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ARTÍCULOS

# Motivation towards Biology and Geology in Secondary School: impact of learning strategies, goals, and academic expectations

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**Abstract:** INTRODUCTION. The aim of this study was to analyse how learning strategies, goals and academic expectations influence motivation towards Biology and Geology in 3rd ESO students, as well as to adapt and validate the SMQ-II to measure such motivation. METHOD. The sample consisted of 177 students from seven secondary schools in Spain. The study used questionnaires to assess motivation, learning strategies, academic goals, and academic expectations. Confirmatory factor analysis (CFA), descriptive, mean difference, and binary logistic regression analyses were performed. RESULTS. The SMQ-II is a valid and reliable instrument for measuring motivation towards Biology and Geology, exhibiting high reliability at the subscale level. The results demonstrated that highly motivated students employed more effective learning strategies and held more positive academic expectations, whereas less motivated students exhibited more negative expectations and utilised less effective strategies. Regression analysis indicated that learning strategies, particularly organisation, and positive academic expectations significantly predicted subject motivation. Additionally, academic goals and emotional frustration management also influenced motivation. DISCUSSION. It can be concluded that, to enhance students' motivation towards Biology and Geology, it is essential to exert a positive influence on their motivation.
**Keywords:** motivation; learning technique; Biology and Geology; secondary education.

## Motivación hacia Biología y Geología en secundaria: impacto de estrategias de aprendizaje, metas y expectativas académicas

ES **Resumen:** INTRODUCCIÓN. El objetivo de este estudio fue analizar cómo las estrategias de aprendizaje, las metas y las expectativas académicas influyen en la motivación hacia la Biología y Geología de estudiantes de 3.º de ESO, así como adaptar y validar el SMQ-II para medir dicha motivación. MÉTODO. La muestra estuvo compuesta por 177 estudiantes de siete institutos de España. El estudio utilizó cuestionarios para evaluar la motivación, las estrategias de aprendizaje, las metas académicas y las expectativas académicas. Se realizaron análisis factoriales confirmatorios (AFC), descriptivos, de diferencias de medias y de regresión logística binaria. RESULTADOS. El SMQ-II es válido y fiable para medir la motivación hacia la Biología y Geología, con alta fiabilidad en sus subescalas. Los estudiantes altamente motivados utilizaron más estrategias de aprendizaje eficaces y tuvieron expectativas académicas positivas, mientras que los menos motivados presentaron expectativas más negativas y usaron estrategias menos efectivas. El análisis de regresión indicó que las estrategias de aprendizaje, especialmente la organización, y las expectativas académicas positivas predicen significativamente la motivación hacia la materia. Además, las metas académicas y la gestión de la frustración emocional también influyeron en la motivación. DISCUSIÓN. Se concluye que, para mejorar la motivación de los estudiantes hacia la Biología y Geología, es crucial fomentar el uso de estrategias de aprendizaje efectivas, promover expectativas académicas positivas y trabajar en la gestión emocional frente a los desafíos académicos.
**Palabras clave:** motivación; técnicas de aprendizaje; Biología y Geología; enseñanza secundaria.

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## 1. Introduction

Motivation can be defined as a set of processes that direct and sustain behaviour towards the achievement of goals, including educational ones (Schunk *et al.*, 2014). The significance of this construct has prompted numerous investigations into academic motivation in the context of teaching and learning. In particular, it has been identified as an essential factor for academic performance (Zhang *et al.*, 2024) and student engagement (Liem, 2021). Furthermore, motivated students have been shown to employ effective learning strategies (Pintrich, 2003).

Motivation is a domain-specific construct and, as such, its conceptualization may vary across different disciplines. For example, Guay and Bureau (2018) highlighted that a high level of motivation towards mathematics and English predicts both better overall and specific performance in these domains. In the field of mathematics, motivational factors and learning strategies have been shown to be closely related (Wild and Neef, 2023). Ardura and Pérez-Britián (2018) identified that, among Spanish secondary school students, motivation towards a future profession is the primary factor for continuity in physics and chemistry, surpassing previous academic performance and other variables. In a different context, Avargil *et al.* (2024) concluded that in university-level chemistry learning, extrinsic motivation has a greater influence than intrinsic motivation on the choice of studies.

### 1.1. Motivation towards STEM subjects

Research on student motivation towards STEM subjects (Science, Technology, Engineering and Mathematics) has grown considerably in recent years (Bayanova *et al.*, 2023; Murphy *et al.*, 2019). However, Murphy *et al.* (2019) have highlighted that there is a paucity of research addressing student motivation as a means of fostering engagement in these disciplines. It has been shown that motivation not only improves academic performance and the choice of STEM careers (Myint and Robbnet, 2024) but also enhances interest and active participation in science (Fiorella *et al.*, 2021).

Teaching biology and geology, as part of the STEM field, requires motivational strategies to ensure students' academic success (Kaiser *et al.*, 2020). Motivation in natural sciences depends on factors such as teacher characteristics, the learning environment, and both internal and external motivators (Sablić *et al.*, 2021). Furthermore, studies such as that by Schneider *et al.* (2016) highlighted that students' interest and engagement increase when they perceive a direct connection between biological content and their everyday lives.

### 1.2. The role of goals, expectations, and learning strategies in motivation

Factors such as goals, expectations, and learning strategies play a substantial role in academic motivation. Rodríguez and Guzmán (2018) highlighted that goals vary throughout secondary education, while Suárez-Valenzuela and Suárez (2023) identified that these, together with learning strategies, serves as predictors of academic performance in secondary education. In the field of STEM subjects, achievement goals have been shown to exert a significant impact on performance and aspirations, although research in this area has focused mainly on mathematics (Murphy *et al.*, 2019). Positive academic expectations have been demonstrated to enhance performance in complex subjects such as science (Farnam and Anjomshoaa, 2020). These expectations have been shown to predict self-efficacy in mathematics (Yesuf *et al.*, 2023) and play a significant role in science learning and the choice of STEM careers (Yeung, 2024). Learning strategies also play a crucial role in motivation and academic outcomes (Farnam and Anjomshoaa, 2020). In secondary school, their effective use improves performance, especially in STEM (Moreno *et al.*, 2024). Furthermore, they act as mediators between attitudes towards science subjects and grades (Okun *et al.*, 2022). Students with positive attitudes employ more elaborate strategies, obtaining better results. However, as Muteti *et al.* (2021) point out, many are unaware of effective study methods, highlighting the need to teach metacognitive strategies.

