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Cognitive Neuroscience and Education: Not a Gap to Be Bridged but a Common Field to Be Cultivated

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Abstract: The research fields of cognitive neuroscience and education are often criticized because of the gap that separates them. In the past 20 years, many actions have been taken to bridge this gap; advantages and criticisms of these efforts have been observed. Only some changes could be documented, and they were not sufficiently commensurate with the efforts. To overcome these limitations, a different metaphor is outlined, consisting of a common field that should be cultivated by scholars operating from both perspectives. The new metaphor moves the perspective from "what is missing" (the bridge) to an existing field that requires concrete actions to be taken. The proposal details which topics from the two disciplines should be considered relevant when cultivating the common field. Then, based on the metaphor of the common field, real-life suggestions about how to develop these competencies are proposed, and recommendations for further actions are provided based on sustainability principles. The utilization of school psychologists (namely, their transition to educational scientists) and the introduction of optional stages and in-tandems involving cooperation between existing university courses in education and neuroscience are seen as feasible interventions. This change in vision is expected to drive further actions toward more effective cooperation between cognitive neuroscience and education.

Keywords: neuroscience; education; psychology; educational neuroscience

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1. Introduction

There is no doubt that cognitive neuroscience and educational sciences are two fruitful research fields. In recent years, they have extended existing theories and helped to inform practitioners. Cognitive neuroscience has contributed to increasing our knowledge about human processes and skills, while education has promoted new and efficient teaching methods and education programs. Nonetheless, many scholars have identified both a strong relation and a wide gap between the two disciplines. While the link between the two disciplines is clear when considering the addressed topics (e.g., learning processes and difficulties, motivation, and group dynamics), strong differences can be found with respect to the adopted methods as well as interdisciplinary communication. Neurocognitive researchers seem to be unable to adequately address issues raised by education practitioners, while many results from neuroscience are not included in theories of education. Since the experimental process in neuroscientific research is gradual and progressive, new research is just one small step forward compared to existing knowledge. Consequently, the small pieces of evidence obtained from experiments are not always able to address the complexity of real-world phenomena. Moreover, it might be difficult for researchers and practitioners in the field of education to understand this information due to the highly specialized language used in neuroscientific articles or to third-hand information that might have changed the original meaning.

The present position paper outlines a proposal to overcome the gap between cognitive neuroscience and education. The current mainstream concept aims to "bridge the gap". Despite the constructive goals that have been presented, that proposal describes some limitations not only regarding the metaphor used but also due to the lack of efficacy of the proposed actions. In the current paper, we introduce a different concept, which is expected to produce better results. Instead of metaphorically focusing on the emptiness of the gap that has to be bridged, it seems more productive to think of a common field to be explored and cultivated, where both disciplines work together to harvest fruits. After describing the current mainstream perspective of the "gap to be bridged", including its positive contributions and limitations, our proposal of the "common field to be cultivated" is outlined and discussed with examples. This is achieved by focusing on sustainability criteria that may enhance the probability of success. The proposal is aimed at several actors, who are described in different parts of the paper. Governors and directors of institutions may be interested in aspects related to the policy, while researchers (either in education or in neuroscience/psychology) could be concerned by the discussion about recent trends and the subjects relevant to an educational neuroscientist. The last paragraph presents actions that could derive from the proposed metaphor and, for this reason, could be of interest to both administrators and researchers.

2. The current Perspective

2.1. The Gap and the Bridge

In recent decades, many scholars have discussed the interaction between cognitive and educational sciences, and they have described the gap between these disciplines. This gap has been considered to have detrimental effects on society.

From the educational perspective, the field of cognitive neuroscience has been criticized for being isolated and not communicating with other social disciplines [1]. This, in turn, has caused these disciplines to think about psychology as being separate from the "major intellectual and global transformations in the past half century" (p. 803). Particular criticism has emerged regarding the relevance of neuroimaging in psychology [2,3], which has produced an intense debate and evoked skeptical judgments regarding the relevance of cognitive science to education [4,5]. Experts in the fields of neuroscience and psychology are often blamed for not being able to communicate their findings or, rather, for not being able to explain what can or cannot be inferred from their research outcomes [6]. Therefore, problems of communication in the field have been suggested to be detrimental to the understanding and dissemination of the results among teachers [7,8].

