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The Role of Pedagogical Reflexology in Fostering Teacher's Professional Reflection in Neuropedagogy

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Abstract: *The article is the first to address how teachers can evaluate their professional reflection within the neuroscience framework. The authors discuss the potential and conditions for teachers' self-monitoring, driven by internal personal stimuli. The article aims to offer a preliminary overview of neuropedagogical literature, paving the way for further research. Additionally, it seeks to outline the neurophysiological basis of teachers' professional reflection and conduct a demonstrative sociological quasi-experiment. This experiment supports the main thesis that reflexivity, reflection, and self-reflection in teachers when driven by intrinsic motivation, can function both as a professional tool and as a subject of transformation in neuropedagogy, while also being measurable and interpretable through neuroscientific approaches. The authors used methods of relevant selection and systematic analysis of scientific sources, along with pedagogical modelling, which involved developing an algorithm to stimulate and sustain natural teacher reflection. They also applied quasi-experimental surveys to assess the presence and level of awareness of three distinct stages of professionally significant reflection among teachers. The study reveals that many existing theories of reflection within academic discourse fail to enhance the effectiveness of professional teacher reflection adequately. This reflection can become natural and ongoing when grounded in one's internal emotional stimuli, with minimal external influences. The authors established the importance of distinguishing and measuring the phenomena of reflexivity, professional reflection, and self-reflection, which can be incorporated into the broader neuro-structure of a specialist's self-regulation. These concepts can also be applied to the theory of pedagogical reflexology. The international significance of the article lies in the potential to apply the self-monitoring model of professional reflection for teachers within the neuropedagogical framework of teacher training programmes. This approach combines the authors' methodical strategies. Its effectiveness suggests that the model can serve as a framework for fostering professional reflection in current educational contexts.*

Keywords: *neuroscientific dimension; self-concep; neuroimaging; neuroscientific extrapolation; teacher subjectivity; structure of professional reflection; double motivation.*

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1. Introduction

The premise of this article is grounded in the validity of traditional reflexological findings, which can now be visualised through neurotechnologies, explored, and applied within the practical humanities-related sphere. It has become clear that human skills are patterns of everyday and professional behaviour, shaped by innate structures (Lee et al., 2020).

These ideas have given rise to a new neurocentric tradition that can be applied not only to human behaviour in a broader sense but also to professional ethics. In Eastern Europe, this interdisciplinary neurocentric approach developed with the teachings of Pavlov (1928-1941), who argued that subjective states are a fundamental reality, influencing daily life and contributing to human social progress. Pavlov (1928-1941) proposed that the neurophysiology of the brain is closely connected to subjective meanings, experiences, and states, which remain inaccessible to direct study (Sokolova, 2022).

Recent advancements in neuroscience, particularly at the crossroads of education, social interaction, and communication, have highlighted that in the context of socially sensitive neuroscience, reflexivity, reflection and self-reflection, encompassing basic and advanced forms of instinctive self-awareness, are crucial for personal development (ontogenesis) in both typical and atypical conditions (Philippi & Koenigs, 2014). Nevertheless, it has only recently become clear in neuropedagogy that teacher's professional reflection is a critical neuro-social factor influencing their behaviour and growth, involving both primitive and neocortical brain structures (Trinidad-Velasco & Reyes-Cardenas, 2020; McCoy & Lynam, 2021).

2. Research Relevance

The general relevance of the problem in question underscores the crucial role of pedagogical reflexology as both a professional and everyday tool for teachers. Its importance becomes evident when examining individual intentions and broader pedagogical trends, which can differ across time and regional contexts.

The immediate relevance of this article is tied to regional issues in Eastern Europe, particularly emerging Ukrainian, neuropedagogy. As members of the Ukrainian scientific community, the authors have drawn attention to the study of reflection in their region and noted its continued importance since the Soviet era. Researchers now examine reflection through a "from practice to mechanisms" framework, with diagnostic training gaining prominence over screening (Losiievska, 2020; Hrynova, 2016). This has led to a neuroscientific focus on reflection across various professions, including law, education, and psychology (Latyshev, 2022). A review of recent pedagogical research shows that "professional reflection" is applied in numerous related educational contexts. Notable progress has been made in promoting professional reflection in specific fields, such as foreign language teaching.

Onishchuk et al. (2020) have explored the role of reflection in foreign language learning concerning the neurophysiological aspects of the second signalling system. Maksymchuk et al. (2020) have shown that stimulating reflection and other deep psychological resources effectively develop health skills among future teachers. Additionally, other research has established a direct link between professional reflection and reflexivity as an instinctive attribution.

However, the authors of this article have identified some intriguing and less studied aspects of reflection associated with irrational, cultural, and personal intentions. To explore these, they propose a theoretical assumption: professional reflection and self-monitoring (self-reflection) cannot be solely motivated by formal, externally imposed requirements for teacher competence and deontology. This perspective is supported by Bubnys (2019), who found that satisfaction, empathy, and the sense of participating in socially significant transformative activities activate inherent psychological resources far more effectively than external or consciously rational stimuli.

Researchers should now also explore the mental-regional variations in professional reflection, which differ between Eastern and Western neuro-cultures, with increased activity observed in the medial prefrontal and temporal-parietal regions of the brain, respectively. Empirical

studies support this viewpoint since neurophysiologists have found that self-reflection in Eastern cultures is associated with the temporal-parietal region, whereas, in Western cultures, it is linked to the medial prefrontal region (Ma et al., 2014). This aligns with traditional psycho-cultural orientations, revealing that for professionals in Western cultures, social roles and their place within society hold significant importance. On the other hand, individuals in Eastern cultures tend to focus on self-reflection independent of social context and are less affected by their professional environment (Ione, 2024). This indicates that self-reflection may be more crucial for Western individuals, who frequently define themselves through their interactions with their surroundings.

The relevance of this article is underscored by integrative interdisciplinary research trends, where reflection is a focal point for neuro-sociology, neurophysiology, neuroethics, and other fields, especially in identifying complex socio-neurophysiological determinants of professional reflection (Salles & Farisco, 2024). Additionally, professional reflection is explored in irrational quasi-research from both phenomenological (self-interpretation) (Philippi & Koenigs, 2014) and neuropsychological (affective-emotional) perspectives (MacFadden & Schoech, 2010). These concepts can be examined through phenomenological discussions of reflexive “self-interpretation” within one’s worldview and in understanding the irrational affective-emotional aspects of core professional skills, which are increasingly supported by neurophysiological evidence. These diverse yet complementary theories necessitate further exploration of the conscious and unconscious mechanisms of professional reflection and address the question of whether a specialist can reflect on their reflections.

