Abstract

Neuroscience research studies the way human brain works. The field of educational neuroscience provides insights into the cognitive processes of the mind that can inform policies, organization, design, planning, implementation and evaluation of education. Are educators informed of the latest developments of neuroscience and their implication for teaching? Literature findings have demonstrated that the lack of awareness is just the tip of the iceberg. In fact, there is an enduring and alarming proliferation of false beliefs around the brain, called neuromyths. Evidently there is an acute training need for of teachers and trainers in all levels of education, especially higher education lecturers and professors. In the higher education sector of many countries research is a clear priority over teaching and learning. Career advancement of academic faculty depends primarily on research rigor and publication record rather than pedagogical acumen and teaching performance. This need for continuous professional development is to be addressed by the Erasmus Plus program “Neuropedagogy” involving partners from five European countries. The project will conduct studies in all participating countries on neuroscience applied to higher education and assemble them into a comprehensive study to identify training needs and directions for subsequent action. Next, it will facilitate the exchange of best practices to prepare itineraries with adequate training skills development required by higher education teachers. Finally, it will develop an innovative training methodology and online community of practice to train and enhance the didactic competences of higher education professionals.

Keywords: Higher education, teaching, neuroscience, neuropedagogy, educational neuroscience, professional development, online learning.

1 INTRODUCTION

The quality of higher education depends on faculty teaching perceptions [1]. Syllabi are lived experiences shaped by the actual employed teaching and learning practices [2]. These practices are determined sequentially by educators’ definitions and comprehension of teaching excellence [3]. Teaching conceptions can be divided into two fundamental clusters: teacher-focused and student-focused [4]. The teacher-focused conception is accepting the premise that knowledge can and should be transmitted from teachers to students. Hence, the procedure of learning can be visualized commonly as tube or conduit, allowing the automatic flow of information from the expert professor’s mind into the novice students. Antithetically, the assumption behind the student-focused approach is that the student is capable and responsible to develop his/her personal knowledge and co-create meaning [5]. In this case, learning can be illustrated as the construction of connected conceptual and procedural building blocks. Strict, teacher-led instruction can reflect a behaviorist theoretical disposition while student-focused approaches have constructivist epistemological underpinnings [6]. Both conceptions can be complimentary and effective for various audiences in different domains and contexts [7]. In the tertiary institutions of many national educational systems, research is valued higher in
comparison to teaching. Career advancement of academic faculty is determined and judged primarily on research publication metrics and impact rather than pedagogical competency and student satisfaction [8]. Higher education teaching is not always effective, relying to a high degree on teacher-focused methods towards large student audiences, i.e., lectures [9]. The field of educational neuroscience provides insights into the cognitive processes of the mind that can inform policies, organization, design, planning, implementation and evaluation of education. Neuroscience research investigates the way human brain works. Human memory system has two sub-systems: working memory and long-term memory. Working memory has a limited capacity. Humans cannot retain more than four to seven information items in the working memory depending on the nature and the characteristics of these information chunks [10]. Forgetting is inherent in our brain so as to discharge irrelevant or insignificant data. The general objective of education is moving and storing meaningful knowledge and skills in the long-term memory. The goal of the study is the improvement and sustaining a top-quality level of teaching and learning in higher education through insights from the field of neuroscience.

2 METHOD
Deep institutional changes in higher education towards quality assurance, public service and internationalization, provokes alterations in the functions, roles, and tasks assigned to the professor, requiring the development of new competencies to the teaching and research personnel. The objective of the Erasmus+ Neuropedagogy project is to train higher education lecturers in an innovative didactic method, based on neuroscience, through an online platform in which a community of higher education lecturers is created to facilitate the development of transversal competences in the area of communication.

In this context, desk literature research was conducted to discover evidence published in the last 40 years towards educational neuroscientific knowledge adaptable to educators’ context. The guiding research question was: what are the fundamental teaching principles according to Neuroscience for application in higher education? The capability of facilitating knowledge construction by the brains of the 21st century students is going to have a strong impact on teaching practice and perceived quality. The search process was conducted in the electronic databases Scopus, Web of Science, Pubmed, Education Resources Information Center (ERIC) and the search engine Google Scholar. Binary expressions were utilized combining keywords “neuroscience”, “educational neuroscience”, “neuroeducation”, “cognitive neuroscience” with “education”, “teaching”, “learning” and “higher education” or “tertiary education”. After screening the abstracts of matching publications, the search yielded 25 studies.