### 1.3. Measuring motivation towards science

Given the impact that academic motivation has on student performance, it is essential to have valid and reliable instruments to assess this construct in the context of science. A number of questionnaires have been designed specifically to measure students' motivation towards science learning. One example is the "*Students' Motivation Towards Science Learning"* (SMTSL), developed by Tuan *et al.* (2005) and validated with secondary school students in Taiwan. This instrument assesses various dimensions of motivation and other fundamental aspects related to commitment and attitude towards science. Another example is the *Students' Adaptive Learning Engagement in Science* (SALES), which was designed by Velayutham *et al.* (2011) to assess key factors related to motivation and self-regulation in science learning among secondary school students.

One of the most widely used instruments is the *Science Motivation Questionnaire II* (SMQ-II), which was developed by Glynn *et al.* (2011). It assesses various motivational dimensions such as intrinsic motivation, self-determination, self-efficacy, and motivation towards a future profession and qualifications. Versions of the SMQ-II can be found in the literature that refer to subjects such as biology (e.g., Lang and Šorgo, 2024), chemistry (e.g., Ardura and Pérez-Bitrián, 2018), mathematics (e.g., Fiorella *et al.*, 2021), and physics (e.g., Kwarikunda *et al.*, 2020). This instrument has been validated for both university and secondary school students and has been translated into at least seven languages (Komperda *et al.*, 2020).

## 2. Objective

Despite the extensive research that has been conducted on the impact of learning strategies in STEM, there is a paucity of on the effects of academic goals and expectations in this context. This scarcity of studies makes it difficult to understand how these variables influence learning in subjects such as Biology and Geology, which tend to be less prioritised than other STEM subjects. Thus, the objective of this study was to analyse how learning strategies, academic goals, and academic expectations influence the motivation of 3rd-year secondary school students towards biology and geology. In this regard, the adaptation and validation of the SMQ-II to measure the motivation of Spanish secondary school students towards Biology and Geology was also undertaken in this study. To achieve these objectives, the following research questions were formulated.

**RQ1.** Is the adaptation of the SMQ-II valid and reliable for measuring motivation towards the subject of Biology and Geology in 3rd year ESO students?

**RQ2.** Are there significant differences in motivation towards Biology and Geology depending on learning strategies, academic goals and academic expectations?

**RQ3.** Can learning strategies, academic goals, and academic expectations predict motivation towards Biology and Geology in 3rd year ESO students?

## 3. Method

### 3.1. Participants

The sample for this study comprised students from seven secondary schools located in different autonomous communities throughout Spain. Non-probability sampling by accessibility was used. Initially, the sample consisted of 221 students, but after data cleansing, it was reduced to 177 students in the third year of compulsory secondary education (ESO). The average age of the sample was 14.49 years (SD=0.62), with a median age of 14 years. With regard to gender, 48.6% of the sample (n=86) were male, and 51.4% (n=91) were female.

### 3.2. Instruments

#### 3.2.1. Dependent variable

The dependent variable was motivation towards biology and geology, measured using the *Science Motivation Questionnaire* II (SMQ-II; Glynn *et al.*, 2011). Following the author's recommendations (Glynn *et al.*, 2011), this instrument, originally designed to measure motivation towards science in general, can be adapted to different areas by simply replacing the word "science" with the desired discipline. In this case, "science" has been replaced by Biology and Geology.

The original structure of the instrument comprises five dimensions, each consisting of five items, for a total of 25 items. The subscale *on motivation towards a future career related to Biology and Geology* measures how students perceive learning this subject as a means to achieve professional goals, for example, "Learning Biology and Geology will enable me to get a good job." *Self-determination* assesses students' perception of autonomy over their learning. This subscale includes items such as "I am confident that I will do well in Biology and Geology exams." *Self-efficacy* refers to students' belief in their ability to perform well in the subject, with items such as "I am sure I can understand Biology and Geology." *Intrinsic motivation* measures the personal satisfaction gained from learning Biology and Geology, with items such as "Learning Biology and Geology gives my life more meaning." Finally, *grade motivation* measures interest in obtaining high grades in the subject. For example, "It is important for me to get an A in Biology and Geology." In this research, the complete instrument was used, respecting its original structure. The original 5-point scale was replaced by a 7-point scale (1 = strongly disagree, 7 = strongly agree) to standardise the scores between instruments. This adjustment has been demonstrated to enhance the sensitivity, precision, and discrimination of the responses and reduces ceiling and floor effects (Coombes *et al.*, 2021; Preston and Colman, 2000).

#### 3.2.2. Independent variables

To measure learning strategies, the *Learning Strategies and Motivation Questionnaire* (CEAM-II) by Roces *et al.* (1995) was used, which assesses, through two subscales, motivational orientation and the use of learning strategies. In this research, the learning strategies subscale was selected. The CFA allowed us to define five dimensions from a total of 18 items.

The *organisation strategies* scale (3 items) it's a scale designed the use of diagrams or concept maps for studying, with an example item being "When I study, I underline to better organise my ideas". The *elaboration strategies* scale (4 items) includes the students' use of techniques such as summarising or paraphrasing, with items such as: "When I study, I gather information from different sources: classes, readings, practical work, etc.". The *time management and study environment* factor (5 items) is aimed to measure how time and environment are organised for studying, with items such as: "I usually study in a place where I can concentrate on my work." The *help-seeking* scale (3 items) assesses the student's willingness to ask for support when in doubt, for example: "I ask the teacher questions to clarify concepts that I do not understand well." Finally, the *critical thinking* factor (3 items) measures the extent to which students use their prior knowledge to solve problems. An example item is: "When a theory, interpretation, or conclusion is presented in class or in books, I try to see if there are good arguments to support it." The goodness-of-fit indices in the CFA of this instrument were CFI=.99, TLI=.87, RMSEA=.07, with internal consistency, measured using McDonald's Omega, of .75 for organisation, .73 for elaboration, .68 for time-management, .50 for seeking help, and .63 for critical thinking.

