exit exam score</i>										AM: direct effect	Indirect-only mediation	Complementary mediation
Indirect effect	0.002	0.7	0.97	0.185	74.7	0.00	0.134	55.6	0.00			
Direct effect	0.254	99.3	0.00	0.071	25.3	0.18	0.122	44.4	0.04			
Total effect	0.256	100.0	0.00	0.256	100.0	0.00	0.256	100.00	0.00			
<i>University enrollment delay</i>										Indirect-only mediation	AM	Competitive mediation
Indirect effect	-0.082	92.1	0.02	-0.015	16.0	0.48	0.408	–	0.00			
Direct effect	-0.007	7.9	0.93	-0.075	84.0	0.39	-0.524	–	0.00			
Total effect	-0.089	100.0	0.29	-0.089	100.0	0.29	-0.116	–	0.00			
<i>University reform</i>										Indirect-only mediation	Competitive mediation	Competitive mediation
Indirect effect	-0.089	76.0	0.00	0.408	–	0.00	0.322	–	0.00			
Direct effect	-0.027	24.0	0.55	-0.524	–	0.00	-0.438	–	0.00			
Total effect	-0.116	100.0	0.00	-0.116	–	0.00	-0.116	–	0.00			

Note. \* = The proportion is not calculated in case of competitive mediation or direct and indirect effects of opposite signs; AM = Absence of mediation.

The mediation analysis revealed an absence of mediation of the two mediators for the father's occupation (employee) and place of birth. The results show an absence of mediation with direct effect for gender, and an indirect-only mediation for father's occupation (other), age at enrollment and field of study in high school. For the high school exit exam score, the results indicate complementary mediation (significant direct and indirect effects of the same sign). In the case of the enrollment delay and the university reform variables, there were significant direct and indirect effects of opposite signs, suggesting that competitive mediation is occurring.

## Discussion

The objective of this research was to analyze the mediating effect of university experience on the relationship between pre-entry attributes and academic persistence at the master's level in STEM in Burkina Faso. The first observation is that a small proportion of students persist to the master's level, although more than in Togo (a country bordering Burkina Faso), where only 20% of first-year science students enroll in the second year (Houme, 2009). Poor academic persistence could be viewed as a loss of skilled workers (Rottinghaus et al., 2018) and as inefficient public spending. Government authorities should address the reasons for dropouts in these programs. Improving academic persistence at the master's level would contribute to socioeconomic development. Sustained economic growth in Africa will require increased STEM capacity building, a better skilled workforce, and more graduates from master's, doctoral, and applied research programs to increase technology uptake and total productivity.

The results of Model 4 indicate that students who have had a repetition are 78% more likely to drop out before the STEM master's degree, whereas those with a scholarship are 23% more likely to persist to the master's degree. Scholarships would allow students to not only pay tuition but also purchase textbooks and persist through the STEM master's degree. These results are consistent with those found for each of the mediating variables. They corroborate those of Kobiané and Pilon (2013) and are consistent with Tinto's model, which posits that university experience, through financial resources, has an effect on academic persistence. Terkla (1985) found that in the United States ( $n = 12,980$ ), financial aid also had a positive effect on academic persistence. These results are consistent with Chen and Desjardins (2010), who showed that subsidized loans on average



had a positive effect on academic persistence, whereas unsubsidized loans had no significant effect. In Burkina Faso, students will repeat a course because they failed it, rather than because they want to improve their grade, which explains the discrepancies with Wood's (2014) study in the United States.

### ***Family Background***

Father's occupation is a variable that has received little attention in the literature (Loye et al., 2017; Murdoch et al., 2012). However, this variable was found to have a significant effect on academic persistence in STEM master's degree in Burkina Faso. Students whose fathers work in a sector other than agriculture and public administration were less likely to persist at the master's level. Our hypothesis is that these students persist less because business activities take place throughout the year, whereas agricultural activities take place during a shorter period (July to October, which corresponds to the school break). Thus, even though students whose fathers are farmers must work with them during the farming season, doing so does not interfere with their studies. The effect of the father's occupation was mainly mediated through the repetition mediator (indirect mediation only), Model 2 revealing no mediation in the case of scholarships. For students whose fathers are salaried workers and those whose fathers are farmers, there was no relationship or mediation with university experience and academic persistence in the STEM master's program.