Given the absence of direct access to neuroimaging tools for measuring professional reflection, the research team will focus on non-invasive neuropsychological and neurosocial methods. According to Kosholap et al. (2021), these methods can be effectively used in various aspects of teacher’s professional development and self-monitoring. Additionally, this article explores adult neuroplasticity, which supports personal development or at least maintains effectiveness and adaptability in dynamic environments during learning, professional performance, and life trajectories (Chen & Goodwill, 2023).

Therefore, this article aims to explore current theoretical perspectives on reflection in the context of neuropedagogy, evaluate their practical validity, and incorporate them into a comprehensive framework for teacher self-monitoring. Additionally, it seeks to develop an algorithm for self-stimulating professional reflection among teachers and demonstrate its effectiveness through a sociological quasi-experiment. The main practical goal lies in validating the measurement of both rational conscious and irrational emotional neural markers of teachers’ inherent reflexivity, professional reflection, and self-reflection as latent meta-control, which is of significant importance in neuropedagogy.

Research methods are both theoretical and practical. Theoretical methods include systemic-thematic and critical analysis of methodical sources, relevant selection (concerning the theme of the research), and synthesis of reflection theories, as well as pedagogical modelling of a self-regulation algorithm for professional reflection, with an extrapolation of psycho-pedagogical data to the neuroscientific field.

In the quasi-experimental phase, the authors used sociological surveys, personal diary diagnostics, quantitative and ranking methods for processing statistical data, and neuropedagogical interpretation.

This interpretation focused on the frequency and semantic analysis of conscious and implicit neural markers related to reflexivity, professional reflection, and self-reflection among teachers, both before and after implementing recommendations for stimulating and supporting natural teacher reflection. Using appropriate models, it is also important to demonstrate how neuroscience influences teaching methods and teacher’s professional reflection.

3. Data Saturation

The required theoretical data were gathered by analysing relevant neuropedagogical theories and related fields, carefully selected in alignment with the article's topic, aim, and key points. The quasi-experimental phase for data saturation was conducted within the pedagogical communities of Kremenchuk and Dnipro Humanities-Pedagogical Colleges (Ukraine), which were selected non-randomly, making the data demonstrative rather than definitive. The experiment involved 100 mathematics teachers since their didactic activity is predominantly driven by rational components. Data saturation with statistical results was achieved through teachers' self-assessments and expert evaluations of professional reflection, conducted by the authors. The small sample size and limited geographic range of data collection are attributed to the restricted laboratory mobility caused by Russia's war against Ukraine.

4. Research Ethics

Ethical guidelines were followed through a) securing voluntary written consent from the teachers at the mentioned educational institutions; and b) ensuring the organizers of the quasi-experiment agreed with the ethics committees and/or legal substructures of the institutions. Participants were briefed beforehand about the experiment's design and potential outcomes. They voluntarily consented and were given the option to withdraw at any time without facing any negative repercussions.

The authors' contribution to the problem in question includes developing an original structural model of a teacher's professional reflection, with "a sort of reflection on reflections" at its core. Additionally, they designed and tested an algorithm to stimulate and maintain natural teacher reflection.

5. Neuropedagogical Traditions and Trends in Studying Teacher's Professional Reflection

Neuropedagogy and the psychology of developing and self-developing reflection in any socio-professional field should be viewed as interconnected. Although recent decades have seen numerous practical studies on professional reflection, no universal practices have yet been established. Instead, general observations and practical recommendations prevail (Harris et al., 2010).

One key insight is that an ideal neurophysiological model offers little value for the educational and corrective aspects of professional reflection. Rather, researchers are engaged in an experimental search for effective tools. It has been concluded that striving to study reflexive aspects of professionalisation in their ideal form or fully uncovering their mechanisms is unnecessary, as it fails to yield practical tools (Mälkki, 2011). What matters is recognising that reflection is a natural phenomenon, encompassing both unconscious behaviours and conscious responses. Equally important is the awareness of both positive (success, prospects, satisfaction, positive outcomes) and negative (uncertainty, doubt) experiences, viewed through the lens of one's natural and professional (social) identity. The authors of this article propose that by focusing on natural rather than purely pedagogical tools for developing professional reflection, one can tap into previously overlooked resources.

A major advancement in neuro-reflexology within education is the recognition that every anthropological phenomenon is inherently ambivalent, encompassing both neurophysiological and cultural (social) dimensions. A key insight from global neurophysiology into the nature of reflection highlights the deep-rooted determination of anthropological phenomena, which inevitably involve both social and neurophysiological components (Lieberman et al., 2002). It follows that mental processes, whether addressing personal needs or professional activities, are always dual, i.e., both inherently reflexive and frequently unconscious (instinctive, introverted, irrational self-reflection within one's worldview) and proactive (social, extroverted, creative, adaptive and consciously oriented toward the objective demands of the real world).

Acknowledging the natural origins of professional reflection and self-reflection as cognitive needs and tools for self-identification enables teachers to effectively integrate and use resources from their work environment (such as educational conditions, lesson objectives, and classroom dynamics) and their emotional state (including mood, interest, and motivation). While earlier research suggested that taking all these factors into account might lead to difficulties or even negative outcomes (Calderhead, 1989), current studies indicate that reflection should not be seen merely as an evaluation of these factors. Instead, teacher reflection is dynamic and adaptable: teachers may reflect on their satisfaction, emotions or rational didactic elements, which in turn shapes healthy transformative behaviour and professional ethics.

Today, theories of reflection that emphasize emotions are increasingly prevalent, as supported by the transformative learning theory (Mälkki, 2011). Essentially, the deep neurophysiological nature of reflection lies in optimising one's life-support system. While changing oneself, one's professional activities, and their conditions are a rational process, emotional reinforcement serves as a crucial "litmus test". Thus, the objective aspects of professional reflection, although influenced by the context and one's phenotypic profile, are deeply rooted in neural resources.

