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Scientific Explanations of Metalearning in Students

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Abstract

When discussing meta-learning in students, our analysis must undoubtedly focus on the main strategies for approaching such a process. In this regard, we consider meta-learning as a specific way of engaging with learning. Such an approach highlights the very concept of metacognition, which entails a comprehensive process of self-regulation in learning itself. Within this context, the aim of this paper is to examine the impact of meta-learning on students in an educational setting. Therefore, we seek to determine the extent to which such an analysis proves effective in the learning process.

Keywords: *Metalearning; students; metacognition; learning process; academic performance.*

Introduction

The scientific inquiry into meta-learning in students necessitates a comprehensive analysis of what constitutes the learning process itself. Thus, our analysis adopts an epistemological approach aimed at capturing the fundamental principles underlying learning. Under these conditions, we consider it essential to undertake an investigative approach to assess the impact of meta-learning in the student environment. Such an endeavor requires a systematic and scientific evaluation of all adopted and implemented strategies that contribute to optimizing efficiency and performance in education

A determining factor in this endeavor is the way meta-learning is defined. Various authors equate meta-learning with metacognition (Drigas, Mitsea, & Skianis, 2022; McCormick, 2003), while others distinguish between the two (Biggs, 1985, 185-212; Seng, & Fam, 1993). Primarily, meta-learning is defined as a means of awareness

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and control over one's personal approach to learning (Jackson, 2004, 391-403). Thus, meta-learning is explained as a component of creativity (Khotimah & Mariono, 2024, 18-31; Kunat, Uszyńska-Jarmoc, & Żak-Skalimowskaet, 2019, 77-90), materialized through cooperation (Charakorn et al., 2021; Womelsdorf, Watson, & Tiesinga, 2021, 79-107) and collaboration. On the other hand, meta-learning is understood as a comprehensive cognitive process through which students can regulate their own learning. It follows that such a process involves awareness of one's own approaches to learning

The process of assuming and adapting one's own meta-learning strategies requires thorough self-assessment from students. This, in turn, allows them to tailor their learning experience to their individual needs (Prain et al., 654-676). In this context, we can acknowledge the concept of learning flexibility, which is influenced by the environment in which it takes shape.

Thus, we observe that the analysis of the impact of meta-learning primarily involves considering the ways in which such an educational approach can be actualized. One argument that can be made in this regard is that the evaluation of progress in learning is possible insofar as we can refer to a set of predefined educational objectives that are acknowledged by the participants. Furthermore, another argument lies in the fact that the strategies applied and utilized can be adjusted at any stage of the learning process. Pragmatic learning fundamentally represents the outcome of the process of enhancing the self-regulation of learning itself.

Secondly, we can discuss the concept of experience within the meta-learning process. The assumption we refer to is that students can be supported in their own learning process to the extent that the strategies employed align with their level of interest and motivation. In other words, if something proves effective in their approach, it is likely to spark a certain interest, which in turn may enhance their motivation to continue the learning process. Conversely, if something does not work, it may indicate a lack of interest or motivation. Therefore, teachers, as facilitators of learning, play a crucial role in stimulating their students within such a meta-learning process

Therefore, it is necessary to test how performance can be assessed both prior to and after the application and realization of the meta-learning process. (Jeder, 2014, 115-122) Such a situation is

justified to the extent that, on one hand, the academic competencies of the students can be identified, and on the other hand, potential gaps in learning can be revealed. In this regard, we can understand their own perception of the learning process they assume within a specific socio-educational context.

How do students learn in today's society?

A multitude of studies indicate significant differences concerning the concept of meta-learning and students' willingness to engage in such an approach (Meyer, 2010). Consequently, academic performance outcomes can be analyzed in relation to the interplay between the implementation of learning methods and students' interest in leveraging them for their own educational development (White & Gunstone, 1989, 577-586). Therefore, it is essential to understand the factors that contribute to significant variations in such an educational process—an understanding that should be framed within the concept of opportunity in experimenting with new strategies (Cheng & Xie, 2021).

In this context, the comprehension of threshold concepts becomes particularly relevant, as they facilitate students' transformation in the learning process. By grasping these concepts, students not only gain autonomy in their learning but also have the ability to personalize their educational journey.

Moreover, such personalization can materialize to the extent that the student plays a major role in the instructional process. In other words, by considering their own interests and needs, students can pursue a deeply individualized learning approach, adapting both themselves and their learning environment to align with their short-term or long-term goals (Blau & Shamir-Inbal, 2017, 69-81). Under these conditions, an individualized learning context entails interactive collaboration, autonomy, and the integration of up-to-date educational software.

Another study addressing the adoption and implementation of strategies related to meta-learning suggests that personalization in learning can be validated insofar as we acknowledge various methods for augmenting the tasks to be developed (Wu, Goodman, Piech & Finn, 2021). A particularly relevant field in this regard is computer

science, where specific algorithms can enhance predictive accuracy, generating a distinct model associated with continuous feedback processes. This model produces a series of prototypes for any form of feedback. Such advancements are made possible through an innovative approach to standardizing source code. In this way, the efficiency of this code has become evident in the implementation of online courses as well as in the assessment of students during academic examinations. Consequently, the application of this model has led to an improvement in strategies aimed at ensuring continuous feedback.

