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GENDER AND RACE: A STUDY OF SELF-EFFICACY IN PHYSICS AMONG UNIVERSITY STUDENTS

Iasmin Ramos [I]
Andrey Camurça da Silva [II]
Glauco Cohen F. Pantoja [III]
TRANSLATED BY Glauco Cohen F. Pantoja [III]

[I] Universidade Federal do Oeste do Pará (Ufopa), Santarém (PA), Brasil; iasmin.ramos@discente.ufopa.edu.br
[II] Instituto Federal do Pará (IFPA), Belém (PA), Brasil; andreycamurca@gmail.com
[III] Universidade Federal do Oeste do Pará (Ufopa), Santarém (PA), Brasil; glaucopantoja@hotmail.com

Abstract

Self-efficacy beliefs have recently been investigated in studies of physics teaching, and are relevant for studying the self-evaluation of individuals on perceived performance in specific tasks. We conducted an exploratory study with 170 students from the Universidade Federal do Oeste do Pará, in which they were asked to respond to the following question: "How does self-efficacy, in physics, of students from the Universidade Federal do Oeste do Pará vary in the dimensions of gender identity and race/color?". Results of applying the Sources of Self-Efficacy in Science Courses questionnaire, translated by us into Portuguese and revalidated with $\alpha = 0.94$, indicate moderate mean differences in self-efficacy in physics, in favor of men, with these variations associated mainly with the source of vicarious experience.

SELF-EFFICACY • PHYSICS • GENDER RELATIONS • RACE

GÊNERO E RAÇA: UM ESTUDO SOBRE AUTOEFICÁCIA EM FÍSICA DE ALUNOS UNIVERSITÁRIOS

Resumo

As crenças de autoeficácia vêm sendo recentemente investigadas na pesquisa em ensino de física e mostram-se relevantes para estudo da autoavaliação de indivíduos sobre o desempenho percebido em tarefas específicas. Realizamos um estudo exploratório com 170 estudantes da Universidade Federal do Oeste do Pará para responder ao seguinte questionamento: "como varia a autoeficácia, em física, de alunos da Universidade Federal do Oeste do Pará nas dimensões identidade de gênero e raça/cor?". Os resultados da aplicação do questionário Sources of Self-Efficacy in Science Courses, traduzido para português e revalidado com $\alpha = 0{,}94$, indicam diferenças de média moderadas na autoeficácia em física a favor dos homens, com tais variações associadas principalmente à fonte de experiência vicária.

AUTOEFICÁCIA • FÍSICA • RELAÇÕES DE GÊNERO • RAÇA

GÉNERO Y RAZA: UN ESTUDIO SOBRE LA AUTOEFICACIA EN FÍSICA DE ESTUDIANTES UNIVERSITARIOS

Resumen

Las creencias de autoeficacia que vienen siendo investigadas recientemente en la enseñanza de física se muestran relevantes para el estudio de la autoevaluación de los individuos sobre el desempeño percibido en tareas específicas. Realizamos un estudio exploratorio con 170 estudiantes de la Universidade Federal do Oeste do Pará para responder a la siguiente pregunta: "¿Cómo varía la autoeficacia, en física, de estudiantes de la Universidade Federal do Oeste do Pará en las dimensiones identidad de género y raza/color?". Los resultados de la aplicación del cuestionario Sources of Self-Efficacy in Science Courses, traducido al portugués y revalidado con $\alpha = 0{,}94$, indican diferencias de medias moderadas en la autoeficacia física a favor de los hombres, con tales variaciones asociadas principalmente con la fuente de la experiencia vicaria.

AUTO-EFICACIA • FÍSICA • RELACIONES DE GÉNERO • RAZA

GENRE ET RACE: UNE ÉTUDE SUR L'AUTO-EFFICACITÉ DES ÉTUDIANTS EN PHYSIQUE

Résumé

Les croyances d'auto-efficacité ont commencé à être étudiées récemment dans le cadre de la recherche sur l'enseignement de la physique et se sont avérées pertinentes pour mesurer l'auto-évaluation d'individus à partir de la perception de leur performance dans l'exécution de tâches spécifiques. Nous avons mené une étude exploratoire auprès de 170 étudiants de l'Universidade Federal do Oeste do Pará pour répondre à la question suivante: "comment l'auto-efficacité des étudiants en physique de l'Universidade Federal do Oeste do Pará varie-t-elle selon les dimensions d'identité de genre, de race et de couleur?". Les résultats issus du questionnaire Sources of Self-Efficacy in Science Courses, traduit en portugais, indiquent, avec une consistance interne de $\alpha = 0{,}94$, des différences de moyenne d'auto-efficacité en physique modérées en faveur des hommes. Ces variations sont principalement associées à une source d'expérience vicaire.

