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Engaging Students in Chemistry and Physics with an Active Methodology

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ABSTRACT
Science, technology, engineering, and mathematics (STEM) play an important role in the global economy through technological innovation, creation, and problem-solving in this century. But it is difficult to capture students' attention to it, and the loss of students in the STEM field hinders society's development, and Portugal is no exception. The students feel that this field is difficult, they feel disappointed as the academic outcomes are more difficult to obtain in the upper secondary, and they easily give up on this area and/or choose other fields. To mesmerize students in the science area and reinforce their positive emotions a project was elaborated based on flipped classrooms with a laboratory station model and started in September 2021. A study case was designed to perceive the impact of the laboratory station methodology and flipped classrooms on the motivation of upper-secondary science students. Self-response questionnaires were applied before and after an intervention phase where students had flipped classrooms and laboratory stations, experimental classes, during one school year. This research concludes that this teaching methodology allows students to maintain motivation throughout the school year. The teacher´s attitudes regarding school, learning and teaching processes, influence students and can trigger positive emotions concerning overcoming school difficulties and barriers they found during their learning journey. It is essential to disseminate these results, as they can help teachers to face the difficulties of engaging students in the learning process in the science field. As the limitation of this study is the small sample (26 students), this study will be replicated with new students in 10th grade and students who were part of this study will continue to be followed as this methodology will continue to be applied in 11grade.

Keywords: Motivation, learning outcomes, flipped classroom, laboratory station class, Student motivation questionary

INTRODUCTION

"*Learning is a complex process which encompasses motivational components (the 'will') and cognitive components (the 'skill') and consists of achieving self-set learning goals through a series of planned actions and strategies"* [1].

The main goal of teachers is to facilitate the students' knowledge construction. Usually, the sciences explain the macroscopic world based on properties related to the microscopic world, and this represents a challenge for chemistry and physics teachers. The strategies used in this research were based on three pillars: hands-on activities (using hands and senses to observe, touch, and manipulate simple apparatus), minds-on activities (using cognitive strategies to solve problems, organize and present data as tables and graphics, and write the text), and emotional and motivational-on activities (students learning self-organization, autonomy, and peer-instructing). In this context, the laboratory station model and the flipped classroom methodology[1] were chosen as active methodologies to be applied in this research. The first allows proximal learning, is student-centred, is based on per-instruction, entails a higher level of student involvement in tasks, and is based on hands-on and minds-on activities (some of which are experimental, others are simulations or games, or problem-solving based on real data). The second one (flipped classroom model) focuses the learning process on students, increases the students' autonomy, and develops time management, personal organization skills, knowledge, and metacognition. These methodologies have the potential to attract students, as they allow emotional involvement and are active and dynamic methodologies centered on students.

To accomplish the aim of this study, considering that perceived instrumentality and guided goal perceptions are students' motivational strategies, data regarding them were collected using a scholar motivation questionnaire (SMQ) and analyzed.

In the next section (1.1) will be presented the challenge and facilitators of learning chemistry and physics in the light of neuroeducation, which justifies the active methodologies used in this research (Flipped classroom with Laboratory station), followed by a brief theoretical foundation of the questionnaire used to acquire and collect data, will be presented (achievement goals theory, self-regulated learning and instrumentality (1.2, 1.3) and finally learning strategies (1.4)) that are in the theoretical base of the data collection instrument- the scholar motivation questionnaire (SMQ).

Learning chemistry and physics: challenge and facilitators

In the last ten years, neuroeducation and neuropedagogy-based activities have been presented as a facilitator to connect students' macroscopic world to the level of the microscopic world [2-4]. To facilitate this transition and "to learn most chemical concepts, students must internalize content by creating abstract mental constructs of accepted scientific models" [5]. As Körhasan and Wang (2016) [6] point out, many of " these concepts are sometimes too abstract and counter-intuitive to understand," which complicates knowledge acquisition and internalization. Students must internalize content by creating abstract mental constructs of accepted scientific models to learn most chemical concepts [6]. Regarding the mental models, Marchak and Shvarts-Serebro [5] consider that there are eight aspects that difficult students' knowledge acquisition, "such as appreciation of chemical representations, prior chemistry knowledge, lack of any mental model and lack of motivation (…) teaching and assessment styles, use of chemical representations, the amount of content and the speed of teaching the content (…). Students must (…) explain how observable chemical phenomena at the macroscopic level results from interactions between particles at the submicroscopic level and express these

[1] The teaching methodology used in a flipped classroom is based on blended learning, which is hybrid teaching, being a mixture of distance and face-to-face instruction. In a "flipped classroom," the teacher first presents the theme to be learned, but without teaching (deepening) it. At home, the student is free to research the subject, listen, watch, and read the materials selected by the teacher, where and when he wants. In the face-to-face classroom, the teacher deepens the themes previously studied by the student.

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processes at the symbolic level" [5] being necessary for a student to have visuospatial and multi-level thinking.

In physics and chemistry, access to the macroscopic level of understanding is not a challenge for students, as it belongs to the "perceptible world and it comprises all that can be sensed, observed, and measured" [5]. But as we cross to the microscopic level, our understanding of it includes "imagining all the particles that compose the system, all the possible interactions between particles, the pattern that might result from these interactions, as well as the degree and modes of movement of these particles" [5] and this includes both physics and chemistry contents. And as Marchak and Shvarts-Serebro state "Whereas the macroscopic level involves perceptual representational competencies, the submicroscopic level involves purely conceptual ones" which is more difficult for students to achieve. It is important to emphasize that for both sciences (chemistry and physics) the symbolic level of understanding manifests itself through the use of a system of verbal and non-verbal expressions (the science language) that allow interpretation and generation of representations of systems through combinations of symbols such as schematic drawings, graphs, diagrams, equations, and formulas [7]. And to pass from macroscopic to microscopic level thinking and deal with abstract concepts students must switch from the concrete world (with specific language and symbols) to describe an "invisible" and abstract world (with a particular language).

To efficiently handle abstract chemical and physics concepts and their relationships, students must undergo a switch in their thinking: they need to make a transition from thinking through general, concrete language and symbols, which they usually use, to thinking through highly abstract phenomena that can be described with other specific language and symbols. And this shift in thinking (from concrete to abstract) necessitates strong docking concepts at each level, knowledge of connections between both levels, and knowledge of each level's language and symbols. It implies constructing scientifically correct mental models of content from which students can retrieve information and apply it to solve new problems. This process, called visualization, is vital to learning physics and chemistry. "Visualization in science can be defined as the mental process of constructing internal imagery, or symbolic visual representations of "entities" such as concepts, ideas, systems, objects, or processes" [5] and is "based on sense-making by use of a combination of visuospatial thinking and language through reasoning" [5]. And this can explain the challenge that students face when they are learning chemistry and physics, and the challenge that is teaching these two sciences areas with efficacy.

Another problem facing teachers and students is the lack of concentration in tasks related to constant task switching, which hinders the teaching and learning process [8-10]. To understand a complex text, students must develop cognitive competencies, and the resilience to do a task, implying that they must develop the willingness to read (uninterrupted), pause (deeply think and reflect on the text information), and give meaning to the text. They need to have the ability and capacity for uninterrupted thinking to maintain a line of thought and hold enough information in working memory to understand the text. But students also need personal contact and interaction, being the peer-instruction essential in the classroom as it allows for relatedness and a sense of belonging to the group and fosters the knowledge construct in pairs [8-12].