Secondly, to measure academic goals, the Skaalvik *Academic Goals Questionnaire* (1997) was used. This questionnaire consists of four scales with a total of 16 items distributed evenly. The scales include: *task orientation,* which assesses students to what extent students focus on learning and mastering content, exemplified in the item "It is important for me to learn new things"; *ego-enhancement orientation,* which measures the students' ability and receive recognition, as reflected in "Succeeding in these studies means doing tasks better than other students"; *ego self-frustration orientation,* which measures the level of concern about the evaluation of others and avoiding situations that could damage self-image, exemplified in "When I answer questions asked in class, I worry about what my classmates will think"; and *effort avoidance orientation,* which refers to a preference for avoiding demanding work and tasks, as illustrated by "I wish we weren't given homework." The CFA validation of the instrument shows good fit indices (CFI=.93, TLI=.92, RMSEA=.07) and adequate internal consistency, with McDonald's Omega values of .72 for task orientation, .75 for ego-enhancement orientation, .71 for effort avoidance orientation, and .91 for ego-frustration orientation. As with the rest instruments used in this research, a 7-point Likert scale was chosen (Combes *et al.*, 2021; Preston & Colman, 2000).

Finally, to measure expectations about the students' academic future, the *Academic Expectations Scale* (Sánchez, 2021) was used, which consists of two subscales with a total of 8 items. These subscales are: *positive academic expectations,* which assess students' belief in their ability to perform well in the subject, exemplified in the item "I am convinced that I will acquire the knowledge and skills that will enable me to obtain a good grade in the subject"; and *negative academic expectations*, which measure the perception of difficulty due to academic challenges, as reflected in "I have the impression that I am going to have a lot of difficulty in the subject." The validation of the instrument shows good fit indices in the CFA (CFI=.95, TLI=.93, RMSEA=.09) and internal consistency, measured by McDonald's Omega, of .86 for the positive academic expectations scale and .84 for the negative academic expectations scale.

### 3.3. Procedure

Prior to data collection, a pilot study was conducted with 10 students to verify the comprehension and functioning of the instruments. No adjustments to the items were necessary. Data collection involved seven Biology and Geologyteachers from educational centres located in different autonomous communities who administered the questionnaires after receiving prior instruction. The process, which included the presentation of the study and an explanation of the instrument, lasted 30 minutes. Participants took part in the study on a voluntary basis, and the anonymity and confidentiality of their responses were guaranteed. Authorisation was requested from the families of the minors to participate in the research, informing them of the objectives and the procedure to be followed for data collection.

### 3.4. Data analysis

A confirmatory factor analysis (CFA) was performed using a structural equation model (SEM) to validate the instruments used in this study. The fit criteria used for the different indices were as follows: $1<\chi^2/df<3$; CFI>.95; TLI>.95; RMSEA<.08; SRMR<.08 (Hu and Bentler, 1999)which includes using the maximum likelihood (ML. The reliability of the instruments was calculated using the McDonald's Omega coefficient. Both confirmatory and reliability analyses were performed using the JASP programme (JASP Team, 2023).

A hierarchical cluster analysis was performed using squared Euclidean distance and Ward's method to classify students according to their motivation towards Biology and Geology. The analysis identified two groups: one with high motivation and one with low motivation. Differences in means between the two groups were analysed using multivariate analysis of variance (MANOVA), estimating the effect size using the partial eta squared statistic. This is interpreted according to the criteria established by López-Martín and Ardura (2023), where a value <.01 is considered very small, between .01 and .05 small, between .06 and .13 moderate, and greater than or equal to .14 large.

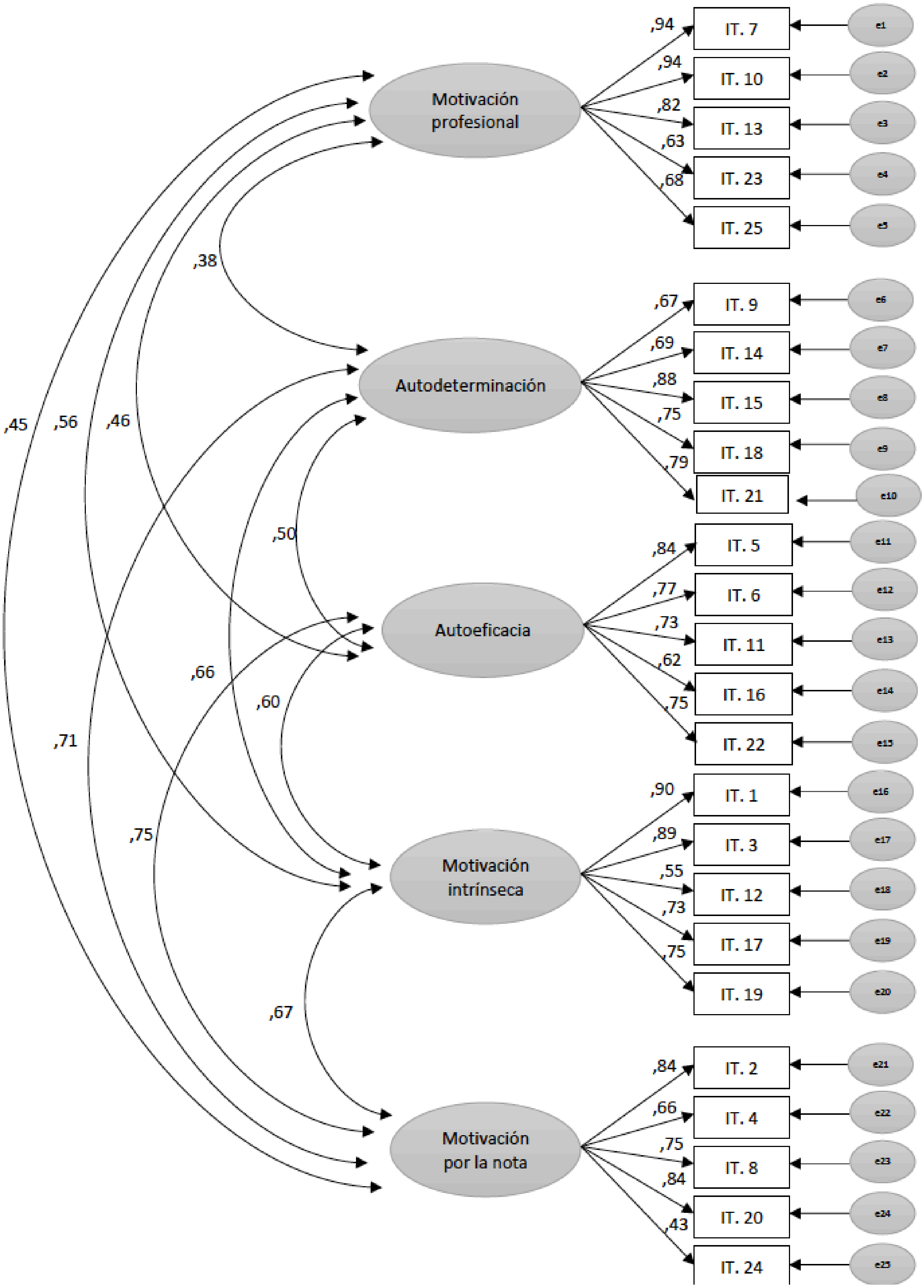
Finally, a block binary logistic regression analysis was performed to determine the extent to which learning strategies, academic goals, and academic expectations predict students' motivation towards Biology and Geology. Each block of variables was introduced using the enter method, which allowed the individual impact of each set on students' motivation towards the subject of Biology and Geology to be evaluated. Cluster analysis, mean differences and logistic regression were performed using the SPSS statistical programme (IBM Corp., 2023).