AUTO-EFFICACITÉ • PHYSIQUE • GENRE • RACE

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STUDIES ON PROFESSIONAL CHOICE (SILVA, 2012) AND ON GENDER AND RACE (PINTO ET AL., 2012) have shown an inclination of women towards work fields socially described as "feminine", such as health and human sciences, and a lesser number of women oriented to exact sciences, socially regarded as "masculine" areas (Cantal & Pantoja, 2019), although there is no strong scientific evidence justifying this discourse which segregates students based on their gender (Rodríguez-Sierra, 2016). Such differences seem to be emphasized when conditions relative to color are put into discussion (Pinto et al., 2012).

Vidor et al. (2020) highlight an analytic approach for discussing gender presuppositions and forms of problematizing gender inequalities in physics – in both research on physics and physics teaching – in their systematic review of literature, obtaining as result that most studies investigated presuppose a binary gender model which restricts this category to specific issues related to the feminine sex. Then, the problem is usually limited to the low number of women pursuing career on physics, therefore problems like the lack of gender diversity in physics, conceptions centered on heterosexual and cissexual which permeate approaches to physics teaching, and the restrained and specific cultural, social, and epistemological norms underlying physics community, are often forgotten.

Differentiation by gender in fields of knowledge is notorious since school and can be comprehended as a condition of a society which defines roles for each one of the sexes (Cantal & Pantoja, 2019). Until today, access to scientific careers in exact sciences is still a challenge for women and minorities, mainly in areas such as physics and mathematics. Because of this situation, it is noted that subjects belonging to these groups take average greater time than white men for constitution of career (Silva et al., 2019).

It is consensual in psychological literature that certain professional choices are influenced, among diverse factors, by self-efficacy (Bandura, 1977; Barros & Batista-Dos-Santos, 2010), a psychological construct reflecting beliefs subjects sustain of having abilities assessed by him/her as necessary for accomplishment of determined task. These data suggest the possibility of existence of gender (Sawtelle, 2011; Pinto et al., 2012) and race (Bandura, 1997) distortions on sources of self-efficacy in exact sciences in distinct scenarios.

There is a great amount of research on self-efficacy in the context of professional guidance, both those studying the relation between self-efficacy and career development (Vieira & Coimbra, 2006) and the ones approaching the association of self-efficacy to choices of professional areas (Gillespie & Hillman, 1993; Lent et al., 1991; Lent et al., 1986). There are other works relating personal interest to this construct (Feehan & Johnson, 1999; Nauta, 2004; Nunes & Noronha, 2008), besides investigations on validation of scales for using in specific professional areas (Kelly & Nelson, 1999) and on gender differences expressed in career choice (Matsui, 1994). More specifically, gender differences related to self-efficacy in physics can be found in the works due to Fencl and Scheel (2005) and Sawtelle (2011)

Despite the theory of self-efficacy (TSE) be promising for understanding knowledge retention and achievement patterns, few studies were developed to understand the impact of classroom experiences on the development of students' self-efficacy in physics and, therefore, the potential effect of self-efficacy in their effort and success on classes or retention in a grade (Fencl & Scheel, 2004). There is a sparse quantity of research on this field, but they show women start introductory physics courses with lower self-efficacy compared to men, even when there is no difference of performance between the groups (Espinosa et al., 2019b). Another relevant finding is the one stating the gender gap becomes larger throughout the semester in a traditional course (Espinosa et al., 2019a), although experimental activities, like modelling episodes, can be useful to

address the problem (Selau et al., 2019). For us, these data are cause of concern, once this can raise women underrepresentation in courses of science and technology (Sawtelle, 2011).

Once there are no works of this nature developed in our context, this research aims at answering the following question: "how does countryside Amazonian students' self-efficacy in physics vary in dimensions of gender identity and race/color?". In sequence, we describe the theory of self-efficacy, the theoretical framework developed in this research.

Theoretical framework

Social cognitive theory (SCT) conceives individuals produce and are produced by social systems. In this perspective, subjects exert influence both on their own actions and on those of the ones which surround them, after all, most part of human behavior is controlled by interactive factors. Although people do not determine the events occurring, they have great contribution for what happens to them (Bandura, 1986).

The basic principle on SCT foundation is agency. This concept is a contraposition to behaviorist principles, once it avoids to approach learning processes in a way which associates individual responses solely to environmental stimuli. Agency unfolds in the intention of influencing the course of life and circumstances in which it is carried on. In this perspective, human beings are understood as proactive, self-regulated and reflexive, which implies presuming them involved on cognitive and behavioral intentional processes during life in society. Therefore, we can affect our own motivations and actions as time goes by (Bandura, 2008).

Human agency has four fundamental characteristics: intentionality; anticipation; reactivity; and reflection. Intentionality is present in the possibility of choosing forms of action, elaboration of action plans and strategies for accomplishment of those. Anticipation is identified in prevision of expected results for future actions, which guide and motivates individual efforts. Reactivity appears in avoidance of dissatisfaction and self-censorship, as much as in regulation of behaviors for achieving a meaningful life and self-value. Reflection is produced from observation of the individual's behaviors by others, also from the analysis and correction of efficacy, motivation, and value of employed actions (Bandura, 2006).