The interaction among rational planning, implementation, and optimisation of pedagogical activities, along with a necessary return to the subjective emotional "self" that seeks growth and satisfaction for continued motivation, supports the identification of a cyclical model of reflection. Conversely, the demands of activity mobilisation and external involvement in educational tasks (such as class schedules, programme constraints, and the need for objective results) necessitate more advanced and mature forms of reflection. Researchers term this as core reflection (Korthagen & Vasalos, 2005).

In current educational contexts, reflection has evolved beyond a purely personal realm. It now encompasses "reflection in action" and becomes an integral part of professional interpersonal dialogue and "developmental conflict". Personal beliefs, impressions, and satisfaction with teaching often come into conflict with collective opinions, interventions, and the reflections of others, creating varied perspectives on how to optimize the educational process. Despite this, teachers' professional freedom remains open to interpretation, as reflection is not strictly governed by educational standards. Instead, reflection highlights the significance of personal reactions, thoughts, and autonomy, necessitating collective discussion and debate (Pareja Roblin & Margalef, 2012). Thus, there is a need to externalize the reflective subjective experience (extroverted reflection) to prevent dissonance between personal beliefs, expectations, and conflicts. Consequently, the educational practice of reflective practitioners should be psycho-social since educators must not only reflect on the personally meaningful outcomes of their work but also take responsibility for social impacts, deontology, interactions, corporate dynamics, and more (Ploderer et al., 2014).

Wheatley (1992) proposed the scientific foundations of reflection in educational mathematical activities based on constructivism in the early 1990s. He suggested that even the independent completion of complex mathematical tasks lacks "motivational force" unless those actions are subject to personal reflection. For instance, a teacher of exact sciences must engage in both rational mathematical tasks and reflective practices simultaneously (Wheatley, 1992). Unfortunately, this approach is rarely emphasised in universities, where the professional "explanation-practice" model is predominant. Therefore, to foster professional reflection among mathematics teachers, it is essential to extend beyond traditional pedagogical and mathematical frameworks.

Researchers have noted that the reflection of mathematics teachers tends to be less prominent and focused compared to that of humanities teachers. In mathematics education, reflection often revolves around specific situational psychophysiological reactions rather than broader competency-based skills. Ricks (2011) highlighted this distinction in his study of novice mathematics teachers preparing for lessons and made key observations. He defined the scope of

professional reflection in the exact sciences by two parameters: reaction – evaluation – awareness of one’s mental processes, and modelling – awareness – evaluation of the didactic strategies employed (Ricks, 2011). This suggests that professional reflection is merely one aspect of general reflection and is often embedded within it. Thus, effective professional reflection requires skills to separate it from the overall flow of mental processes that support one’s subjectivity.

In examining the reflections of future mathematics teachers through numerous experimental studies, (Chamoso et al., 2012) provide valuable insights. They explored how students reflect on their readiness for self-learning and teaching as they near the end of their studies and manage their academic portfolios. These reflections encompassed the quality and preparedness for their learning and development and their readiness for their initial teaching experiences. Their findings indicate that pre-professional reflection can uncover important insights and challenges before entering the field. For instance, extensive portfolio preparation offers an objective view of one’s progress and self-awareness, allowing teachers to identify the outcomes and issues of prolonged training. The research identified key obstacles to effective reflection, including anxiety over complexity, excessive self-focus, and professional insecurity stemming from inexperience (Chamoso et al., 2012). Consequently, the research concluded that while professional and pre-professional reflection may not always provide adequate tools for self-improvement, it effectively highlights problematic areas in preparation and personal biases and anxieties.

Researchers have tackled these challenges in recent years through personal self-improvement and effective pedagogy within institutional settings such as schools, colleges, classrooms, and teacher teams. Studies on supervising teacher reflection have included detailed data recording in journals. Bature & Atweh (2020) conducted a qualitative thematic analysis of data gathered from observations, reflective interviews, and specialised journal entries. The most robust and valid findings emerged from studies involving small groups of teachers, ideally 3 to 5 mathematics teachers from the same team. Based on their research, Bature & Atweh (2020) offered recommendations for implementing professional reflection practices among mathematics teachers, focusing on a) reflexive meetings with colleagues; b) documenting teaching moments that enhance positive attitudes and engagement with pedagogical practice; c) establishing mechanisms for receiving feedback from students and colleagues. During the experiment, novice teachers adapted to the institutional and team frameworks and experienced a new level of trust between themselves and their students.

The latest and most promising neuropedagogical research on teacher reflection is closely related to the practical use of adult neuroplasticity, namely, the brain’s ability to change its structure in response to new knowledge and experiences (Chen & Goodwill, 2023). This involves both a practical aspect (maintaining flexibility) and a cognitive one (teachers who understand how the brain changes during learning can more effectively reflect on and adapt their teaching methods to enhance outcomes). In this regard, the integration of artificial intelligence (AI) is at the forefront of the intersection between neuroscience and pedagogy. Indeed, AI and machine learning can support teacher reflection, for example, through AI-powered self-assessment tools or personalised learning algorithms that track cognitive load and reflection in real-time. However, current debates largely focus on ethical reflection and teacher’s responsibility when involving external “artificial” agents in the “human soul” (Salles & Farisco, 2024).

These research areas are promising because effective neuropedagogy, emphasising efficient practices and a balanced focus on both students and teachers, supports the development of professional reflection among mathematics teachers and enhances their job satisfaction. It is evident that these two processes are interconnected and influence each other.

6. The Correlation of Reflexivity, Reflection and Self-Reflection in Neuropedagogy

In the 19th century, teaching resources were traditionally classified as internal or external (Calderhead, 1989). It was believed that external resources required a lengthy process of internalisation to become part of a teacher’s toolkit. Today, however, it is understood that all

informational and psycho-emotional elements of teaching form a synergistic construct that is most effectively activated in specific moments and work contexts (Ashton, 2015). In this regard, the interplay between objective (conscious) and subjective (latent) aspects of the educational process occurs, making it unnecessary to view them as separate or independent. As teachers begin their lessons, they are observed to constantly shift between following a structured plan and engaging in internal tactical self-regulation.

This section relies on the idea that the primary psychological resource behind daily activities is deeply rooted in neurophysiology. Messmann & Mulder's empirical research (2015) demonstrates that a teacher's effectiveness and capacity for daily work are motivated not by obligation but by the fulfilment of personal, both professional and non-professional, needs. The authors of this article believe that reflection serves as the crucial link between a teacher's "self-concept" (self-perception as "who I am"), their need for personal satisfaction (self-perception as "how I feel at this moment"), and their identification with students as key reference points (self-perception through others).