Furthermore, within the framework of digital pedagogy, meta-learning must be realized by considering the development of metacognitive skills and self-regulated learning. In this regard, the specialized literature highlights the necessity of integrating educational technologies into the learning process (Nanjundaswamy, Baskaran & Leela, 2021, 179-185). Through these technologies, collaborative learning becomes possible, along with the development of interdisciplinary competencies (Beel et al., 2019). Moreover, students can more easily establish connections between theoretical content and practical applications.

In this way, it can be argued that learning autonomy is sustained over an extended period. When students experiment with different learning strategies, they can maximize their academic performance. Additionally, their awareness of developing a personal learning style enables self-assessment of their progress.

By identifying potential gaps in knowledge, students can learn collaboratively to address these deficiencies. Teaching strategies that incorporate debates, case study analysis, and teamwork can facilitate the application of concepts and theories in real-world socio-educational contexts (Jackson, 2004). Furthermore, providing timely and appropriate feedback can enhance and optimize students' learning experiences.

Moreover, by monitoring their own progress, students have the opportunity to regulate their learning process. In this regard, they need to be trained on how to effectively track and assess their instructional journey. Such an approach highlights the adaptation and calibration of their learning behaviors in alignment with the objectives and strategies established within the meta-learning process.

Providing students with digital and online resources represents another fundamental pillar in the realization of meta-learning. This assumption is justified by the fact that new technologies facilitate and enhance the learning pace of students. Another supporting argument is that online resources contribute to the individualization of learning styles while also incorporating an opportunity cost perspective in the learning process itself. In other words, students learn what to "sacrifice" and what to prioritize in their learning journey. The cost of achieving success in the learning process is determined by the cost of sacrificed or inefficient opportunities within it.

Of course, the relevance of communication in the meta-learning process cannot be overlooked. By adopting and utilizing new learning strategies, students have the opportunity to interact—either in person or online through specialized platforms—and collaborate, thereby facilitating the exchange of ideas. Online learning inherently involves the continuous updating of information, knowledge, and specialized research.

On the other hand, the meta-learning process itself also brings to light certain limitations in its implementation. One such limitation is the risk that online learning may become superficial. Therefore, in our view, a deeper engagement with content is necessary, along with a reconsideration of the ways in which new strategies are effectively utilized.

Another limitation of online meta-learning is the potential isolation of students, which can lead to mental health issues (Foumany, Salehi & Ifaei, 2014, 61-67). In this context, a statistical correlation was explored between self-esteem, mental health, and meta-learning. The conclusion drawn from this study was that rethinking and recalibrating one's views on learning can reduce negative, harmful thoughts. In this way, it is possible to improve mental health.

Similar studies have shown that interventions aimed at preventing mental health disorders have long-lasting effects, particularly in reducing symptoms of depression and anxiety. Therefore, research in this area of science is necessary as it can yield positive results in the field of mental health studies. Furthermore, preventive approaches can significantly reduce the costs associated

with long-term treatments (Winzer, Lindberg, Guldbrandsson & Sidorchuk, 2018, 1-27).

Moreover, when discussing the implications of personalized learning, we can consider the idea of learning flexibility. Through the concept of flexibilization, new conceptual, theoretical, and practical models can be developed, aiming to make metalearning sustainable. (Vizitiu, Costea, Silişteanu & Constantinescu, 2023). Such sustainability becomes valid in an educational context if the development of self-regulation skills is promoted. In this way, academic tasks can be managed efficiently, and adaptability, as a psychological trait, serves as a fundamental criterion in deciphering aspects related to metalearning.

Scientific insights into metalearning for students

When considering the idea of leveraging meta-learning in students, our research must focus on the methods of developing and improving skills that highlight (self)reflection and (self)regulation of the learning process. In this context, we are interested in understanding how students construct their own learning strategies to improve their academic performance. It involves decoding strategies for managing personal gaps in knowledge and identifying creative and innovative solutions aimed at achieving professional success in both the short and long term.

The existence of models and theories regarding the concept of meta-learning (Brazdil, Carrier, Soares & Vilalta, 2008) provides a series of scientific explanations through which we can obtain insights that highlight the need for identifying new teaching-learning-assessment strategies within the instructional process. Thus, on a theoretical foundation, we can develop an applied framework for understanding cognitive processes, as well as for leveraging teaching models built on the idea of balancing "less excessive" formalization with creativity. In this regard, we emphasize the importance of raising awareness of the meta-learning process, starting from the concept of autonomy and the effective utilization of curricular content.

At the same time, we can accept the idea that an effective educational strategy in meta-learning is determined by the way of thinking and adopting a specific type of content. Thus, we are talking

about reflective thinking, which can be correlated with a creative approach. In this way, we are convinced that the learning process acquires a pragmatic connotation. In other words, students' results largely depend on their cognitive styles as well as the learning paradigm they adopt.