The achievement goal theory

A vast number of studies in the context of academic achievement have been reported [1, 13-17]. According to the achievement goal theory, students can have learning goals (mastery goals) or performance goals [18].

Students guided by learning goals define their competence in a task by achieving self-referential patterns [19-20], are intrinsically motivated to understand and master focused tasks, develop skills [21], and improve the level of performance or previous learning (self-referential). Students pursue increasingly challenging tasks, believing that success is fundamentally dependent on the effort they put into these tasks. They perceive errors as aspects of the learning process, not as failures, and result from insufficient or inadequate effort in the preparation or implementation of the task. When students evaluate their achievement of learning outcomes, they compare themselves and their previous performances in similar tasks, using a criterion of personal progression as a normative criterion for evaluating [22].

Instead, when students pursue performance goals, their concern is not to understand and master learning tasks, but rather to have better grades than their colleagues and leave a good impression of their performance. Students motivated by performance goals define their feeling of competence compared to colleagues. Its main objective is to overcome the academic results of peers, demonstrate superior capabilities, and get positive judgments about their competence [21, 22].

The goal achievement theory incorporates schools and teachers into the equation of student motivation, making them co-agents and co-responsible in the proceedings for the students' (dis)motivated attitude and or behaviour in the classroom. and emphasize the influence of learning environments on the orientation of students' goals, school performance, and psychological well-being in motivating them. It also stresses the importance of the type of goals promoted by the teacher in the classroom (associated with teaching and instructional practices) and the structure of objectives promoted by the school culture. This theory considers that the effect of these contexts is mediated by students' cognitive-motivational structures (their perception of the teacher's goals and the school and the content of its motivational objectives) [23].

Research carried out regarding the goal achievement theory has shown that the orientation of the teacher's personal goals guides the adoption and differential valuation of classroom structure goals with which lecture practices are associated, which make certain contents, methodologies, and purposes of teaching [24, 25]. The student's perception of the type of goal achievement (mastery vs. performance) promoted in the classroom, by the teacher, is mediated by the students' motivational processes (their orientation toward the achievement of the goals) and influences the adoption of congruent goal achievement, which affects the quality of learning and school performance. Teachers' classroom instruction and teaching practices shape and frame goal achievement, influencing goal learning orientation and/or task achievement performance [24]. As Weinstein and Mayer (1986, p. 315) emphasize, the importance of teachers' roles throughout the educational process, "good teaching includes teaching students how to learn, how to remember, how to think, and how to motivate themselves" [26]. This effect is mediated by the way students perceive their goals and their achievement outcomes.

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Teachers who promote a learning-oriented classroom consider the learning process as an active process and this is reflected in their practices of instruction/teaching [24], value formative assessment practices, encourage students with the diverse, student giving challenging and meaningful tasks, and foster understanding of the contents, but also explain the reasons of its importance. These teachers request the involvement and interaction of students [23], give opportunities to repeat schoolwork, and provide alternative tasks that students should choose [26]. They also give feedback about the learning process in private, reinforcing the idea that errors are part of the learning process. They are concerned with students, giving them cognitive, social, and emotional support, and strengthening their learning progress [27].
On the other side, the teachers who promote a performance-oriented classroom opt for instructional practices. They give only a type of work, form capacity-based groups (level groups), highlight the evaluations (summative) and classifications [27] and point out the importance of giving correct answers and avoiding errors [23]. They give public feedback on the results of the evaluation, highlighting the lowest and highest grades and/or giving special privileges, depending on the results. These teacher practices, emphasize a classroom structure with performance-oriented goals and reinforce students' perceptions of a goal-performance-oriented classroom [22], which leads them to focus on the perception of their capacity, and decay interest in the learning task, not leading to deep processing [28] or the use of metacognitive processes [29]. They are also associated with unadaptive academic results, which relate negatively to test scores [30-33].

Self-regulated learning (SRL) model and instrumentality

Manganelli and collaborators (2019) [1] state that "The self-regulated learning (SRL) model (…) provides a conceptual framework that defines learning as a constructive and active process: students set their aims and then regulate and control their motivation, cognition, and behaviour while taking social and contextual factors into consideration." [1]. These areas of regulation (motivation, cognition, and behaviour) interact and are determinants of learning outcomes and academic performance [34]. The perceived instrumentality of the tasks influences self-regulation and learning [14, 35]. If a student views self-regulation strategies as useful tools for achieving academic success, they are more likely to use them [36].

At the school level, instrumentality represents the extent to which school tasks are understood by students, as a means to achieving personal future goals, as well as their future explicit utility [9, 25, and 35], being a motivational construct that is a predictor of the student's adopted behaviour [9, 25]. The researchers, Husman and Lens (1999), distinguish three types of instrumentality (exogenous instrumentality with external regulation, endogenous instrumentality with internal regulation, and exogenous instrumentality with internal regulation) and they argue that total motivation to learn comes from the utility (instrumentality) of the task in a near and distant future [35]. And society promotes this vision for educational purposes.

Many of the goals pursued by the students are not final objectives, but instrumental or intermediate objectives (sub-goals), the achievement of which brings about other sub-objectives or the ultimate objective. The pursuit of sub-goals and final goals creates a form of motivation for the present tasks, called instrumental motivation [14, 21, 35]. Instrumental motivation is defined as the degree of perceived utility and importance of the current task in achieving future goals that are not inherently related to the activity itself [14, 21, 35].

Instrumental motivation is a type of extrinsic motivation, in which the learning is not perceived as an objective itself, but as a way to achieve it. Although it is extrinsic, instrumental motivation necessarily impairs (or makes it impossible) intrinsic motivation for the current task, just as extrinsic rewards do so in certain circumstances [14, 38]. In this sense, the perception of the instrumentality (utility value) of the task, for achieving future objectives may increase the total motivation to do the task, compared to a task that is, just an objective, with no future implications.

An empirical investigation carried out in a school context has shown that: intrinsic motivation is qualitatively better than extrinsic motivation being associated with the depth, persistence, and pleasure in learning; and that extrinsic motivation has a low motivational quality, negatively affecting intrinsic motivation, learning, and school performance [23, 39].

Learning Strategies

Self-regulation of learning can be characterized by three fundamental processes: cognitive strategies (learning, memorizing, and understanding), metacognitive strategies (supervision during the execution of the task), and motivation (effort required to implement these strategies) [40]. The strategies of elaboration and organization of information, rehearsal, critical thinking, and monitoring of learning are essential for regulating the learning process.
Weinstein (1988) classifies learning strategies as repetition/reply strategies, development strategies, organization strategies, strategies for monitoring understanding, and effective strategies. For him, replay/repetition strategies can incorporate rehearsal strategies for basic learning tasks (important in acquiring knowledge) and rehearsal strategies for complex learning tasks (relevant to knowledge that extends beyond superficial learning). The rehearsal strategy refers to the practice of knowledge, the repetition of concepts, facts, and definitions to memorize them [41,42].

The strategies for development (and organization) are important in helping students understand more deeply what they are reading or studying and storing information in their long-term memories [43]. The organization strategy refers to, the process of selecting the main ideas of a text, choosing and highlighting essential information during learning, and using different techniques such as taking notes, underlining important sentences, and summarizing information [42, 43]. The organization implies an "elaboration strategy" (it refers to the creation of links between information taken from different sources) [44] and involves different approaches, such as gathering information from different sources (lectures, readings) and different knowledge domains and creating networks between them or building links between previous knowledge and new learning material [34, 45].