From the other perspective, neuroscientists and psychologists often tend to underrate educational research and educators: some think that educators should simply apply and verify psychological theories, and some scholars believe that educators are unable to understand these theories. An old stereotype describes psychology as providing theories that education should apply to its fields [9,10]. In fact, when the term "education" is used in psychological journals, it is likely to be associated with concepts such as "application" or "practice". Ideally, there is nothing wrong with providing educators with suggestions based on psychological research, but bias may occur when psychologists are not responding to real issues in education and provide unsolicited solutions. Thus, the gap between these fields is not only related to communication between the disciplines but also related to the lack of fruitful cooperation.

The mainstream adopted the "bridge" as the most adequate metaphor to represent the solution to address the gap. Several papers have included results and perspectives related to both disciplines based on the concept of the bridge. Excluding anecdotal reports, the first scientist to introduce the concept was Bruer [11]. In this influential paper, he described the presence of two bridges between cognitive sciences and education: the one between education and cognitive psychology, which was a "well-established bridge, now nearly 50 years old" (p. 4), and the other between neuroscience and education, which "fails because its advocates are trying to build a bridge too far" (p. 4). According to Bruer,

under the umbrella term "cognitive sciences", there are differences between some of the constituting disciplines. However, given that the findings in neuroscience are generally easily shared among the scientific community of psychologists, the "too far" bridge between neuroscience and education should not be that far at all. Scholars working in cognitive neuroscience are not concerned with working on either neuroscience or cognition: the field accommodates those studying phenomena using both perspectives or just one of them [12]. Therefore, either the gap described by Bruer does not exist, or both bridges are ineffective. Evaluating the existing debate, the second interpretation is likely to be the most feasible to describe the circulating ideas. Indeed, the considerable effort made by scholars in the last 20 years to overcome limitations between disciplines is a concrete sign that limitations exist. Teachers and educators have shown an increasing level of interest in neuroscience, and scholars of both neuroscience and education have tried to enhance their knowledge about brain development and its effects on educational practice.

Two particular lines of work have emerged: discussions about whether such a bridge is feasible or not, and research measuring how far that bridge is and how to create it.

2.2. Examples of Bridging Cognitive Neuroscience and Education

For a long time, educational psychology has played an important role in linking neuroscience and education. Educational psychology has a 100-year history of researching learning processes and how they can be improved in the context of education, representing an important bridge between psychology and education [13,14]. However, as stated by Mayer [13], educational psychologists have often been criticized by their colleagues in psychology for being too "educational", meaning that they focus primarily on problems relevant to education rather than on controlled laboratory experiments. On the other hand, educators have often criticized educational psychologists for being too "psychological", referring to their efforts to develop education strategies based on scientific methods and theories rather than trusting teachers' popular beliefs and experience. It has been argued that the convergence of the two criticisms is a strength of educational psychology since it enables us to gainfully advance both psychological and educational theories.

An additional problem raised by Mayer [14] is the way in which educational psychology strives to bridge psychology and education. Until the second half of the twentieth century, the bridge between the two disciplines was either one-way, i.e., psychology providing learning theories that were expected to be applied by practitioners, or dead-end, i.e., psychological research lacking educational relevance and educational practice lacking theoretical reflections. Only later did educational psychology begin to adopt a two-way bridge by developing evidence-based learning theories related to the context of education. Although this two-way bridge was much more productive than the previous ones, some further criticisms arose concerning the absence of cognitive neuroscience in this relationship [15], and educational psychologists were criticized for not devoting sufficient attention to the brain [16].