Subjects use perceptions they create about themselves as tools for achieving goals, and for aiding them on control they exert on the environment they live (Pajares & Olaz, 2008). Naturally, individuals produce beliefs about their own capacity of organizing and carrying out certain courses of action for reaching determinate results. These ones are named self-efficacy beliefs and have been widely studied both in different stages of life and in distinct contexts (Bandura, 1986). The TSE is contained as central element in SCT, and it was essential for Bandura to complete his social learning theory (Bandura, 1977).

Self-efficacy beliefs impact on a considerable number of variables related to individual's *performance*, such as: choice of courses of action conducted by someone; struggle committed for reaching goals; time used for persisting when tackling obstacles; thought patterns concerning hindrances or support to subject's own actions; susceptibility to environmental stressors; and level of fulfillment achieved by the individual (Bandura, 1986, 1997). People with higher levels of self-efficacy tend to interpret difficult tasks as challenges to be faced and, therefore, are inclined to be more resilient and struggled than the ones with lower levels of self-efficacy.

Self-efficacy is not a static attribute, it is postulated in a way regarding changes which are dependent on achievement and performance. Self-efficacy beliefs can be developed from four main sources of information (Fencl & Scheel, 2004; Pajares, 2002):

- *performance achievement:* concerns direct experiences of the individual – successes and failures contribute, respectively, for consolidation or weakening of belief in personal efficacy – and it is considered the most influent source in development of self-efficacy (Bandura, 1994);
- *vicarious experience:* is referred to experiences of social models perceived by the individual – the performance of a model deemed similar by the subject impacts directly on his/her self-efficacy beliefs – and it is considered to be the second most influent source in development of the sense of efficacy (Bandura, 1994);
- *verbal persuasion:* corresponds to the result of social statements perceived by the individual – people verbally persuaded of having capacities for performing certain activities tend to invest more effort for keeping it than those who doubt on themselves and focus on personal weaknesses when solving a determined problem – it is considered the third most influent source of self-efficacy (Bandura, 1994);
- *physical and emotional states:* are tied to signs like stress and tension reactions, generally associated to evidence of vulnerability to weak performance, and it is taken as the less influent source of self-efficacy (Bandura, 1994).

These different sources of self-efficacy rarely operate separately and independently. People not just experience the result of their struggle, but they also observe the others in similar situations and, from time to time, they receive social assessment on how adequate their performance is. Especially considering that these influences affect one another, the power of one source can notably be changed depending on the strength of the others (Nunes, 2008).

Methodological procedures

This research was conducted with students from all the three academic units of the Universidade Federal do Oeste do Pará (Ufopa) head *campus*, located in Santarém. Besides the students enrolled in Ufopa, there were respondents from other institutions, once the questionnaire was turned public in university's website. In the study developed, there was a group of answers due to 181 undergraduate students, from 11 institutions of higher education. 170 respondents were academics enrolled at Ufopa and the other 11 ones were students from 10 institutions (among which there were public and private ones) that had access to the questionnaire on the internet.

This work can be classified in four different ways: concerning the approach, it can be considered quantitative; regarding its design, it can be taken as quasi-experimental; looking on its aim, it can be classified as exploratory; and judging by its intention of intervention, it can be understood as descriptive.

A quantitative approach aims to analyze a human or social problem by means of a test of a theory composed by variables numerically quantified, that can be studied by statistical models, which have as objective determining if generalizations predicted by it has an empirical basis or not (Knetchel, 2014). The quasi-experimental research design is characterized by the fact that the independent variable is measured in a group of subjects chosen without the control of the researcher (Fiorentini & Lorenzato, 2006). Exploratory research aims at providing greater familiarity with the problem (Gil, 2008) and, normally, it is the initial step in the process of investigation, due to the experience and aid it brings in hypothesis formulation for further research (Cervo & Bervian, 1996). Descriptive investigation points at describing the characteristics of certain population or of a given phenomenon and interpret them, besides that it does not try to modify or interfere in the studied reality (Rudio, 2007).

Once we intended to achieve a great number of individuals, a questionnaire was adopted as instrument of data collection (Vieira, 2009), namely, the Sources of Self-Efficacy in Science Courses – Sosesc-P – (Fencl & Scheel, 2005). It is a psychometric test,[1] whose answers are grouped into a Likert scale with items varying from *I totally disagree* to *I totally agree*. The test has 33 questions evaluating the four sources of self-efficacy (performance achievement, vicarious experience, verbal persuasion, physical and emotional states). Such instrument was validated in English language and with high value of internal consistency ($\alpha = 0.91$).