Another learning strategy is the critical thinking strategy refers to the process of questioning and evaluating the learning material, as well as elaborating a personal opinion about the topics being studied [34]. Some researchers consider critical thinking as an important learning strategy, referring to how? each student can use previous knowledge to dock new knowledge in new situations, reflect on new facts, seek evidence, and/or evaluate alternatives [46].

Metacognition is defined by Pintrich and Schrauben (1992) [43] as "the knowledge of one´s knowledge, process, and cognitive and affective states" but also as "the ability to consciously and deliberately monitor and regulate one´s knowledge, processes, and cognitive and affective states". It includes knowledge of the learning strategies that students know are best appropriate to the situation, the proper mobilization of cognitive resources and the knowledge learning tasks, and the strategies that need to be used to carry out these tasks. Understanding monitoring strategies involve the definition and assessment of learning goals, the selection and use of learning strategies, and the modification of these strategies to facilitate the pursuit of goals. The monitoring strategy refers to the metacognitive processes that students use to control and adjust their cognitive processes [47, 48]. Through these skills, students can be aware of their progress in learning, check if there are any gaps in their knowledge, and choose the cognitive strategies that are more useful to reach their study objectives.

The strategies of rehearsal and organization are usually seen as surface-level processes that are more focused on the memorization and reproduction of the material studied than on really trying to understand it [49]. Instead, the strategies of elaboration and critical thinking represent deep-level processing techniques, which are aimed at understanding the learning material instead of simply reproducing it [49].

Motivation, emotion, and active learning

Social conditions that support the individual's experience of autonomy, competence, and relatedness promote the highest-quality types of engagement in activities. If the teacher provides autonomy support in the classroom, it will nurture and meet the basic psychological needs of the student (autonomy, competence, and relatedness). This, in turn, will increase classroom engagement and predict their involvement.

In the present research on the intervention process, the teacher's hard work is accomplished at home (after school classes), where he/she prepares materials, corrects worksheets or other tasks, and plans the next lesson and students' home or school activities. At school, teachers give support and individually explain the misunderstood contents, monitor task accomplishment, and reinforce the students' motivation.

The case of laboratory station methodology

Despite all teacher efforts, planning the lessons to facilitate the understanding of chemistry and physics and to give meaning to contents using everyday life examples of their application, learning these two subjects continues to be a challenge to students. It was shown by research that this is not enough, students must engage and be emotionally involved in the lesson and have an active attitude during it [8, 9, 11, 12, 50, 51]. And these must be a continuous effort and not a punctual learning strategy. According to Sousa (2011) emotions plays an important role in brain functions, as they affect learning, memory, and recall. To promote long-term memory school activities must have both cognitive and emotional components [8]. As Streb and collaborators (2015) emphasize "(…) children need the experience of emotions to achieve their highest potential because emotions have important implications for almost all aspects of cognition that are relevant in educational contexts: emotions broaden attention [4,12], enable divergent, creative and flexible thinking and problem-solving [17,21–23], enhance elaborate processing and subsequent memory [2,14,24], and increase knowledge-driven functions such as priming [5]" [52]. Deci and Ryan also emphasized in their paper in 2020 that, "Patall et al. (2019) found that in lessons wherein teachers engaged in autonomy-supportive behaviours such as offering choice, providing rationales, focusing on students interests or questions, and other specific autonomy-supportive behaviours, students reported greater interest in the material" [53]. In this sense, planning and constructing learning activities, not only promote knowledge construction but must aim to induce meaningful learning experiences and this involves not only creating sense-making tasks but also personal meaning-making tasks [5]. The laboratory station methodology enables students' autonomy development, students' time management, and collaborative work but also the emotional connection, learning chemistry and physics, and developing scientific competencies [10] and helps to increase students´ motivation to learn and self-efficacy [9]. It should be noted that Laboratory station lessons and worksheets are based on certain premises, which must be considered when they are elaborated [10].

This process (experimental classroom with laboratory stations) is more demanding for both teacher and students and requires an active effort from both. Before the classes teacher must construct the guided worksheet, and prepare all materials needed in kit stations. The teacher previously prepares the working materials (kits) according to the worksheet constructed and organizes the physical space of the class. During classes, the teacher must monitor time (to warn students to change stations after the timeout) and pass through the groups to clarify doubts, give support, and encourage students to perform the tasks (if necessary) [9, 10]. After the class, the teacher must evaluate the worksheet and prepare new materials.

Engaging students emotionally: flipped classroom

Engagement refers to a student's active involvement in a learning activity. And this applies not only to the laboratory station methodology [10] but also to the flipped classroom methodology. The flipped classroom is constructed, structured, and planned (with defined learning outcomes) by the teacher, to introduce content that must be initiated or developed by students. Students must develop autonomy, manage time outside of school, and be aware of study methods. Students must schedule their home activities and organize individual study time so that they review the materials provided by the teacher before the lesson and learn. The students need to structure and manage their study time so that this schedule is meaningful to them. As Deci and Ryan (2020) [53] state "the most positive teaching and parenting styles being high in both autonomy support and structure (…). Unlike controlling behaviors, structuring entails setting clear expectations and goals, having consistency in rules and guidelines, and providing informational support for engagement and rich efficacy feedback. Good structure "scaffolds" learning so that students rarely face non-optimal challenges, and feedback is thus largely positive and efficacy supportive." [53].

The cycle of a flipped classroom used in this research project is represented in Fig. 1. First, the teacher plans a lesson, and selects or/and produces materials related to the content students must study. Send the materials to a digital platform accessed by students and teachers. The teacher guide students in the learning journey by monitoring their progress. At home, students watch, listen, read, or produce written information after research. At school, students have laboratory station classes where they do experimental or practical work or have a lesson where they apply the knowledge they've learned. This class always starts with an evaluation (online formative assessment) regarding the contents they had to study at home, followed by teachers' feedback explaining doubts that emerge during an assessment. After that, usually, students do a worksheet with diversified activities in groups and/or pairs to deepen the contents. Before or after this class, students will perform a laboratory station lesson, according to the learning outcomes and the desired students' achievements. The laboratory stations will be done essentially by students (peer-instruction, homogeneous group), using worksheet guides and teacher support (as was previously presented).

