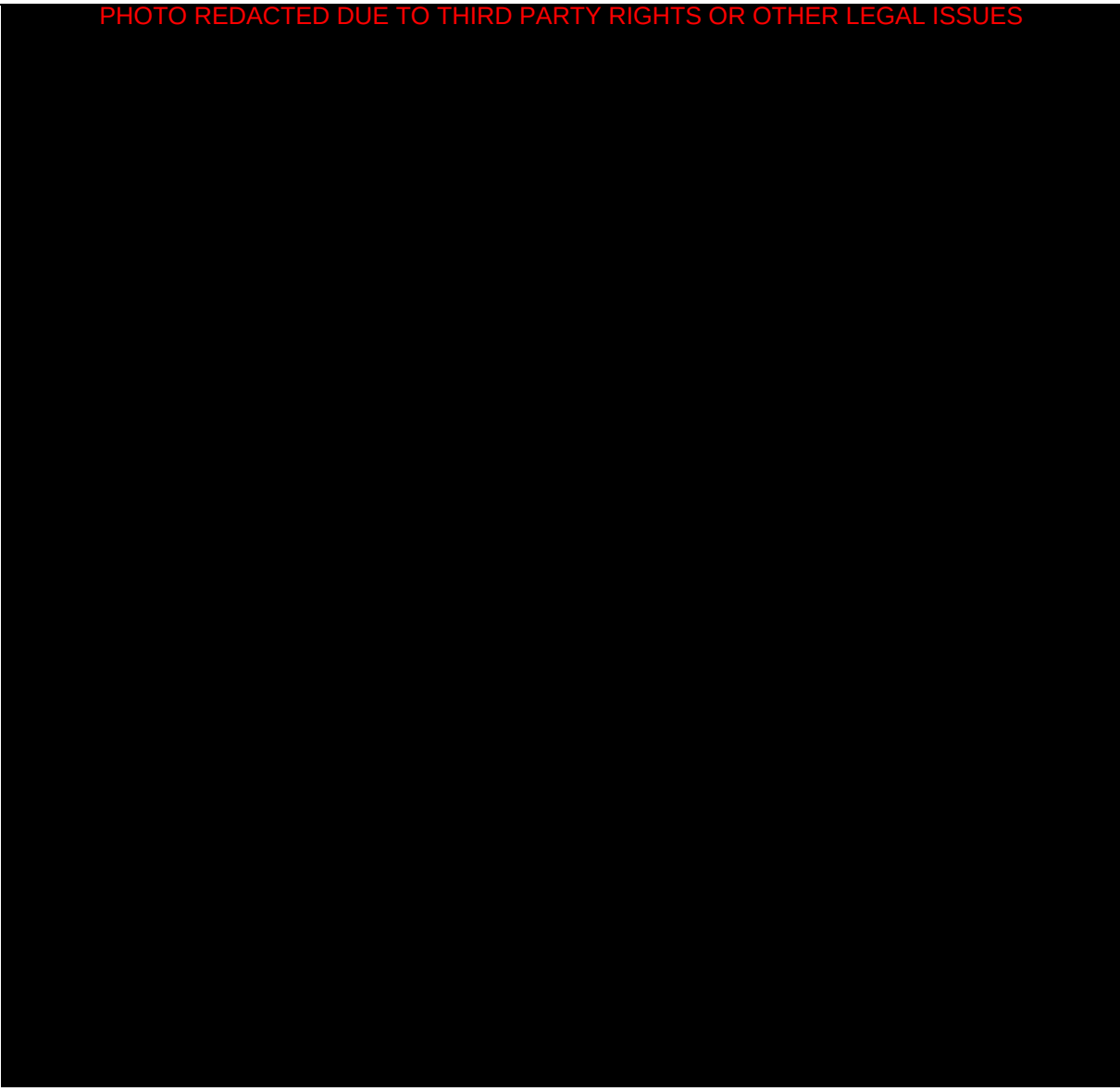
Innovation Investigation

Perceptions of the role of neuroscience in education

Paul Howard-Jones, Sue Pickering and Anne Diack



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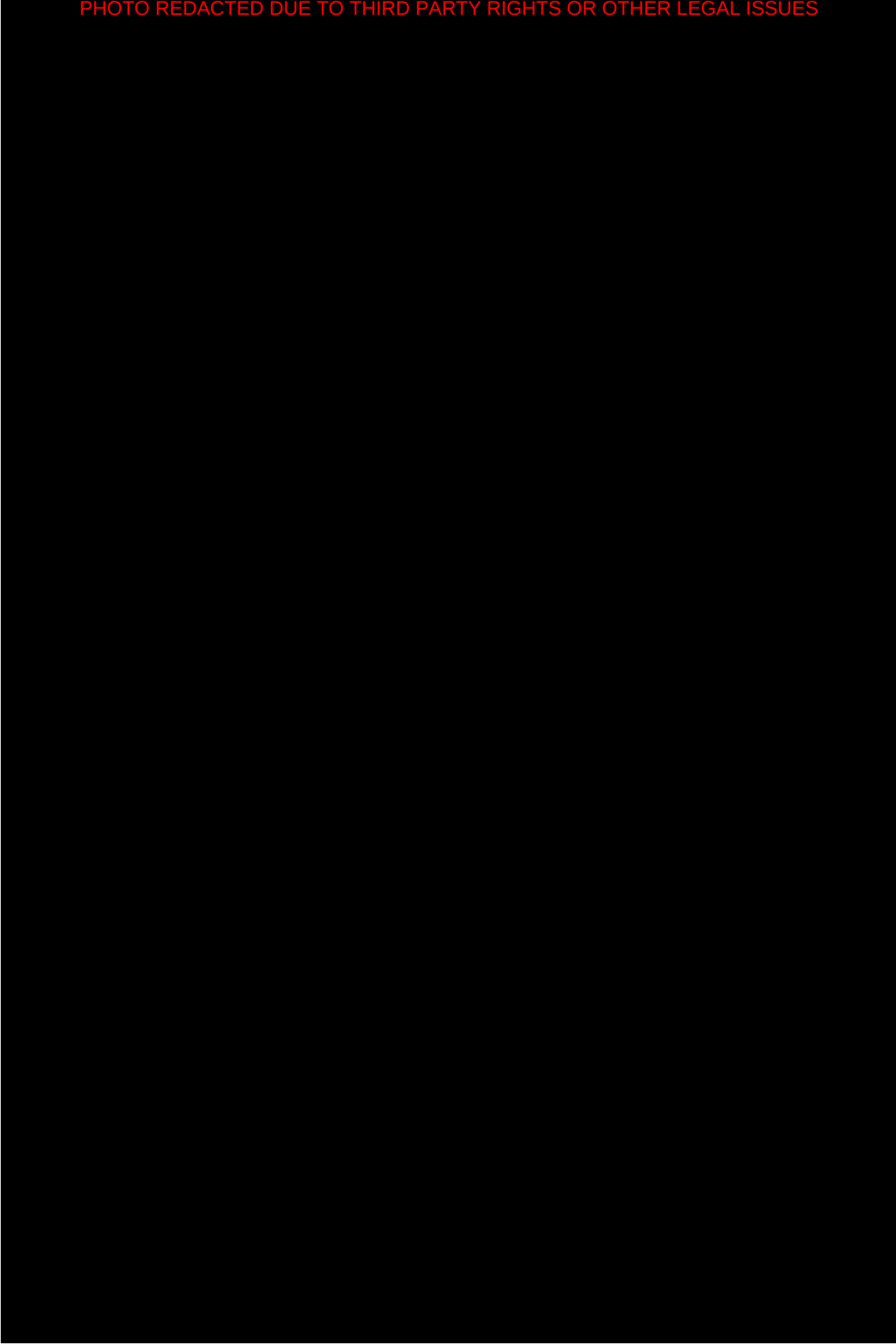
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Foreword

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The series *Innovation Investigation* is published by The Innovation Unit to make certain research available in an accessible format to both policy makers and practitioners. *Perceptions of the Role of Neuroscience in Education* is the sixth title in the series[1]. Other topics covered are school effectiveness; personalised learning; school councils; using evidence from research in schools, transfer and scaling up and, to be published shortly, teachers as innovative professionals .

In this *Innovation Investigation* publication Paul Howard-Jones and Sue Pickering of the University of Bristol present the findings of research carried out for The Innovation Unit. The research was commissioned to inform a series of seminars between educationalists and neuroscientists organised by the Teaching and Learning Research Programme (TLRP) and Economic and Social Research Council (ESRC) held in 2005-2006. The *Perceptions* research itself is now to be published in the forthcoming issue of *Brain, Mind and Education*, the journal of the International Mind, Brain and Education Society[2].

The Innovation Unit funded this research following a presentation Paul Howard-Jones had made to a meeting of a group of some of the country's leading neuroscientists, educators, and BBC education policy makers, and later The Innovation Unit. This group met from 2000-2004 and was part of a more general drive to try to build bridges and develop a common language, or modes of discussion, between neuroscientists and educators. (Other interdisciplinary developments are covered in the body of this report.) The group incubated a number of interdisciplinary projects of which this particular study was one.

This report does three things. First, it documents the overall debate about neuroscience and education, and it should be noted that although this is a developing field as new scientific findings

1 Hopkins D, Reynolds D, Gray, J (2005), *School Improvement – Lessons from Research*, DfES Innovation Unit.
Rudduck, J, Brown N, Hendy, L (2006), *Personalised Learning and Pupil Voice: The East Sussex Project*, DfES Innovation Unit.
CUREE (2007) *Harnessing knowledge to practice: accessing and using evidence from research*, The Innovation Unit.
CUREE (2007) *Transferring learning and taking innovation to scale: case study materials,* The Innovation Unit.
Whitty, G, Wisby E, Diack, A (2007) *Real decision making? School councils in action*, The Innovation Unit.

2 Pickering, SJ and Howard-Jones, PA (2007) *Findings from a study of UK and International Perspectives*, in: Brain, Mind and Education, 1(3), 109-113.

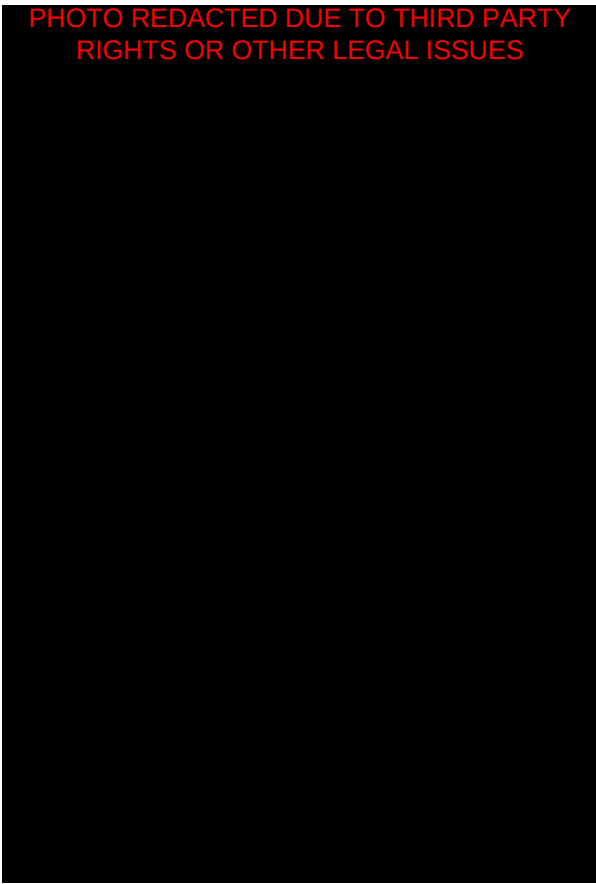
3 Maguire EA et al (2000) *Navigation-related structural change in the hippocampi of taxi drivers*, in: Proceedings of the National Academy of Sciences of the United States of America, Vol. 97, Issue 8, 4398-4403, April 11, 2000.

are being released on a frequent basis, there are some general issues that have continuing resonance. Second, it investigates the perceptions of teachers about the importance of neuroscience in their training. Third, it documents where this sample of teachers obtained their knowledge about neuroscience and what impact, if any, it was having on their classroom practice.

As the report shows, current teacher training programmes generally omit the science of how we learn, so the information that teachers are getting comes from a number of sources.

One source is the general media. The field of neuroscience makes attractive copy for journalists. The study of the brain is seen as exciting and can lend itself to some headline grabbing claims or findings. Some of these can cover the science with a fair degree of accuracy as in the story about London taxi drivers[3] which reported that cab drivers' 'grey matter' enlarges and adapts to help them store a detailed mental map of the city. Taxi drivers given brain scans by scientists at University College London were found to have differences in the hippocampus compared with other people. Parts of their hippocampi were larger. (The hippocampus is the part of the brain associated with navigation.) The scientists also found part of the hippocampus *grew* larger as the taxi drivers spent more time on the job. Although not all the individual elements of the research were reported, the basic findings did get widespread press attention – helped, also, probably, by word of mouth from some London cab drivers! Not all brain research findings offer such media friendly 'hooks' on which to hang a story.

Other sources of information for the teaching profession are conferences, in-service training courses, books, materials and journals (both professional and academic). In a number of instances information from these sources is based on so-called 'brain-based' teaching methods. Following the declaration by the US in 1990 for the next ten years to be the 'Decade of the Brain'. authorities, teachers and entrepreneurs developed and promoted a number of 'brain-based' education ideas. Those that are more evidence-based, such as strategies for enhanced memory, tend to draw their evidence from psychology, rather than neuroscience. Others have not been scientifically or educationally assessed with any rigour, but often use pseudo-scientific explanations to support their credibility.