The self-efficacy score for the subjects is the sum of the Likert score due to the 33 questions. To avoid biases related to the kind of affirmative, the Sosesc-P is split in direct and inverse questions. The first ones are affirmatives in which concordance is related to high values of self--efficacy, for example, the statement "I received good grades on my assigns in Physics". The latter ones are statements in which discordance is associated to high levels of self-efficacy, for instance, the assertion "I received bad grades on my assigns in Physics".[2] Regarding this, it is necessary to invert the scale of inverse questions for us to have a valid construct and for making a coherent measurement of internal consistency of the questionnaire (Hora et al., 2010).

Scores attributed to direct questions vary from 1 (strongly disagree) to 5 (strongly agree), while inverse questions vary from 5 (strongly disagree) to 1 (strongly agree). Out of the 33 questions of the instrument, 15 are inverse and were submitted to an adequation process of its scores so that their conceptual meaning could be compared to the ones due to direct questions and then, it would be possible to adjust measurement of self-efficacy. Using the example of the person who strongly agrees with having good grades in Physics and strongly disagrees with having bad grades in Physics, we infer that he or she must have a high level of self-efficacy for both items, because both evidence high performance achievement. Chart 1 describes scores attributed both to direct and inverse questions.

Chart 1
Scores attributed accordingly to their order

Response	Direct	Inverse	Self-efficacy
Strongly disagree	1	5	Very low
Disagree	2	4	Low
Neutral	3	3	Median
Agree	4	2	High
Strongly agree	5	1	Very high

Source: Author's elaboration.

The questionnaire was translated into Portuguese language and it is hosted on the platform Google Forms, a free tool for information collection, aiming at turning the access easier for the participants involved in this research. The questionnaire had four sections asking for: assigning an informed consent form; declaration of institutional bond; information of variables of interest; and research instrument.

The informed consent form stated that subjects' participation in the research was voluntary, that the investigation would not bring them any harm or danger and that data were

1 Psychometric tests are based on the measurement theory and, more specifically, psychometrics uses numbers to describe psychological phenomena, while impressionist tests, although using numbers, are founded on linguistic description. Psychometric tests use the forced choice method, scales in which the subject must simply check his answers (Silva, 2008).

2 This statement is not in the questionnaire, we formulated it for turning comparison easier.

secretive, even because we would not collect their information permitting their identification, as name. Declaration of institutional bond differentiated students enrolled at Ufopa, the context of the research, and students from other institutions, and it was introduced for adopting rigorously the chosen research focus. Variables of interest included career, gender identity, age, race/colour and, in the case of indigenous students, ethnicity. The research instrument consisted in Sosesc-P translated into Portuguese. The questionnaire can be accessed in https://forms.gle/HvtreGtJZfWApH7A7.

For information available for choosing concerning variables of interest, we were careful to assure at least five different options of gender identity: male, female, transsexual male, transsexual female, non-binary, and we opened space for self-declaration (fuzzy, gender fluid, etc). We omitted the word cisgender, respective to identification between sex and gender, to not run the risk of blank answers due to non-recognition of the expression. By the same reason, we chose the shortened version of transgender, trans, in virtue of its social adoption, which is widely used by the press. Concerning race, we used the classification of the Instituto Brasileiro de Geografia e Estatística (Osorio, 2003), which we supposed the participants were adapted with, once the university had already asked them this information when they were admitted as students. In this classification, we have as categories black, *pardo*,[3] indigenous, yellow, and white. Respectively to ethnicity, classification restricted to indigenous students, it was self-declared, because there are a huge number of indigenous people in Amazon, and it would be impossible to put all of them in only one browser.

After data collection, a process of internal validation of the questionnaire of conducted, and it aimed at determining if the instrument measures the variable this research intend to measure (Oliveira, 2008). Once Sosesc-P was already validated in English language, it would be possible that the translation process could modify its internal consistency and, then, we decided to revalidate the questionnaire in Portuguese language. For this objective, we used Cronbach's *alpha*, a coefficient designed for this goal. Cronbach's *alpha* can be used even when the questionnaire is applied only one time (Sarstedt & Mooi, 2011) and it can be influenced by the number of items which constitute it – the greater the amount, the greater is the probability of obtaining a high value for *alpha* (Pasquali, 2003; Sisto, 2005). To carry out the calculation relative to this coefficient, we used the SPSS[4] statistical package.

After the validation of the questionnaire, we implemented a normality test to know if the sample which we were working with was normal or not, which would imply the choice of a parametrical or non-parametrical test. Parametric statistics are conditioned to the pattern of normal distribution of data and to absence of disperse values, also known as outliers. Using them for analyzing a set of non-normal data leads to obtention of elevated measures of dispersion which are non-reliable. Therefore, normality of data is one of the suppositions which are often adopted for determining which kind of statistical test may be employed (Nascimento et al., 2015).

There are more than fourty normality tests available in literature (Lopes et al., 2013), what drove us to a choice. Our decision considered the Kolmogorov-Smirnov test, because it is an adherence test verifying if data follow a normal distribution, it admits the kind of distribution of the tested variable is continuous, it compares the accumulated frequency distribution expected for a theoretical distribution under the condition of null hypothesis (H_0) with the accumulated

3 Lacking better translation, we used the original word, which is equivalent to a grayish-brown skin color. In fact, it comprises a spectrum of skin colors that would not be considered not white and not black. There are discussion concerning the term, once this division is not deemed right from the standpoint of black movements. They usually state that pardos are black, because they descend from africans.