This might have contributed to the emergence of a new interdisciplinary field between neuroscience, psychology, and education, also called *Neuroeducation*, *Educational Neuroscience*, or *Mind, Brain, and Education*; this field aimed to improve educational outcomes by gaining a deeper understanding of the underlying mechanisms of learning [17,18]. In fact, since the 1990s, the number of journals, scientific associations and organizations, online communities, funding opportunities, and even university courses aiming to create a bridge between neuroscience, psychology, and education has increased considerably [18]. One example is the *International Mind, Brain and Education Society* (IMBES: [19]). This scientific association was founded in 2004 with the aim of creating a common space to facilitate the interaction and collaboration between the fields of biology, education, and cognitive and developmental sciences. According to their mission, both science and practice would profit from a bidirectional interaction. An additional aim of the IMBES is to enable the proper implementation of the knowledge gained from the different disciplines into the context of education. These aims were achieved by organizing a biennial conference, workshops, and

symposia; by promoting collaborations between researchers and experts from the different subject areas; and by publishing the journal *Mind, Brain, and Education*.

Similar to the scientific journal established by the IMBES, many other journals (e.g., *Trends in Neuroscience and Education* and *Educational Neuroscience*) have been founded in the past few years and have the same mission of collecting theoretical and empirical research articles related to the intersection of neuroscience, psychology, and education [18]. These journals have been created to build a bridge that spans from the increasing knowledge about learning processes gained from the single disciplines of cognitive psychology and neuroscience to the application of this knowledge in education. Moreover, these journals attempted to create two-way bridges between these research fields by fostering collaborations between experts in education, psychology, and neuroscience to translate findings and make them understandable to the broad readership coming from the different fields.

Another scientific association with a similar scope is the *European Association for Research on Learning and Instruction* (EARLI: [20]), which, in 2009, founded a Special Interest Group called *Neuroscience and Education*. This group aimed to unite researchers in education, neuroscience, and cognitive and developmental psychology. Neuroscience and Education is grounded in the principle of interdisciplinarity, and the group is committed to creating a fruitful two-way bridge between educational research and neuroscience. Specifically, it focuses on research that is conducted at the intersection of the two disciplines rather than research that is only related to one field. These aims are achieved by organizing a biennial conference, symposia, and workshops to foster interactions and partnerships between researchers in the two disciplines. Moreover, special consideration is given to the discussion about the training of scholars coming from the two fields, which is considered a fundamental requirement for the successful creation of interdisciplinary research. Similarly, the *Centre for Educational Neuroscience*, which was founded in 2008, brings together researchers in child development, neuroscience, and education from the University College London (UCL), the Birkbeck University of London, and the UCL Institute of Education [21]. The primary aim of this research center is to advance the emerging discipline of educational neuroscience by connecting the three disciplines of developmental psychology, neuroscience, and education and developing strategies to maximize learning outcomes. The insights from neuroscientific and psychological research on learning are translated to the field of education and evaluated based on their effectiveness in the classroom. This goal is pursued not only by creating interdisciplinary research collaborations but also by creating new graduate and postgraduate training courses as well as professional development prospects to train experts in this new interdisciplinary field.

The increasing interest in the training of these interdisciplinary experts is also exemplified by the growing number of university courses at both the master's and doctoral levels. For instance, the Harvard Graduate School of Education has started an interdisciplinary master's degree program as well as a doctoral degree program named *Mind, Brain, and Education*, in which connections between different disciplines, such as cognitive science, psychology, neuroscience, education, anthropology, linguistics, computer science, philosophy, and other fields, are drawn. A master's degree course in Educational Neuroscience has also been created by the Universities of London and Bristol, aiming to form new professional and research figures who are experts in the fields of cognitive science, psychology, neuroscience, and education. The aim of these new training courses is to create "multilingual" figures who are able to communicate with and to experts from these different areas to avoid misinterpretations and the formation of well-known neuromyths.