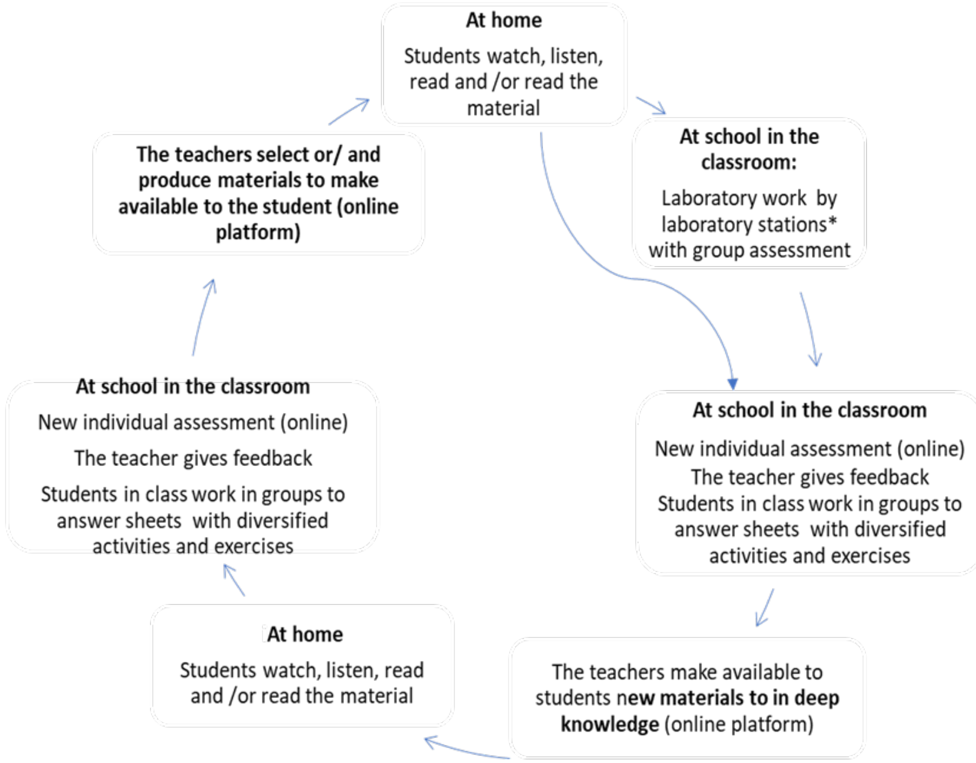

Figure 1. The cycle of the flipped classroom with laboratory stations integrated [9].

To monitor the learning process, the teacher collects and analyzes data weekly, giving timely feedback to students. Learning outcomes are monitored through regular formative assessments of an evaluative and descriptive nature. Students' achievement and learning outcomes were monitored using laboratory questionnaires (guided worksheets), which have experimental protocols activities and closed and open questions regarding chemistry contents (during the laboratory stations class, where students work in homogeneous groups), online questionnaires (flipped classroom) (with the individual assessment), and practical/theoretical classroom activities (where students work in heterogeneous groups). Evaluation test (individual assessment), classroom questions (individual assessment). Also, important to monitor the learning and teaching processes is the feedback from the activity assessment questionnaire regarding the activities carried out over the period, which is collected at the end of each period.

This research aims to perceive the effects of active methodologies (flipped classroom and laboratory station classes) on the student's motivation. The research questions were: How the intervention (flipped classroom and laboratory station models) influence the students' motivation? What type of instrumentality was promoted by the teacher and perceived by students? What kind of goals do students have to achieve their academic goals? Which learning strategies were used by students during the research? Have they changed with time?

MATERIALS AND METHODS

This research consists of a case study, exploratory and descriptive, with a methodology based on self-response questionnaires in a convenient experimental population of the 10th grade (26 students (15 and 16 years old) in the upper secondary school in the Lisbon metropolitan area. The students that were the object of study are in the same class and were chosen randomly among other classes. Some students enjoy physics and chemistry, while others enjoy only physics or chemistry. The intervention (the methodology of the laboratory stations model and flipped classroom) was implemented between September 2021 and June 2022.

Intervention

Regarding the intervention (flipped classroom with laboratory station), the data collection occurred at the end of each period (November, and June). During the school year (32 weeks), students performed seventeen experimental classes at laboratory stations. They also experienced the flipped classroom throughout the school year.

The teacher informed students that, the survey was anonymous, as the instrument was for research purposes only, and, that the main goal of the research was to understand the impact of the laboratory station classes and the flipped room on their motivation. The intervention process began in September 2021 and finish in June 2022.

Data collection

The scholar motivation questionnaire (SMQ) validated for the Portuguese population [16, 17] was applied at the end of November 2021 and in June 2022. The SMQ is a structured self-response questionnaire, based on others (Cuestionário an Estudiantes; Learning Climate Questionnaire; Perception of Instrumentality Scale [16]), consisting of 87 closed questions, that assess, from the student's point of view, school motivation, the use of learning strategies, and the student's academic performance. SMQ is a multidimensional questionnaire, on a 5-point Likert scale, that evaluates, from the student's point of view, their motivational processes, the objective structure promoted by the teacher in the classroom, the teacher's motivational style, the differential use of learning strategies, and their school performance (Table 1). SMQ scales are quoted using a five-point Likert scale. Students respond to each item by opting for an alternative, on a 5-point scale. (1: If you think the phrase is totally false; 2: If you think the phrase is false; 3: If you think the phrase is truer than false; 4: If you think the phrase is true; 5: If you think the phrase is totally true). The students used the five response possibilities to answer the items. The quotation of the items corresponds to the numerical value suggested in each response (Table 1).

Table 1. Structure of Motivational Scales of the SMQ. Dimensions, scale and items of the scholar motivation Questioner of (SMQ)

Dimensions	Scale	items
A. Perception of the orientation of the teacher's goals	A1. Learning (Learning-oriented objectives)	70, 7, 9, 57, 37
	A2. Performance (Performance-Oriented Goals)	6, 16, 20, 41
B. Perception of the instrumentality promoted by the teacher	B1. EX-E (Exogenous instrumentality with external regulation)	71, 88, 94, 18
	B2. EX-I (Exogenous instrumentality with internal regulation)	34, 45, 51, 66, 74, 97
	B3. EN- I (Endogenous instrumentality with internal regulation)	29, 32, 43
C. Perception of classroom climate	C1. Autonomy vs. Control (Teacher as the promoter of autonomy versus controller)	24, 39, 42, 59, 76, 80
D. Guiding students' goals	D1. Learning (Learning-oriented objectives)	3, 8, 25, 28, 33, 36, 98
	D2. Performance (Performance-Oriented Goals)	12, 14, 19, 26, 31, 53, 63, 67
E. Students perceived instrumentality	E1. EX-E (Exogenous instrumentality with external regulation)	62, 65, 72, 78, 87, 93
	E2. EX-I (Exogenous instrumentality with internal regulation)	22, 47, 79,91
	E3. EN-I (Endogenous instrumentality with internal regulation)	40, 69, 84, 90, 96
F. Learning strategies	F1. Rehearsal	21, 23, 49, 92
	F2. Elaboration	38, 56, 75, 83, 86, 89
	F3. Organization	15, 35, 44, 52
	F4. Critical thinking	17, 46, 50, 73, 95
	F5. Metacognitive self-regulation	4, 11, 13, 27, 30, 48, 54, 58,68, 81

The research regarding Goal Achievement is reflected in two dimensions: “A. Perception of the orientation of the teacher's objectives” and “D. Guiding students' goals”. The instrumentality data was classified into two dimensions: "B- perception of the instrumentality promoted by the teacher" and "perceived instrumentality." The learning strategies scale assesses the use of it by students according to a structure of 29 items organized in 5 scales: the rehearsal strategies scale (F1); the elaboration strategies scale (F2); the organization strategies scale (F3); the critical thinking scale (F4); and the metacognitive strategies scale (F5), Table 1.

RESULTS AND DISCUSSION

Items analysis and the level of accuracy of the SMQ

The respondents used, for the 87 items, the five response possibilities. The descriptive statistics presented arithmetic mean values ranging from 2.41 to 4.18 at the time of data collection (end of November 2021), with most statistics clustered around the mean value (3.64). The standard deviation values lie between 0.55 and 1.41. The Cronbach’s alpha coefficient for the total scale (87 items) was 0.944, showing very good values for internal consistency. This data suggests a good capacity for the SMQ to discriminate the subjects against the dimensions to be evaluated. The descriptive statistics for all 87 items ranged from 1.76 to 4.52 at the second data collection point (June 2022), with the majority of statistics clustered around the mean value (3.58). The standard deviation values lie between 0.55 and 1.41. The Cronbach's alpha coefficient for the total scale (87 items) was 0.943, showing very good values of internal consistency. To summarize the results, a table with the dimensions, scale, average scores, and scale average from the two moments of collecting data is presented, in Table 2.