## 4. Results

### 4.1. Validity and reliability of the SMQ-II

The SMQ-II is an instrument that has been constructed on a solid theoretical structure. Based on this foundation, a confirmatory factor analysis (CFA) was performed to determine whether the structure of the instrument was adapted to the context of the Biology and Geology subject area. A factorial model was proposed including the five latent variables of the original instrument. In our analysis, we found a $\chi^2/df$ value of 2.73. Additionally, the five-factor model presents indices indicating a good fit to the experimental data: GFI=.99, CFI=.83, RMSEA=.09 and SRMR=.07. The CFA results confirmed the original structure of the instrument, retaining the five factors and 25 original items of the SMQ-II (see Figure 1).

Figure 1. Factor model of the SMQ-II adapted to the subject of Biology and Geology




McDonald's omega statistic was used to assess the reliability of each subscale of the instrument. According to the interpretation guidelines for this statistic (McDonald, 1999), the results suggest a high reliability on all scales evaluated: professional motivation (ω=.91), self-determination (ω=.87), grade motivation (ω=.82), intrinsic motivation (ω=.87), and self-efficacy (ω=.86).

## 4.2. Differences in learning strategies, expectations and academic goals according to student motivation towards Biology and Geology.

To answer the second research question, the participants were first classified, using hierarchical cluster analysis, into two groups of students with high (n=83) and low (n=94) motivation towards biology and geology. As shown in Table 1, the MANOVA test revealed significant differences between the two groups (*V*=.63, *F*(5.17)=58.76, p<.001). Specifically, highly motivated students scored significantly higher on all dimensions assessed. The effect sizes were high, especially in motivation towards a scientific profession ($\eta_p^2$ =.44) and intrinsic motivation ($\eta_p^2$=.42).

Table 1. Analysis of differences in means between students with high and low motivation towards the subject of Biology and Geology

| | | | BG motivation | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Totals | | High (n = 83) | | Low (n = 94) | | *F* | $\eta_p^2$ |
| | M | SD | M | DT | M | DT | | |
| Motivation towards a future scientific career | 4.22 | 1.75 | 5.44 | 1.21 | 3.13 | 1.40 | 136.23** | 0.44 |
| Self-determination | 5.44 | 1.37 | 6.27 | 0.76 | 4.71 | 1.38 | 82.31** | 0.32 |
| Grade motivation | 5.23 | 1.41 | 6.16 | 0.66 | 4.41 | 1.39 | 107.96** | 0.38 |
| Intrinsic motivation | 5.05 | 1.36 | 5.99 | 0.75 | 4.23 | 1.23 | 128.61** | 0.42 |
| Self-efficacy | 4.67 | 1.37 | 5.53 | 0.79 | 3.90 | 1.32 | 95.28** | 0.35 |

** p<.01

As shown in Table 2, there are significant mean differences between students with high and low motivation towards Biology and Geology in several dimensions related to learning strategies (V=.32, *F*(5.17)=16.40, p<.001), academic goals (V=.21, *F*(4.17)=11.29, p<.001) and academic expectations (V=.26, *F*(2.17)=31.03, p<.001). Highly motivated students scored higher on learning strategies compared to less motivated students, whose scores were lower. Regarding academic goals, highly motivated students were more task-oriented (M=6.05), while those with low motivation showed a greater tendency to avoid effort (M=4.11 vs. M=3.53). Furthermore, more motivated students had significantly higher academic expectations (M=6.14), whereas those with low motivation had more negative expectations (M=3.25).

The results indicate moderate to large effect sizes for most of the analysed variables. Of particular note were the orientations towards effort avoidance with an effect size of .40, followed by positive academic expectation ( =.26) and orientation towards ego self-frustration ( =.24). These dimensions suggest a considerable impact on motivation towards Biology and Geology. Also noteworthy are the elaboration strategy ( =.21) and task orientation ( =.17), which reflect moderate effects. The remaining variables show lower effect sizes, but are still indicative of considerable effects.

Table 2. Results of the analysis of the difference in means between the two groups

| | | | BG motivation | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Totals | | High (n = 83) | | Low (n = 94) | | *F* | $\eta_p^2$ |
| | M | SD | M | DT | M | DT | | |
| Organisational strategies | 4.30 | 1.79 | 4.92 | 1.73 | 3.77 | 1.68 | 19.99** | 0.10 |
| Time management and study environment | 4.42 | 1.26 | 4.93 | 1.15 | 3.96 | 1.18 | 30.67** | 0.15 |
| Seeking help | 4.76 | 1.37 | 5.26 | 1.18 | 4.31 | 1.37 | 23.82** | 0.12 |
| Processing strategies | 4.50 | 1.35 | 5.17 | 0.99 | 3.92 | 0.10 | 46.68** | 0.21 |
| Critical thinking | 4.03 | 1.34 | 4.52 | 1.12 | 3.60 | 1.38 | 23.52** | 0.12 |
| Task orientation | 5.54 | 1.16 | 6.05 | 0.73 | 5.08 | 1.28 | 36.96** | 0.17 |
| Ego-boosting orientation | 3.81 | 1.55 | 4.17 | 1.58 | 3.49 | 1.43 | 8.91** | 0.05 |
| Avoidance orientation | 3.84 | 1.47 | 3.53 | 1.40 | 4.11 | 1.47 | 7.10** | 0.40 |
| Ego self-frustration orientation | 4.04 | 2.05 | 4.37 | 1.97 | 3.74 | 2.09 | 4.24* | 0.24 |
| Positive academic expectations | 5.38 | 1.37 | 6.14 | 0.88 | 4.73 | 1.39 | 62.32** | 0.26 |
| Negative academic expectations | 3.19 | 1.51 | 2.22 | 1.35 | 3.25 | 1.51 | 22.21** | 0.11 |

** p<.01; * p<.05

### 4.3. Predicting motivation towards Biology and Geology based on learning strategies, goals and academic expectations

The third research question aims to predict which variables influence students' motivation in the subject of Biology and Geology. To address this question, a block binary logistic regression analysis was used, which rendered three explanatory models to be proposed (see Table 3).