3 RESULTS
3.1 Neuroscience-based didactic principles
Following the analysis of the included studies, the following six didactic principles and areas of emphasis were identified: (i) students’ attention span, (ii) dual coding, (iii) chunking of content, (iv) teaching with emotions, (v) creativity and critical thinking and (vi) consolidation and retrieval.

3.1.1 Attention span
Currently lectures are the predominant teaching method in higher education. However, how much do students learn from attending lectures? How long can they stay concentrated and focused on them? While researchers note that learners’ attention declines during a lecture, there is no consensus on their exact attention span as it depends on many factors related to their dispositions and current psychological state, teacher’s practice and other contextual factors. Some researchers claim that attention decreases after the first to fifteen minutes of a lectures
and that cycles of vigilance and non-attention become shorter progressively [11], [12]. Newer studies establish that pedagogically informed lessons with active elements such as student to student and teacher to student interactions can keep students concentrated on task during longer periods [13].

3.1.2 Dual coding – multimedia

It is known that the older students are, the more the support for teaching using visual elements, such as photos, diagrams, and videos, decreases. Most university educators believe that the spoken word as a means of communication is sufficient for adult students to understand and adapt to new knowledge. However, the didactic principle of Neuroscience indicates that using both visual and verbal processing channels in the teaching process, as well as multimedia, is an effective learning process, as students receive more than one code. Thereby activating the dual-coding process, using pictures, graphics, concept maps, and diagrams is an excellent aid to learning [14]. The learner takes the role of “knowledge constructor who actively selects and connects pieces of verbal and visual knowledge”. The student takes the role of “knowledge constructor who actively selects and connects pieces of verbal and visual knowledge”. Thus, the student manages to build meaningful connections between words and pictures and process them actively in long-term memory. Therefore, the theory of dual-coding [15] and the cognitive theory of multimedia learning [16], based on Wittrock’s generative theory [17], considered Neuroscience the theoretical basis for the development of more effective learning activities.

3.1.3 Chunking of content

Feeding students’ minds with a large quantity of new data exercise a high degree of pressure to their working memory which has a limited capacity. For the long-term retention of information, it is recommended that content is divided into manageable and self-contained parts. Fiser et al. [18] state that a learner’s long-term memory should be built on the strong link between working memory and the nature of the representation of information observed. When the stored items are viewed as complex multi-dimensional objects, capacity can be increased, and conversely, when the distinctiveness of these items is minimized, capacity is reduced. Norris et al. [19] state that the input might be actively recoded into chunks, each of which takes up less memory capacity than items not forming part of a chunk, or that chunking is based on redintegration. If chunking is achieved by redintegration, representations of chunks exist only in long-term memory and help to reconstruct degraded traces in short-term memory. Neuroscience indicates that chunking is a way to greatly increase students’ working memory. Students' brain encodes content, perhaps groups of content chunks, as one chunk of information.

3.1.4 Emotions in learning

The feelings of students are often a neglected issue in higher education. However, research has shown that affective procedures influence cognitive processes of learning [20]. Negative emotions can distract or even inhibit learning while positive emotions can cultivate an ethos and academic culture conducive to learning [21]. Emotions imprint experiences into our memory. In other words, emotions can be perceived as a catalyst for learning. Lecturers need to establish and maintain a positive, supportive emotional atmosphere in their classes that will inspire optimism and willingness for engagement and personal development [22]. Teaching methods deriving from the teacher’s passion and love for the subject matter can support students in the development of their internal curiosity and interest [23].
3.1.5 Creativity & Critical Thinking