Perception of orientation goals

There are two types of goals: performance goals (which involve striving to receive external confirmation of their achievement) and learning goals (focused on the task and the process of doing it).

Observing the results from dimensions A (perception of the orientation of the teacher's objectives) and D (guiding student´s goal) (Table 2), considering the goals achievement theory, it is possible to validate that students' perceptions regarding teacher goals are essentially learning goals (A1) which are reflected in the guiding student's goal, which is predominately learning goals too (D1, Table 2). Mastery goals (learning goals) involve the desire to learn new material or develop the student's abilities. On the contrary, performance goals refer to the desire to have better results than others or avoid having worse results than them (an avoidance of performance) and are not cultivated or reinforced by the teacher in the classroom. Considering these, the results corroborate the conclusion: the perception of the orientation of the teacher's objectives is correlated with guiding students' learning and that they are based on promoting learning and less performance, Table 3, and this fact remains all over the school year.

Perceived instrumentality

The combination of task goals and intrinsic motivation with extrinsic objectives (extrinsic rewards or other controlling variables) is particularly common in students. The student's motivation to study, results from intrinsic but also extrinsic motivation and is related to the perception of instrumentality to achieve extrinsic rewards. Extrinsically motivated behavior can be internally or externally regulated. If regulation is internal, it is oriented towards achieving significant goals for the individual, that are part of its structure of personal objectives or are integrated into the concept of self. If the regulation is external, it obeys pressures or impositions outside the subject (threat of punishment, promise of reward).

Students perceived instrumentality is first exogenous with internal regulation (E2) (4.17 in the first collection moment and 4.27 in the second collection moment) and then endogenous with internal regulation (E3) (4.08 in the first collection moment and 4.10 in the second collection moment) and is related to students' perceptions of the instrumentality promoted by the teacher in their teaching practice and the classroom. It is possible to recognize that the decrease, that occurred in E1 is related to the dimension scale regarding external factors (exogenous and external performance factors) (A2 and D2), Table 2.

Concerning the perception of instrumentality promoted by the teacher, it is from the students' eyes: mostly endogenous and internal (4.14 in the first collection moment and 4.17 in the second collection moment), followed by exogenous instrumentality with internal regulation (3.90 in the first collection moment and 4.06 in the second collection moment). These results agree with the perception of orientation goals promoted by the teacher and with the classroom climate.

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Table 2. Specific Comparison of average score between the two moments of collecting data

Dimensions	Scale	November 2021		June 2022		Gain/ loss	% of loss/gain
		average scores±SD	Scale average	average scores±SD	Scale average		
A. Perception of the orientation of the teacher's goals	A1. Learning	3.91±0.12	3.41	3.94±0.36	3.42	+0.03	<+1%
	A2. Performance	2.91±0.06		2.90±0.51		-0.01	<-1%
B. Perception of the instrumentality promoted by the teacher	B1. EX-E	3.45±0.11	3.83	3.46±0.78	3.90	+0.01	<+1%
	B2. EX-I	3.90±0.08		4.06±0.07		+0.16	+3.2%
	B3. EN-I	4.14±0.06		4.17±0.02		+0.03	<+1%
C. Perception of classroom climate	C1. Autonomy vs Control	3.38±0.10	3.38	3.45±0.16	3.45	+0.07	+1.4%
D. Guiding students' goals	D1. Learning	4.18±0.39	3.96	4.05±0.36	3.24	-0.13	-2.6%
	D2. Performance	3.73±0.66		2.43±0.66		-1,3	-26%
E. Students perceived instrumentality	E1. EX-E	3.30±0.57	3.85	3.06±0.69	3.81	-0.24	-4,8%
	E2. EX-I	4.17±0.10		4.27±0.12		+0,10	+2%
	E3. EN-I	4.08±0.22		4.10±0.21		+0.02	<+1%
F. Learning strategies	F1. Rehearsal	3.67±0.39	3.72	3.56±0.31	3.68	-0.11	-2.2%
	F2. Elaboration	3.78±0.18		3.76±0.16		-0.02	<-1%
	F3. Organization	3.75±0.20		3.82±0.47		+0.07	+1.4%
	F4. Critical thinking	3.55±0.13		3.51±0.15		-0.04	<-1%
	F5. Metacognitive self-regulation	3.83±0.23		3.76±0.20		-0.07	-1.4%
Average			3.69		3.58		

Perception of Classroom climate by the students

The teacher's motivational style understood as a continuum: from highly controlling to highly reinforcing student autonomy, is very important in helping students develop their autonomy. Also, the teacher's teaching style in the classroom is essential and acts as a facilitator of classroom engagement. Analyzing the results, of the classroom climate perception, it is possible to perceive that students' perception of it is related to autonomy (autonomy can be defined as the perception of being the self as the source of one´s behavior) development and less control. But there is a slight increase in the average from 3.38 to 3.45. The perception of learning classroom climate by students (dimension C, Table 2) in the first collection moment is favourable to the autonomy culture in the classroom (average 3.38), and as time passage occurs this perception is reinforced (average 3.45). Núñez and León (2019) showed that perceived autonomy support, mediated by autonomous motivation, implied a greater engagement in performing tasks [67]. Streb and collaborators (2015) found, oppositely, that when children were in learning environments that emphasized social relatedness and autonomy support (kindergarten vs. schools; voluntary workshops vs. regular lessons) they showed emotional arousal indicative of greater engagement and energy mobilization [52].

Learning strategies and learning outcomes

The learning strategies were measured by the F dimension. It is important to note that improving study habits among secondary students was one of the project's objectives. and implies time management, the construction by the student of their timetable, and the organization of the subject studied. And in fact, the learning strategies most commonly used by students were organization (3.75 in the first collection moment and 3.82 in the second collection moment), elaboration (3.78 in the first collection moment and 3.76 in the second collection moment), and metacognition (3.83 in the first collection moment and 3.76 in the second collection moment). Table 2 shows that critical thinking maintained the score value during the two collection data moments (3.55 in the first collection moment and 3.51 in the second collection moment) and rehearsal had a decrease (3.67 in the first collection moment and 3.56 in the second collection moment).

Manganelli and collaborators (2019) mention that "cognitive strategies are the thinking processes that students use in order to obtain understanding, knowledge, and skills. The self-regulation of learning (…) defines cognitive self-regulation as a process through which students choose and adopt different cognitive strategies to elaborate, organize, and memorize the learning material and control their improvements in the acquisition of knowledge. (…) that autonomously motivated students tend to achieve better academic performance by using critical thinking, while students who are driven by controlled motivation have lower academic performance." [1]. It is possible to perceive, from the data that, students used cognitive engagement strategies (which refers to the use of deep learning strategies such as elaboration, metacognition, or critical thinking) when they tried to learn.

An overlooking of scores dimensions

Higher scores or values on each scale reflect higher levels of the variable that the scale intends to measure. So, when the score values, on each scale, are higher than the average of the possible scores obtained on that scale, this attribute is considered relevant. The scales have different maximum scores, and to determine which scale was more relevant, the ratio (in percentage) of the average score obtained and the maximum value of each scale are presented in Table 3.