4 Statistical Package for the Social Sciences.

frequency observed and it demands a sample equal to or greater than 77 answers ($n \geq 77$) to indicate if the distribution is normal or not (Scudino, 2008; Nascimento et al., 2015). All these criteria were the most adequate to our work.

After running the normality test, we had to decide which parametrical test would fit better for studying differences among groups. We took the Anova – an acronym for Analysis of Variance –, because it focuses on analyzing three or more groups (Dancey & Reidy, 2006). Independent variables used for this procedure were gender identity and race/color.

This test is equivalent to test *t* because of one of its criteria for use – the quantity of groups in each of the variables –, however, it is structured for three or more groups (Dancey & Reidy, 2006). Independent variables used for comparison were, again, gender identity and race/color.

After conducting the Anova, we took a test of multiple comparison, something usually made after applying a parametric test with more than two factors. We used Tukey's test (1953), which describes the results by means of unplanned comparisons, that is, the researcher does not need to establish the comparisons between means that he or she is supposed to carry out without having seen the data (Howell, 2012). This test is the adequate procedure after using the Anova, if and only if it permits to reject the null hypothesis (Cargnelutti Filho et al., 2003). We the follow to the discussion of the results of this work.

Data analysis

Analysis of results is divided in three sections: in the first one we aim at proving statistically that the questionnaire measures the variable it proposes to estimate (Giuffre, 1997a, 1997b); in the second one we explore the variations between the levels of self-efficacy of Ufopa students in relation to physics, in whether gender or race; and then, we relate the data obtained with results priorly presented in the literature on self-efficacy. It shall be highlighted that this is the first time Sosesc-P is validated in Portuguese language.

Internal validation of the questionnaire

The instrument Sosesc-P was validated by Fencl and Scheel (2005), but it is important to assure the items maintain internal consistency when translated to another language. Then, proceeding with calculation of Cronbach's *alpha* (α_c), we obtained the measure $\alpha_c = 0.94$, a value which is superior to the one originally found by Fencl and Scheel (2005), in a study involving 218 students. The α_c consists in a reliability measurement varying from 0 to 1, and the values ranging from 0.60 to 0.70 are considered the inferior limit of acceptance (Hair et al., 2009). The value of α_c obtained in this study shows that the translated items produced low levels of variability for the n = 181 respondents, what consequently diminishes the errors associated to the scores and points to acceptable reliability.

We estimated the reliability for each one of the sources of self-efficacy: performance achievement (PA); vicarious experience (VE); verbal persuasion (VP); and physical and emotional states (PES). In this study, the value of *alpha* for the source VE (0.66) is on the inferior limit of acceptance. The other sources, with values of *alpha* superior to 0.80, confirm the consistency of the items translated for Portuguese language. The values of α_c for the four sources of self-efficacy and the number of items related to each one of these sources are presented in Table 1.

Table 1
Cronbach's alpha *value for the four sources of self-efficacy and the total number of itens pertinent to each of the sources*

Sources of self-efficacy	Cronbach's *alpha*	Number of items
PA	0.87	10
VE	0.66	7
VP	0.76	7
PES	0.79	9

Source: Research data.

Knowing this, it was possible to follow on the analysis of Ufopa students' self-efficacy in physics, because we had an instrument with acceptable reliability. Then, we discuss the differences in self-efficacy in terms of gender and race.

Analysis of differences in self-efficacy

In the present study we focused in discussing how Ufopa undergraduate students' levels of self-efficacy in physics (n = 170) vary. The respondents of this group were, average, 22.42 years old (standard deviation – SD: 5,51) and range changing from 17 to 45, which constitute a young sample. In our composition of data, we grouped *fuzzy* and *non-binary* together once there were few responding subjects (one fuzzy and two non-binary). Traxler et al. (2016) strongly criticized studies which explicitly reduce gender differences in an objective and binary way. Regarding this, as described previously, we approached our measurement process in a non-binary way for gender identity, however, most responses were binary, as shown in Table 2.

Table 2
Respondent distributions (n = 170) in variables gender identity and race/color

Race-color/Gender identity	Men	Women	Others
Yellow	1	1	0
White	23	19	1
Indigenous	1	1	0
Pardo	62	55	2
Black	10	5	0
Total	93	81	3

Source: Research data.

Considering composition self-efficacy scale, it can be separated in four sources of self-efficacy or presented as the average of the scores obtained by the respondents in all items of the test. Then, the scale of self-efficacy comprehends values between 33 and 165 points. The scales of each sources have their own maximum and minimum values determined accordingly with the number of items it possesses.