At this stage of the research, it is essential to introduce three levels of teacher's professional reflection: reflexivity, professional reflection, and self-reflection. This implies that a teacher's competence should encompass instinctive, frequently unconscious group-level awareness (reflexivity), consciously developed professional awareness (reflection), and an area that requires continuous practice and refinement, namely, "how I reflect on, evaluate and monitor myself" (self-reflection). The latter, being underexplored, is particularly intriguing as it bridges instinctive reactions with social-professional dynamics, integrating deeply personal elements with professional self-regulation.

Initially, this may appear as a closed cognitive loop: "I shape myself – I shape others – others, in turn, shape me" or "I reflect on others – others react to my influence and reflect on it – I reflect on myself". While this is partially true, it is metaphysical rather than ontological. Recent studies on teacher reflection reveal that the various types (or levels) of teacher reflection are not merely tools for self-identification and self-regulation, but rather resources, whose individual components and instruments function synergistically.

As is known, screening of the medial prefrontal cortex has confirmed the similarity between external reflection and self-reflection (Jenkins & Mitchell, 2011). One might anticipate that the mechanisms of double professional self-reflection ("a sort of reflection on reflections") will soon be explored through neurophysiological studies, potentially revealing a common underlying nature between these processes. In the meantime, this article proposes a three-component structure of a teacher's professional reflection, presented on a metaphysical level as a concentric model of interconnected levels (see Figure 1).

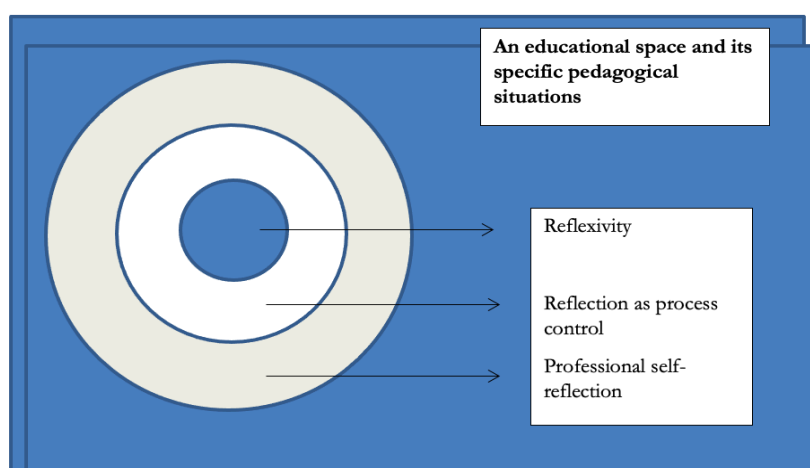


Figure 1. A structural model of a teacher's professional reflection
Source: the authors' own conception

At the core of a teacher's professional identity lies reflexivity, which serves as a natural instinctive resource and a broad determinant of behaviour. The distinction between reflexivity and professional reflection, viewed as control of the external process, is nuanced, as outlined in the previous section. However, the most intricate and remote from neuropedagogy is professional self-reflection. This type of reflection must be enacted both reflexively and contextually: teachers are continuously and consciously required to manage their professional reflection, which in pedagogical terms means exercising automatic control over not only their activities but also their professional reflection. This involves ongoing responses to the question, "How do I self-reflect?"

Even though this model is valid, it lacks complexity. Consequently, before conducting quasi-experimental research, it is crucial to describe the process through relevant discussions. This article emphasizes practical aspects, yet it also aims to highlight essential insights from neurocognitive research using deductive logic. The most relevant mechanisms for manifesting a teacher's professional reflection appear to be *cognitive load*, *neural feedback*, and *the neurological basis of interaction*.

Sableski et al. (2019) describe a teacher's professional reflection as a metacognitive process that involves assessing one's teaching practices, understanding the effectiveness of instructional methods, and adjusting them to meet student needs. However, this view is only partially accurate, as reflection or self-reflection, which operates continuously in the background, is not entirely a conscious cognitive tool and is associated with an altered state of consciousness in the presence of others. Similarly, it is vital to consider cognitive load, as teachers process vast amounts of information both consciously and unconsciously (monitoring student behaviour, adapting content to their needs, and reflecting on their performance).

As noted by Blackley et al. (2021), effective classroom decision-making, proactive teacher behaviour, and reduced cognitive load are linked to a positive mental state and reinforcement. At the same time, reflection, as a form of control, can increase cognitive load and overall psychological stress. This suggests that even professional reflection is not an entirely positive phenomenon.

Another argument against the notion of complete metacognition in reflection is the teacher's use of neural feedback. The teacher's neural network rapidly, automatically, and predominantly unconsciously processes non-verbal signals from students (such as gestures, facial expressions, and tone of voice), facilitating instant analysis and response to the situation. This mechanism enables the teacher to modify their actions based on students' immediate reactions. Consequently, neural feedback encourages the reflective process as a "reaction to reactions", since processing these responses gives the teacher immediate information to help adapt teaching strategies effectively.

The role of mirror neurons in a teacher's professional reflection presents a particularly fascinating topic of discussion. On one hand, teachers can intuitively "read" students' emotional states through mirror neurons. This allows them to meet student needs more effectively while also immersing themselves in the learning process emotionally and cognitively. In turn, this enhances both their reflection and students' progress. However, recent experimental research conducted by Heyes & Catmur (2022) shows that mirror neurons have minimal influence on verbal interaction or any specific identified channel within the educational context. Instead, they facilitate associations, copying, imitation of physical actions, kinetics, and kinaesthetic aesthetics in their holistic, unconscious representation. These observations not only undermine the value of mirror neurons in complex and effective teacher reflection but also lead researchers to explore the current situation of mirror neurons (Heyes & Catmur, 2022).

Thus, the model of a teacher's professional reflection is viewed as a multi-level process that involves cognitive activity, neural responses, and the neurological principles of interaction. Certain mechanisms can act as conscious tools of professional reflection (for instance, neurofeedback, which can be employed deliberately), while others function merely as background resources (such as social interaction and empathy in the classroom, influenced by mirror neurons).