The first model includes learning strategy variables. In this block of the analysis, the coefficients of the variables were all significant (p<.05) except for the critical thinking strategy. This first model was statistically significant ($\chi^2$=68.29; p<.001) and correctly classifies 75.5% of cases. The result obtained for the Hosmer and Lemeshow test showed that the data fit the model (p=.19). The inclusion of academic goal variables in the second model implied a significant improvement in the model ($\chi^2$=84.119; p<.001). In addition, it correctly predicted 79.1% of cases, showing an increase in the explanatory power of the model (Nagelkerke's $R^2$=0.50). The model fit the data satisfactorily (p=.57). Finally, model III introduces variables related to students' academic expectations. The inclusion of these variables results in a more robust model ($\chi^2$=105.066; p<.001). The overall percentage of correct classification increases 82.5%, with a remarkably high explanatory power (Nagelkerke's $R^2$=0.60). As in the previous cases, Model III fits the data (p=.59).

Table 3. Results of binary logistic regression analysis

| | Model I | | | Model II | | | Model III | | |
|---|---|---|---|---|---|---|---|---|---|
| | B | E.E. | R.P. | B | E.E. | R.P. | B | E.E. | R.P. |
| Constant | 8.15 | 1.27 | | 11.82 | 2.25 | | 16.87 | 3.42 | |
| Organisational strategies | -0.28* | 0.11 | 0.76 | -0.28* | 0.13 | 0.76 | -0.27* | 0.14 | 0.76 |
| Time management and study environment | -0.54* | 0.18 | 0.58 | -0.68** | 0.20 | 0.51 | -0.57* | 0.23 | 0.57 |
| Seeking help | -0.38* | 0.15 | 0.68 | -0.43* | 0.17 | 0.65 | -0.41* | 0.19 | 0.66 |
| Processing strategies | -0.42* | 0.19 | 0.66 | -0.21 | 0.23 | 0.81 | -0.23 | 0.26 | 0.79 |
| Critical thinking | -0.16 | 0.17 | 0.85 | -0.17 | 0.18 | 0.84 | -0.25 | 0.20 | 0.78 |
| Task orientation | | | | -0.40 | 0.26 | 0.67 | -0.18 | 0.28 | 0.83 |
| Ego-boosting orientation | | | | -0.13 | 0.14 | 0.88 | -0.18 | 0.16 | 0.83 |
| Avoidance orientation | | | | 0.72 | 0.16 | 1.07 | 0.56 | 0.18 | 1.06 |
| Ego self-frustration orientation | | | | -0.31* | 0.11 | 0.73 | -0.41* | 0.13 | 0.66 |
| Positive academic expectations | | | | | | | -0.99* | 0.32 | 0.37 |
| Negative academic expectations | | | | | | | -0.40 | 0.25 | 0.96 |

B: regression coefficient; S.E.: standard error; OR: odds ratio.
** p<.01; * p<.05

Table 3 shows that learning strategies play an important role in motivation towards Biology and Geology. With the exception of critical thinking, the rest of the strategies contribute to levels of motivation towards the subject studied. Specifically, according to model I, the organisational strategy was the variable that contributes most. Therefore, students who use organisational strategies more frequently are less likely they are to show low motivation towards Biology and Geology (odds ratio 0.76). Along the same lines are time management and study environment (B=-0.54; p<.05; odds ratio 0.58) and seeking help (B=-0.38; p<.05; odds ratio 0.68). In this first model, the elaboration strategy was also significant, being a learning strategy that contributes to motivation in Biology and Geology (B=-0.42; p<.05, odds ratio 0.66). However, when academic goal variables were incorporated into model II, the elaboration strategy ceased to contribute, and ego self-frustration orientation became significant (B=-0.31; p<.05). Thus, a one-unit increase in the value of this variable decreases the probability of low motivation by 27% (odds ratio 0.73). Finally, in model III, the incorporation of positive academic expectations was decisive. Thus, when students are confident in their ability to perform well, the probability of having low motivation towards the subject of Biology and Geology decreases (B=-0.99; p<.05). Consequently, a one-unit increase in the value of this variable decreases the probability of belonging to the group of students who have low motivation towards the subject (odds ratio 0.37).

## 5. Discussion

The study aimed to analyse how learning strategies, academic goals and academic expectations influence the motivation of 3rd year ESO students towards Biology and Geology. To this end, the SMQ-II was adapted and validated to measure the motivation of Spanish secondary school students in this subject.

The first research question focused on evaluating the validity and reliability of the SMQ-II as an instrument for measuring motivation towards Biology and Geology among Spanish students in the third year of compulsory secondary education. The results confirmed the original five-factor structure in the context of Biology and

Geology. These results aligned with previous studies that have validated this instrument in other cultural contexts and scientific disciplines (Ardura and Pérez-Bitrián, 2018; Guay and Bereau, 2018; Lang and Šorgo, 2024). Nevertheless, it should be noted that many studies have failed to provide sufficient evidence of validity to support the proposed internal structure of the instrument (Komperda *et al.*, 2020). However, in the present study, the high reliability of the subscales confirmed the robustness of the instrument. This finding highlights the effectiveness of the SMQ-II in adapting to different educational contexts and scientific areas. Given that motivation can vary depending on the subject, having specific tools to measure it in each subject is essential to better understand the motivational factors of students.