The respondents from Ufopa presented average self-efficacy of 102.6 (SD = 14.91), a result clearly below the results obtained by Sawtelle (2011), which varied between 108.96 and 127.34 points. So, we computed subjects' scores considering the 33 items of the test and the scores related to each one of the four sources. Table 3 show the average scores and standard deviation in variables gender identity and race/color.

Table 3
Average scores and standard deviation in variables gender identity and race/color

Variables	Groups	Self-efficacy (33; 165)*	Scale separated in sources			
			PA (10; 50)	VE (7; 35)	VP (7; 35)	PES (9; 45)
Race/color	Yellow	106.0 (7.78)	32.0 (4.24)	21.5 (0.71)	23.5 (0.71)	29.0 (3.54)
	White	99.9 (14.02)	31.4 (3.68)	21.8 (4.09)	20.06 (3.59)	26.1 (4.78)
	Indigenous**	99.0 (NA)	33.0 (NA)	21.0 (NA)	24.0 (NA)	21.0 (NA)
	Pardo	104.0 (15.50)	32.0 (4.13)	22.9 (4.86)	22.0 (4.06)	27.1 (5.44)
	Black	99.6 (12.60)	31.6 (2.93)	21.4 (4.13)	20.7 (3.89)	25.9 (4.83)
Gender identity	Men	105.0 (13.8)	32.3 (3.65)	23.4 (4.23)	22.1 (3.62)	27.7 (5.21)
	Women	99.4 (15.4)	31.3 (4.12)	21.4 (4.81)	21.0 (4.19)	25.7 (4.98)
	Others	104.0 (26.1)	30.7 (5.86)	23.3 (6.51)	23.7 (5.51)	26.3 (9.07)

Source: Research data.
* Minimum and maximum possible values in the scale. ** Insufficient data for determining standard deviation.

Visually, the results shown in Table 3 indicate that *pardos* and yellow have greater self-efficacy than the other groups. Concerning gender identity, self-efficacy is lower for women. It is convenient to use statistical tests to analyze if these differences are significant, to evaluate the size of the effect – that is, if differences are low or high – and identify where these differences occur.

The choice for any test requires knowing before how data are distributed. For this reason, we conducted the Kolmogorov-Smirnov normality test for a single sample considering a confidence interval of 95%. We verified the test scores follow a normal distribution of probability ($p = 0.945$), regarding that $p > 0.05$ leads us to accept the null hypothesis that, for this test, is compatible with the normality of the sample.

Confirmed the normality of data, we made an Anova for comparison of groups. We verified self-efficacy differences only among groups of the variable gender identity. Self-efficacy observed among groups of variable race/color is not different, that is, *pardos*, white, black, indigenous, and yellow have equivalent levels of self-efficacy. This time conducted with a scale separated in four sources, Anova evidenced the existence of significant differences in the source *vicarious experience*, also concentrated in the variable *gender identity*. Results of this Anova can be seen with greater detail in Table 4, which exhibits the statistics due to the test, denoted by *F*, and the value of *p*.

Table 4
Values of F statistics and the p-value (CI 95%) in variables gender identity and race/color (n = 170)

Variables	Anova parameters	Self-efficacy (33 items)	PA	VE	VP	PES
Gender identity	F	3.44	1.44	3.87	2.10	2.92
	p	0.034*	0.24	0.023*	0.13	0.057
Race/color	F	0.81	0.23	0.75	1.42	0.78
	p	0.518	0.92	0.559	0.23	0.542

Source: Research data.
* Non-significant for confidence level of 0.05.

Then, once evidenced the existence of statistically significant differences between means of the comparation groups, we shall answer where these deviations occur and indicate their magnitude.

For this, we carried out the Anova' *post hoc,* the Tukeys' HSB test, considering the level of confidence of 0.05. We identified that the difference in self-efficacy is significant only when comparing men and women (p = 0.026), with 5,6 of mean difference (MD). The calculation of the effect by means of the Cohen's d coefficient (0.0413) shows the magnitude of the difference is low, which suggests the group of men participating of the study shows self-efficacy whose values are slightly above the ones informed by women (Espírito Santo & Daniel, 2017). Concerning *vicarious experience*, the difference also occurred exclusively in comparison between men and women (MD = 1.85, p = 0.016). The self-efficacy levels and, particularly, the source of vicarious experience, in variable gender identity, can be visually understood in Figure 1. It is possible to observe that the group of men has median immediately above the group of women in both cases.