### ***Individual Attributes***

Female students were less likely to enroll in STEM master's studies compared to their male counterparts. Women in Burkina Faso spend a great deal of time doing housework (cooking, laundry, etc.) and caring for household members, which limits the amount of time they spend studying. This situation acts as a barrier to persistence in STEM, and compromises their access to decent jobs and autonomy (World Bank, 2020). The same difference between genders is found in the United States and Europe (Ehrenberg, 2010; Green & Sanderson, 2018; Smeding, 2012), but the opposite finding holds true in Canada (Kamanzi et al., 2016). Neither the scholarship nor the repetition variable can explain this divergence. One way to broaden the scope of this study would be to include a variable capturing the levels of academic preparation, which have been found to explain some of the difference in academic persistence between genders

(Griffith, 2010; Price, 2010). Further research on study practices, socio-professional projects, and pedagogical approaches could provide additional insight into these findings.

Differences arising from students' age when enrolling in university have also been studied (Green & Sanderson, 2018; Kokkelenberg & Sinha, 2010). According to these authors, starting STEM studies at a young age would be beneficial in improving academic persistence. In this study, the effect of age was mediated by repetition (indirect mediation only), Model 2 revealing no mediation in the case of scholarships.

Place of birth (rural or urban) was found to have no direct or mediated relationship with university experience and academic persistence at the master's level in STEM. The rationale for including this variable in the research was that in Burkina Faso, as in many African countries, high schools and universities are generally located in urban areas (Schewel & Fransen, 2018), which means that students born in rural areas have to overcome the challenges of moving to the cities.

### ***Prior School Experience***

Unlike other studies (Kokkelenberg & Sinha, 2010; Price, 2010), this research found no differences in academic persistence at the master's level in STEM between students who had studied STEM in high school and students coming from other programs of study. This could be due to the low proportion of students from other programs pursuing STEM degrees at the university level. The inclusion of either the scholarship or repetition mediator showed an absence of mediation with direct effect between the field of study in high school variable and academic persistence. An indirect-only mediation was observed when both mediators were included. Although the field of study in high school variable does not predict academic persistence in STEM, its effect can be explained by the two mediating variables related to university experience (scholarship and repetition). This supports the claim by Zhao et al. (2010) that there is no need for a significant effect from the independent variable to analyze mediation. It should be noted that it was only in the presence of both mediating variables that an indirect-only mediation was observed. This suggests that scholarships and better student support can explain the effect of the field of study in high school variable. Further research is needed to better explain these results. For example, as highlighted by

Ehrenberg's (2010) work, the effect of this variable could be mediated primarily through another university experience variable, namely student performance in university courses.

High school exit exam score has been found to be predictive of persistence in STEM master's studies in Burkina Faso, as it has been in other countries (Green & Sanderson, 2018; Kamanzi et al., 2010; Kokkelenberg & Sinha, 2010; Price, 2010). No mediation was found from the scholarship mediator alone, but indirect mediation was found when only the repetition mediator was included. When both mediators were included, complementary mediation was observed, which helps explain some of the relationship between pre-entry attributes and academic persistence in the STEM master's program. Further research is needed to attempt to explain these results, specifically on the relationship between student performance in high school and student performance in university courses (Ehrenberg, 2010).

Students who enroll after a one-year delay were less likely to persist to the STEM master's degree compared to those who enrolled earlier. An indirect mediation from the scholarship mediator was found. A competitive mediation was found when both mediators were included. Scholarships are available to recent high school graduates who meet the eligibility requirements (age, enrollment delay, parental income, etc.). Students who do not enroll immediately after passing the high school exit exam are unlikely to receive a scholarship. Thus, delay in enrollment would be negatively associated with scholarship receipt, which is positively associated with persistence. This could explain the competitive mediation observed. To our knowledge, this variable is absent from the scientific literature and needs to be better understood.