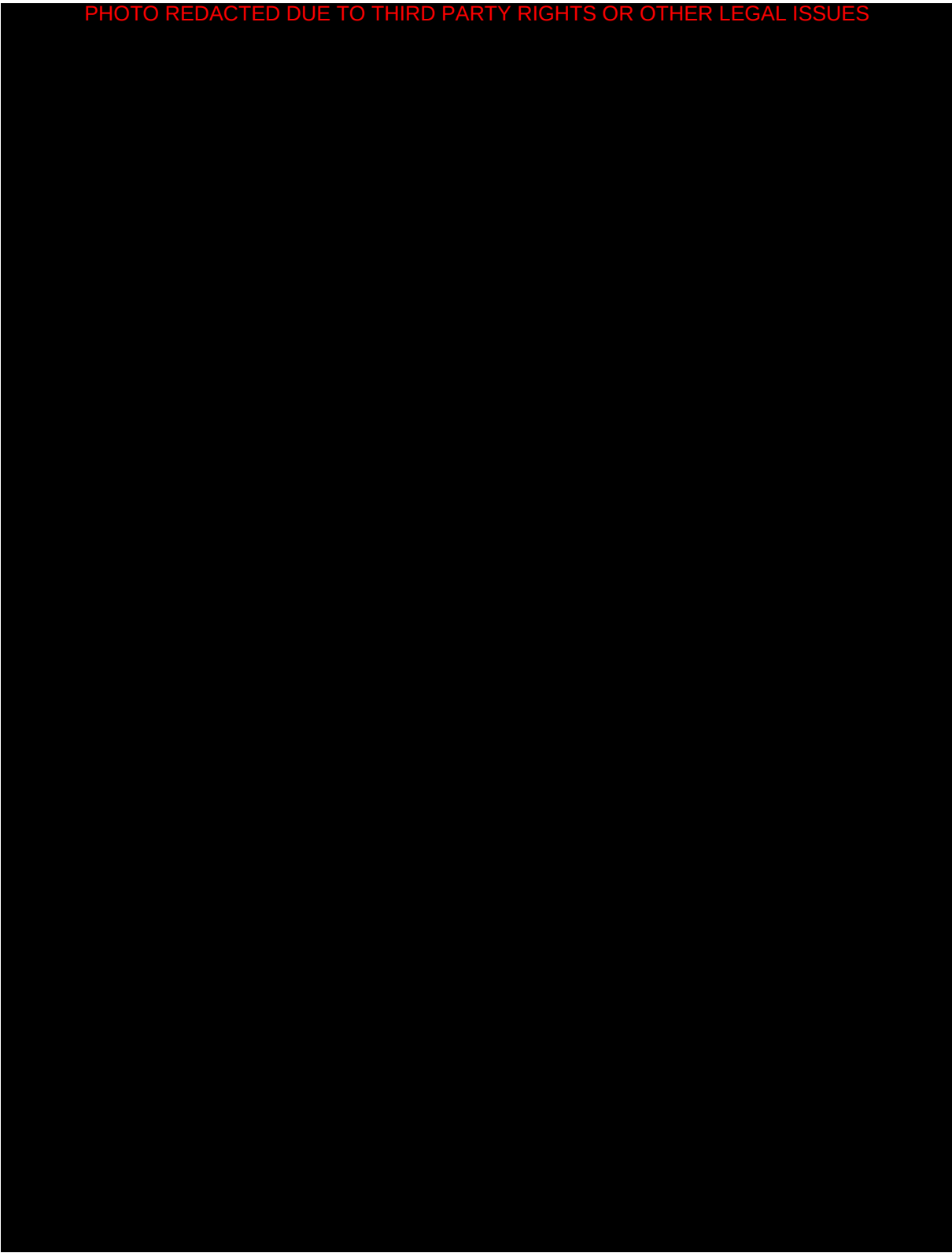
The authors of this *Innovation Investigation* note that if such programmes are effective, we may not yet understand why. These programmes include initiatives such as Brain Gym and methods intended to appeal to different brain-based learning styles (eg visual, auditory and kinaesthetic learning - or VAK). Although the scientific basis of these methods is highly contentious, many teachers reported that they had found them very useful, particularly when children were less receptive to more traditional teaching methods. One respondent said that such approaches "improved the success of the teaching and learning" and led to "happier children who are more engaged in the activities".

However, as Dr Paul Howard-Jones, co-author of this report, says "Much of what teachers perceive as brain-based teaching, such as educational kinesiology, is promoted in very dubious pseudo-scientific terms and we still don't really know how, and even if, it works. Other programmes, such as those involving learning styles, draw on some meaningful science but, when children get labelled as 'a visual learner' or 'an auditory learner' and are only ever taught in either a visual or auditory way, then the science is being seriously over-interpreted and misapplied. The good news, however, is that efforts to bridge the gap between neuroscience and education are debunking many of these ideas, and opening up fresh opportunities for valuable and exciting initiatives that are both scientifically and educationally sound."

In 2006, the Office of Economic Cooperation and Development published a report of an international conference on Personalising Education held in London, organised jointly by the OCED, The Innovation Unit and the think-tank Demos. One of the papers presented at the conference was on 'Brain Research and Learning Over the Life Cycle' in which Manfred Spitzer, head of the Psychiatric Hospital at the University of Ulm in Germany, argued that while we might be in the comparatively early stages of understanding how the brain functions, we know enough "to bet on the fruitfulness of personalised learning" [4]. (Personalisation and how it can be resourced in schools is one of the strands of The Innovation Unit's Next Practice in Education programme.)
It may well be that apart from trying to understand some of the popular ideas about the brain that have flourished and are impacting on teaching and learning, more general themes such as personalisation and the role of emotion in learning deserve further scientific research and will provide fruitful lines of enquiry.

What is clear is that it is important for educationalists and teachers along with scientists and researchers to share together what they are finding out about successful learning in this new interdisciplinary field of neuroscience and education, and if you want to take some of these issues further, log on to The Innovation Unit website (www.innovation-unit.co.uk) to find out how to debate the findings and implications of this report.

4 Spitzer. M (2006) *Brain Research and Learning over the Life Cycle in Personalising Learning (Schooling for Tomorrow)*, OCED Paris.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1. Historical and literary contexts

Historical

In 1990, the decade of the brain was launched in the US. This prompted successful attempts by authorities, teachers and entrepreneurs to promote a number of 'brain-based' education ideas such as 'Right brain versus left brain' thinking and individuals, Brain Gym and learning styles. Those 'brain-based' ideas that are more evidence-based, such as strategies for enhanced memory, tend to draw their evidence from psychology, rather than neuroscience (Bruer, 1999). Others, such as those found in brain gym, have not been scientifically or educationally assessed with any rigour, but often use pseudo-scientific explanations to support their credibility[1]. If such programmes are effective, we may not yet understand why. The potential ease and willingness by which neuroscientific findings are 're-interpreted' in educational and political domains was demonstrated most powerfully in the early years education debate. In 1996, Hillary Clinton decided to emphasise at a well-publicised White House meeting that brain research showed how the environment determined whether children "grow up to be peaceful or violent citizens, focused or undisciplined workers, attentive or detached parents …". Such ideas inevitably influenced attitudes about the importance of early years education as reflected, in the UK, by the introduction of the Early Learning Goals in 1999. And yet, a later review of the neuroscience literature has concluded that evidence from brain research does *not* support a selective educational focus on children's earliest years (Blakemore and Frith, 2005, p35).

About 10 years after the flourishing of this initial, and often unscientific, interpretation of the brain's role in education, a small number of neuroscientists began persistent and active efforts to suggest that education could indeed benefit from greater awareness of our understanding of the brain. Most notably, Uta Frith and her colleague Sarah-Jayne Blakemore were commissioned by the Teaching and Learning Research Programme (TLRP) to carry out a review of neuroscientific findings that may be of relevance to educators (Blakemore and Frith, 2000). This review attacked a number of myths, including those concerning critical periods, and highlighted some new areas of potential interest to educators such as the role of sleep in learning. Rather than point out areas where neuroscience could be immediately applied in education, the review sought to highlight neuroscientific questions that might be of interest to educators, thus making an important initial step towards defining an interdisciplinary area of collaborative research. In January 2001, to promote further discussion about a possible research agenda, the TLRP wrote to 439 institutions,

1 There is evidence that Brain Gym improves reaction time (Sifft and Kahlsa, 1991), but the underlying mechanisms and the relevance of this finding to education have not been well researched.

including 233 scientific institutions and 193 education departments in higher education, asking for comments on the report by Blakemore and Frith. In addition to identifying any omissions, respondents were particularly asked to provide (in bold) 'identification of key research questions, … their priority … and estimate of their tractability (in terms of return on research effort)'.

Only 14 education departments responded to the request. Two of these declined to comment on the basis of insufficient expertise. The other 12 identified the following areas shown in Table 1.

In this table, those topics not mentioned in the review are shown in italics. Thus, more than a third of the suggestions made by educators had not been prompted by Blakemore and Frith's collation of existing neuroscientific evidence but were calling for neuroscience to initiate new lines of inquiry into issues of broad educational interest.

The report on the consultation concluded that no collaborative research agenda had yet emerged (Desforges, 2001). However, it also reported how both the education and scientific communities were very complimentary about both contents and timeliness of the review, and, in response to the consultation, the Lifelong Learning Foundation went on to select and fund a small number of pilot research projects.

In 1999, at the same time as the Blakemore and Frith report was being commissioned in the UK, the supranational OECD project on 'Learning Sciences and Brain Research' was being launched by the OECD's Centre for Educational Research and Innovation (CERI). The first phase of the project (1999–2002) brought together international researchers to review potential implications of recent research findings in brain research for policy makers. The second phase (2002–2006) channelled its activities on 3 main issues (Literacy, Numeracy and Lifelong Learning) within 3 trans-disciplinary and international

Table 1

Proposed area for research questions	Number of respondents identifying this area
Developmental disorders, including dyslexia	4
Implicit/explicit memory	4
Gender differences	3
Working memory	1
Sensitive/critical periods and plasticity	3
Evidence for Piagetian stages of development	*2*
Multiple Intelligences	*2*
Creativity	*2*
Other	*2*

networks co-ordinated in collaboration with 3 leading institutions (Sackler Institute-USA, INSERM-France, RIKEN Brain Science Institute-Japan).

A number of key events took place in 2005 that have supported further research collaboration between neuroscience and education. Professor Usha Goswami opened the Centre for Neuroscience and Education at the Faculty of Education, University of Cambridge. The TLRP funded a major seminar series 'Collaborative Frameworks in Neuroscience and Education' that has been bringing together experts in education and neuroscience to discuss future research possibilities. This seminar series later gave rise to a very popular commentary about the area (Howard-Jones, 2007). Abroad, Japan had already initiated 2 very large programmes of research in this interdisciplinary area and the German government began the NIL Neuroscience and Education programme for research from November 2005. Blackwells began publishing a new journal in Neuroscience and Education in 2007.

Literary

The work carried out at the beginning of this decade by Blakemore and Frith has been updated, extended and published as a book (Blakemore and Frith, 2005). The OECD Brain and Learning project has also published a summary of its interim findings (OECD, 2002). Both these publications, at national and supranational levels, highlight similar areas of interdisciplinary interest, such as plasticity, emotion and the understanding of common developmental disorders such as dyslexia.

This contrasts with the emphasis found in most educational 'brain-based' programmes, which still reflect the types of unscientific concepts first promoted in the 1990s. Some of these approaches make fleeting claims of having a brain basis and then develop independently of reference to neuroscience. In 'Hands on: How to Use Brain Gym in the Classroom', Cohen and Goldsmith (2000) explain:

"laterality cooordinates the left and right sides of the brain to communication effectively, correlating to the midline movements; centering co-ordinates the top and bottom areas of the brain for organisation of thoughts and action, correlating to the Energy Exercises, and emotions correlating to Deepening Attitudes; focus co-ordinates the receptive brain stem with the expressive forebrain for comprehension and perspective, correlating to the lengthening Activities. Brain Gym results in thorough integration of all these dimensions and leads to significantly improved performance." (Authors' emphasis in colour to indicate technical terms specific to Brain Gym.)

This text, and others like it, expresses the belief that activity in a wide range of neural mechanisms can be influenced by specific physical exercises. In the sense described here, such ideas are at odds with present scientific understanding.

Another basic concept expressed in this book for teachers is that water provides

energy, (even though water is one of the few things we regularly ingest that has no calorific content). Children are encouraged to sing to the tune of 'Frere Jacques':

"Let's drink water,
I love water.
It gives me
Energy."

Brain Gym has also promoted the concept of 'brain buttons' (Indentations between the first and second ribs directly under the collar bone/clavicle to the right and left of the sternum/breastbone). Originally from acupuncture, Cohen and Goldsmith (2000) claim that if children provide themselves with pressure at these points, it will help re-establish the organisation necessary for reading and writing. Other exercises include the Cross-crawl, promoted on the basis of activating left/right, top/bottom and back/front areas of the brain simultaneously, and varieties of 'Hook-up' for calming and stress-relieving effects.

Approaches to learning that come under the heading of Accelerated Learning are a more eclectic mixture of popularly-reported neuroscience and psychology, together with classroom based observation/expertise/report. Books that promote 'accelerated learning' often include many claims that concepts are scientifically based. Indeed, concepts from psychology and neuroscience are often introduced as a means to promote and explain learning mechanisms. As in Brain Gym, there is a still an emphasis on the desirability of balance between the left and right part of the brain. For example, in Smith (1996), we are reminded " Remember that the synergy generated in creating new pathways between left and right results in all-round improvement".

Accelerated learning also often embraces other popular brain concepts in education:

- Multiple Intelligences: Gardner's theory of multiple intelligences promotes the idea of many plastic, rather than one fixed, intelligence (Gardner, 1993)

- Learning Style Preferences: Here, psychological evidence supports the possibility that individual preferences exist regarding how we like to learn. In education, learners may be allocated to one of three types of learning style (visual, auditory or kinesthetic - VAK). It is believed, but still unproven, that presentation of material in a way that suits a learner's preferred learning style can improve their learning. (Of course, it could be argued that the reverse might be more helpful as a remedial intervention to improve processing associated with the other learning styles). Other variations on the basic concept of learning preferences/styles can include sorting of pupils into more or less categories. For example, some texts encourage teachers to determine if a child is left or right brained (eg Hoffman, 2002).