Looking at the average score, regarding the perception of the orientation of the teacher's goals (dimension A) they are similar in the two data points collected. The same evidence is verified in the perception of the instrumentality promoted by the teacher and in the perception of classroom climate (dimension C) (Table 3). The "perceived instrumentality promoted by the teacher" in the three scales used (B1, B2, and B3) has similar average scores in the two collection data moments.

There is no significant change in the average score in "perceived instrumentality" (E) and the same happened to "learning strategies" (F). But a tendency is observed in the dimension "guiding students' goals (D dimension) in the two scales (D1 and D2) - there is a decrease in the average score (Table 3).

The maximum ratio is observed in perceived endogenous instrumentality with internal regulation (82%) and perceived exogenous instrumentality with internal regulation (initially with 83% and finally with 85%). This is in line with the perception of instrumentality promoted by the teacher, which is predominately endogenous instrumentality with internal regulation (83% in both moments) and perceived exogenous instrumentality with internal regulation (80% in the first moment and 81% in June).

Looking at the "Students' Performance Oriented Guided Goals," it is possible to observe that it has the lowest ratio: average score/ maximum score of the scales (initially with 54% and in June with 49%) and a decrease from the first moment of data collection to the second, as also the perception of the performance goals orientation of promoted by the teacher (58%) in both moments, Table 3.

Observing the average score value of each scale regarding the maximum value of the same, it is interesting that, in June (the second moment of data collection) the perceived instrumentality with exogenous characteristics but with internal regulation has the highest value (85%) and the lowest is for the scale of performance on the topic of "students guiding goals (D2)". These results put into evidence the attributes that students considered relevant. Students perceived instrumentality (or utility) of learning is based on internal processes, which indicates that the driving force of learning is self-personality. This is reinforced by the instrumentality promoted by the teacher, which is essential internally and focuses on learning processes and the self.

Considering the results presented regarding learning strategies, we can assume that all of them are relevant to the participating students and that they maintain their relevance during the school year. And this is consistent with the theories proposed by SRL, which describe the effects of motivation on academic performance as being mediated by learning strategies [34, 47, 48]. This intervention proves to be a good teaching methodology to maintain students' internal motivation and pursue their journey in the science field [65-66].

It is relevant to note that almost all dimensions analyzed maintain their average score values, but guidance-oriented goals by performance decrease.

These results corroborate the literature regarding these issues. Taylor and collaborators showed that intrinsic motivation was associated with higher performance and academic achievement [55]. Froiland and Worrell (2016) also presented evidence that intrinsic motivation predicted student engagement and higher achievement [56]. But research findings suggest that intrinsic motivation tends to decline over the school years [57-61] but can be reinforced by hands-on activities [61], and this was the rule of laboratory station methodology. Autonomously motivated students pursue learning activities as a personal choice and/or pleasure and, therefore, feel a sense of psychological freedom. And this was also achieved by the use of laboratory station work and flipped classrooms, as both focus on students and engage them in their learning process by reinforcing their responsibility (in studying at home), and autonomy (they had to organize and respect their own study time), but also give them a pleasure as they enjoy doing laboratory station tasks at school [62-66].

Table 3. Data regarding item maximum score, score and standard deviation were obtained in the two collected moments. Scores are calculated by averaging the individual item scores. Higher average scores represent a higher level of perceived autonomy support.

Dimensions	Scale	Maximum scores	November 2021		Average score ratio (%)	June 2022		Average score ratio (%)
			Sum of average score	SD		Sum of average score	SD	
A. Perception of the orientation of the teacher's goals	A1. Learning	25	19,57	3,43	78	19,72	2,84	79
	A2. Performance	20	11,65	2,89	58	11,60	3,05	58
B. Perception of the instrumentality promoted by the teacher	B1. EX-E	20	13,81	2,87	69	13,84	2,43	69
	B2. EX-I	30	23,96	3,73	80	24,36	2,40	81
	B3. EN-I	15	12,42	1,71	83	12,52	1,36	83
C. Perception of classroom climate	C1. Autonomy vs Control	30	20,27	4,54	68	20,56	3,98	68
D. Guide-oriented students' goals	D1. Learning	35	29,46	4,21	84	28,36	5,06	81
	D2. Performance	**40**	**21,81**	**6,74**	**54**	**19,44**	**6,51**	**49**
E. Students perceived instrumentality	E1. EX-E	30	19,81	5,19	66	18,52	5,19	62
	E2. EX-I	20	16,68	2,92	83	17,08	2,33	85
	E3. EN-I	25	20,42	3,00	82	20,48	2,83	82
F. Learning Strategies	F1. Rehearsal	20	14,69	2,58	73	14,24	2,72	71
	F2. Elaboration	30	22,38	3,56	75	22,56	3,21	75
	F3. Organization	20	15,00	2,37	75	15,28	2,41	76
	F4. Critical thinking	**25**	**17,77**	**3,17**	**71**	**17,56**	**2,82**	**70**
	F5. Metacognitive self-regulation	50	38,35	5,14	77	37,16	5,33	74

CONCLUSIONS

"An important peculiarity shared by self-determined motivation and cognitive self-regulation is that they can be effectively fostered by means of specific teaching styles and learning environments (…). Therefore, they constitute key targets for interventions aimed at enhancing students' academic performance" [1]

This research aimed to perceive the influence of active methodologies on the student's motivation. This study looked at how students perceived instrumentality, their perceptions of guiding goals, and the learning strategies they used to achieve their academic goals. Instrumentality (a motivational construct) allows students to realize that the activities carried out in the present are means to achieve their future goals (which promotes their involvement and appreciation of them).

Laboratory station methodology (used to improve the learning process, motivation, and emotional involvement in physics and chemistry) and flipped classroom methodology (used to improve study habits and autonomy, self-regulation, and motivation) were chosen as active methodologies to be used in this research.

The results show that the type of classes used (flipped classroom with laboratory station methodology) helped students maintain their motivation and be more resilient and persistent in science.

The type of instrumentality that emerged was endogenous with internal regulation, but also exogenous with internal regulation. This allows arguing that the motivation to learn and to achieve learning outcomes are directly related to the utility, or instrumentality, of the intrinsic and extrinsic goals. They perform the tasks because they have future value on the one hand, but also because they enjoy learning.

The findings also show that instrumentality, as promoted by the teacher and perceived by students, has an impact on motivation and increases students' involvement and appreciation of the tasks. Students perceived that the Chemistry and Physics teacher promoted learning-oriented goals and developed an education-oriented instructional practices approach to learning, which in turn influenced their perception of the structure of learning goals and influenced their adoption of learning goals. And this agrees with the literature that emphasizes, that the teacher's classroom attitudes, instructional/teaching practices, and teaching strategies influence students and can help mobilize students to the learning task and be a facilitator of the student's scholarly journey. The educational research considers that when the teacher emphasizes a structure of intrinsic, mastery, or learning goals, it induces the activation of a similar content goal in students, associated with the mobilization of deep learning strategies, and better academic results and these were observed in the present research.

Students perceived the classroom climate as encouraging student autonomy, with deep and surface approaches to learning relying on cognitive and metacognitive strategies. The intervention presented in this paper, not only allowed the continuous use of learning strategies but also promoted students' learning achievement and outcomes.

The use of deep learning strategies (use of metacognitive skills, and greater involvement in self-regulated learning) is linked to the guidance of students' goals, and guidance for learning goals has been linked to the use of deep learning strategies (use of metacognitive skills, and greater involvement in self-regulated learning). And this study confirmed these relationships.