7. Designing an Evaluation Algorithm for Stimulating and Supporting Teacher's Natural Reflection

Initially, the authors of the article asked teachers from humanities-pedagogical colleges to participate in a brief survey to explore their motivations for professional reflection. This survey, which was employed during the quasi-experimental phase of the research, is based on the conceptual model of teacher reflection developed by Colton & Sparks-Langer (1993). It features both closed-ended statements and open-ended questions addressing various aspects of teacher self-awareness and self-regulation, including flexibility, criticality, awareness, social responsibility, decision-making, effectiveness, and satisfaction (positive emotions). Table 1 outlines the top 5 motivations identified by teachers during the initial stage of the quasi-experimental evaluation of professional reflection.

Table 1. Ranking of motivations for maintaining professional reflection among pedagogical college teachers

Motivation for teacher reflection as a component of professional competence (presented in descending order)	Number of teachers who prioritised these statements
1. Following regulations, lesson topics, timing, classroom control, etc.	43
2. Effectiveness of lesson delivery, professional flexibility.	21
3. Sense of duty, fear of administrative oversight.	17
4. Maintaining a respectable teacher's image, reputation, style, etc.	16
5. Irrational anxiety about the self-control process, "double-check".	15
6. Preserving an inherent self-identification of the "self-image".	13

Source: the authors' own conception based on the results of the quasi-experiment

Clear markers of self-reflection occupy the third and fifth positions in the ranking, which, according to the subjective interpretations of the surveyed teachers, are tinged with anxiety, fear and latency.

The validity of the author's structural model is further supported by the analysis of freely expressed self-observations from participants in the quasi-experiment. During the data collection phase of the quasi-experiment, the authors encouraged teachers to apply the suggested algorithm for monitoring professional reflection at their discretion (see Figure 2).

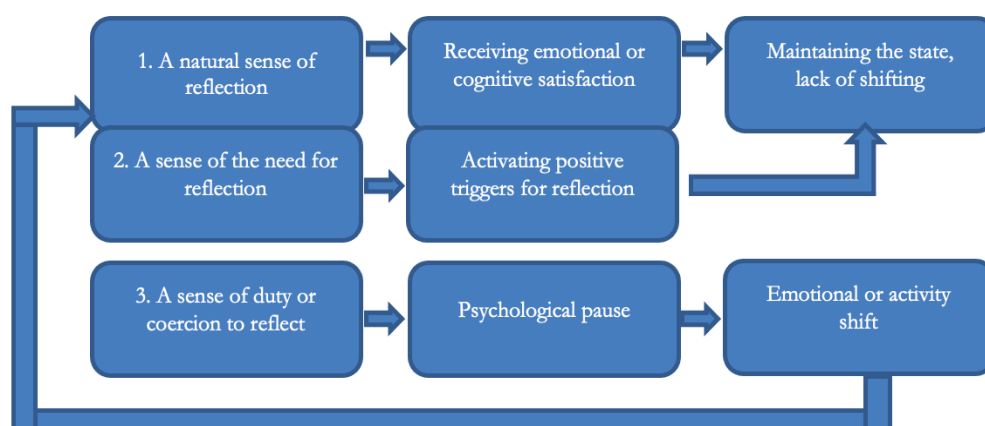


Figure 2. The author's algorithm for stimulating and supporting teachers' natural reflection

Source: the authors' own conception

Over a period of 2 months, participants were encouraged to engage in reflection prompted by the question, "I wonder what kind of teacher I am", and document their thoughts in a journal. While the authors did not analyze the content of these journals or other written reflections, they carried out a basic written survey after 2 months. This survey explored two dimensions (irrational and rational) related to the motivations for professional reflection. The findings are shown in Table 2.

Table 2. The motivation behind teacher’s voluntary professional reflection

Motivation type	A specific motive	The number of teachers who prioritised these motives
Irrational, internally stimulated types of motivation	An undifferentiated need	14
	Satisfaction	41
	Curiosity	22
Rational, externally stimulated types of motivation	Duty	11
	Responsibility	10
	Coercion	2

Source: the authors’ own conception based on the results of the quasi-experiment

Table 2 also reveals that teachers primarily engage in conscious self-reflection, or “a sort of reflection on reflections”, driven by cognitive and emotional motives rather than external demands for teacher competence. When comparing these findings with the previous table’s data, it becomes evident that the mental aspect of such dual reflection is minimal without directive intervention, while the authenticity and depth of these reflections are significantly greater in the absence of external pressure. Thus, in evaluating one’s professional competence professionally (apologies for the tautology), the main factor is not professional standards but neuropsychological needs for secondary self-reflection and self-awareness. Positive emotions and satisfaction from acknowledging high-quality work and a well-formed professional self-image are the predominant influences.

The obtained results reveal an apparent dichotomy between irrational (internal) and rational (external) motives. In the practical neuropedagogical process, however, this contrast is not evident, or teachers use mechanisms to mitigate or mask this divergence. Furthermore, the data indicate that positive reinforcements and intrinsic motivations (such as satisfaction and curiosity) are far more influential predictors of effective professional reflection than external, rational factors (such as duty or responsibility). This highlights the need for discussions on systematic models that bridge this perceived dichotomy and align the motivational factors influencing teacher reflection.

The authors of the article selected and justified a framework that represents a unified range from the various potential models available. This model relies on the assumption that internal and external motivators are not opposing forces in teacher’s work and development (Strom et al., 2021).

Table 3. A nuanced model of motivational factors in teacher’s professional reflection

Internal motivators	External motivators	Synergy
Intrinsic satisfaction	Professional requirements	
A teacher reflects through the sense of intrinsic satisfaction and purpose derived from teaching, along with the desire for continuing professional development.	A teacher reflects on the need to meet standards, fulfill the curriculum, and report to the administration.	Satisfaction counterbalances dissatisfaction, while their interplay creates more effective performance.
Personal professional development	Social recognition	
A teacher reflects out of a drive for self-realisation and a commitment to improving teaching skills.	A teacher must engage in reflection and self-development to meet the expectations of positive feedback from colleagues, students, parents, and the administration.	Social recognition serves as a reward for growth, which holds intrinsic value.
Creative self-expression	Assessment and reporting	
Teacher reflection is a means of seeking new approaches to teaching, addressing pedagogical challenges, and fostering the creative process.	Teacher reflection is a tool for aligning with external factors such as standards and requirements for professional certifications, training, or assessments.	Assessment is a “self-reaction to self-expression”, projected onto external expectations.