Another way that teachers and pupils encounter ideas about the brain is through resources directed at pupils. In teaching young children about science, provisional truths are often created which can be expected to vary in their relation to

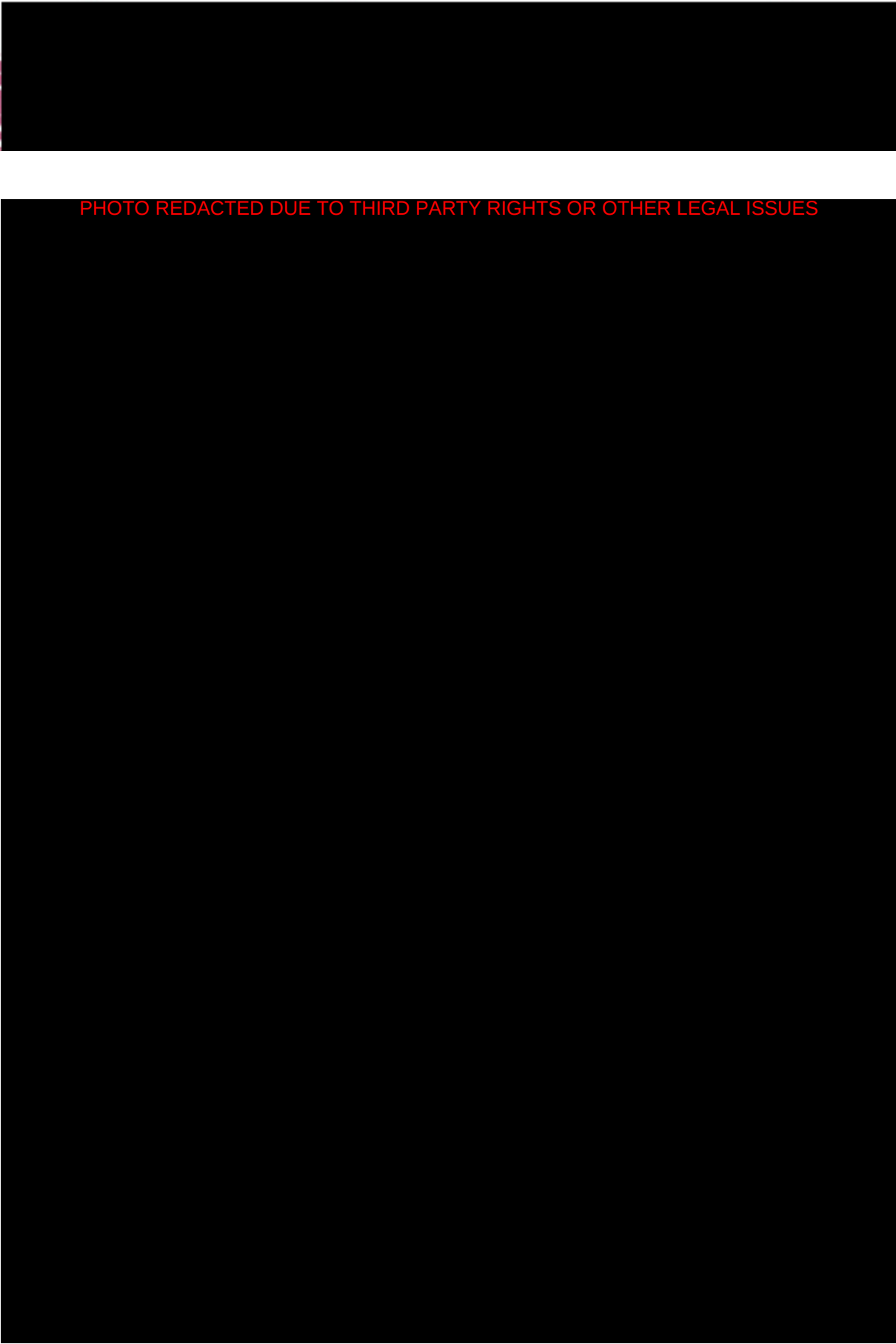
modern accounts. However, the common assumption that the brain is the seat of consciousness can add extra dimensions to how provisional truths about this particular concept are represented. Some of these even possess a moral tone. In Hoffman (2002), children (aged 9–15) are told "avoid saying bad things about yourself and about other people because your brain will believe you".

Another selection of books, intended exclusively for teachers, are characterised by a different set of features regarding their approach. These have:

- extensive referencing to scientific literature
- integrated discussion of cognitive, psychological and neuroscientific studies (ie using cognitive science as a link between what we know about the brain and what we know about learning)
- discussion of both what is and isn't known, including reference to results showing possible limitations of positive effects
- *less* to say about many of the most popular brain-based educational ideas such as Brain Gym, learning styles, hydration, left-brain/right-brain balance etc., and may often attempt to debunk these, some of these texts (eg Wolfe, 2001, Jensen, 1998) mention the role of movement and individual differences in learning, but there is generally a different emphasis provided than in the texts discussed above
- critical reviews of scientific literature focusing on issues of educational interest such as:
  - attention
  - motivation, reward and stress
  - memory
  - environments
  - mathematics and reading.

Finally, in addition to text by Blakemore and Frith (2005) there are other examples of scientists attempting to speak directly to educators. Accounts such as Byrnes (2001) provide a considerably more critical and informed examination of those areas (and others) listed in the previous paragraph, but resist providing direct and practical classroom advice.

To summarise this review of the contexts of the present consultation, it appears that educators and scientists are again paying serious attention to the notion that education can be improved with insights from neuroscience, and preparations are well underway to support the flourishing of a new field with an interdisciplinary research agenda. Central to the success of any effort to improve education are the support, understanding and expertise of teachers – who remain exposed to brain-based concepts from earlier and sometimes unscientific enterprises. Against the history of such entrepreneurial brain-based programmes and a background of renewed global effort to conjoin these two disparate fields, this consultation reports upon the views of teachers about how they see the relevance, or otherwise, of neuroscience to education.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2. Evidence

Evidence for the consultation was collected in two stages. The first stage involved the preparation and distribution of a short questionnaire designed to identify key issues in educators' perceptions of the role of neuroscience and education. This was then followed by a number of semi-structured interviews with teachers. Additional information about the views of educators and others on the role of neuroscience in education was obtained from discussions held at the ESRC-TLRP Collaborative Frameworks for Neuroscience and Education seminars.

Initial survey of key issues

Following the distribution of a pilot questionnaire to local teachers, the final version of the questionnaire was developed (see Pickering and Howard-Jones, 2007). This questionnaire was designed to ask educators a number of general questions about their thoughts, beliefs, views and knowledge on the link between neuroscience and education. Specifically the questionnaire included both open and closed questions designed to obtain information about:

1. educators' understanding of the terms 'education' and 'neuroscience'
2. their views on how important an understanding of the brain is in a range of educational activities (with children and adults), including the design, delivery and content of educational programmes; early screening for learning problems; provision for individuals with special needs of various kinds; and understanding of the role of nutrition in education
3. where educators had obtained information about neuroscience and education
4. ideas that they had come across in which the brain was linked to education
5. whether their institution had used educational initiatives based on ideas about the brain, and if such initiatives were useful
6. the importance of a number of issues in the application of neuroscience to education, such as: communication between interested parties, relevance, accessibility of information, and ethical issues.

The initial survey of key issues was carried out during two conferences held in June and July 2005. The first conference was the 'Learning Brain Europe' conference held in Manchester. This conference was organised by a group of headteachers from the Macclesfield area, following their attendance at a similar conference in the USA (the Learning Brain Expo - http://www.brainexpo.com/). In the delegates pack for the Learning Brain Europe event the organisers state:

The next two days represent a unique opportunity for teachers to hear about how

the latest research on brain science can be adopted to improve the learning experience for children and teachers.

The inspiration for the conference came from the Brain Expo conference that teachers ... have experienced in the USA over the past few years. Teachers have come back inspired and invigorated, and have instigated real change in their classrooms.

We are determined that this fantastic experience should be available to a wider audience in the UK, and have invited key speakers from the USA and the UK who, we believe, offer a rare combination of inspiration, practical strategies and fun!

The conference actually formed two INSET days for teachers in LAs in the Manchester area. Attendance for local teachers was therefore free, and all teachers in the relevant LAs were released from their teaching for at least one of the two days in order to attend. Approximately 1300 teachers attended the conference for either one or both of the days that it ran.

A number of invited speakers made keynote speeches during the conference including Alistair Smith, Spencer Kagan and David Sousa. All of the aforementioned individuals have published work on 'brain-based learning'.

Questionnaires were included in the delegates' packs and teachers were encouraged throughout the conference to complete and return them. The total number of completed questionnaires from this event was 270.

A questionnaire was also included in each of the delegates' packs of all those attending the 'Education and Brain Research Conference' held at the University of Cambridge in July 2005. This three-day conference marked the launch of the 'Centre for Neuroscience in Education' at Cambridge and was attended by approximately 250 delegates (including teachers and other educational professionals). Speakers included established academics in the areas of neuroscience and psychology, such as Usha Goswami (conference organiser), Mark Johnson, Uta Frith, Kurt Fischer, John Geake and Guy Claxton.

Delegates were encouraged to complete the questionnaire and return it to us during the conference. A total of 71 completed questionnaires were collected from this event.

Interviews with teachers

On the basis of the survey of key issues carried out with the questionnaire, a number of semi-structured interviews were carried out. Some of the interviews were conducted with delegates at the 'Education and Brain Research Conference' in Cambridge while others were carried out with local teachers in Bristol.

The aim of the interviews was to probe in more detail teachers' views about the role of the brain in education and to follow up on responses made in the initial survey. Thus, the structure and content of the interviews varied between participants, depending on the nature of the responses made. A total of 11 interviews were carried out.

Discussions from the ESRC-TLRP Collaborative Frameworks for Neuroscience and Education seminars

The ESRC-TLRP Collaborative Frameworks for Neuroscience and Education Seminar Series consists of six seminars, the first one of which was held in April 2005. The aims of the seminar series were (Howard-Jones and Pickering, 2005):

- to review contemporary work in the associated fields of neuroscience and human development and consider the existing contributions offered by these fields to the study of key educational issues
- to review the extent to which the fields of neuroscience and human development have successfully permeated educational thinking and to explore their potential and limitations in influencing our thinking about general teaching and learning issues
- to explore how theoretical perspectives arising from neuroscience and human development may conjoin with, and enrich, current theoretical frameworks in education
- to identify the issues, opportunities and constraints that may arise in the near future as a result of advances in the fields of neuroscience and human development
- to identify means by which research capacity in this interdisciplinary area can be developed, and to examine the theoretical, practical and strategic basis for research capacity building.

Data for this consultation was gathered from discussions held during the first and third seminars in the series. Following a series of presentations by invited speakers during the first half of each of the two day-long events, delegates were arranged into four groups and asked to spend one hour discussing issues that relate to the bringing together of neuroscience and education. For the first seminar, discussions were guided in part by the question: 'What sort of evidence should inspire educational change?'. The third event, held in October 2005, included discussions around the topic: 'By what routes should neuroscience enter our classrooms?'. Summaries of these discussions can be found at the Seminar Series website (http://www.bris.ac.uk/education/research/sites/brain/).

3. Analysis and Discussion

Initial survey of key issues

Data for the consultation was obtained from the analysis of 150 of the completed questionnaires distributed at the two brain and education conferences held in 2005. The sample included the 71 questionnaires from the 'Education and Brain Research Conference' in Cambridge plus a randomly selected sample of 79 completed questionnaires from the 'Learning Brain Europe' conference in Manchester.

The 150 respondents who completed the questionnaires were educational professionals from schools and other educationally related institutions. The majority (54%) of respondents were teachers based in primary and secondary schools (Primary, 27% and Secondary, 27%), including 17 headteachers. The remaining 46% of respondents held a number of different positions in the world of education, including education consultants, school inspectors, teacher trainers and assistant teachers.

A separate analysis of responses of teachers (only) in terms of the conference they were attending and their phase (primary or secondary) was also carried out. Outcomes from the survey were essentially similar across the educational community, except where highlighted. Therefore, we first report the views of the entire sample as representative of the educational community as a whole, before focusing in depth upon teachers' responses arising from the interviews.

1. Educators' understanding of the terms 'education' and 'neuroscience'.

In any effort to understand educators' perceptions about the role of neuroscience in education, it is first important to establish how participants view the concepts of education and neuroscience. Thus, the first two questions in our initial survey asked: 'What do you understand by the term "education"?' and 'What do you understand by the term "neuroscience"?'.

Responses to the question 'what do you understand by the term "education"?' were analysed first, and five major categories of response were created from the data. Thirty-one percent of respondents gave an answer that included the terms 'learn' or 'learning'. Examples of responses from this category were "*giving people the opportunity to learn effectively*", or "*all experiences of learning and engagement*". Around 19% of participants felt that the term 'education' referred to the development of a person's potential, as illustrated by the following response: "*every child achieving their academic and social and emotional potential*". A further 15% of respondents appeared to view education as being part of the preparation of individuals for life in their society, whereas around 7% of the sample emphasised the life-long nature of the education process. A definition that involved 'knowledge' was given by 8% of the respondents. Around 17% of the respondents gave an answer that did not easily fit into the five categories described above. Some of these responses included

references to cognition, for example, *"the development of cognition while actively engaging curiosity",* while others took a more pragmatic stance, describing education as *"preschool and school based provision as regulated by government policies ..."*.

Respondents' understanding of the term 'neuroscience' was less varied. Over half (60%) of the sample described neuroscience as the study or science of the brain. Around a quarter of respondents (24%) indicated that neuroscience was concerned with learning or understanding about the brain, while a further 13% thought that it was about how the brain works.

2. Respondents' views on how important an understanding of the brain is in a range of educational activities (with children and adults), including the design, delivery and content of educational programmes; early screening for learning problems; provision for individuals with special needs of various kinds, and understanding of the role of nutrition in education.