Perspective taking

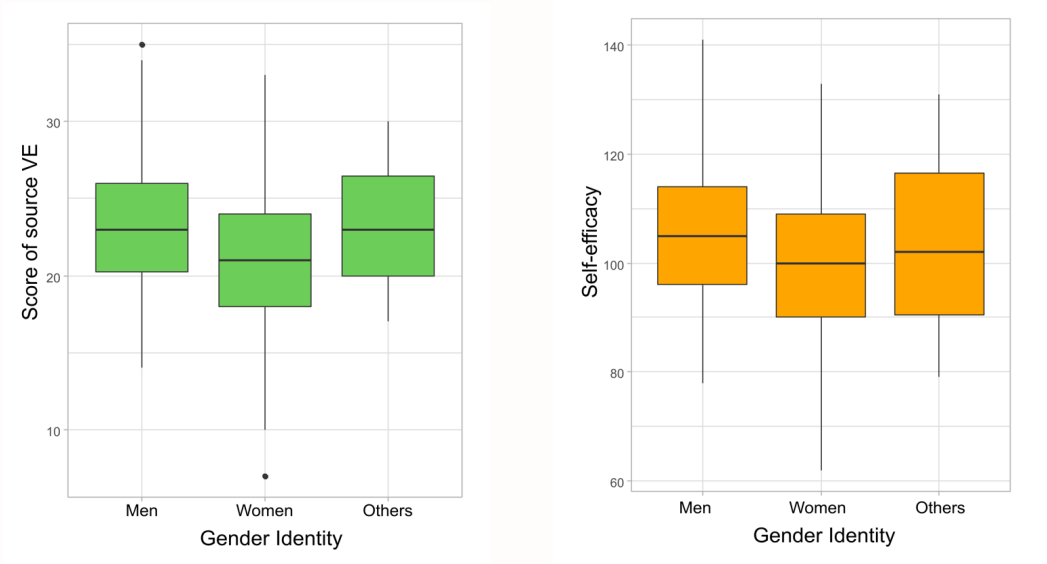
In her work, Sawtelle (2011) relates that are significant differences between men and women, describing men as more successful on the source of self-efficacy *performance achievement* (PA), while women show better results in the source of self-efficacy *vicarious experience* (VE). Our analysis permits to identify differences in the source VE as the most influent for the mean differences relative to gender identity, for the groups of *men* and *women*, but differently of the result obtained by Sawtelle (2011). The result we found indicated that in relation to the source of self-efficacy VE, men are more successful than women. Li et al. (2020) describe that women are severely underrepresented in physics and in courses related to physics, in which there are generalized gender stereotypes on who can excel or not (men can and women cannot), and moreover there is a systemic disadvantage for women that comes from sustaining this stereotype since their tender age.

From this, we raised a hypothesis that Ufopa female students may feel underrepresented in physics and/or in courses related to this science. This implies the possibility of them to not create female models in which they can inspire or compare to, what would cause a deficit in VE. The possibility that women have sparse interactions with classmates is compatible to the findings of Espinosa et al. (2019a), which point social interactions can be positive for raising students' VE.

Moreover, a considerable number of women state they face adversities between private and professional lives, caused, mainly, by hindrances in conciliating academic necessities and family obligations, with one of the most cited situations was related to maternity (Lima, 2011, 2013; Nehmeh & Kelly, 2018; Santos, 2016; Silva & Ribeiro, 2014). Although this is associated more directly to personal experience than vicarious experience, the existence of support networks for women that face these difficulties could be a possible solution to increase both dimensions of performance achievement, by giving direct contribution to their academic background, and vicarious experiences, indirectly, by providing models for inspiration and comparison.

Studies show the creation of opportunities for producing support networks, as, for example, a conference dedicated to female students in physics, may be productive and positive (Buck et al., 2014). Besides that, it can be fruitful to widen work environments and turn the study scenarios more collaborative, in a way favors greater environmental support to these students. This can turn the workplace favorable to family, provide information on scientific career options and opportunities inside and outside academia, besides contributing for persistency and academic-professional women's success (Vidor et al., 2020).

Figure 1
Mean differences in the variable gender identity



Source: Research data.

Another point to be noted is that, out of 33 questions, 15 were responded with average value equivalent to "neutral", what can indicate the Ufopa students' maybe do not feel so instigated to study physics. Espinosa (2016) showed that, among the diverse challenges which are faced by Physics professors in their professional practice, the lack of motivation and negative attitudes related to the subject seem to be omnipresent among students, what ends up directly influencing the learning results achieved. Changing the classroom in a way that makes students more active seems to be one of the forms of altering this situation. Another variable influencing this is the form of evaluation because it can produce variations in students' stress level and, consequently, in self-efficacy. In the present study, we cannot make judgments about evaluation or new teaching methodologies but is possible to raise the hypothesis that active participation in Physics classes, in the context of Ufopa, is still incipient.

Final remarks

There is considerable research relating self-efficacy with professional guidance (Vieira & Coimbra, 2006), career development (Anderson & Betz, 2001), professional choice for specific areas (Gillespie & Hillman, 1993; Lent et al., 1991; Lent et al., 1986), individuals' interests (Feehan & Johnston, 1999; Nauta, 2004; Nunes & Noronha, 2008), gender differences expressed in career choices (Matsui, 1994) and physics, in terms of gender (Fencl & Scheel, 2005; Sawtelle, 2011). We observed, from this review, that, although there is a huge number of works associating self-efficacy with professional guidance and career development, academic research is sparse concerning the relation between self-efficacy and physics.