The long-standing communication difficulties between neuroscience, psychology, and education may be one of the core challenges of educational neuroscience. For more than 100 years, research on memory and learning has shown what does and does not work in the classroom. Nonetheless, many teachers still apply methods that are known not to work (e.g., teaching according to learning styles [22]). Research has shown that there could be many causes behind the misapplication of neuroscientific research. One of the most relevant causes is the lack of criteria that can be used to discriminate between true and

false neuroscience (being "believers" [23,24]), inertia with respect to using poor methods, even if teachers are shown opposing evidence ("detrimental pedagogy" [25,26]), and the overgeneralization and/or oversimplification of neuroscientific research [27]. A recent review by Feiler and Stabio [28] described how hard it is to translate from one "language" to the other and to efficiently improve education practices by using the findings obtained from research on learning processes. This problem and its related costs have surely contributed to the emergence of the above-presented examples, which express the need to create a common space between the sciences of learning and education to facilitate the dialogue between the different fields and bring them forward. The idea of a common field is, therefore, already considered a better strategy than creating a bridge between the two disciplines. However, to date, the metaphor of the bridge is still active as a goal to be pursued, mainly because there were no concrete and shared ideas that could substitute for it. In the following paragraphs, the proposal of the "common field" is outlined and discussed in light of its sustainability, considering that the moment to change the paradigm is likely to be mature.

3. Creating a Sustainable Common Field between Cognitive Neuroscience and Education

To create a common field between cognitive neuroscience and education, in recent years, some key questions have been put on the discussion table. (1) What should an educational neuroscientist know about these disciplines? (2) Is there a need to train new specialists, or are there other more sustainable alternatives?

3.1. What Should Educational Neuroscientists Know about Neuroscience, Psychology, and Education?

Based on both past and current actions, the relevant knowledge that educational neuroscientists should show may be determined by considering the strengths and the weaknesses of a field. Regarding the specific knowledge that should be taught in educational neuroscience programs, there should be a balanced selection of the most crucial information from neuroscience and psychology relevant to education, as well as both of these topics from education that are most closely related to neuroscientific research and information about the work in education.

In the following paragraphs, a prototypical list of subjects is proposed, indicating the essential topics about cognitive neuroscience and then education. The proposal is mainly addressed to both governors and heads of departments, who are in charge of defining courses of study at the university level. To increase efficacy, the subjects should be presented to undergraduate students, but it would not be inappropriate to present them to postgraduate students if enough interest is signaled. However, it should be clear right from the beginning that these courses should be taught following the principle of graduality through a path whose complexity smoothly increases. For example, when starting from aspects with a high level of proximity to everyday life and moving to multifactorial aspects, it is difficult to understand without a baseline level of knowledge. In addition, the two fields (cognitive neuroscience and education) should not be taught in sequential order, but rather both programs need to start in parallel, with the aim of eventually merging them together.

It has been proposed that an important goal would be providing teachers with courses addressing the basic knowledge of neuroscience and psychology, although the main focus should be on MBE science, which relates to both theory and practice [29]. A comprehensive review by Xu and colleagues [30] showed how different themes from neuroscience are mapped in the field of education through a bibliometric analysis. Among the most common subjects found in the existing educational offerings delivering cognitive neuroscience to teachers, three lines are mainly described: (a) cognitive processes, their development, and neuropsychology; (b) social and group management; and (c) health and clinical diseases and their treatment. The first line should provide the framing of what cognitive processes are, how they develop and work, and how they are rooted in the brain and body. Making use of

learning as a prototypical example [31], the following outcomes could be addressed (this list is neither conclusive nor exclusive): principles of perception and attention, the organization and processing of learning and memory, language and numerical processing, how these processes change with age, brain plasticity, and the role of neurotransmitters. The second line is expected to cover aspects related to interpersonal relationships and interactions, communication, and persuasion. For example, group formation could be approached by ranging from interpersonal social biases to motivational systems and biological needs. The third line would be devoted to discussing the continuum between health and diseases within the framework of wellbeing and quality of life. As an example of the topic, mood disorders can present a variety of degrees of depression, from normal reactions to severe impairment, indicating that they could be handled just with counseling and prevention or require treatment integrating psychological and pharmacological interventions. The reasons for such resolutions should be motivated by a biological rationale so that opportunities and limitations for several actions that could take place in school can be derived.