Against this backdrop, respondents went on to provide information about how important they felt an understanding of the brain was in a number of specific educational activities. Views were sought regarding the education of adults and children separately. In each case, participants were asked to give a rating from 1 to 5 (with 1 being 'not important' and 5 being 'very important') for the relevance of an understanding of the brain in each of the different activities.

Data was analysed by combining ratings of 1 and 2 into a 'low rating of importance' and ratings of 4 and 5 into a 'high rating of importance'.

(a) Children

Figure 1 indicates the percentage of respondents giving low and high ratings of importance to an understanding of the workings of the brain in the various activities with children. Overall, it is clear from Figure 1 that respondents felt that an understanding of the workings of the brain was important in all of the activities listed. The area in which most respondents (83%) felt that this was important was the provision for children with special educational needs of a behavioural and/or emotional and a physical and/or sensory nature. However, other areas received almost as many high ratings, including the design (76%) and delivery (77%) of educational programmes, the provision for individuals with special educational needs of a cognitive nature (80%), early screening for learning problems (76%) and an understanding of the role of nutrition in educational achievement (70%). The only area in which respondents gave lower ratings in any significant numbers was that concerning decisions about curriculum content, with 19% of the sample giving ratings of only 1 or 2 here.

(b) Adults

A similar analysis was carried out on responses to educational activities concerning adults. The results from this analysis are shown in Figure 2. Here we

Figure 1. Percentage of respondents giving either a high rating or a low rating regarding the importance of an understanding of the workings of the brain in a range of educational activities with children.

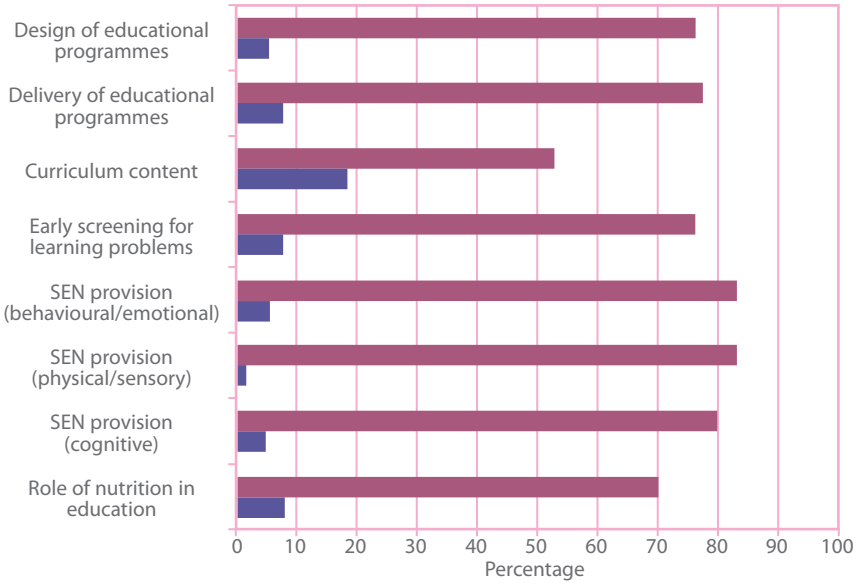
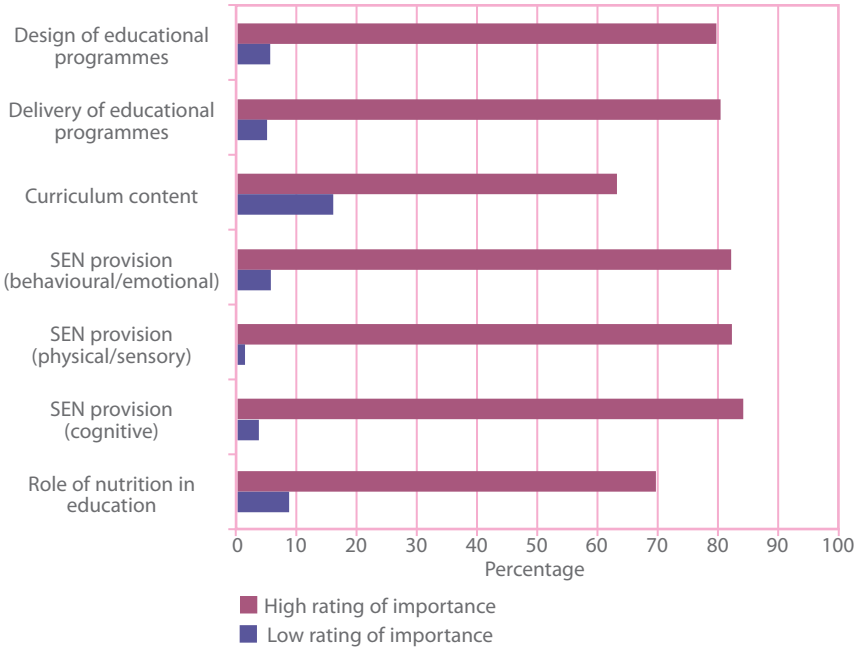


Figure 2. Percentage of respondents giving either a high rating or a low rating regarding the importance of an understanding of the workings of the brain in a range of educational activities with adults.



can see that a significant percentage of respondents have given high ratings of importance to an understanding of the workings of the brain in educational activities with adults. The greatest number of high ratings was given to the provision for individuals with special educational needs, especially those with needs of a cognitive nature (83%). The design and delivery of educational programmes were also thought to benefit from an understanding of the workings of the brain (with 79 and 80% of respondents giving ratings of 4 or 5 to these activities, respectively). In a similar manner to that of the education of children, decisions about curriculum content was the only area for which more than 10% of low ratings of importance were received.

Taking these two analyses together, it is clear that the sample of educational professionals that took part in the questionnaire study believe that an understanding of the workings of the brain is important in a whole range of educational activities, with both children and adults. Respondents felt that educators would benefit from knowledge about the brain, not just in the domain of special educational needs, where much of the neuroscientific attention has been directed in recent years, but in activities related to the design and delivery of educational programmes more broadly. The one area where this view was less strong concerned the *content* of what is being taught. Although at least half of respondents thought that an understanding of the workings of the brain was important for this aspect of educational activity, just less than a fifth of participants felt that it was not important.

An additional analysis was carried out to examine separately the responses of participants who had attended the two different conferences (Learning Brain Europe - LBE and Education and Brain Research - EBR). The percentage of each of the two subgroups of participants who gave high or low ratings to the importance of knowledge about the brain is shown in Table 1(a) for the education of children and Table 1(b) for the education of adults.

The analysis of responses to this question, by conference attended, reveals that the general trends described for the whole sample are present in the data. However, some interesting differences between the two groups of conference attendees are noticeable. In particular, the percentage of high ratings of importance for all of the educational activities is somewhat lower for the Education and Brain Research conference group than the Learning Brain Europe group. The reasons for this difference are not clear, however some possible contributors to this difference include: differences in the types of brain-based educational activities that were discussed at the two conferences, differences in the experience of respondents in applying neuroscience to education, and differences in the extent to which participants had been exposed to ideas about neuroscience and education. Overall, then, the EBR group seem more moderate in their enthusiasm for the role of the brain in education, whereas the LBE group seem to be experiencing very high degrees of enthusiasm for the role of the brain in these different types of educational activity.

Table 1(a). Percentage of respondents giving either a high rating or a low rating regarding the importance of an understanding of the workings of the brain in a range of educational activities with children, by conference attended.

	LBE		EBR	
	low rating	high rating	low rating	high rating
Design of educational programmes	1	82	10	69
Delivery of educational programmes	1	89	14	65
Early screening for learning problems	3	87	13	63
Curriculum content	13	63	25	41
SEN provision (cognitive)	3	90	7	69
SEN provision (physical/sensory)	0	92	3	73
SEN provision (behavioural/emotional)	0	94	11	72
Role of nutrition in education	4	82	13	56

Table 1(b). Percentage of respondents giving either a high rating or a low rating regarding the importance of an understanding of the workings of the brain in a range of educational activities with adults, by conference attended.

	LBE		EBR	
	low rating	high rating	low rating	high rating
Design of educational programmes	0	85	11	72
Delivery of educational programmes	0	90	10	69
Early screening for learning problems	8	77	25	46
SEN provision (cognitive)	1	90	6	76
SEN provision (physical/sensory)	0	87	3	75
SEN provision (behavioural/emotional)	0	89	11	73
Role of nutrition in education	4	80	13	58

3. Where have educators obtained information about neuroscience and education?

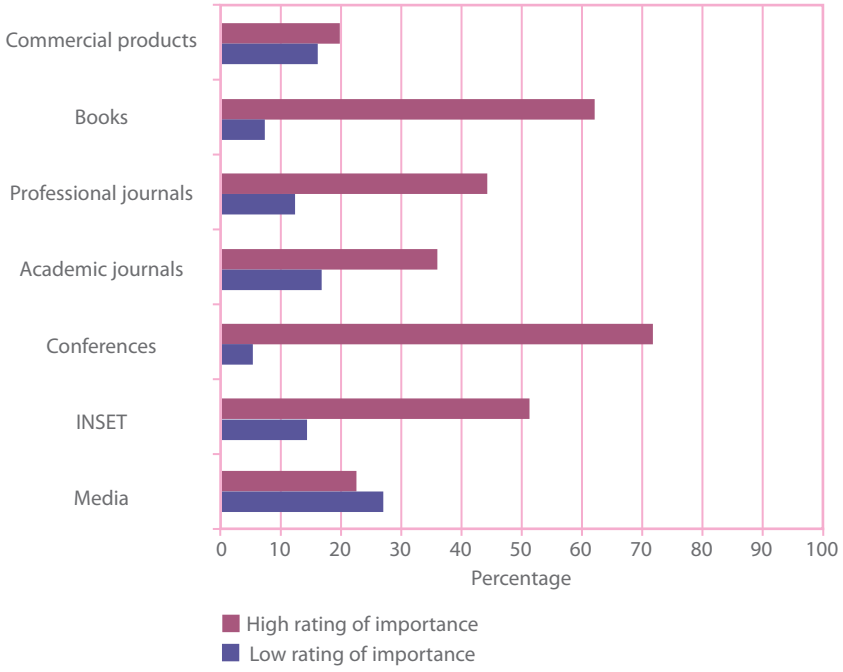
In order to establish how participants have obtained information about neuroscience and education, we asked the question: 'Which, if any, of the following sources have provided you with information about the role of the brain in education?'. We also asked participants to rate the importance of each source to them (using the 1 to 5 scale described earlier). Figure 3 shows the percentage of participants who rated the

different sources as either very important (ratings of 4 and 5) or not important (ratings of 1 and 2).

The graph in Figure 3 indicates the significant number of high ratings of importance given to both conferences (71%) and books (62%). In contrast, only around 20% of participants gave commercial products and the media high ratings of importance, with the media receiving more low ratings of importance (27%) than high ratings. It is notable from the results presented above that in-service training was thought to be an important source of information about neuroscience and education by more than half of the respondents. Journals were also listed as sources of information on this topic, although respondents appeared to think that professional journals were of greater use than academic journals, for this purpose.

As well as rating sources of information already listed on the questionnaire, respondents were free to add other sources and ratings of their importance. Eleven respondents listed additional sources as: the internet (5 responses) and discussion with others (6 responses), including colleagues, friends and children. Most rated these sources as important, although some viewed their discussions as less important providers of information about neuroscience and education.

Figure 3. Percentage of respondents giving either a high rating or a low rating regarding the importance of a number of potential sources of information about neuroscience and education.



In order to explore the responses of the LBE and EBR conference groups on this issue separately, ratings of usefulness for the different sources of information were collated for each subgroup of respondents. The percentage of participants attending the two conferences that gave ratings of 1 and 2 (low rating of importance) or 4 and 5 (high rating of importance) to the various information sources is shown in Table 2.

Notable differences in the percentage of participants giving high and low ratings of importance are seen particularly for books (more of the EBR participants felt that books were an important source of information than the LBE participants) and in-service training (where this trend was reversed). As the LBE conference was actually an in-service training day for the participants at this conference, it is perhaps not surprising that more of this group rated INSET as an important source of information than the EBR group. The reason for the much higher numbers of participants from the EBR conference rating books as very important compared to the LBE participants is less clear. It is evident from this data that information in written form (books and journals) seems to be viewed as a more important source of information overall by the EBR subgroup than the LBE subgroup.

4. What ideas had educators heard of in which the brain was linked to education?

In order to get a sense of the knowledge that participants already possessed about neuroscience and education, they were asked to list any ideas that they had heard of in which the brain is linked to education. Using the 1 to 5 scale described earlier, participants were also asked to rate the usefulness of such ideas.

As the participants were attending one or either of the two conferences on neuroscience and education, there is some

Table 2. Percentage of respondents giving either a high rating or a low rating regarding the importance of a number of potential sources of information about neuroscience and education, by conference attended.

	LBE		EBR	
	low rating	high rating	low rating	high rating
Media	20	28	35	15
INSET	9	67	20	34
Conferences	6	71	4	72
Academic journals	23	24	10	49
Professional journals	18	33	6	56
Books	13	46	1	80
Commercial products	16	19	15	21

inevitable mention of the ideas that had been presented during the conferences. This is evident in responses that mention the work of key speakers, such as David Sousa, Alistair Smith (Accelerated Learning) and Spencer Kagan (Cooperative Learning, Kagan Structures) and Blakemore and Frith. However, it also seems clear that many participants came to the conferences with prior knowledge of brain-related educational concepts and initiatives.

The ideas provided were grouped into six categories as follows: educational kinesiology (including Brain Gym), learning styles (including multiple intelligences, VAK, and left-brain/right-brain learning), ingestion and the brain (including nutrition, water and drug-use), emotion and learning, teaching and learning approaches (such as mind maps, cooperative learning and accelerated learning) and more specific cognitive and neuropsychological knowledge. The number of times that ideas in these six domains were listed by respondents is indicated in Table 3.