The second research question sought to analyse differences in learning strategies, goals, and academic expectations according to the level of motivation among Biology and Geology students. The results showed that highly motivated students use effective learning strategies more frequently, while less motivated students use them to a lesser extent. This finding, in line with previous studies in other contexts (Farnam and Anjomshoaa, 2020; Pintrich, 2003), highlights the importance of teaching effective learning strategies, as many students resort to ineffective methods because they are unaware of more appropriate alternatives (Cembrani *et al.*, 2023). Even when they are aware of effective strategies, some students do not apply them (Rea *et al.*, 2022). In terms of academic goals, students who are motivated towards Biology and Geology focus on learning and mastering the content, while less motivated students tend to avoid demanding tasks. An important finding is that more motivated students tend to be more concerned about external evaluation and to avoid situations that could damage their self-image, suggesting that high self-expectations can lead to frustration. This highlights the need for teachers to implement strategies to manage frustration and help students maintain a positive attitude in the face of challenges (Huang and Zhu, 2023).

The results also suggest that students who are highly motivated towards Biology and Geology have higher learning expectations. In contrast, students with low motivation tend to have negative expectations. These results are consistent with previous studies that highlight how positive academic expectations improve performance in complex subjects, such as science, and are key in choosing STEM careers (Farnam and Anjomshoaa, 2020; Yeung, 2024). Therefore, it is essential to work not only on students' academic skills, but also on their perceptions of their ability to succeed.

The final research question explored how learning strategies, goals, and academic expectations predict student motivation towards Biology and Geology. Although Wild and Neef (2023) point out the importance of learning strategies in predicting student motivation towards mathematics, this study shows that variables such as academic goals and expectations must also be considered in the case of biology and geology. Specifically, the results emphasise that strategies such as organisation, seeking help and time management have a significant influence on predicting motivation towards Biology and Geology. Furthermore, the results indicate that students' frustration with themselves can drive them to try harder and maintain their motivation, despite difficulties. Tsai (2020) also mention the benefits of frustration during learning. However, these authors also point out that persistent frustration without adequate support can lead to decreased commitment and learning.

A notable finding is that ego self-frustration orientation is shown to be a more significant predictor of motivation than elaboration strategy. This suggests that emotional management, particularly the ability to cope with personal frustration, may be a more decisive factor in academic motivation than some cognitive learning strategies. In this vein, as Wang (2012) points out, tolerating frustration has an impact on students' learning ability. This highlights the importance of incorporating interventions into teaching that help students manage their emotions and frustrations in the face of academic challenges. Finally, positive academic expectations also emerge as an important factor in predicting motivation. Therefore, students' perceptions of their ability to succeed in the subject influence their level of motivation. This relationship is consistent with previous studies, which highlight how these expectations also predict self-efficacy in specific areas, such as mathematics, where a positive perception of academic competence can foster motivation (Yesuf *et al.*, 2023).

One finding of this study indicates that critical thinking does not significantly impact on students' motivation towards Biology and Geology. This suggests that students do not perceive this strategy as relevant to their motivation in this subject, showing a preference for more practical approaches, such as study organisation, time management, or seeking help when faced with difficulties. This result contrasts with those reported by Valenzuela *et al.* (2023), who state that greater motivation implies greater application of critical thinking. However, these same authors (Valenzuela *et al.*, 2023) point out that if a student is not interested in or does not see the usefulness of applying critical thinking in a given situation, they are unlikely to use it, even if they have the necessary ability to do so. Therefore, the lack of critical thinking in Biology and Geology could be related to the instrumentalization of learning, whereby students tend to prioritise the skills necessary to pass the subject and meet immediate objectives. These findings raise questions about whether the methodology and assessment in Biology and Geology encourage critical thinking, and if not, whether students perceive it as a key element for successful performance in these subjects. Although this skill is essential for learning, its impact could be limited if it is not explicitly incorporated into pedagogical approaches, as students tend to focus on what they consider relevant to achieving their academic goals (Palma *et al.*, 2021).

One of the limitations of the study is the use of self-report instruments, which, although common in educational research (Pekrun, 2020), may be subject to social desirability biases or personal interpretations of the items by students. Another limitation is the sample size. While this is a moderate sample size for the proposed design, it should be noted that the study's results are an initial approximation of the topic under consideration.

Another limitation that must be taken into account derives from the RMSEA fit index value obtained in the Academic Expectations Scale and the SMQII (.09). Although recommendations usually place the acceptable threshold at values below .08, in these cases it is slightly exceeded. However, according to Byrne's (2010) recommendations, a model's fit should be evaluated based on the joint consideration of several indices rather than a single index. In this study, joint evaluation of the fit indices suggests that the model fits reasonably well.

Regarding the reliability of some of the subscales, McDonald's omega values between .60 and .70 were obtained, which are considered acceptable (Hayes and Coutts, 2020). Although the CEAM II *help-seeking* subscale obtained a more accurate omega value, this result can be interpreted bearing in mind the small number of items in this subscale, which tends to decrease internal consistency estimates. Nevertheless, this value should be interpreted with some caution.

Finally, it would be interesting for future studies to incorporate other variables that could be relevant to the study. For instance, it would be interesting to consider the characteristics of the family environment, the classroom climate, or factors related to the characteristics and expectations of teachers, as these can influence students' motivation and academic performance. Another interesting area for comparison would be the academic motivation of students in different STEM areas to identify possible differences and similarities in the factors that influence their motivation and performance. Such comparison could help to determine whether motivation varies according to discipline and which strategies might be most effective in each context.

## References


Ardura, D. & Pérez-Bitrián, A. (2018). The effect of motivation on the choice of chemistry in secondary schools: Adaptation and validation of the Science Motivation Questionnaire II. *Chemistry Education Research and Practice*, *19*(3), 905-918. https://doi.org/10.1039/C8RP00098K

Avargil, S., Sterimbaum, G., & Dahley-Zoabi, H. (2024). Factors shaping the choice in chemistry: insights from undergraduate students within a societal context. *Chemistry Education Research and Practice, 25*(3), 934-948. https://doi.org/10.1039/D4RP00058G

Bayanova, A. R., Orekhovskaya, N. A., Sokolova, N. L., Shaleeva, E. F., Knyazeva, S. A., & Budkevich, R. L. (2023). Exploring the role of motivation in STEM education: A systematic review. *Eurasia Journal of Mathematics, Science and Technology Education, 19(*4), Article em2250. https://doi.org/10.29333/ejmste/13086