Moreover, Dekker and colleagues [32] suggested that, in addition to courses in cognitive neuroscience, teacher training should include competencies to evaluate scientific research [33]. This would enable practitioners to better discriminate between pseudoscience and scientific facts. This skill is particularly important because scientists are often asked to be more careful when explaining what can and cannot be derived from the results of their research [8,34]. Instead of being trained to read scientific literature, teachers mainly obtain second- or third-hand information from lecturers, who have often learned from other lecturers or from popular science books or basic scientific articles that they are not necessarily equipped or motivated to fully understand [35]. The problem with scientifically inexpert lecturers is that they frequently have difficulties in critically recognizing study limitations or distinguishing between useful and useless information [36], which might increase the dissemination of neuromyths among educators.

On the other hand, an educational neuroscientist should develop expertise in the field of education since only direct experience in teaching can give a clear understanding of both methods and constraints related to this profession. Research in education solicits attention to three main pillars: pedagogy, educational contexts, and the general praxis of teaching [37]. The first pillar, i.e., pedagogy, should provide the theoretical background by exploring several approaches that are currently relevant in the scientific domain: constructivism and collaborative, integrative, and reflective and inquiry-based learning. The second pillar entails knowledge and reflections about the complexity and quality of educational contexts and relationships, as well as the specificity and importance of educational work. It is important to establish a connection between internal processes (aims, actions, etc.) and the environment in which they take place (either the mental or physical environment). The third pillar is devoted to indicating several methods used in the teaching process: cooperative learning, flipped classroom, jigsaw method, circle time, role playing, experienced learning, Montessori, and many others. An educational neuroscientist should be aware of these methods to obtain insights into the everyday work of an educator.

The improvement in communication between the two fields, as argued by Zadina [35], highlights the importance of defining and training educational neuroscientists. Accordingly, the training of educational neuroscientists should be as thorough as for other professionals rather than offering some cross-disciplinary courses to already established education or science specialists. The author also claimed that such a training program should include a teaching internship for these educational neuroscientists, in which they are guided by a teacher and have experience teaching different kinds of learners, especially those with difficulties. Furthermore, the training program should include further communication skills necessary to implement, for example, discussion groups in which educators and neuroscientists are given the opportunity to share their viewpoints and ways of thinking and communicating. In this way, both professionals and graduate students in both education and neuroscience would develop practical knowledge and a reciprocal understanding of the other field. The dual perspective and experience of educational neuroscientists would

enable them to adapt theories and research to the real needs of education, as well as adapt educational practices to the insights provided by neuroscientific findings.

3.2. Training New Specialists: A Critical Analysis

Contrary to high hopes, programs related to educational neuroscience have been shown to have had little impact on educational practices, thus failing to bridge the neuroscience–education gap. Supporting this observation, Wilcox and colleagues [38] argued that an alternative should be found. According to the authors, school psychologists might represent undeveloped candidates to fill the empty space between neuroscience and education. Although the idea seems promising because these candidates already possess knowledge about the two domains, there could be hidden caveats, which might hinder the success of that proposal. Indeed, the current training for school psychologists produces "undeveloped candidates", who may not be prepared enough to fulfill all of the tasks. Moreover, research has shown that both laypersons and experts in fields other than psychology and neuroscience are more likely to believe in neuromyths when they possess little knowledge about psychology and/or neuroscience [39]. Numerous studies have shown how widespread neuromyths are among practitioners in educational settings [31,40,41]. Among other causes, Pasquinelli [42] indicated distortions of scientific facts and the misinterpretation of experimental results, while neuromyths could be maintained by the social reiteration of such messages (familiarization) and confirmation bias. This pattern would clearly require the intervention of an educational neuroscientist to interrupt vicious circles. A recent review by Rousseau [43] reports current intervention approaches. The most common solutions proposed consisted of either proposing training to in-service teachers or introducing neuroscience courses during teachers' education or after their graduation. However, a series of studies showed that taking one neuroscience course is not enough to reduce teachers' misconceptions about the brain [44,45], whereas taking several courses had only a small effect on the reduction in neuromyths in educators [46]. Other approaches used anecdotal evidence to mitigate intuitive thinking or specific refutation-based corrective lessons, but their effects ranged from modest to impressive [47,48] and should be interpreted with caution. The lesson learned from research about neuromyths in education strongly suggests that the solution of introducing neuroscience to educators' postgraduation training does not lead to the expected improvement.