From Table 3 we can see that respondents mentioned ideas about 'brain-based' teaching and learning approaches 64 times. Examples of instances from this category of responses include: mind maps, cooperative learning, accelerated leaning, whole brain learning, thinking skills, brain-friendly learning and Kagan Structures. As noted above, a number of these ideas were presented to participants at the 'Learning Brain Europe' conference, so it is less easy to determine whether the high incidence of this type of response is dependent upon this recent exposure or if it reflects knowledge that participants had before attending the conference. An alternative explanation for the dominance of this type of response is that ideas that translate directly into practice are the ones that respondents (as educators) are most likely to be aware of, and pay particular attention to.

This view gains some additional support from the finding that ideas related to educational kinesiology were mentioned a total of 48 times by the respondents. In most cases the term 'Brain Gym' was actually

Table 3. Six categories of brain-based ideas listed by respondents, the number of times each was mentioned, and the number of ratings of very useful (5) or not useful (1).

	no. of times mentioned	very useful (5)	not useful (1)
Educational kinesiology	48	16	6
Learning styles	45	17	4
Ingestion and the brain	13	7	2
Emotion and learning	14	9	0
Teaching and learning approaches	64	29	1
Cognitive and neuropsychological knowledge	49	23	2

used. Educational kinesiology, and more specifically, Brain Gym, appears to share some common features with the teaching and learning approaches mentioned above, namely a brain-basis is suggested, and the concept readily translates into practice.

Ideas concerning differences in styles of learning were also mentioned over 40 times, although here a number of different specific concepts were noted, including: learning styles; multiple intelligences; preferred learning styles; Visual, Auditory, and Kinaesthetic (VAK) learners; right and left brain thinkers; and multisensory learning.

Responses grouped in the sixth category (cognitive and neuropsychological knowledge) were those responses that indicated awareness of ideas that emanated from cognitive or neuropsychological academic research, such as knowledge of neuropsychological techniques, brain-based disorders, cognitive skills or brain processes. Ideas of this kind were listed 49 times by the sample.

Participants mentioned ideas that were linked to the ingestion of a particular substance 13 times, including issues such as prenatal nutrition, drinking water, fish oil supplements and the impact of alcohol and drugs. Knowledge relating to the role of emotion in neuroscience and education was evident in 14 of the responses. These included mention of emotional intelligence and the role of emotion in learning.

Not all respondents gave ratings of usefulness for their responses. In the cases where this did happen, some interesting variations occurred. Ideas in each of the categories attracted a range of ratings from 1 (not useful) to 5 (very useful). Table 3 indicates the number of times that each of these two ratings was given in the six categories of response. The greatest number of ratings of 'very useful' was found in the teaching and learning approaches category (29) while the number of 'not useful' ratings in this group of responses was just 1.

Ideas grouped in the category of cognitive and neuropsychological knowledge also received a high number of ratings as 'very useful' (23) and only 2 ratings of 'not useful'.

Overall the number of 'very useful' ratings for each category of response significantly exceeds the number of 'not useful' responses. However, the number of 'not useful' ratings for the educational kinesiology is the largest. Here 6 respondents indicated that that they did not think that this was useful, just over one third of the number of respondents who felt that it was very useful. Clearly opinions are divided on this aspect of educational practice.

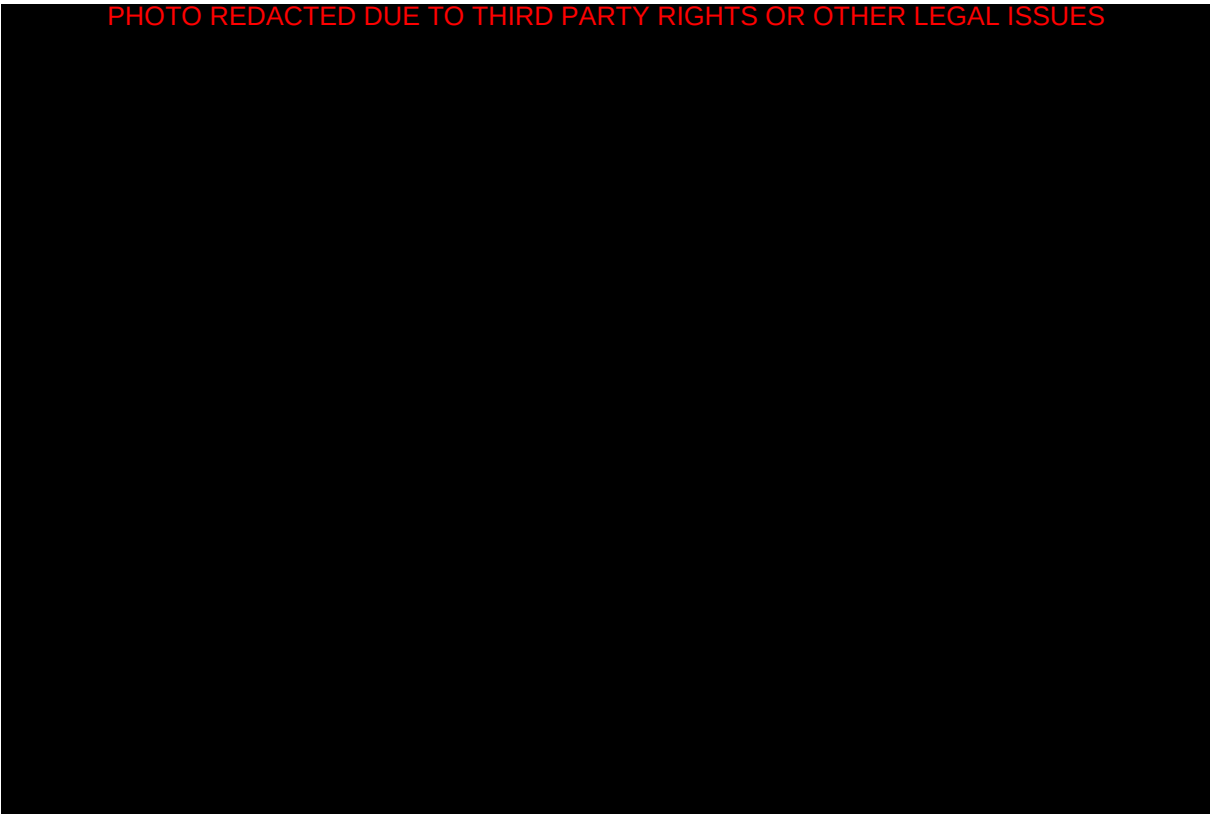
5. Have respondents' institutions used educational initiatives based on ideas about the brain, and if so, were such initiatives useful?

Following on from questions about ideas that respondents were aware of in which the brain was linked to education, we wanted to gain information about the extent to which brain-based teaching and learning techniques had actually been used in their institutions. To this end, we asked

participants to list any educational initiatives based on ideas about the brain that had been used in their schools, colleges and other teaching and learning institutions.

One hundred and eight of the 150 respondents in the sample indicated that they had used educational initiatives in their institutions that were based on ideas about the brain. Nineteen participants indicated that they had not. Some participants did not make any response to this question, while others made a response to indicate their views on the matter, but not whether they had used the initiative as such (eg *"as a member of the LA, I am concerned that staff in schools have too many initiatives - they need ideas that will make their work easier"*). A small number of the responses revealed that while participants had not used such initiatives yet, moves were underway to incorporate this type of approach (eg *"tutors are finally taking on board some of the ideas'* and *'whole school staff training in progress"*).

Of the 108 positive responses to this question, many included references to initiatives that had been mentioned in answer to the previous question. Twenty-four respondents indicated that they used Brain Gym in their schools; the same number listed initiatives that were earlier grouped under the heading of 'learning styles' (such as VAK, multiple intelligences, left brain/right brain, and visual thinking). A further 42 respondents noted examples of the 'teaching and learning approaches' described above, including mind mapping, learning to learn, cooperative learning, mind-friendly learning, Kagan Structures, brain-friendly learning, cognitive



acceleration, assessment for learning, and thinking/questioning/critical skills.

Only one respondent mentioned that they had used initiatives linked to the brain that concerned emotion and learning (emotional intelligence) and similarly, only one respondent indicated that they specifically used water in their institution. Initiatives not fitting into the categories derived in the analysis of the previous question included: anger management, self-esteem, dyslexia-friendly approach, multi-sensory teaching scheme for reading, gender, cognitive intervention programmes, neurofeedback and working memory test battery.

Responses to this question go some way to describing the range of perspectives that educators have on this issue. For example, some respondents were clearly very enthusiastic about the use of such initiatives, as evidenced by comments such as:

"yes, massive whole local authority development"

"not yet, but soon!"

"we are undertaking whole school staff training at the moment"

"not to the extent needed"

whereas others clearly reflected a more sceptical approach:

"not yet - management sceptical of new ideas"

"as a member of the LA, I am concerned that staff in schools have too many initiatives - they need ideas that will make their work easier"

"Detached CPD. Engagement of all staff in having a clear understanding".

This last comment is quite interesting in that it appears to convey a sense that the school has made a decision to take a critical stance in its dealings with initiatives such as those discussed here. The comment above it indicates an awareness that brain-based initiatives are just one of a number of different ideas that are presented to educators for inclusion into their practice.

An additional question asked respondents if they (or others in their institution) had found the initiatives they had mentioned useful, and if so, how. Ninety-six respondents indicated that they, or others, had found the initiatives mentioned above useful; two said they did not. A further 12 respondents gave answers that have been broadly characterised here as 'not sure', however the individual responses in this category appear to communicate a number of different viewpoints. Some respondents indicated that they had not found the initiatives useful "yet", while others felt that they did not know if they had been useful. Some degree of uncertainty was communicated by respondents in the 'not sure' group, as evidence by responses such as:

"I am now confused as to the usefulness of learning styles"

"lack of clarity about theories behind approaches have prevented full scale adoption"

"don't know if directly linked to brain research".

Yet others have responded in such as a way as to suggest that the initiatives have been of moderate use, or that while some in their institution have found them useful, they personally have not.

Many of the respondents who had given a positive response to the question of the usefulness of the initiatives that had been used provided an explanation of their response. In strong evidence here is the issue of motivation and enjoyment of the learners. Responses such as:

"motivates children"

"see the pupils faces - they tell us every time!"

"yes - the fun element is particularly useful within the tight structures of the literacy and the numeracy flow"

"yes, helps motivation, decreases depression"

reveal the degree to which educators seem to find initiatives useful in increasing the positive feelings that the learners have about their studies. Yet another theme that emerges from these responses is that of having more options to draw upon in the teaching of both mainstream and special needs children. This view is illustrated by the following responses:

"yes, better choice of teaching strategy to match learning styles"

"yes as part of a rich and varied 'pull down menu' of strategies and techniques available to our teachers"

"yes in teaching literacy to dyslexic pupils"

A further set of responses suggests that some of the initiatives used help the children to work more effectively:

"yes, students more engaged in own learning"

"improved the success of the teaching and learning, happier children who are more engaged in the activities"

"gets engagement which leads to improved behaviour and greater understanding of lesson content"

"yes, the class seems more animated and they concentrate better"

Overall then, it appears that a significant number of the questionnaire sample had used teaching and learning techniques based on ideas about the brain and had found such techniques useful.

6. How do educators view the importance of issues arising in the application of neuroscience to education, such as: communication between interested parties, relevance, accessibility of information, and ethical issues?

The final matter explored in the questionnaire study concerned a range of issues that might arise in the course of applying neuroscience to education. Respondents were asked to rate the importance of each of the issues (using the 1 to 5 scale described earlier). As with previous questions that asked for a rating of importance, responses were grouped into a 'high rating of importance' (ratings of 4 and 5) and a 'low rating of importance' (ratings of 1 and 2). The percentage of respondents giving low and high ratings of importance for the five issues is shown in Figure 4.

The graph in Figure 4 very clearly illustrates the high degree of importance ascribed to each of the issues arising from the application of neuroscience to education. Around 80% of respondents felt that a

two-way dialogue between educators and neuroscientists, relevance to the 'real' classroom, avoiding the misinterpretation of science and easily accessible information were very important aspects of this multi-disciplinary venture. Ethical issues in brain research were rated as very important by only 51% of respondents, however, and 12% of respondents rated the level of importance of this issue as low.

The sample of participants who took part in this questionnaire study clearly value a genuine dialogue between brain researchers and education practitioners. Similarly, respondents appear to feel that work that links neuroscience and education should be relevant to what actually goes on in the classroom and be easily accessible to educators. However, it is apparent that the misinterpretation of science in the process of its application is also of concern to this group. Why ethical issues should not be of as great a concern to educators is not clear from this analysis.

Analysis of the importance ratings for the two subgroups of conference attendees revealed few differences, except in the area of ethical issues (see Table 4). The overall pattern of responses is very similar across the two groups, with only one exception. This concerns the percentage of respondents who rated 'ethical issues' as not important. Although the number of high ratings of importance for this issue is very similar across the two subgroups, substantially more of the EBR subgroup rated this issue as not important. As indicated above, the precise reason for the larger percentage of low ratings of importance

Figure 4. Percentage of respondents giving either a high rating or a low rating regarding the importance of different issues arising from the application of neuroscience to education.

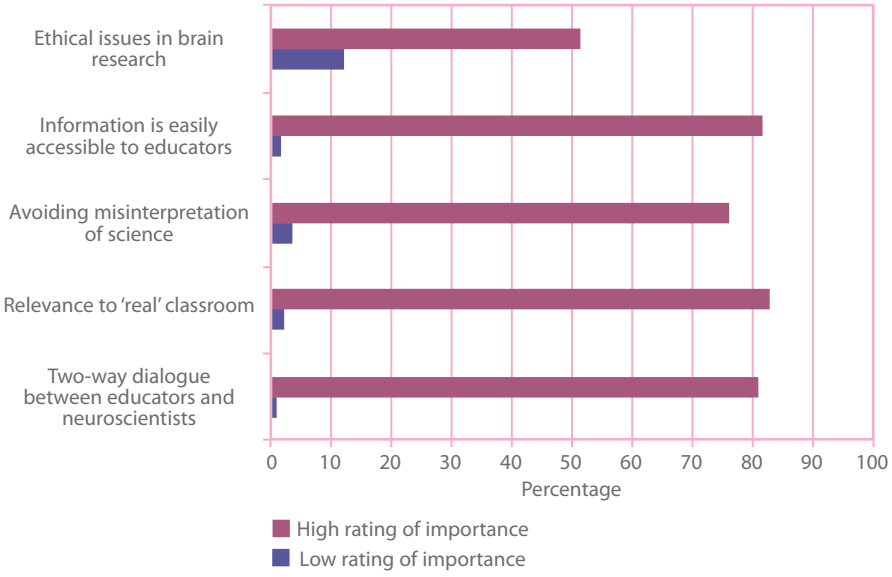


Table 4. Percentage of respondents giving either a high rating or a low rating regarding the importance of a different issues arising from the application of neuroscience to education, by conference attended.