Students enrolled after the 2000 university reform showed improved persistence at the STEM master's level. As part of this reform, the university moved from a certificate system to a modular system, which allows students to enroll in a course multiple times until graduation (which was previously limited to three enrollments prior to this reform). In addition, financial aid has been improved for many students and the awarding of scholarships has been increased. Indirect mediation was found when only the scholarship mediator was included. Competitive mediation was found when only the repetition mediator was included and when both mediators

were included. The existence of competitive mediation suggests the presence of other mediating variables (e.g., peer and faculty interaction) not included in the analysis (Zhao et al., 2010).

### ***Limitations***

We recognize that this study could have further contributed to the understanding of academic persistence in STEM fields by examining the effect of additional key variables, such as parental education, student-teacher interactions, learning conditions, student support, and teaching methods. Furthermore, research on undergraduate and doctoral persistence in African countries with similar education systems should also be conducted.

### **Conclusion**

The results of this study provide a better understanding of the factors surrounding academic persistence at the master's level in STEM in Burkina Faso. It reveals the mediating role of university experience (scholarship and repetition) on the relationship between pre-entry attributes and academic persistence. This study:

- 1) is one of the first to look at STEM education in the context of Burkina Faso and Africa;
- 2) involves the analysis of 14 student cohorts (nearly 14,000 students);
- 3) uses Cox's (1972) regression model to account for the longitudinal nature of academic persistence;
- 4) uses the modern mediation analysis approach of Zhao et al. (2010).

The two mediating variables (scholarship and repetition) mediate the effects of pre-entry attributes (father's occupation [other], age at enrollment, and field of study in high school) on academic persistence at the master's level in STEM in Burkina Faso—the effects being mostly mediated by the repetition mediator. Regarding the high school exit exam score variable (complementary mediation), the two mediators partially explain its relationship with academic persistence at the master's level in STEM. According to Zhao et al. (2010), this suggests that other mediating variables should be included in the analysis. In order to improve enrollment rates in the STEM master's program, initiatives should be implemented to provide need-based scholarships and to increase support for students so as

to reduce repetition. The effects of enrollment delay and university reform on academic persistence in the STEM master's program are partially mediated by both mediators (competitive mediation). The scholarship mediator alone explains the entire effect of these two variables. The contribution of scholarships is essential for better academic persistence, but repetition appears to play a crucial role in mediating the effects of the university reform and enrollment delay variables. This indicates that scholarships are not enough to ensure better academic persistence in STEM and that it is necessary to provide better student support so as to prevent repetitions.

Students who enrolled after the 2000 university reform are twice as likely to pursue a master's degree in STEM in Burkina Faso than those who enrolled before the reform. However, master's degree enrollment rates remain low. University experience plays an important role in mediating the effects of pre-entry attributes. Improving student support and providing resources to reduce repetition should be a priority. Finally, although one of the goals of the university reform was to ensure equal access to quality education, women still persist less than men in STEM fields. Initiatives should be implemented to address this situation.

Academic persistence is known to be essential to enhancing a country's human capital and strengthening its economic and social development. Improving academic persistence at the master's and doctoral level in STEM fields, as well as promoting research on this issue, could help Burkina Faso address some of its social and health issues (e.g., malaria, waterborne diseases, hunger, etc.) and improve the lives of its citizens. Implementing initiatives to provide inclusive, quality education would also enable the country to make progress in terms of sustainable development.

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## NOTES

1. For more details: <https://www.worldbank.org/en/country/burkinafaso/overview#1>
2. NDE: *natural direct effect*, NIE: *natural indirect effect* and OR: *odds ratio*.
3. Slight differences appear beyond three decimal places.

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