This research presents limitations: the first is the small number of participant students, and the second is that the intervention was applied only to students in the same grade (10th). The intervention process will be applied again in 2022-2023 in the same school, following these students and including another class of new students. This will allow us to replicate the research with a larger and more diverse sample.

References

Manganelli, S., Cavicchiolo, E., Mallia,L., Biasi, V., Lucidi; F & Alivernini, F .(2019) The interplay between self-determined motivation, self-regulated cognitive strategies, and prior achievement in predicting academic performance, Educational Psychology, 39:4, 470-488, DOI: 10.1080/01443410.2019.1572104

Marchak, D., Shvarts-Serebro,I. & Blonder, R. (2021). Crafting Molecular Geometries: Implications of Neuro-Pedagogy for Teaching Chemical Content. Journal of Chemical Education(2021), online source. Accessed March 15, 2021. https://pubs.acs.org/doi/abs/10.1021/acs.jchemed.0c00306

Marchak, D., Shvarts-Serebro, I. & Blonder, R. (2022). Teaching Chemistry by a Creative Approach: Adapting a Teachers' Course for Active Remote Learning. Journal of Chemical Education

Reddy, K., Haritsa, S.V., Rafiq, A. (2021). Importance of Brain-Based Learning in Effective Teaching Process. In: Thomas, K.A., Kureethara, J.V., Bhattacharyya, S. (eds) Neuro-Systemic Applications in Learning. Springer, Cham. https://doi.org/10.1007/978-3-030-72400-9_14.

Marchak, D. & Shvarts-Serebro, I. (2021). 14 The Multidisciplinary Learning Grid: A Conceptual Space to Develop Neuropedagogy-based, Arts-integrated Chemistry Activities. In L. Bigon & N. Shaked (Ed.), The Arts of the Grid: Interdisciplinary Insights on Gridded Modalities in Conversation with the Arts (pp. 204-224). Berlin, Boston: De Gruyter. https://doi.org/10.1515/9783110733228-017

Körhasan, N. D., & Wang, L. (2016) "Students' Mental Models of Atomic Spectra." Chemistry Education Research and Practice 17, 743–755.

Rau, M. A. (2017). "Conditions for the Effectiveness of Multiple Visual Representations in Enhancing STEM Learning." Educational Psychology Review 29, 717–761.

Sousa, D. A. How the Brain Learns (4th ed.). California: Corwin Press, 2011.

Coutinho, I. R. (2022). Teaching and Learning Chemistry and Physics with a Laboratory Stations Model in a Flipped Classroom – A Preliminary Report. Advances in Social Sciences Research Journal, 9, 73-104.

Ribau, I. (2020). Practical Work by Laboratory Stations, an Innovation in Experimental Work. Universal Journal of Educational Research. 8, 17-26. DOI: 10.13189/ujer.2020.080103

Tokuhama-Espinosa. (2008). The scientifically substantiated art of teaching: a study in the development of standards in the new academic field of neuroeducation (mind brain and education science). A PhD dissertation, Capella University, June 2008.A2 [58]

Tokuhama-Espinosa. (2013). Making classroom Better. 50 practical application of mind brain and education. W. W. Norton & Company.

Deci, E. L., & Ryan, R. M. (2000). The "What" and "Why" of goal pursuits: Human needs and the self-determination of behavior. Psychological Inquiry, 11, pp. 227-268.

Lens, W. (2009). Motivation in Education: Enjoying the present while striving for the future. Coimbra presentation handouts.

Lens, W. (2001). How to combine intrinsic task-motivation with the motivational 87 effects of the instrumentality of present tasks for future goals. In A. Efklides, J. Kuhl & R. M. Sorrentino (Eds.), Trends and prospects in motivation research (pp. 23-36). Dordrecht, Nederlands: Kluwer Academic Publishers

Cordeiro, P. M. (2010). Construção e validação do Questionário de Motivação Escolar Para a população Portuguesa: Estudos exploratórios [Construction and validation of School Motivation Questionnaire for the Portuguese population: Exploratory studies]. (master thesis dissertation). Universidade de Coimbra, Portugal.

Cordeiro, P. M., Figueira, C. A. P., da Silva, J. T.& Matos, L. (2012). School Motivation Questionnaire for the Portuguese Population: Structure and Psychometric Studies. The Spanish Journal of Psychology, vol. 15 (3), 2012, 1441-1455. Universidad Complutense de Madrid.

Elliot, A. J., & Harackiewicz, J. M. (1996). Approach and avoidance achievement goals and intrinsic motivation: A mediational analysis. Journal of Personality and Social Psychology, 70 (3), pp. 461-475.

Elliot, A. J. (1999). Approach and avoidance motivation and achievement goals. Educational Psychologist, 34, pp. 169-189.

Elliot, A. J. (2005). A conceptual history of the achievement goal construct. In A. J. Elliot & C. S. Dweck (Eds.), Handbook of competence and motivation (pp. 52-72). New York: Guilford.

Lens, W., & Vansteenkiste, M. (2006). Motivation: About the "why" and "what for" of human behavior. In K. Pawlik & G. d'Ydewalle (Eds.), Psychological concept: An international historical perspective (pp. 249-270). Hove, UK: Psychology Press.

Anderman, E.M., & Wolters, C. (2006). Goals, Values, and Affect. In P. Alexander and P. Winne (Eds.), Handbook of Educational Psychology. (2nd ed., pp. 369-390). Mahwah, NJ: Lawrence Erlbaum.

Matos, L., Lens, W., & Vansteenkiste, M. (2009). School culture matters for teacher`s and student's achievement goals. In A. Kaplan, S. Karabenick, & E. De Groot (Eds.), Culture, self, and motivation: Essays in honour of Martin L. Maehr (pp. 161-181). Information Age.

Ames, C. (1992). Classrooms: Goals, structures, and student motivation. Journal of Educational Psychology, 84 (3), pp. 261-271.

Pintrich, P. R. (2000). An achievement goal theory perspective on issues in motivation terminology, theory, and research. Contemporary Educational Psychology, 25, pp. 92-104.

Kaplan, A., Middleton, M. J., Urdan, T., & Midgley, C. (2002). Achievement goals and goal structures. In C. Midgley (Ed.), Goals, goal structures, and patterns of adaptive learning (pp. 21-53). New Jersey: Lawrence Erlbaum.

Patrick, H., Anderman, L. H., Ryan, A. M., Edelin, K. C., & Midgley, C. (2001). Teachers' communication of goal orientations in four fifth-grade classrooms. The Elementary School Journal, 102 (1), pp. 35-58.

Graham, S., & Golan, S. (1991). Motivational influences on cognition: Task involvement, ego involvement, and depth of information processing. Journal of Educational Psychology, 83, pp. 187-194.

Grolnick, W. S., & Ryan, R. M. (1987). Autonomy in children's learning: An experimental and individual difference investigation. Journal of Personality and Social Psychology, 52 (5), pp. 890-898.

Ames, C., & Archer, J. (1988). Achievement goals in the classroom: Student's learning strategies and motivation processes. Journal of Educational Psychology, 80 (3), pp. 260-267.

Anderman, E., & Midgley, C. (1997). Changes in personal achievement goals and the perceived classroom goal structures across the transition to middle-level schools. Contemporary Educational Psychology, 22, pp. 269-298.