	LBE		EBR	
	low rating	high rating	low rating	high rating
Two-way dialogue between educators and neuroscientists	1	66	0	97
Relevance to the 'real' classroom	0	84	4	82
Avoiding the misinterpretation of science	4	66	3	87
Information is easily accessible to educators	1	76	1	87
Ethical issues in brain research	5	54	20	48

in the Cambridge EBR conference delegates is unclear. Perhaps the two examples of ethical issues that were given with this question (use of animals, scanning children) were not perceived as being especially relevant to the type of neuroscience that is being applied to education at the present time.

Summary of the findings from the questionnaire study

Responses to the questionnaire study indicate the degree of interest that neuroscience and education holds for many education professionals. A significant proportion of the participants appear to feel that knowledge of the workings of the brain is important in both the design and delivery of education. This is true for the education of children and adults, both in mainstream and special educational domains. The only area of education where this knowledge was thought to be less important was in decisions about curriculum content.

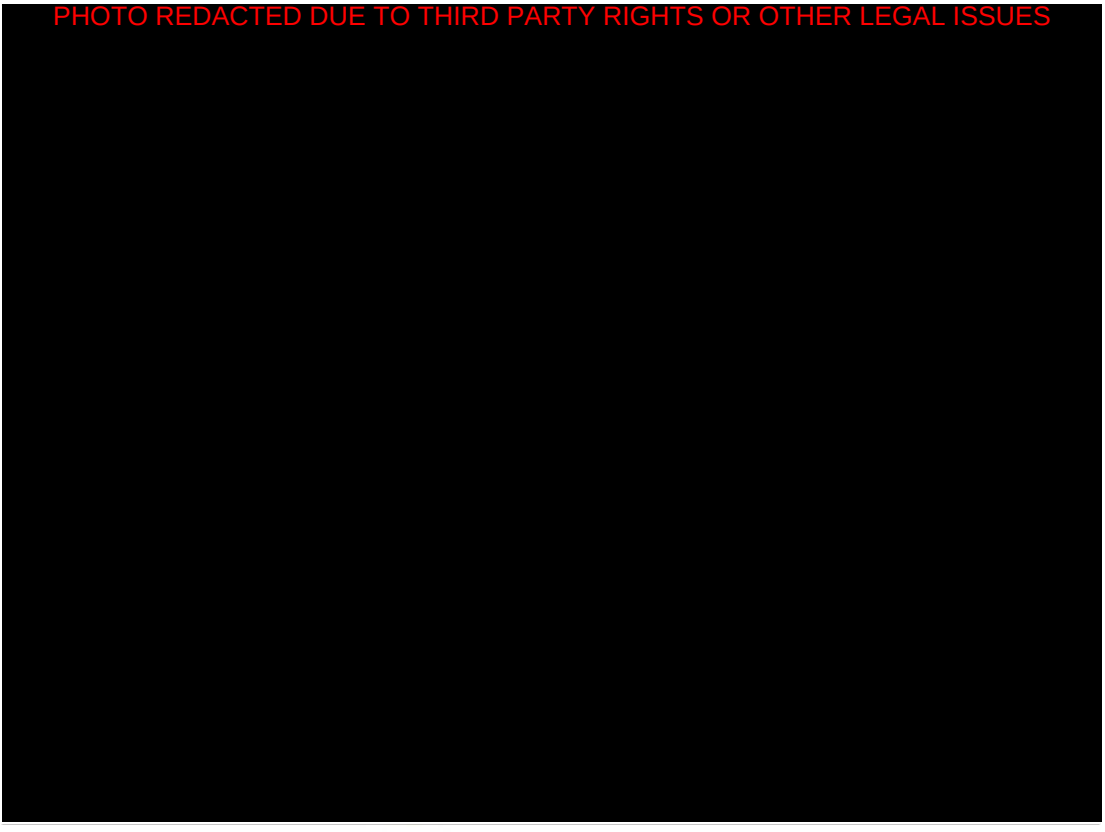
Many of the sample that took part in this study had gained information about neuroscience and education from conferences. This is perhaps unsurprising as the questionnaire study was carried out during two conferences on the subject of the brain and education. Respondents gave the greatest number of high ratings of importance to this source of information, however they also appeared to place considerable value on books and in-service training days. While some respondents felt that commercial products and the media were important sources of information about the brain and its role in education, almost as many participants felt that these sources were not useful.

Most respondents had heard of ideas in which the brain has been linked to education. Six categories of response were derived from the data: educational kinesiology, learning styles, ingestion and the brain, emotion and learning, teaching and learning approaches, and cognitive and neuropsychological knowledge. A

further category of 'other' was created to cover responses that did not fall into the six categories listed above. Practical strategies for use in the classroom (including educational kinesiology and teaching and learning approaches) dominated the responses. However, ideas from the academic worlds of cognition and neuroscience were also in evidence here too. Overall, most of the ideas listed were rated as very useful, however opinion was clearly divided in some cases (eg regarding Brain Gym).

Many of the respondents (108 of the 150) reported that either they, or their institutions, had used teaching and learning techniques based on ideas about the brain; 96 respondents had found these techniques to be useful - for improving the affect of learners, increasing the effectiveness of teaching and learning, and providing a greater repertoire of teaching options for educators.

Respondents rated issues relating to communication and relevance to practice and practitioners as very important in bringing neuroscience and education together. They appeared to be less concerned about the issue of ethics in brain research, however.



Interviews with teachers

Eleven semi-structured interviews were carried out with teachers. Four of the teachers were from LA schools in the Bristol and surrounding area and seven were from a range of schools and LAs, but had attended the Education and Brain Research conference in Cambridge, where interviews were carried out.

Interviews were transcribed and then examined for key themes. Three key themes emerged:

a) What teachers know about the brain and how they came to know it.

b) Teachers' views on how brain-based information should be used in education.

c) Issues in bringing together neuroscience and education: pitfalls, problems, barriers and challenges.

These themes are discussed in greater detail below in the context of the responses of participants during the interviews.

(a) What teachers know about the brain and how they came to know it.

A number of the teachers appeared almost embarrassed to admit that they had spent many years as teachers without thinking about the brain at all. For example:

"... it's an awful thing to say, being a teacher, but I think you'd probably find a lot of people in the same boat - I'd never really given the brain much thought, because it's just something that you take for granted."

However, now that they had begun to think about the brain (as a consequence of courses or conferences that they had attended, things that they had read, etc.) they believed that consideration of the workings of the brain was important to education:

"And I've gone from one extreme to the other, from not thinking about it at all to suddenly thinking, oh my God, it's crucial for everything, it's really, really important ... the impact that it might have on our thought processes, and then also our physical actions."

"I think it's incredibly important, because particularly now I find it's affecting my teaching already and particularly my reading groups ..."

Many of the teachers that were interviewed indicated that they knew about some of the educational initiatives described in the analysis of questionnaire responses, such as Brain Gym, thinking skills, learning styles accelerated learning, learning difficulties (such as dyslexia, autistic spectrum disorders and ADHD), multi-sensory learning and water/fish oil. However, other ideas about the role of the brain also emerged. One participant attending the Cambridge conference told us:

"I was told that if you tilted your head it would release a chemical into the brain that prepared it for learning more."

When asked about where participants had obtained information about the role of the brain in education, responses again echoed those made in the questionnaire

study. A number of participants indicated a central role for in-service training or teacher conferences.

"In-service training I've found very beneficial, particularly training that we did in conjunction with the educational psychologist when they ran things for us like Brain Gym and teaching thinking skills, they were really, really good."

"... the rest of the school had an INSET day the other day and they were talking about Brain Gym, which is the latest thing ..."

A number of participants were, or had been, SENCOs, and this seemed to play a role in their ability to attend specific training days:

"... I got to choose my INSETs, so therefore I would choose INSET which would help or would move me just a little bit closer. But I wouldn't have been offered those had I not been a SENCO ... I think it should be more widely available to classroom teachers, I don't think you need to be a SENCO for it to be important really."

In-service training seems to have taken a number of forms. In some cases, interested staff or members of the senior management team have received training on a topic and then made decisions about whether to relay this back to the rest of the school staff:

"... I think it was one of the teachers had gone to a conference or something and they just ... gave the information about [Brain Gym]."

"Bits and bobs from INSET, bits and bobs that other people have been on and they've come back and they've cascaded to other teachers."

"... I think that as a headteacher I should know about all of the different ways ... and then it's up to me to work out how we can share it in the school ..."

In other cases, classroom teachers had attended conferences or forms of training that have brought them into contact with knowledge about the role of the brain in education.

"... as a dyslexia tutor you get a certain amount of training but it's probably not deep enough, and obviously as an individual we try to pursue it a bit more."

Other sources of knowledge about the brain were also mentioned. These included the Internet, TV (for example, the BBC programme *Child of Our Time*), and from books. Professional journals and newspapers such as the *Times Education Supplement* were also mentioned as potential sources of information for teachers. Some interested teachers had read papers in academic journals, but at least one participant made the point that this can be: *"quite challenging, particularly if your previous educational experience has not been scientific."*

One viewpoint that did seem to emerge from the interviews with teachers concerned the ability of the information source to be accessible, inspirational and, above all, able to deal with the practical needs of the teacher's role.

"Where did I get that? I think it may have been from Alistair Smith or somebody like that, who was brilliant. I suppose this is where I got a few of my ideas from, when you go and see someone who puts what they're talking

about into practice, they try it out on you, so instantly it's more memorable anyway - you think, oh yeah, I remember that INSET, he had us standing up and trying to rub our tummy and pat our head at the same time ... you remember it more."

In reference to the Learning Brain Europe conference in Manchester, one participant, who had attended both that conference and the Cambridge conference noted:

"I did feel, though, that [the Learning Brain Europe] conference helped people to leave with practical strategies that they could use tomorrow in their classrooms. This [Education and Brain Research] conference will require teachers to be able to interpret what's been said to them - which is fine for those teachers that are so interested that they will have given up 3 days of their holiday to come to it ... But for the teachers who would rather sit at the back of the training session with their arms folded and say 'I've been teaching for 25 years, what can you tell me about teaching', this format [Cambridge conference] would not be acceptable to them, they would vote with their feet and walk out."

On the subject of what teachers know about the brain and how they know it, it is clear that responses made during the interviews map onto, and extend, those from the questionnaire study. Teachers are aware of a number of brain-related educational issues including teaching and learning approaches and educational kinesiology, plus some knowledge from the academic worlds of psychology and neuroscience. The process by which this information reaches teachers seems to involve interested teachers (including special needs co-ordinators and headteachers) going out from the school to events such as conferences and training days. Ideas that link neuroscience and education seem to have considerable appeal and have been taken back into school by the interested teachers. The process of knowledge dissemination is quite complex, therefore, and a number of factors seem to play a role in whether a school takes on neuroscience and education, and how. One important factor seems to be the extent that the knowledge comes from a source that is memorable and that provides teachers with practical strategies for working with learners. However, it is clear that some educational professionals are keen to make themselves aware of the scientific basis of neuroscience and education initiatives, even though this means that they will be required to engage with conference presentations, journal papers and books, which are perceived as more challenging to consume:

"Because if I read in the TES that there's something going on that I'm interested in, then I'll write it down ... for instance, a few years ago somebody had done some really big research on spelling and I sent off for the book, and that was from reading about some research that had been done and who to get the book from ... I think it was one of the universities ... And I sent off for it."

The issue of how best to disseminate information about neuroscience and education was a strong theme throughout many of the interviews and regardless of how the teachers who took part in this study had obtained knowledge about this topic, many of them had strong views on how the process of dissemination might be

handled in the future. In particular, teachers stressed the importance of accessibility of knowledge. Two key issues emerged in relation to this point: the lack of time available to teachers to find out about scientific initiatives like neuroscience, and the mismatch between the nature of the information disseminated by academics and the existing knowledge and needs of teachers. In relation to the issue of time, one interview participant told us:

"I feel ... inspired to find out the truth really, and not so readily believe what you read in the TES or any other article, where you just blindly believe it and don't actually find out the facts for yourself. But like lots of people have said today, there isn't the time, I barely ever read the TES, let alone any other publication, let alone finding journals in libraries, etc. And I know that seems like an excuse, but teachers, unless they're in the Summer holidays - they don't have the time to pursue things like that - whether they're interested or not, they just don't have the time."

This viewpoint was common in the interview responses. Although many of the interview participants had obtained information about neuroscience and education from academic sources, they were sceptical about how this process would work for all teachers.

"I feel very privileged that I've got the time ... [to read], but when you're teaching you're too tired."

"I'm just trying to be realistic and thinking about lots of teachers that I know within the profession, there are some that are really, really enthusiastic and will go out of their way to take on new ideas and learn about new

things, but then there are a lot more who are simply trying to keep up with things and trying to keep a balance between their home life and their school life, so they don't really have the time, or feel that they have the time, to look into these things in a lot of depth."

Here we see that although INSET had been seen as a good way of providing teachers with knowledge about neuroscience and education, there were also limits to the role that this form of dissemination might play:

"... with [teaching and learning] products, what happens is, oh, right, we've got an INSET day in 3 weeks time ... And then when [the teachers] turn up at the INSET day and the subject is presented to them, that's when they'll maybe start thinking about it and then maybe they'll make links with what they've heard before, or maybe what they've read somewhere but not really taken on board."