Further ideas about training specialists based on existing study programs will be difficult to implement. A possible solution that is unlikely to be accepted consists of training teachers and neuroscientists on their reciprocal subjects. This would require study programs to be modified or enlarged so that either the total number of lessons would increase or lessons about other subjects would diminish, given that the standards described by the Bologna reform need to be respected, at least in European universities [49,50]. If it is not feasible to bend current study programs, one may wonder whether it could be worth creating a new study program that encompasses all of the subjects described in Section 3.1. To our knowledge, although the number of study programs has increased, only a few have been successfully established: one already cited and offered jointly by Birkbeck and UCL's Institute of Education (London, UK), one by Vanderbilt University (Nashville, TN, USA), and one by Columbia University (New York, NY, USA). We consider these courses to be exemplary in their programs and missions. In addition to the advantages of such offerings, many issues could be foreseen for the majority of universities. In these cases, this idea does not meet sustainability criteria, such as (maximum) net gain in the trade-off between costs and incomes and resource maintenance and efficiency [51]. The creation of a new study program requires extensive work. Few universities would be likely to have enough personnel to cover the relevant pillars described for this profession. When there are universities in which an adequate mix of both (neuro-)psychological and educational instructors is present, generally, they do not collaborate much because they need to be focused on their respective study programs. Thus, the definition of a common study program, the linked stages (which partner institutions, which objectives, etc.), and

the learning outcomes also need to be created, partially independent of the particular needs of the two groups of instructors. More importantly, even if such a graduate student were to be produced, the current market seems unsuitable to host and appreciate the student in terms of a regular salary. In current society, to our knowledge, there are no professional figures who are paid for this sort of work. For example, teachers and instructors are paid by school principals and are supposed to possess the correct tools to teach apprentices. Moreover, an "educational counsellor" would not be easily accepted when the professional figure of a school psychologist already exists. In the mind of a school director, it would not be sustainable to hire a specialist who offers the competencies of a teacher and of a school psychologist. School psychologists are mainly required to assist teachers in the domain of clinical/developmental psychology, providing help while dealing with behavioral or educational problems in the classroom [38]. Thus, at least in the first moments, there could be competition between the educational neuroscientist and the school psychologist (it is obvious that teachers cannot lose their job). One of the primary goals consists of persuading administrators and school directors that an educational scientist would not just replace the competencies of a school psychologist but will extend cooperation, including teaching methods, and will be likely to engage in better interactions with teachers. When educational neuroscientists are established and accepted for their roles, it would be easy to convert the study programs that generate school psychologists into those generating educational scientists. Until that moment, however, the creation of a new study program for a new professional figure should be momentarily replaced with the modification and adaptation of existing study careers.

There are different reasons why the three ideas (the introduction of neuroscience courses to teacher training after graduation, the adaptation of institutional study courses, and the creation of a new study course) are likely either to fail or not to produce results. First, the transformation of careers by following a master's program or specific training after graduation is likely to suffer from the proactive interference of existing knowledge. Due to inertia, it is difficult to make people change methods and concepts that have been used for many years [52]. Thus, the "academic age" may be one factor that could hinder the effectiveness of the training programs provided thus far. In fact, changes are more likely to occur earlier than later in a career trajectory [53]. Second, expertise [54] could also limit flexibility and, accordingly, the possibility of learning new materials. For example, when facing new challenges, the expertise gained during a career may cause people to fail because of inflexibility and "less efficient restructuring of the existing knowledge in order to incorporate new information" ([55], p. 164).