Source: the authors’ conception

Instead, these motivators exist on a single spectrum where they can interact, either amplifying or moderating motivational aspects of teacher reflection. When developing this model,

the authors aimed to address the correlation between internal and external motivators and the mechanisms of their synergy (see Table 3).

As noted, the pairs of external and internal motivators in the horizontal rows (such as intensity and professional requirements) are complementary rather than opposing, ultimately balancing an externally dichotomous system. A closer examination of the model's components shows that internal motivators seamlessly transition into external ones within this continuum, with the potential for them to either reinforce or counterbalance each other. For instance, a teacher might initially engage in reflection to fulfill external obligations, such as preparing a report or completing certification, only to discover over time that this process provides personal satisfaction through professional growth. On the other hand, intrinsic motivation for self-development can drive a teacher to meet high professional standards.

To explore the epistemological details necessary for integrating the proposed models into existing research, it is essential to refer to the book by Meftah (2024). In this work, neuroplasticity, self-reflection and emotional intelligence are identified as fundamental natural tools within the framework of active pedagogy. When paired with dynamic teaching methods, such as mind mapping and problem-based learning, these natural abilities will facilitate effective communication and navigation through the chaotic flow of information. However, it is important to recognize that empirical studies on neurofeedback and self-reflection are primarily being conducted in medical and special education settings, focusing on deviations from the norm (Hasslinger et al., 2020). The authors of this article hope that similar research involving normothymic educational actors will be conducted shortly.

8. Conclusions

Based on the micro-social research conducted in a quasi-experimental setting and the theoretical discussion outlined above, one can draw several neuropedagogical conclusions: both debatable (concerning existing perspectives on the research topic) and practical, which reflect the productive and motivational aspects of teacher reflection.

1. A detailed review of theoretical sources on pedagogy and neuroreflexology indicates that neurophysiological insights have had limited influence on educational and professional reflection so far, although ongoing experiments aim to identify effective tools. One of the initial breakthroughs in neuroreflexology within education is the recognition of every anthropological phenomenon as having both neurophysiological and social dimensions. Understanding professional reflection as a natural cognitive need allows teachers to use their resources independently. Today, reflection is evolving from a personal activity into an interpersonal dialogue, serving as a means to foster neuroplasticity. Reflection among science teachers tends to be less pronounced than that of humanities teachers, while for novice students, it can highlight key perspectives and challenges in their professional journey.

2. Continuing discussions on the establishment of correlations among reflexivity, reflection, and self-reflection in neuropedagogy lead to the conclusion that, historically, teaching resources were classified as internal or external. However, today's researchers prove that the cognitive, informational, and psycho-emotional aspects of pedagogical practice create a cohesive synergistic complex that manifests in specific contexts. In this regard, reflection acts as a crucial mechanism linking the teacher's "self-concept" (identifying "who I am"), their emotional state (identifying "how I feel"), and the students as reference figures (identifying through others). The authors of this article have developed a three-component model of teacher reflection that consists of reflexivity, professional reflection, and self-reflection, grounded in neuromechanisms, which underscores the importance of unconscious and irrational processes even among experienced teachers.

The main results of the article lie in the authors' functional algorithm for studying and self-monitoring teacher reflection. This has made it possible to validate the proposed presuppositions and confirm the triadic neurostructure of teacher reflection, facilitating its use at the crossroads of neuropedagogy and educational psychology.

The comparison of the obtained quasi-experimental results proves that rational methods for assessing reflection are ineffective. Teachers tend to “model” their motivations and prefer external stimuli, such as duties. However, using the algorithm, keeping a journal and exploring deeper motivations have shown that the main drivers of professional reflection are irrational and rooted in the satisfaction of needs. Consequently, self-reflection emerges as a neurodetermined tool for meta-control.

The authors’ observations reveal that emotions are the immediate outcome of conscious and unconscious professional self-reflection. These emotions play a key role in supporting the teacher’s tactical work in the “here and now”. Thoughts, conclusions, and overall satisfaction with teaching usually emerge later, making them less relevant to the immediate reflexive process.

The article suggests that self-reflection in professionals from non-social and non-creative fields can justifiably remain partially unconscious, as fully conscious reflection could disrupt the coherence and inspiration of the educational process. However, every specialist who influences others must consciously reflect on themselves in a professional subjective manner, as they are shaping both their own identity and the identities of those they impact.

Besides, this article confirms the results of recent research that natural teacher reflection, whether focused on the self or the work context, can shift motives, enhance self-organisation and spark innovative and transformative work behaviour on both personal and collective levels (Messmann & Mulder, 2015). Therefore, professional reflection is not always a conscious process; it is a deliberate search for new conditions, resources, methods, and attitudes that drive progress, even when ego-centred motives are involved. This transformative and flexible approach has become especially prominent in the “era of emotional and artificial intelligence”, where proactive and spontaneous behaviour often outweighs reactive and pre-planned actions. This fact highlights the practical side of this research since its findings can be used to design training programmes for a new generation of teachers and create projects on neuro-interactions between teachers, students, and AI within learning environments.

Meanwhile, the article aligns with Kreber’s perspective (2006), which highlights the depth and distinctiveness of the teacher’s reflective process as a means to maintain and develop one’s “self” and self-regulate similarly to everyday life and survival.

However, the authors disagree with the idea that the transformative model of teacher reflection is entirely self-regulating since it is influenced by external social stimuli and triggers. Instead, Kreber’s concept (2006) of a bodily-affective-cognitive reframing of professionalisation appears more relevant. The authors also do not agree with the notion that successful professional activity for teachers can be achieved through “continuous critical reflection” combined with personal responsibility (Williams, 2002). These factors are not inherent but result from self-imposed adherence to the deontological guidelines of educational institutions and prescribed teacher competencies.

This article is more in agreement with Boud & Walker (1998), who suggest that excessive or technological application of reflection in professional settings leads to internal conflict, psychological resistance, and formal ethical behaviour. Furthermore, it is clear that the structure of teacher reflection is triadic, encompassing process control reflection, self-reflection, and “a sort of reflection on reflections”.