"... when you go to in-service training for those sort of conditions [eg ADHD], the real causes and what might be able to be done about those causes are skimmed over, I think, very, very quickly, because usually what teachers are concerned about is how they deal with the outcomes, it's not sort of considered that it's our job to think about why it's actually happening ..."

"... I think INSET days are a really good opportunity ... but they tend to be quite short and there's so many things that the school wants to cover. ... I've always thought that the information they give you is very good, but it's never in-depth enough. And what you're wanting is to be able to read something and digest it and understand it and then have an opportunity to talk about it afterwards."

Many respondents seemed to feel that the language, tone and message of some of the more academic information on neuroscience and education was not helpful to teachers.

"The neuroscientists ... some of them have got a fantastic wealth of knowledge, but it's difficult for them to translate that knowledge into a format that is comprehensible to the teachers and relevant to the teachers."

This viewpoint was common amongst the respondents, some of whom appeared to feel that this was a problem created by the academics themselves, while others put it down to their own ignorance and inability to understand. Indeed, some teachers appeared to discount themselves from being able to deal with neuroscientific knowledge in its academic form.

"I did a few of those conclusions myself listening to [academic researchers'] results, I'd say, oh well, that must mean that I can do this in the classroom, when actually they concluded it in a completely different way because ... I'd misread the result, or misinterpreted it, or overgeneralised it."

"I wouldn't like to know all of [the brain's] ins and outs, because I probably wouldn't understand it, to be honest, knowing my limitations."

Some of those who took part in the interviews acknowledged that there was a big difference in the skills of communication between many academics in the world of neuroscience and the individuals associated with the teaching and learning approaches. There was a sense amongst some teachers that a suggested lack of scientific basis

to some of the teaching and learning approaches lent weight to a view of the individuals that promoted these as 'snake oil sellers'. Despite this, one respondent felt that the more populist disseminators had an advantage over the academics in terms of their ability to communicate effectively with teachers:

"... [the academics are] not seen as communicators always, whereas the snake oil sellers are often gifted communicators, and they're the ones that the teachers take home to come and teach them on their INSET days."

The comments in this section paint an interesting but complex picture of the extent to which the needs of teachers are being met in terms of the dissemination of knowledge about neuroscience and education. Although a significant number of education professionals do seem to have a curiosity about the brain and its role in teaching and learning, it was felt that not all teachers are interested, certainly at this stage, in finding out more about neuroscience and education. Much of the information that does find its way to teachers comes via INSET days, and often concerns teaching and learning approaches, such as Brain Gym, which translate easily into practice. Some teachers, particularly those with a responsibility for pupils with special educational needs, may have encountered information about cognitive and neuroscientific basis of learning problems through training courses, conferences and their own reading. However, most teachers feel that academics are not always well placed to deliver information in a way that is accessible and useful for them. This is despite the fact that a small, but apparently growing, number of teachers are beginning to feel a need to establish a scientific basis for some of the teaching and learning techniques that they have been using.

One possible route for disseminating knowledge about neuroscience and education is through teacher training. This idea was discussed during a number of the interviews. Regardless of whether they had undertaken a BEd or PGCE, respondents reported that they had not received information about the workings of the brain during their training. This is unsurprising, as most respondents had trained at a time when relevant neuroscientific knowledge was unlikely to have been available. More telling perhaps is the lack of psychological input reported by respondents. Although one of the teachers did feel that she had benefited from training in child development, others indicated that they would have liked to have learned more about psychological and neuroscience issues as they relate to teaching. Participants certainly felt that, as knowledge from these domains was now developing well, it should be included into initial teacher training.

"I think that as a start it should be more of an important issue in terms of teacher training, because ... I just find with the education system that you're ... almost like a rat in a wheel once you get into the system, because there's never enough time for anything ... Whereas I think if it's something that is kind of embedded at teacher training level, so when people start on their career at that stage they think, oh yes, this is really, really important and this is

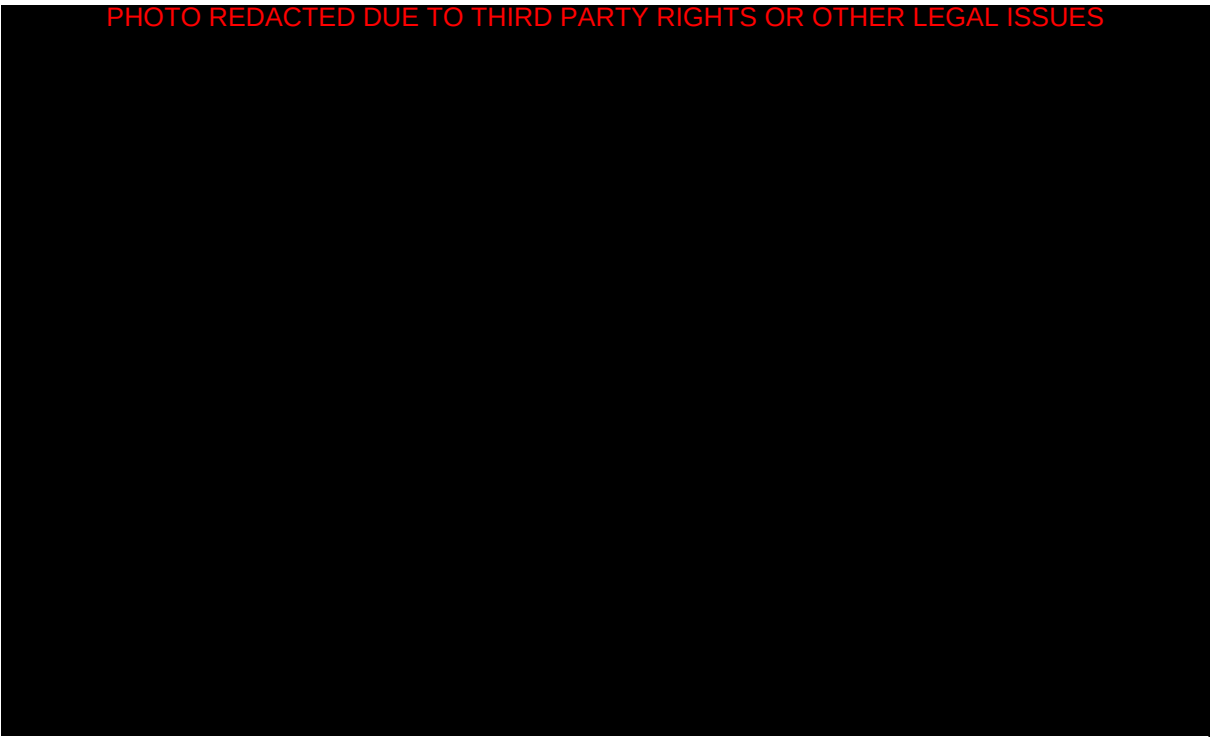
something which needs to have an impact throughout my teaching career, because it's something that's always going to be influential in terms of maybe how children are learning and responding to what I'm doing."

Participants noted that teachers already in post might benefit from input on neuroscience and education through Continuing Professional Development, although as we have seen, if this takes the form of INSET days, there are issues regarding the effectiveness of the dissemination process that may require further attention.

(b) How might knowledge from neuroscience be used in education?

An important issue in the bringing together of neuroscience and education concerns teachers' views on how best to use the growing body of knowledge that is developing from academic research in neuroscience and related disciplines. A number of themes emerged from the discussions with teachers. The first made a link between neuroscientific knowledge and special educational needs. However, it was clear than some teachers felt very strongly that neuroscience should be in a position to inform the teaching of all learners, not just those with purported neurological differences. A further theme was that of the development of a broad-based understanding of human learning processes, which might then enable teachers to work confidently and flexibly to meet the varying needs of learners. These ideas are examined in more detail below.

In discussing the role of neuroscientific knowledge in the education of children with special educational needs, one teacher commented:



"I think what I would really like to find out is how you can take the information that you've got about problems within the brain and turn that into practical ways of overcoming those problems."

Interestingly, the emphasis here is on the translation of knowledge into practice:

"Because at the moment I feel that I am sort of beginning to get an understanding of why things for some children are not going right, but having that knowledge doesn't make me know what to do to help them in practical terms. So it's kind of linking the knowledge about specific difficulties with specific ways of teaching to overcome those difficulties."

The same participant also points out:

"If you go into schools and say, right, we've identified that this is happening within the brain and it affects children in this way, we now know why children are having problems with, say, literacy or numeracy, because such and such is occurring in the brain, we've scientifically proved that it's happening in all of them ... I don't think that that's enough for teachers, because what they're looking for you to say is ... what do we have to do to make sure we can help children, that we can help the children to overcome that problem?"

Thus, from this respondent (and others) comes the view that it is not the role of the teacher to carry out the translation of knowledge from academic research in neuroscience into specific teaching strategies. This process needs to have occurred before teachers become involved. However, another perspective stresses the collaborative nature of the development of educational practice from neuroscientific knowledge:

"... what I think teachers benefit from most in terms of training and new initiatives is being given the time and money to be able to go off for a day or whatever to talk to other professionals, not just teachers but also neuroscientists, any other scientists, anyone else who's got anything relevant to say, and actually talk about the evidence that there is to support these new things, so that teachers can make their own mind up about how they fit into the classroom."

"... before [researchers] go about applying information, I think [they] should visit [schools] and see what it's like in order to be able to do that, because otherwise [their] suggestions just might not be suitable at all."

Regardless of the specifics by which the process occurs, other teachers have voiced their enthusiasm for the role that knowledge from neuroscience appears to play in teaching individuals with special educational needs:

"… we've got a programme that works for children who have reading difficulties … And I think that that's directly coming from studies on neuroscience that have looked at working memory and the workings of the brain and the impact of language and so on … I think that's been really useful."

"It helps me. And I think it would also help particularly support assistants in school, who tend to be the people who generally work with these children. If you can say so and so does this … because … and he has to do it this way because of that, then it would actually help them."

Knowledge from neuroscience appears to be viewed as a potential explanatory force for the difficulties experienced by individuals with special needs. This view is illustrated by the following comment:

"I think knowledge of why children have problems learning what they do is powerful both for the teachers and for the pupils and their parents, because it takes some of the pressure off … it takes away a lot of the … emotional overtones of finding it difficult to learn to read, or not being good at maths, or whatever else it is."

Neuroscience knowledge was felt to be relevant to mainstream education too.

"I'd like to see it focussing on what typical learners do and how they learn, because there's a lot of children in our schools that aren't learning as effectively as they could be doing and I think that it's important to focus on them as well as the special needs kids … And I think that teachers will be very interested in what they can do for the majority of children."

"… if you understand more of the workings of the brain – if that informs teaching then that informs all teaching."

In many ways this view relates to the third theme that emerged from the data, the idea that knowledge about the brain might provide teachers with a greater understanding of the needs of all learners, and, therefore, be able to deliver their teaching in a more flexible and confident way. When asked how knowledge about the brain would be used, one participant replied:

"To inform my teaching and to have a better understanding of the individuals that I'm working with."

In response to the same question, another participant said:

"Just to support things in the classroom, just to have a knowledge. It's lovely actually … it feels better if I've got a background that I can … and I've used the background of child development, and the background of the brain might actually just be strength really. And I think that would impact on other things that I decide to do."

Yet another participant indicated a view that knowledge from neuroscience could be incorporated into educational practice in a very broad but pervasive way:

"I think it's probably in the context of what teaching actually is – the sort of 'meta-view' of it, because at the moment in secondary schools, teachers are very much subject-based and now with the development of neuroscience you have to see teachers more as educators … so they actually understand the stages that children learn at, how they learn more …"

Interestingly, some teachers expressed opinions that link all three of the themes that have been discussed here, namely the potential role for neuroscience to inform *inclusive* education.

"… if those activities can be activities that will be good for dyslexia, Aspergers, etc. … as well as the normal learners then you're talking about quality education or inclusive education … It's all about inclusion …"

When asked whether teachers would view what goes on in the brain as important as the other factors affecting a child's learning, one participant answered:

"I think that they'd consider it amongst everything else, probably as equally important. Particularly now, because if you have an inclusive setting and you've got lots of people with differences and difficulties …"

Thus, one factor that may have a bearing on teachers' desire to learn more about then brain may be the increasingly inclusive approach to education in British schools. If teachers are faced with a more diverse population of learners, knowledge from neuroscience may provide one way to understand this population better and make appropriate provision for their needs.

The teachers that took part in this interview study have clearly articulated an enthusiasm for knowledge from neuroscience to be applied to educational settings. This does not, however, mean that this group of teachers does not recognise that some serious issues must be recognised, and dealt with, for this initiative to be successful. Some of these issues are discussed in the following section.

(c) Issues in bringing together neuroscience and education: pitfalls, problems, barriers and challenges.

Issues arising from the application of neuroscience and education that were rated as very important by participants in the questionnaire study included the need for a genuine dialogue between brain researchers and education practitioners, relevance to what actually goes on in the classroom and ease of accessibility to educators. The teachers who took part in the interviews echoed these views.

On the subject of communication between teachers and neuroscience researchers, one participant said:

"I think it would be a great shame not to have that communication. But how you do it to suit both parties I think would need a lot of consideration, because … as interesting as the information is, for a teacher you have to have some practical implication and it has to be deliverable and manageable … and I think previously that's what's caused difficulties … people don't suggest how you might go about it. And I think that it's important to think about that."

The issue of language was raised by another teacher, who said:

"The other thing that I sort of noticed is that there's two different sorts of language. In terms of how things are presented there's a different language that labels things … teachers will say one thing and the researchers will say something else."

This participant went on to suggest that there was a need for a *"common ground of what things are called or guide notes so that people know what it is that they are talking about."*

The match between the outcomes of research and the needs of teachers was raised by yet another participant, who said: *"I think one of the things that I am looking for when I am reading lots of these journal*

articles and things when they're talking about their findings and they're talking about implications, they don't seem to match what goes on in a classroom and how you would be able to deliver it to the majority."