The goal of this investigation was, then, studying how varies Ufopa students' self-efficacy in physics regarding the dimensions of gender identity and race/color. For this, we conducted a descriptive research based on data collection from a questionnaire priorly validated in English language, but not in Portuguese language, the Sosesc-P (Fencl & Scheel, 2005). As dependent variable, we took self-efficacy and its four sources and, as independent variables, we used gender identity and race/color. As contexts, we took the six Ufopa's institutes and received representative

respondents for our research. Then, we designed a valid study in the described context, but with a questionnaire with high reliability level. This study consisted in a descriptive, exploratory, quantitative, and quasi-experimental research. In Amazonian context, it is the first investigation on this topic, what assures the work is unprecedent

From this research, it was possible to validate the Sosesc-P in Portuguese language, which is very useful for educational purposes, in especial for the field of physics teaching. We understand that the use of this questionnaire in other works can provide data and interpretations of diverse sociocultural contexts, besides allowing of other interest variables, like socioeconomic class, for example. Other important question to be approached is the level of dissonance between personal efficacy and the real abilities subjects have.

Concerning the results, in gender identity, analysis of variance of self-efficacy in physics revealed a statistically significant difference between the groups of men and women, accordingly to what we identified in scientific literature (Fencl & Scheel, 2005; Sawtelle, 2011). This difference was calculated as moderated and it was associated, priorly, to the source of *vicarious experience*. Regarding race/color, we did not find any statistically significant difference for this context. For generalizing to Amazonian region, it would be important to study cases in other universities, but, from this research, it is possible to elaborate an initial sketch of what happens in the case of Ufopa, a genuinely Amazonian university.

We sustain the investigations on self-efficacy beliefs related to gender and race are recent, and we understand the importance of our data for scientific community, mainly for the area of research in physics teaching. However, insofar we develop knowledge on the theme, we note there are various cultural, social, and epistemological tacit norms restricted and specific to the physics community (Vidor et al., 2020), and that our society is based in heterosexual and cissexual normative presuppositions (Traxler et al., 2016), what can be reflected both in subjects' choices for traditionally binary gender roles, as occurs for differences in self-efficacy respectively to a characteristic bound to the representativity of subjects, which is unfavorable to women.

Besides that, we glimpse that science and science education are constituted as *cultures of power*, and most of individuals aiming at having success as scientists and/or science students are white, from middle and upper economic classes, men, and heterosexual (Barton & Yang, 2000). For this reason, the analysis of self-efficacy beliefs is relevant for studying evaluation of individuals on the perceived achievement in specific tasks and can aid us in comprehending a small fraction of differences in contexts experienced by Ufopa academics in Physics classes, their perceptions and hindrances related to this field and to other areas of knowledge related to it.

These results have important didactic implication in educational research once they reiterate gender differences in the physics educational field, which were already verified in literature (Fencl & Scheel, 2005; Sawtelle, 2011; Espinosa et al., 2019b), which calls attention for the necessity of conduction of public policies of physics teacher formation and changes in teachers' practices envisaging to reduce this bias. Aspects like the existence of female representants in positions on exact sciences (representativity), the conduction of consistent social debates on gender relations and the reflection on teaching models that can raise women's participation in the field of exact sciences are extremely important, in special in a blatantly patriarchal and sexist society. In our context, knowing that vicarious experience is a variable which provokes differences in self-efficacy in physics, when gender identities are compared, can make easier the construction of strategies focusing, specially, in this aspect.

This study, for having exploratory nature, did not concerned the types of didactical strategies that can reduce the gender gap for Ufopa students. Even if we could do it, a classroom would have about thirty students, which would lead us to choose one or two specific careers to analyze, and

this would be inviable for generalization in this moment. Results of literature has pointed that the modelling episodes could help to overcome this problem (Selau et al., 2019) and that gender biases tend to be accentuated in traditional Physics courses (Espinosa et al., 2019b). To evaluate the institutional implementation of forms of teaching work like these at Ufopa, it would be necessary to develop more investigation, which would be underlying the knowledge produced in the study developed here. This is one of our more immediate worries from now on since we have arrived at these important findings.

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This paper is part of the undergraduate thesis due to Iasmin Ribeiro Ramos, who was responsible for conception; methodological design; data processing; data validation; formal analysis; and writing, review, and edition of the text. Andrey Camurça da Silva was responsible for conception; methodological design; data validation; formal analysis; writing, review, and edition of the text. Glauco Cohen Ferreira Pantoja was responsible for conception; methodological design; data validation; formal analysis; writing, review, and edition of the text; managing and supervision of the research. For the english version, the latter was responsible for its translation.

Data availability statement

Data underlying the research text are informed in the paper.

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Cadernos de Pesquisa indicates the following correction:
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On the page 1: Iasmin Ramos, https://orcid.org/0000-0002-4781-1076

Please, consider: Iasmin Ramos, http://orcid.org/0000-0002-0662-9155