9. Research Limitations

The authors acknowledge that the sociological quasi-experiment conducted for this article has served a demonstrative and factual purpose. However, to fully grasp the broader trends in teacher self-reflection, large-scale experimental studies across different regions are needed. The authors recommend conducting longitudinal studies on teacher reflection using neuroimaging methods, as well as research on how reflection develops over time in different educational contexts. This underscores the potential for continued research on the topic.

The quasi-experimental design, based on non-randomised samples from two Ukrainian teacher colleges, limits the generalizability of the findings. Furthermore, using personal journals introduces subjectivity, which affects the reliability of the conclusions. Future research should involve a more diverse, randomised sample to improve generalizability. Additionally, a mixed-methods approach could be beneficial, integrating qualitative data from personal journals with objective measures such as neuroimaging techniques (e.g., fMRI or EEG).

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References

- Ashton, R. (2015). Educational neuropsychology. In J. Reed, K. Byard, & H. Fine (Eds.), *Neuropsychological Rehabilitation of Childhood Brain Injury* (pp. 237–253). Palgrave Macmillan. https://doi.org/10.1057/9781137388223_12
- Bature, I. J., & Atweh, B. (2020). Mathematics teachers reflection on the role of productive pedagogies in improving their classroom instruction. *International Journal of Educational Methodology*, 6(2), 319–335. <https://doi.org/10.12973/ijem.6.2.319>
- Blackley, C., Redmond, P., & Peel, K. (2021). Teacher decision-making in the classroom: The influence of cognitive load and teacher affect. *Journal of Education for Teaching*, 47(4), 548–561. <https://doi.org/10.1080/02607476.2021.1902748>
- Boud, D., & Walker, D. (1998). Promoting reflection in professional courses: The challenge of context. *Studies in Higher Education*, 23(2), 191–206. <https://doi.org/10.1080/03075079812331380384>
- Bubnys, R. (2019). A journey of self-reflection in students' perception of practice and roles in the profession. *Sustainability*, 11(1), Article 194. <https://doi.org/10.3390/su11010194>
- Calderhead, J. (1989). Reflective teaching and teacher education. *Teaching and Teacher Education*, 5(1), 43–51. [https://doi.org/10.1016/0742-051X\(89\)90018-8](https://doi.org/10.1016/0742-051X(89)90018-8)
- Chamoso, J. M., Cáceres, M. J., & Azcárate, P. (2012). Reflection on the teaching-learning process in the initial training of teachers. Characterization of the issues on which pre-service mathematics teachers reflect. *Teaching and Teacher Education*, 28(2), 154–164. <https://doi.org/10.1016/j.tate.2011.08.003>
- Chen, S. H. A., & Goodwill, A. M. (2023). Neuroplasticity and adult learning. In K. Evans, W. O. Lee, J. Markowitsch, & M. Zukas (Eds.), *Third international handbook of lifelong learning* (pp. 763–781). Springer. https://doi.org/10.1007/978-3-031-19592-1_43

- Colton, A. B., & Sparks-Langer, G. M. (1993). A conceptual framework to guide the development of teacher reflection and decision making. *Journal of Teacher Education*, 44(1), 45–54. <https://doi.org/10.1177/0022487193044001007>
- Harris, A. S., Bruster, B., Peterson, B., & Shutt, T. (2010). *Examining and facilitating reflection to improve professional practice*. Rowman & Littlefield Publishers. <https://rowman.com/ISBN/9781442204454/Examining-and-Facilitating-Reflection-to-Improve-Professional-Practice>
- Hasslinger, J., D'Agostini Souto, M., Folkesson Hellstadius, L., & Bölte, S. (2020). Neurofeedback in ADHD: A qualitative study of strategy use in slow cortical potential training. *PLoS One*, 15(6), Article e0233343. <https://doi.org/10.1371/journal.pone.0233343>
- Heyes, C., & Catmur, C. (2022). What happened to mirror neurons? *Perspectives on Psychological Science*, 17(1), 153–168. <https://doi.org/10.1177/1745691621990638>
- Hrynova, O. M. (2016). Psykholohichni osoblyvosti ekzystentsiinoi refleksii v maibutnikh pedahohiv na rannikh etapakh profesiinoi pidhotovky [Psychological features of existential reflection of future teachers on early stages of professional training]. *Naukovyi visnyk Khersonskoho derzhavnoho universytetu. Seriya: Psykholohichni nauky* [Scientific Bulletin of Kherson State University. Series “Psychological Sciences”], 4, 99–104. http://nbuv.gov.ua/UJRN/nvkhp_2016_4_20
- Ione, A. (2024). *Neuroscience and art: The neurocultural landscape*. Springer Nature. <https://link.springer.com/book/10.1007/978-3-031-62336-3>
- Jenkins, A. C., & Mitchell, J. P. (2011). Medial prefrontal cortex subserves diverse forms of self-reflection. *Social Neuroscience*, 6(3), 211–218. <https://doi.org/10.1080/17470919.2010.507948>
- Kosholap, A., Maksymchuk, B., Branitska, T., Martynets, L., Boichenko, A., Stoliarenko, O., Matsuk, L., Surovov, O., Stoliarenko, O., & Maksymchuk, I. (2021). Neuropsychological bases of self-improvement of own physical health of future teachers in the course of university education. *BRAIN. Broad Research in Artificial Intelligence and Neuroscience*, 12(3), 171–190. <https://doi.org/10.18662/brain/12.3/226>
- Korthagen, F., & Vasalos, A. (2005). Levels in reflection: Core reflection as a means to enhance professional growth. *Teachers and Teaching*, 11(1), 47–71. <https://doi.org/10.1080/1354060042000337093>
- Kreber, C. (2006). Developing the scholarship of teaching through transformative learning. *Journal of Scholarship of Teaching and Learning*, 6(1), 88–109. <https://files.eric.ed.gov/fulltext/EJ854916.pdf>
- Latyshev, O. (2022). Systemni pryntsyipy i mekhanizmy refleksii [System principles and mechanisms of reflection]. *Psykholohichniy chasopys* [Psychological Journal], 8(2), 74–84. <https://doi.org/10.31108/1.2022.8.2.7>
- Lee, C. D., Meltzoff, A. N., & Kuhl, P. K. (2020). The braid of human learning and development: Neuro-physiological processes and participation in cultural practices. In N. S. Nasir, C. D. Lee, R. Pea, & M. McKinney de Royston (Eds.), *Handbook of the cultural foundations of learning* (pp. 24–43). Routledge. <https://doi.org/10.4324/9780203774977-3>
- Lieberman, M. D., Gaunt, R., Gilbert, D. T., & Trope, Y. (2002). Reflexion and reflection: A social cognitive neuroscience approach to attributional inference. In M. P. Zanna (Ed.), *Advances in Experimental Social Psychology* (Vol. 34, pp. 199–249). Academic Press. [https://doi.org/10.1016/S0065-2601\(02\)80006-5](https://doi.org/10.1016/S0065-2601(02)80006-5)
- Losiievska, O. H. (2020). Rozvytok komunikatyvnykh kompetentsii profesionalizmu u maibutnoho fakhivtsia humanitarnoho profilu [Enhancing communicative competence in professional development of future humanities specialists]. *Teoretychni i prykladni problem psykholohii* [Theoretical and Applied Problems of Psychology], 2, 205–212. <https://doi.org/10.33216/2219-2654-2020-52-2-205-212>