Midgley, C. (Ed.). (2002). Goals, goal structures, and patterns of adaptive learning. Mahwah, NJ: Erlbaum

Urdan, T., Midgley, C., & Anderman, E. M. (1998). The role of classroom goal structure in students: Use of self-handicapping strategies. American Educational Research Journal, 35 (1), pp. 101-122.

Crede, M., & Phillips, L. A. (2011). A meta-analytic review of the motivated strategies for learning questionnaire. Learning and Individual Differences, 21, 337–346. doi:10.1016/j.lindif.2011.03.002

Husman, J., & Lens, W. (1999). The role of the future in student motivation. Educational Psychologist, 34, 113-125.

Miller, R. B., & Brickman, S. A. (2004). A model of future-oriented motivation and self-regulation. Educational Psychology Review, 16, 9-33. http;//dx.doi.org/10.1023/B:EDPR.0000012343.96370.39

Lens, W., Herrera, D., & Lacante, M. (2004). The role of motivation and future time perspective in educational counseling. Psychologica, 43, 169-180.

Deci, E. L., & Ryan, R. M. (1985). Intrinsic motivation and self-determination in human behaviour. New York: Plenum Press.

Matos, L., Lens, W., & Vansteenkiste, M. (2007). Achievement goals, Learning strategies and language achievement among Peruvian high school students. Psychologica Belgica, 47 (1/2), pp. 51-70.

Bouffard, T., Boisvert, J., Vezeau, C., & Larouche, C. (1995). The impact of goal orientation on self-regulation and performance among college students. British Journal of Educational Psychology, 65, 317-329.

Weinstein, C. E. (1988). Assessment and training of student learning strategies. In R. R. Schmeck (Ed.), Learning strategies and learning styles (pp. 291-316). New York: Plenum Press.

Weinstein, C. E., & Palmer, D. R. (2002). Learning and study strategies inventory user manual.Clearwater, FL: H&H Publishing Company, Inc.

Pintrich, P. R., & Schrauben, B. (1992). Students' motivational beliefs and their cognitive engagement in classroom academic tasks. In D. H. Schunk & J. L. Meece (Eds.), Student perceptions in the classrooms (pp. 149-183). New Jersey: Lawrence Erlbaum.

Vermunt, J. D. (1998). The regulation of constructive learning processes. British Journal of Educational Psychology, 68, 149–171. doi:10.1111/j.2044-8279.1998.tb01281.x

Pintrich, P. R., & De Groot, E. V. (1990). Motivational and self-regulated learning components of classroom academic performance. Journal of Educational Psychology, 82 (1), pp. 33-40.

Pintrich, Smith, Garcia & McKeachie (1991) Pintrich, P. R., Smith, D. A. F., Garcia, T., & McKeachie, W. J. (1991). A manual for the use of motivated strategies for learning questionnaire (MSLQ). Ann Arbor, Michigan: University of Michigan.

Pintrich, P. R. (2004). A conceptual framework for assessing motivation and self-regulated learning in college students. Educational Psychology Review, 16: 385–407. doi:10.1007/s10648-004-0006-x

Pintrich, P. R. (2003). A motivational science perspective on the role of student motivation in learning and teaching contexts. Journal of Educational Psychology, 95, 667–686. doi:10.1037/0022-0663.95.4.667

Rozendaal, J. S., Minnaert, A., & Boekaerts, M. (2003). Motivation and self-regulated learning in secondary vocational education: Information-processing type and gender differences.Learning and Individual Differences, 13, 273–289. doi:10.1016/S1041-6080(03)00016-5

Hardiman, Mariale (2012). The Brain-Targeted Teaching Model for 21st Century. California Corwin Press.

Lu, Li., Gow, A., & Zhou, A. (2020). The Role of Positive Emotions in Education: A Neuroscience Perspective. Mind, Brain, and Education 14(3) 220–234.

Streb, J., Keis, O., Lau, M., Hille, K., Spitzer, M., & Sosic-Vasic, Z. (2015). Emotional engagement in kindergarten and school children: A self-determination theory perspective. Trends in Neuroscience and Education, 4, 102-107.

Ryan, R. M., & Deci, E. L. (2020). Intrinsic and extrinsic motivation from a selfdetermination theory perspective: Definitions, theory, practices, and future -directions. Contemporary Educational Psychology, 61, Article 101860. https://doi.org/ 10.1016/j.cedpsych.2020.101860

Vansteenkiste, M., Simons, J., Lens, W., Soenens, B., Matos, L., & Lacante, M. (2004). Less is sometimes more: goal content matters. Journal of Educational Psychology, 96 (4), pp. 755-764

Froiland, J. M., & Worrell, F. C. (2016). Intrinsic motivation, learning goals, engagement, and achievement in a diverse high school. Psychology in the Schools, 53(3), 321–336.

Lens, W. (2006). Etudiez bien à l'école, c'est important pour votre avenir: conséquences motivationnelles de la perception de l'utilité [Study hard at school, it is important for your future: Motivational effects of perceived utility]. Revue Québécoise de Psychologie, 27, 117-133.

Lepper, M. R., Corpus, J. H., & Iyengar, S. S. (2005). Intrinsic and extrinsic motivational orientations in the classroom: Age differences and academic correlates. Journal of Educational Psychology, 97(2), 184–196.

Gillet, N., Vallerand, R. J., & Lafreniere, M. K. (2012). Intrinsic and extrinsic school motivation as a function of age: The mediating role of autonomy support. Social Psychology of Education, 15, 77–95

Gottfried, A. E., Marcoulides, G. A., Gottfried, A. W., Oliver, P. H., & Guerin, D. W. (2007). Multivariate latent change modeling of developmental decline in academic intrinsic math motivation and achievement: Childhood through adolescence. International Journal of Behavioral Development, 31(4), 317–327.

Scherrer, V., & Preckel, F. (2019). Development of motivational variables and self-esteem during the school career: A meta-analysis of longitudinal studies. Review of Educational Research, 89(2), 211–258

Guthrie, J.T., Wigfield, A., Humenick, N.M., Perencevich, K.C., Taboada, A.D., & Barbosa, P. (2006). Influences of Stimulating Tasks on Reading Motivation and Comprehension. The Journal of Educational Research, 99, 232 - 246.

Reeve, J., & Lee, W. (2014). Students' classroom engagement produces longitudinal changes in classroom motivation. Journal of Educational Psychology, 106(2), 527–540.

Reeve, J., Jang, H., Carrell, D., Jeon, S., & Barch, J. (2004). Enhancing high school students' engagement by increasing their teachers' autonomy support. Motivation and Emotion, 28(2), 147–169.

Matos, L. (2005). School culture, teacher´s and student´s achievement goals as communicating vessels: A study in Peruvian Secondary schools. Unpublished doctoral dissertation. University of Leuven, Belgium.

Niemiec, C. P., & Ryan, R. M. (2009). Autonomy, Competence, and Relatedness in the Classroom Applying Self-Determination Theory to Educational Practice. Theory and Research in Education, 7, 133-144. https://doi.org/10.1177/1477878509104318

Nicholls, J.G. (1984). Conceptions of ability and achievement motivation. In R. Ames & C. Ames (Eds.), Research on Motivation in Education: Vol. 1. Student Motivation (pp. 39–73). New York: Academic Press.

Núñez, J.L. & León, J. (2019). Determinants of classroom engagement: a prospective test based on self-determination theory, Teachers and Teaching, 25:2, 147-159, DOI: 10.1080/13540602.2018.1542297 To link to this article: https://doi.org/10.1080/13540602.2018.1542297.