The transformation of careers during their study may either create confusion in students or be felt as a deviation from their objectives when the path is not effectively balanced. Moreover, if the reason to study for such a goal does not correspond to acknowledgment by society, it is hard to ask students to deploy their time and efforts in exchange for an indefinite future. While it seems that the future (not) foreseen by students could be a common reason for the rejection of both the adaptation of existing university paths and the creation of new study courses, the resistance of both university bodies and the government may relate to the latter only.

4. Alternative Ideas Based on the "Common Field" Metaphor

The problem seems insurmountable if none of the options indicated in the previous paragraph are sufficiently convincing. However, when considering the metaphor about the new field to be cultivated, further solutions could emerge. For example, when the focus is on the field, different experts could talk about what "fruits" they want to obtain (namely, goals and/or application of the research) and define who will be in charge of the actions to obtain such fruits. Thus, it is important to enhance communication between the two disciplines [34]. In this vein, researchers in neuroscience and education may sit at the same table and talk about the needs of schools and students, that is, organize moments in which they can talk together on a timely basis. However, these moments should not

be one-directional or a conference where either educators simply listen to neuroscientific news or neuroscientists follow educators describing what has happened during their work. While waiting for an educational neuroscientist to come, in addition to the large venues that are already organized, there should be workshops at a local level with laboratories cohosted by both an educator and a school neuroscientist, in which they support each other in training their peers (or making them reflect) on relevant topics. The preparation of such laboratories is dependent on this pair. Working in pairs is more efficient than working in groups because it requires only mutual coordination, and the risks of confusion or the bystander effect are not present. Moreover, these workshops are likely to be considered a "pedagogical activity" and could be as effective as described in [56].

A further concrete proposal that could promote such collaboration could be based on the school psychologist, as proposed by Mason [57]. Educational and school psychologists understand and speak both basic languages of neuroscience and education, representing a valuable resource to link the two fields. The idea was further developed by Wilcox and colleagues [34], who provided extensive motivation to support investments in the training of educational and school psychologists. Indeed, to become effective, the following needs must be met: (a) their competencies will be strengthened by including those indicated in Section 3.1, so the professional figure would be gradually transformed into the educational scientist, and (b) an intervention from the government to establish this job in every country and to ensure that the wages are adequate. While the transition to educational scientists occurs, it could be worthwhile to explore the feasibility of such a proposal on a large scale by recruiting a research network operating in different countries and continents. The results could also support future requests in other countries in which the presence of educational and school psychologists is not envisaged.

An important attempt could be made at the university level, although all of the issues outlined before must be considered as constraints. While university education based on a dedicated course of study is currently difficult to institute, informal education accompanying academic curricula seems not to have been explored thus far. An interesting method is in-tandem learning, which is used to learn foreign languages. O'Rourke [58] defined it as "an arrangement in which two native speakers of different languages communicate regularly with one another, each with the purpose of learning the other's language" (p. 434). While scholars [7,8] have highlighted problems in communication between (neuro-) psychology and education, this method could be feasible to help foster dialogue between students learning the two disciplines. A series of in-tandem opportunities could be developed from the bachelor's degree for students in cognitive neuroscience and education who would like to explore reciprocal fields for the sake of curiosity, personal motivation, or work opportunities. These activities may be treated in their study curriculum as credits for optional subjects, as part of their stage, or as a diploma supplement (provided to students at the end of their studies, including all of the relevant activities that were not required in the regular study course). In this way, students may come into contact with peers and receive informal training that could provide them with the basis for future collaboration, which is likely to prevent the development of neuromyths. For those interested in receiving further education, there is still the possibility of officializing their work by attending any of the master's programs organized by universities and associations aimed at integrating neuroscience and education. The effect of these master's programs is expected to be enhanced if the participants already possess basic knowledge in both disciplines. The only constraint for both of these ideas consists of the requirement that there are either university courses or institutions nearby dealing with both disciplines. Nonetheless, it is also possible to overcome these limitations by using the Internet or specific moments in the academic year. For example, a tandem could connect two students at two different universities by using social media; a stage could be performed in a partner institution, while the sending university grants the student with the opportunity to attend courses, where their presence is not mandatory.