- Ma, Y., Bang, D., Wang, Ch., Allen, M., Frith, Ch., Roepstorff, A., & Han, Sh. (2014). Sociocultural patterning of neural activity during self-reflection. *Social Cognitive and Affective Neuroscience*, 9(1), 73–80. <https://doi.org/10.1093/scan/nss103>
- MacFadden, R. J., & Schoech, D. (2010). Neuroscience, the unconscious and professional decision making: Implications for ICT. *Journal of Technology in Human Services*, 28(4), 282–294. <https://doi.org/10.1080/15228835.2011.562636>
- Maksymchuk, B., Matviichuk, T., Solovyov, V., Davydenko, H., Soichuk, R., Khurtenko, O., Groshovenko, O., Stepanchenko, N., Andriychuk, Y., Grygorenko, T., Duka, T., Pidlypniak, I., Gurevych, R., Kuzmenko, V., & Maksymchuk, I. (2020). Developing healthcare competency in future teachers. *Revista Romaneasca Pentru Educatie Multidimensionala [Romanian Journal for Multidimensional Education]*, 12(3), 24–43. <https://doi.org/10.18662/rrem/12.3/307>
- Mälkki, K. (2011). *Theorizing the Nature of Reflection* [Doctoral dissertation, University of Helsinki]. University Press. <http://urn.fi/URN:ISBN:978-952-10-6982-6>
- Mefteh, K. C. (2024). *Active Pedagogy and Neuroeducation: In-depth Reflections for Innovative Teaching*. IntechOpen. <https://www.intechopen.com/online-first/89288>
- McCoy, S., & Lynam, A. M. (2021). Video-based Self-reflection among Pre-service Teachers in Ireland: A qualitative study. *Education and Information Technologies*, 26(1), 921–944. <https://eric.ed.gov/?id=EJ1280929>
- Messmann, G., & Mulder, R. H. (2015). Reflection as a facilitator of teachers' innovative work behaviour. *International Journal of Training and Development*, 19(2), 125–137. <https://doi.org/10.1111/ijtd.12052>
- Onishchuk, I., Ikonnikova, M., Antonenko, T., Kharchenko, I., Shestakova, S., Kuzmenko, N., & Maksymchuk, B. (2020). Characteristics of Foreign Language Education in Foreign Countries and Ways of Applying Foreign Experience in Pedagogical Universities of Ukraine. *Revista Romaneasca Pentru Educatie Multidimensionala [Romanian Journal for Multidimensional Education]*, 12(3), 44–65. <https://doi.org/10.18662/rrem/12.3/308>
- Pareja Roblin, N., & Margalef, L. (2012). Learning from dilemmas: Teacher professional development through collaborative action and reflection. *Teachers and Teaching*, 19(1), 18–32. <https://doi.org/10.1080/13540602.2013.744196>
- Pavlov, I. P. (1928-1941). *Lectures on conditioned reflexes*. Lawrence. <https://wellcomecollection.org/works/yzvjt8mu>
- Philippi, C. L., & Koenigs, M. (2014). The neuropsychology of self-reflection in psychiatric illness. *Journal of Psychiatric Research*, 54, 55–63. <https://doi.org/10.1016/j.jpsychires.2014.03.004>
- Ploderer, B., Reitberger, W., Oinas-Kukkonen, H., & van Gemert-Pijnen, J. (2014). Social interaction and reflection for behaviour change. *Personal and Ubiquitous Computing*, 18, 1667–1676. <https://doi.org/10.1007/s00779-014-0779-y>
- Ricks, T. E. (2011). Process reflection during Japanese lesson study experiences by prospective secondary mathematics teachers. *Journal of Mathematics Teacher Education*, 14, 251–267. <https://doi.org/10.1007/s10857-010-9155-7>
- Sableski, M. K., Kinnucan-Welsch, K., & Rosemary, C. (2019). Facilitating Teacher Reflection Using a Metacognitive Tool. *Mid-Western Educational Researcher*, 31(3), 312–332. <https://scholarworks.bgsu.edu/mwer/vol31/iss3/4>
- Salles, A., & Farisco, M. (2024). Neuroethics and AI ethics: A proposal for collaboration. *BMC Neuroscience*, 25(1), Article 41. <https://doi.org/10.1186/s12868-024-00888-7>
- Sokolova, L. V. (2022). Origins of Russian cognitive psychophysiology. In Ch. Forsythe (Ed.), *Russian cognitive neuroscience* (pp. 3–25). Brill. <https://www.ebay.com/itm/386931649611>
- Strom, K., Mills, T., & Abrams, L. (2021). Illuminating a continuum of complex perspectives in teacher development. *Professional Development in Education*, 47(2–3), 199–208. <https://doi.org/10.1080/19415257.2021.1901005>

- Trinidad-Velasco, R., & Reyes-Cardenas, F. (2020). Exploring Chemistry Teachers' General Pedagogical Knowledge Through Teachers' Self-reflection. *Science Education International*, 31(3), 263–272. <https://doi.org/10.33828/sei.v31.i3.5>
- Wheatley, G. H. (1992). The role of reflection in mathematics learning. *Educational Studies in Mathematics*, 23, 529–541. <https://doi.org/10.1007/BF00571471>
- Williams, B. (2002). Developing critical reflection for professional practice through problem-based learning. *Journal of Advanced Nursing*, 34(1), 27–34. <https://doi.org/10.1046/j.1365-2648.2001.3411737.x>