In this regard, the specialized literature discusses the prediction of students' performance based on a "click-stream." In other words, students' behavior is explained using a predictive model grounded in neural networks. Such networks are automatically optimized and aim to identify strategies that facilitate the improvement of online learning. Therefore, through such a model, clear structures of predictive models can be identified (Hidalgo, Ger & Valentin, 2021, 3352-3365).

Extrapolated to the area of student performance, such a model plays a significant role in predicting students' performance. This educational approach can be especially clarified in online learning environments, taking into account the users' learning experience. Therefore, the emphasis on AI and educational software that facilitates machine learning provides clear foundations within this model, concerning the adoption of new opportunities related to the use of meta-learning in the instructional process.

Furthermore, the use of algorithms in meta-learning is a relevant aspect for research. Through these algorithms, students' performance in e-learning courses can be explained (García-Saiz & Zorrilla, 2017, 1449-1459). By considering training (collecting meta-features), and then making predictions, a valid model can be generated regarding the effective use of data algorithms. Therefore, meta-learning serves as a solution for machine learning through the use of specific algorithms.

Thus, we observe that through AI, the idea of self-regulation in the learning process can be embraced. Such a concept of self-regulation is also found in Zimmerman’s model (SRL – Self-Regulated Learning). This model highlights the main methods through which learning is possible (Zimmerman, 2013, 135-147). Starting from goal-setting and identifying learning strategies (the planning phase), taking into account the monitoring of progress and resource management (the performance phase), and reaching performance evaluation through self-motivation (the self-reflection phase), self-

regulation of learning can be realized. In other words, such a model becomes effective by enhancing teaching strategies within the instructional-educational process.

Such a model can be correlated with the concept of meta-learning in that it emphasizes awareness and the continuous improvement of cognitive processes (Zimmerman, 2002, 64-70). Additionally, through the stages proposed by Zimmerman, the learning process itself can be optimized. In other words, self-regulation (viewed as a cyclical process) and meta-learning adhere to the principle of homogeneity (they share common points) in the process of adaptation and optimization of the learning process itself.

The existence of self-regulation is correlated with the dimension of metacognitive knowledge in Flavell's theory. In other words, we can acknowledge that between the two concepts, there is more of a complementary relationship (behavioral self-regulation complements cognitive awareness). However, it is important to note that, according to Flavell, planning through self-regulation plays a crucial role in the development of metacognitive knowledge (Flavell, 1979, 906-911). In contrast, according to Zimmerman's theory, students can establish and monitor their own action strategies, as well as track their own progress. For example, if a student realizes that they have spent too much time on one topic and neglected another, they can decide to reorganize their time next time. Thus, both self-regulation and metacognition support reflective learning, which is an essential element of meta-learning.

Extrapolating such ideas into the area of meta-learning, we can acknowledge that machine learning facilitates the improvement of performance itself. Additionally, through the use of specific AI algorithms, we note that machine learning involves a level of understanding adapted to new educational contexts. In other words, through understanding, the student can learn how to learn, addressing a variety of subjects in different educational contexts.

In this regard, we can correlate the concept of meta-learning with that of evaluating understanding. In other words, we can say that through meta-learning, content is processed at the cognitive level, meaning that the improvement of predictive performance is possible through the use of an algorithm for adjusting and optimizing specific parameters. Unlike meta-learning, the evaluation of understanding a

specific content requires a comprehensive and in-depth analysis of the cognitive process that generates a particular type of response. Therefore, we can appreciate that between these two conceptual dimensions, there is a strong epistemological connection.

From such an epistemological perspective, curriculum content can be assumed insofar as it is taken on and processed in relation to the idea of understanding. Thus, it becomes imperative to apply and implement, in an educational context, an inter- and transdisciplinary transfer of theories and knowledge. In this way, we can speak of behavioral predictions of students regarding personalized/individualized learning methods. Therefore, they can have the capacity to self-assess, adjust some of their own learning strategies, as well as (de)construct their own new conceptual and theoretical structures, and make epistemic connections between them.

Conclusions and proposals

Based on the ideas analyzed and presented in this paper, the following key points can be synthesized:

Meta-learning as an educational process primarily involves awareness and self-regulation in the learning process. At the same time, through this approach, academic performance can be improved, and the learning process can be flexible. Therefore, the idea of personalizing the strategies utilized in personal study becomes highly relevant.

In this manner, we can admit that the educational process is becoming more efficient. Additionally, facilitating self-regulation is primarily determined by optimizing academic performance. Of course, interactivity plays a crucial role in such a process, and this interactivity is made possible through the use of artificial intelligence.

Metalearning, when correlated with the use of new technologies, highlights the necessity of implementing strategies to prevent mental health issues. Reflective learning plays a significant role in this regard. We can assert that meta-learning has a major role in the psychological well-being of students.

In this educational context, several potential research directions can be identified regarding the analysis of the relationship between meta-learning and students' adoption of personal strategies. One of these directions could involve an investigation into the ways

new technologies can contribute to self-regulation of learning. Another identified direction highlights the need for studies that correlate meta-learning with academic motivation and satisfaction. Last but not least, we believe a comparative research study could be conducted to explore different methods and approaches specific to each research field, aiming to optimize the learning process.

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