With respect to other proposals, the current set of ideas is expected to be more sustainable when considering both the associated costs to be established and the probability of attracting attendants. The ideas proposed in the past were mainly based on the direct training of professionals already instructed in a different discipline, who would need to insert a new extraneous discipline into the set of skills and experience created during previous years. The likelihood of the success of such ideas was low [59] and generally below the results expected in return for a large investment. The ideas of creating cohosted meetings on a timely basis, investing in school psychologists and educational neuroscientists, and promoting informal opportunities such as tandems and stages are definitely more convenient than the establishment of institutional training with respect to the amount of organization, the duration of the intervention, and the associated costs. Moreover, if the experiences are diluted at a slower pace and they accompany the academic paths of students thought of as implicit learning, they are more likely to be accepted. Students are more constantly exposed to knowledge than in a training class, which should make them retain concepts about the lacking discipline. Thus, the impact of 0 and cultivating a common field is associated with satisfying levels of sustainability compared to other competing proposals.

5. Conclusions

During the past 30 years, considerable effort has been made to create a link between cognitive neuroscience and education. The metaphor of the bridge that should be built to fill the gaps between the two disciplines has spread within the scientific community. The retrospective evaluation of this effort showed light and shadow. On the one hand, the increased attention devoted to this gap has promoted the creation of both more research and more valuable programs (study courses, scientific associations, etc.). On the other hand, research has demonstrated that intervention programs for practitioners did not produce the desired effects. Moreover, some interventions required a high amount of organization, coordination, and work, which could be effectively managed only in certain positive circumstances.

The purpose of the present paper was to propose a different metaphor and to examine whether the adoption of this new metaphor could be more efficient in producing effects while, at the same time, being more sustainable. Instead of focusing on what is missing, the image of a common field to be cultivated asks people in cognitive neuroscience and education to actively contribute to yield results relevant to both disciplines. The new paradigm originated from the integration of previous suggestions with new proposals to achieve the goal of feasible cooperation. For instance, the creation of periodic focus groups including professionals and researchers from both disciplines, the transition from school psychologists to educational neuroscientists, and the creation of opportunities during a degree program, such as internships and informal tandems between the two disciplines, should be acknowledged in the curriculum. These ideas are likely to satisfy principles of sustainability, being at students' choice, as they require a low amount of organization and few regulation changes, as well as generally low associated costs.

Further research is needed to validate whether these suggestions could take place and achieve the expected results. More importantly, it would be worthwhile to evaluate whether the new metaphor would be able to generate the desired outcomes. For this purpose, there is a need for (a) the concept to be disseminated and adopted, replacing the previous idea of the missing bridge, and (b) time to evaluate the actions taken based on it. While researchers are more likely to be responsible for the former effort, administrators would be in charge of the execution of the latter actions. To be successful, both of these actors need to cooperate to achieve these goals.

In our opinion, the metaphor of a common field is appropriate for the process of connecting education and neuroscience. Changes always require energy, but with respect to the principles of efficiency, the effort involved in the previous actions just needs to be redirected to less demanding goals. Moreover, in people's imagery, the heavy bricks that are

required to build a bridge would be replaced with natural seeds and plants that are cared for by a community of farmers. Thus, it is much more in line with a natural process that is expected to occur between the peer disciplines of cognitive neuroscience and education.

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