Byrne, B. M. (2010). *Structural Equation Modelling with AMOS*. Taylor & Francis

Cembrani, V., Serbati, A., & Mulatti, C. (2023). Study methods and learning strategies: What do students know? A survey at the University of Trento. *Journal of Educational, Cultural and Psychological Studies, 27,* 101–119. https://doi.org/10.7358/ecps-2023-027-cemb

Coombes, L., Bristowe, K., Ellis-Smith, C., Aworinde, J., Fraser, L. K., Downing, J., Bluebond-Langner, M., Chambers, L., Murtagh, F. E. & Harding, R. (2021). Enhancing validity, reliability and participation in self-reported health outcome measurement for children and young people: A systematic review of recall period, response scale format, and administration modality. *Quality of Life Research, 30,* 1803–1832. https://doi.org/10.1007/s11136-021-02814-4

Farnam, A., & Anjomshoaa, H. (2020). The relationship between metacognition skills with academic motivation and academic achievement among high school students in Kerman, Iran. *International Journal of Pediatrics*, *8*(1), 10759-10766. https://doi.org/10.22038/ijp.2020.45608.3731

Fiorella, L., Yoon, S. Y., Atit, K., Power, J. R., Panther, G., Sorbu, S., Uttal, H., & Veurink, N. (2021). Validation of the Mathematics Motivation Questionnaire (MMQ) for secondary school students. *International Journal of STEM Education, 8*(52). https://doi.org/10.1186/s40594-021-00307-x

Glynn, S. M., Brickman, P., Armstrong, N., & Taasoobshirazi, G. (2011). Science motivation questionnaire II: Validation with science majors and nonscience majors. *Journal of Research in Science Teaching*, *48*(10), 1159-1176. https://doi.org/10.1002/tea.20442.

Guay, F., & Bureau, J. S. (2018). Motivation at school: Differentiation between and within school subjects matters in the prediction of academic achievement. *Contemporary Educational Psychology*, *54*, 42–54. https://doi.org/10.1016/j.cedpsych.2018.05.004

Hayes, A. F., & Coutts, J. J. (2020). Use Omega rather than Cronbach's Alpha for estimating reliability. But… *Communication Methods and Measures*, *14*(1), 1–24. https://doi.org/10.1080/19312458.2020.1718629

Hu, H. L. & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modelling: A Multidisciplinary Journal*, *6*(1), 1-55. https://doi.org/10.1080/10705519909540118

Huang, Z. & Zhu, G. (2023). Exploring the strategies of frustration education for high school students. Taking Mianyang High Schools in Youxian District as examples. *SHS Web of Conferences, 171*, Article 02005. https://doi.org/10.1051/shsconf/202317102005

IBM Corp. (2023.) *IBM SPSS Statistics for Windows (version 29.0.2.0)* [Computer software]. IBM Corp.

JASP Team. (2023). *JASP* (Version 0.18.3) [Computer software]. https://jasp-stats.org/

Kaiser, L. M., Großmann, N., & Wilde, M. (2020). The relationship between students' motivation and their perceived amount of basic psychological need satisfaction – a differentiated investigation of students' quality of motivation regarding biology. *International Journal of Science Education*, *42*(17), 2801–2818. https://doi.org/10.1080/09500693.2020.1836690

Komperda, R., Hosbeins, N., Philips, M. M., & Barbera, J. (2020). Investigation of evidence for the internal structure of a modified science motivation questionnaire II (mSMQ-II): a failed attempt to improve instrument functioning across course, subject, and wording variants. *Chemistry Education Research and Practice*, *21*, 893-907. https://doi.org/10.1039/D0RP00029A

Kwarikunda, D., Schiefele, U., Ssenyonga, J., & Muwonge, C. M. (2020). The relationship between motivation for, and interest in, learning physics among lower secondary school students in Uganda. *African Journal of Research in Mathematics, Science and Technology Education*, *24*(3), 435-446. https://doi.org/10.1080/18117295.2020.1841961

Lang, V. & Šorgo, A. (2024). Motivation to learn Biology: Adaptation and validation of a Science Motivation Questionnaire with Slovene secondary school students. *International Journal of Instruction*, *17*(3), 137-156

Liem, G. (2021). Achievement and motivation. *Educational Psychology, 41*, 379-382. https://doi.org/10.1080/01443410.2021.1924475

López-Martín, E. & Ardura, D. (2023). El tamaño del efecto en la publicación científica [Effect size in scientific publishing]. *Educación XX1*, *26*(1), 9-17. https://doi.org/10.5944/educxx1.36276

McDonald, R. P. (1999). *Test theory: A unified treatment*. Lawrence Erlbaum Associates, Inc.

Moreno, A. S., Quílez-Robres, A., González, E. M., & Cortés-Pascual, A. (2024). Estrategias de aprendizaje y rendimiento académico en materias STEM en Educación Secundaria [Learning strategies and academic performance in STEM subjects in secondary education]. *Revista Fuentes*, *26*(1), 36-42. https://doi.org/10.12795/revistafuentes.2024.23324

Murphy, S., MacDonald, A., Cen, A., & Danaia, L. (2019). Towards an Understanding of STEM Engagement: A Review of the Literature on Motivation and Academic Emotions. *Canadian Journal of Science, Mathematics and Technology Education*, *19*(3), 304-320. https://doi.org/10.1007/s42330-019-00054-w.

Muteti, C. Z., Zarraga, C., Jacob, B. I., Mwarumba, T. M., Nkhata, D. B., Mwavita, M., Mohanti, S., & Mutambuki, J. M. (2021). I realised what I was doing was not working: the influence of explicit teaching of metacognition on students' study strategies in a general chemistry I course. *Chemistry Education Research and Practice, 22(*1), 122-135. https://doi.org/10.1039/D0RP00217H

Myint, E. T., & Robnett, R. D. (2024). Correlates of adolescents' STEM career aspirations: the importance of academic motivation, academic identity, and gender. *European Journal Psychology of Education, 39*, 189–209. https://doi.org/10.1007/s10212-023-00681-w

Okun, T., Rijavec, M., & Caleta, M. (2022). Association between Attitudes towards Science Subjects and Grades: The Mediation Role of Learning Strategies. *Problems of Education in the 21st Century*, *80*(4), 547-564. https://doi.org/10.33225/pec/22.80.547