Creative problem solving and critical thinking are valuable competences in an increasingly innovation-focused employment landscape. However, they are not always a tangible goal in university courses [24]. It is believed that critical thinking is an extra skill for students to adapt, while the major aim is subject’s domain understanding. In addition, creativity, it is commonly believed that is referring exclusively to specific subject domains, for example in art lessons or poetry. Neuroscience indicates that critical thinking skills improve students’ decision-making muscles, speed up their deductive thinking skills, and improve their judgment. Educators could develop effective learning activities, helping students to spot errors in reasoning, for example, think slowly and deliberately before making a snap judgment or decision, gather information before jumping to conclusions, and find the most rewarding aspects of any opportunity. Alongside critical thinking, creativity has been found to relate to activation in brain structures associated with the dopamine reward system [25]. Thus, creativity dopamine could not only enhance learning processes referring to students’ working memory but also could enhance their interest in joyful teaching experiences related to creative thinking. Moreover, Klingberg [26] proposed that if students’ working memory was trained, could lead to changes in brain activity. Ritter et al. [27] indicate that diversifying experiences through learning activities is an example of training students’ creativity. Moreover, educators could activate students’ episodic memory [28] and develop improvisation activities [29] to develop effective training activities. Not to forget the favorite students’ puzzle-based open-ended tasks that on the one hand enhance their interest and on the other boost their creativity [30].

3.1.6 Consolidation & Retrieval

Educators need to take into consideration students' prior knowledge and also realise the way it affects any memory processes, as this consideration is important for the optimization of students' learning. Retrieval practice -denoted as the testing effect [31]- is “the strategy of recalling facts, concepts, or events from memory in order to enhance learning” [32]. Through retrieval-based learning students repeatedly recall information across multiple studies and sessions, enhancing their long-term retention when compared to other methods of learning, such as re-reading [33], [34], and concept mapping [35]. This retrieval-based benefit on long-term learning is commonly designated as the testing effect [31], [34].

3.2 Science-based Professional Development

For these didactic principles to be applied in practice, a carefully crafted roadmap was laid out. First, need detection studies should be conducted in the European countries on Neuroscience applied to higher education and synthesize them to identify training needs and instructions for further action [36]. Second, best teaching and learning practices should be located and exchanged to prepare suitable itineraries for the development of training skills required by university faculty members. Next, an innovative modular training course should be developed to train the target group and empower them to build and apply Neuroscience-based teaching skills. This educational resource should be tested and pre-assessed often in pilot trial runs where participants will have the opportunity to inform and adapt their teaching skills according to neuroscientific directions and innovative methodologies. Finally, to create a truly European network, an online platform will serve as the epicenter hosting the course "Didactic method based on neuroscience". Simultaneously this platform should facilitate the creation of a community of practice for higher education professionals. The community of university professors is an innovative element that will allow exchanging knowledge and experiences to apply didactic methods based on Neuroscience in higher education teaching [37]. This collaborative aspect can also diffuse into local tertiary institutions promoting unity and communication within regional, national and sectorial academic


communities, among professors, administrators and students, to enable it to lead as an educational model of the higher education system in Europe.

4 CONCLUSION

Universities and higher education institutions have the moral obligation and social mission to adapt to the needs of their students considering the state of current and future employment and society. Neuroscience sheds continuously new light on how human brain works and how it influences learning. At the same time, educators’ knowledge about the brain is not only incomplete, but to a large degree skewed. Monologues from elevated podiums are no longer enough for effective teaching. Multimedia and active learning with multiple interactions are vital to quality education. Teachers should be able to apply them, as well as regulate non-verbal communication and body language. All these techniques have a high potential impact in education. The desired pedagogical innovation should consider knowledge of the value of emotions in learning and the consolidation of memory, improved levels of attention, the importance of games and digital platforms in learning and creativity and flexibility in teaching. Next steps include a diagnostic training needs identification and analysis to detect the prior knowledge, teaching practices and opinions of academic faculty. Another ambitious task will be distilling and adapting lessons learned from Neuroscience to inform and improve the design and development of an optimized e-learning platform. Systematic professional developments such as the Neuropedagogy project are necessary to disseminate valid knowledge and good practices and empower academic faculty members to innovate teaching practices in higher education. This project aims to provide new and useful directions for teaching and learning practices that are grounded in modern neuroscience such as positive reinforcement and considering curriculum modification to enhance teaching of social competencies, social problem-solving skills and emotional regulation. In conclusion, A one-time training is not enough for a sustainable change; developing collectively self-awareness as teachers and cooperating in a community is vital.

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REFERENCES