Palma, M., Ossa, C., Ahumada, H., Moreno, L., & Miranda, C. (2021). Adaptación y validación del test Tareas de Pensamiento Crítico en estudiantes universitarios [Adaptation and validation of the Critical Thinking Tasks test in university students]. *Journal of Studies and Experiences in Education*, *20*(42), 199-212. https://doi.org/10.21703/rexe.20212042palma12

Pekrun, R. (2020). Self-Report is Indispensable to Assess Students' Learning. *Frontline Learning Research*, *8*(3), 185–193. https://doi.org/10.14786/flr.v8i3.637

Pintrich, P. R. (2003). A Motivational Science Perspective on the Role of Student Motivation in Learning and Teaching Contexts. *Journal of Educational Psychology, 95*(4), 667–686. https://doi.org/10.1037/0022-0663.95.4.667

Preston, C. C., & Colman, A. M. (2000). Optimal number of response categories in rating scales: Reliability, validity, discriminating power, and respondent preferences. *Acta Psychologica*, 104(1), 1–15. https://doi.org/10.1016/S0001-6918(99)00050-5

Rea, S. D., Wang, L., Muenks, K., & Yan, V.X. (2022). Students Can (Mostly) Recognise Effective Learning, So Why Do They Not Do It? *Journal of Intelligence*, *10*(4), 2-28. https://doi.org/10.3390/jintelligence10040127

Roces, C., Tourón, J., & González-Torres, M. C. (1995). Validación preliminar del CEAM-II (Cuestionario de Estrategias de Aprendizaje y Motivación II) [Preliminary validation of the CEAM-II (Questionnaire on Learning Strategies and Motivation II)]. *Psicológica: Journal of methodology and experimental psychology*, *16*(3), 347-366.

Rodríguez, D., & Guzmán, R. (2018). Relación entre perfil motivacional y rendimiento académico en Educación Secundaria Obligatoria [Relationship between motivational profile and academic performance in compulsory secondary education]. *Education Studies*, *34*, 199-217. https://doi.org/10.15581/004.34.199-217

Sablić, M., Mirosavljević, A., & Labak, I. (2021). Students' Motivation in Natural Science Classes. In L. Daniela (Ed.), *Human, Technologies and Quality of Education* (pp. 635-644). University of Latvia.

Sánchez, I. (2021). *Estudio sobre las variables estratégico/metodológicas y afectivo-motivacionales de estudiantes y profesores-tutores desde la perspectiva del b-learning* [Tesis Doctoral, Universidad Nacional de Educación a Distancia] [*Study on the strategic/methodological and affective-motivational variables of students and teacher-tutors from the perspective of b-learning* [Doctoral Thesis, National University of Distance Education]]. https://hdl.handle.net/20.500.14468/17748

Schunk, D. H., Meece, J. R., & Pintrich, P. R. (2014). *Motivation in Education: Theory, Research and Affiliation*. Pearson.

Skaalvik, E. M. (1997). Self-enhancing and self-defeating ego orientation: Relations with task and avoidance orientation, achievement, self-perceptions, and anxiety. *Journal of Educational Psychology*, *89*(1), 71–81. https://doi.org/10.1037/0022-0663.89.1.71

Schneider, J., Krajcik, J., Lavonen, J., Salmela-Aro, K., Broda, M., Spicer, J., Bruner, J. , Moeller, J., Linnansaari, J., Juuti, K., & Viljaranta, J. (2016). Science Classroom Activities and Student Situational Engagement. *Journal of Research in Science Teaching, 53(*3), 400–421. https://doi.org/10.1002/tea.21306

Suárez-Valenzuela, S., & Suárez, J. M. (2023). [Predictive value of learning strategies, academic goals, educational styles, and parental expectations on performance in secondary education.] *Revista Complutense de Educación*, *34*(4), 881-894. https://doi.org/10.5209/rced.80219

Tuan H., Chin C., & Shieh S. (2005). The development of a questionnaire to measure students' motivation towards science learning. *International Journal of Science Education*, *27*(6), 639–654. https://doi.org/10.1080/0950069042000323737

Velayutham S., Aldridge J., & Fraser B. (2011). Development and Validation of an Instrument to Measure Students' Motivation and Self-Regulation in Science Learning. *International Journal of Science Education*, *33*(15), 2159–2179. https://doi.org/10.1080/09500693.2010.541529

Valenzuela, J., Nieto, A., Ossa, C., Sepúlveda, S., & Muñoz, C. (2023). Valor predictivo sobre el rendimiento de estrategias de aprendizaje, metas académicas, estilos educativos y expectativas parentales en ESO [Relationships between motivational factors and critical thinking]. *European Journal of Education and Psychology*, *16*(1), 1-18, https://doi.org/10.32457/ejep.v16i1.2077

Wang, N. (2012). Study on Frustration Tolerance and Training Method of College Students. In B. Liu, M. Ma, and J. Chang (Eds.), *Information Computing and Applications* (pp. 663–668). Springer. https://doi.org/10.1007/978-3-642-34062-8_86

Wang, Y. L., & Tsai, C. C. (2020). An Investigation of Taiwanese High School Students' Basic Psychological Need Satisfaction and Frustration in Science Learning Contexts in Relation to Their Science Learning Self-Efficacy. *International Journal of Science and Mathematics Education,* 18, 43–59. https://doi.org/10.1007/s10763-019-09950-x

Wild, S., & Neef, C. (2023). Analysing the associations between motivation and academic performance via the mediator variables of specific mathematical cognitive learning strategies in different subject domains of higher education. *International Journal of STEM Education*, *10*(32). https://doi.org/10.1186/s40594-023-00423-w

Yesuf, Y. M., Kebede, S. A., Zewdu, A., & Gebru, D. M. (2023). Predictors of high school students' mathematics self-efficacy in Addis Ababa: The importance of educational expectations. *Frontiers in Psychology*, 13, 927757. https://doi.org/10.3389/fpsyg.2022.927757

Yeung, J. W. (2024). The Dynamic Relationships between Educational Expectations and Science Learning Performance among Students in Secondary School , and Their Later Completion of a STEM Degree. *Behavioural Sciences*, *14*(6), 506. https://doi.org/10.3390/bs14060506

Zhang, F., Bae, C. L., Broda, M. D., & Koenka, A. C. (2024). Motivation and Opportunities-to-Learn in Science as Predictors of Student Science Performance. *The Journal of Experimental Education*, 1-19. https://doi.org/10.1080/00220973.2024.2306404