An additional issue for the link between research and practice concerns the nature of the research process, and the disagreement that often exists between different researchers in the same field. *"I think that possibly one of the biggest hurdles, though, is where there isn't a consensus amongst researchers. How do you present your findings? Because whatever one group says, somebody else says something different."*

At least two suggestions were made during the interviews regarding approaches to dealing with some of the problems of bringing practitioners and researchers from two very different domains together to provide fruitful outcomes. One suggestion concerned getting teachers more involved in the research process: *"… I think there's much more of perhaps opportunity for getting interested teachers to conduct full-scale research…some teachers would be very interested and would have the background where they could actually do it … Just trying things out, or saying this is what we see from the MRI scanning, this is what the effects you might see as a result of it are."*

Another suggestion involved the development of co-ordinators – professionals who are able to act as a bridge between the two disciplines. Within schools it was suggested that, rather than requiring individual teachers to develop a knowledgebase around neuroscience and assess the usefulness of initiatives based on neuroscientific knowledge, there might be a need for a co-ordinator – *"… somebody within the school who is perhaps given responsibility for keeping updated on all sorts of recent developments …"* or *"some experts to bridge the gap … people that understand the educational terms and the scientific/technical terms to be able to see how it sort of translates from one to the other to make it useful … you need someone to be really picking holes in things and really getting the essence of what that experiment has or hasn't found out and then how that translates into layman's terms or teacher's terms to help in the classroom."*

Participants in the questionnaire study were overwhelmingly positive about the benefits of many of the teaching and learning initiatives used in their institutions that were based on ideas about the brain. This enthusiasm is reflected in the discussions with interview participants; however, some of the teachers that spoke to us had begun to question the scientific validity of some of these initiatives. A contributing factor to this process of re-evaluation was undoubtedly the information that was presented by some of the speakers at the Education and Brain Research conference (where some of the interviews were carried out), which indicated a lack of scientific support for the effectiveness of educational programmes such as Brain Gym. When faced with this conflict between what can be supported scientifically and what is seen to be an effective teaching tool in the classroom, some interesting points were made by the interview participants. At last one participant communicated a sense of embarrassment and betrayal on hearing

that the methods that she had been using in school had been properly scientifically scrutinised before they were promoted to teachers:

"It almost sounds silly now I say it, but I was so convinced by it … So I guess it's a bit disappointing when you find out that something actually isn't … how you were led to believe it was …"

This participant went on to say: *"There isn't one person here [at the Education and Brain Research conference], I'm sure, one teacher, who doesn't know about visual learning, auditory learning, Brain Gym, and it's because … I guess it's something easy to understand and I don't mean that in a patronising way, it's something that you can grasp onto, it's something that you know what you can do about it … And I guess that that's sort of got watered down more and more, people don't need to see the evidence that it works any more, they're just told it so they believe it because they haven't got time to go and investigate it for themselves."*

The above participant went on to describe teachers as being *"a bit vulnerable to somebody in the know telling us that works"*, however, not all teachers were as unsettled by the suggested lack of scientific basis for the initiatives that they had been using. In

fact some teachers, a minority of less than a quarter according to the survey, did not seem to feel that a lack of scientific support was necessarily relevant to the success of a teaching tool in the classroom. When asked whether a participant needed a scientific underpinning in order to use a teaching technique, the response given was: *"No, because if it works it means that we're quite happy to do it. We've been doing it for years without scientific underpinning … What the scientific underpinning does tell you is why it's working, why it works; as opposed to we know it works."*

"I suppose scientifically if they can say that it doesn't [work] then it doesn't, but it's not going to stop people doing it if it actually works with kids and they can see benefits."

Thus, one of the challenges for those seeking to bring neuroscience and education together is the need to develop an understanding of the criteria used by the different professional groups when assessing effectiveness. A related issue, and one which links to the views expressed by the participant who felt rather let down by the suggested lack of scientific support for some brain-based educational techniques, is how information about effectiveness can best be made available to educators. A suggestion made during the discussions at the first ESRC-TLRP Neuroscience and Education Seminar (Group 3) concerned the development of a database of educational initiatives, similar to that developed in medicine, providing information about research carried out with the different initiatives. Another approach to the challenge of helping teachers to be able to make informed decisions about educational initiatives is based upon the provision of training in critical skills for the teachers. A number of teachers in the interview study felt that these might be good ideas: *"because I just think … it would give you more autonomy then. Because I think it's a great shame that there's so many initiatives and ideas and opportunities to experiment and try things out, but … if you have more experiments that are not successful or don't think are having an impact, then it become very tiresome. And you really want to cut that out because it can also create inconsistencies, which then affect the students … I think it can also perhaps even create a feeling that you lose trust if someone keeps telling you to do lots of different things without any validity to it. And instead of making people cynical, I think it would be more beneficial if you could make them critical."*

One additional issue that was discussed briefly during some of the interviews was the potential for neuroscientific knowledge to bring with it some risks as well as opportunities. Such knowledge might, for example, lend itself to the development of a highly biologically deterministic approach to learners and learning. A number of participants felt that this might be one of the risks of encouraging a neuroscientific perspective on education*: "I think that there would be a danger that you pigeon-hole people, and if you class people purely on biological definitions then there perhaps would be a danger that you give them a kind of finite ability … it's like, oh, they've got this and therefore can only do it this way and they can only learn so much …".* A related issue concerns teachers' views on the relationship

between medical and educational concerns, as embodied by learning problems such as ADHD. Here, rightly or wrongly, teachers may find some comfort in the idea that children with this condition cannot help how they behave. Such perspectives may benefit from the use of neuroscientific knowledge for support. On a more positive note, however, a number of teachers appear to be interested in the concept of neural plasticity, an idea that may help to challenge views of fixed learning abilities for all people.

Summary of the findings from the interviews with teachers

There remain a number of questions to be answered regarding the best way to deliver additional knowledge and skills concerning neuroscience and education to teachers, if indeed teachers are interested in developing such skills. It seems clear from the responses of questionnaire and interview participants that, while they have expressed an interest in neuroscience and education, not all teachers will share this enthusiasm and interest. An additional challenge to the development of this multidisciplinary domain is the limited time that teachers have available to interact with this developing area. Given the existing pressures on teachers' time, ease of accessibility of information seems to be crucial, but can this be achieved without sacrificing some of the integrity of the neuroscience research? There certainly seems to be a desire to establish a form of dissemination that is 'teacher-friendly' in structure, tone and purpose. What form this might take has yet to be established, although INSET days appear to be a possible candidate, along with professional teaching journals. Many participants have suggested that information about the role of the brain in education may be best delivered during initial teacher training, in order to prepare teachers to be able to deliver education using a range of approaches as needed.

Discussions from the ESRC-TLRP Collaborative Frameworks for Neuroscience and Education seminars

An important component of the ESRC-TLRP Collaborative Frameworks for Neuroscience and Education seminar series was the opportunity to assemble professionals from a number of relevant disciplines to discuss how the domains of neuroscience and education might work together. Four discussion groups were formed in each of the first and third seminars in the series. In each case the groups were made up of representatives from a number of different disciplines including: neuroscience, psychology (research and practice), education research, teaching, teacher education, and others.

Discussion was informed by a series of presentations that had occurred during the morning of the seminar. In addition to this, participants in the discussion were asked to consider a specific question for each of the two seminars. In the first seminar this question was: "What sort

of evidence should inspire educational change?" and in the third seminar: "By what routes should neuroscience enter our classrooms?". Discussions were audiotaped and transcribed as part of the work of the seminar series. Summaries of the discussions are located at the seminar website (http://www.bris.ac.uk/education/research/sites/brain/).

A number of interesting themes emerged from a review of the discussions, most of which echo the ideas that emanated from both the questionnaire and interview studies described above. For example, many of the discussion groups identified the significant interest that teachers appear to have in the brain, but also commented that this is often manifested in the adoption of teaching and learning approaches that *seem* to be based on the brain, but actually have no neuroscientific research to support them. The view that teachers are, for a number of reasons, particularly vulnerable to the ideas put forward by charismatic figures selling various 'brain-based' teaching strategies was also voiced by a number of the discussants. However, a number of the participants raised the issue that some of these strategies have been found to be useful in the classroom. Can neuroscience provide information that can be usefully applied in a classroom setting?

The voice of neuroscientists was evident in discussions where they were able to provide a sense of the relatively early stage of development of their discipline. It was suggested that the available technology places limits on what can be investigated. Although technology is changing all the time, techniques such as MRI may not be able to provide the kind of data that makes a great deal of sense in relation to the world of the classroom. Other techniques such as MEG and EEG may have more promise for this, however. A number of the discussants also pointed out that the tasks that can be investigated using neuroscience techniques are often very simple, and do not necessarily reflect the complexity of what a child experiences in the classroom.

However, a number of the contributors to the discussions did have positive experiences of knowledge from neuroscience being related to education, and there was a general view throughout discussions that this was an endeavour worth pursuing (especially as many schools seem to have embraced the idea anyway).

Some of the groups discussed the problems associated with bringing two very different disciplines together and noted the differences in language, perspective and need found in neuroscience and education. A suggestion was made that a hybrid professional might be developed — someone who was able to work comfortably with both disciplines and to act as a bridge between them. Ideas such as these were also found in the interviews with teachers described above. Issues concerning the training of teachers were also discussed. Overall, many of the participants in the discussions felt that there was scope for both professional groups to develop an understanding of each other's worlds, for the sake of the development of an interdisciplinary perspective on how best to deliver education to all.

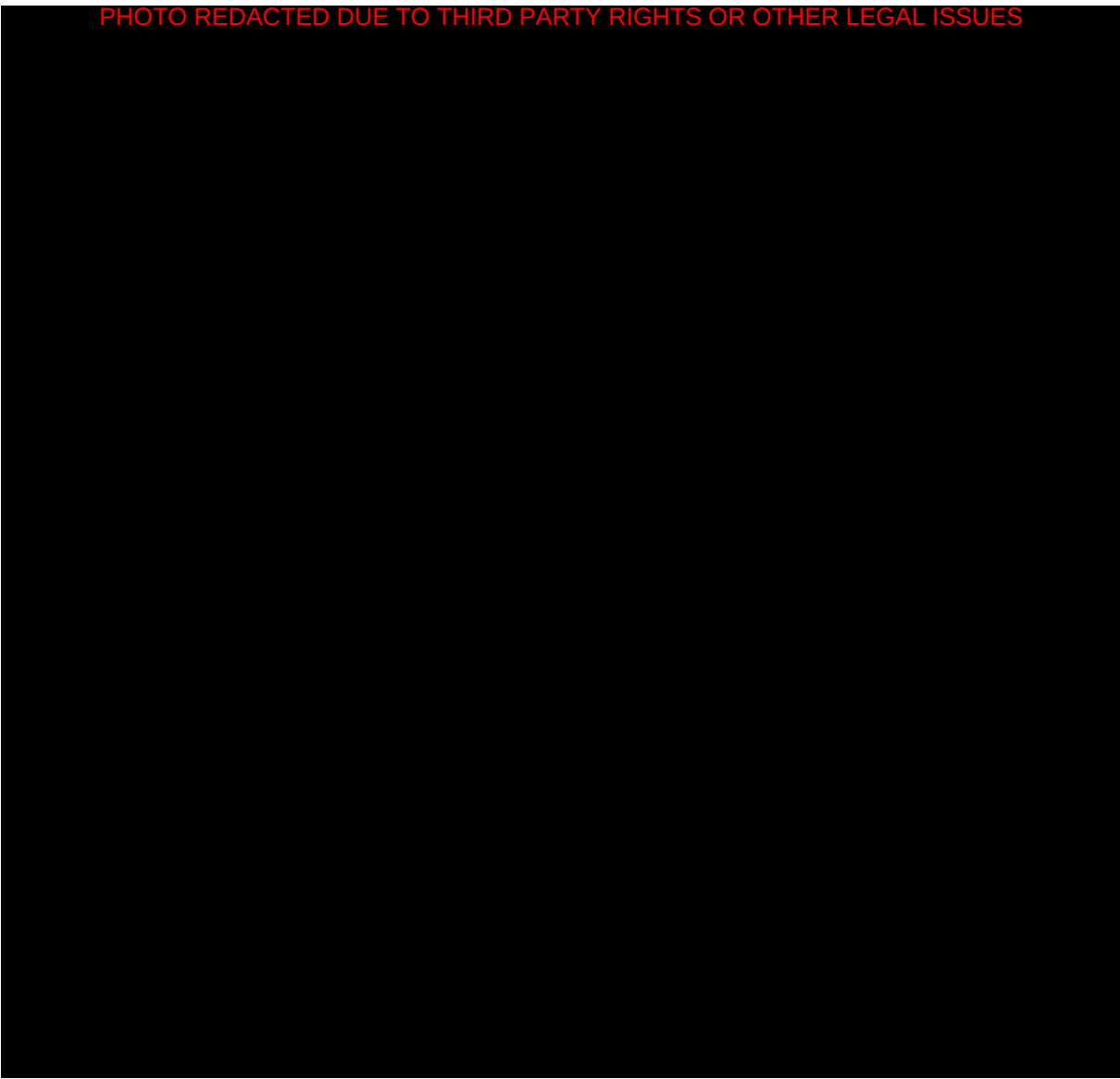
4. Conclusions

In summary:

- There is generally a positive interest, across the educational community, in applying insights from neuroscience to education.
- Educators consider both the evaluation of classroom impact *and* the verification of any proposed scientific basis as important in such ventures.
- Perceptions of applying neuroscience in education have been partly influenced by so-called 'brain-based' learning programmes whose science is now seriously contested. While many teachers feel they have observed improved learning outcomes from these programmes, the teachers we interviewed would appreciate greater access to evaluative evidence that scrutinises their scientific basis and their effectiveness.
- Irrespective of debates about current brain-based learning programmes, those working in education are supportive of future collaboration between neuroscience and education, but emphasise the need for improved communication and a two-way dialogue that is grounded in the practical needs of educators.

5. Further Consultation

With help from the OECD, the same survey was carried out online from the OECD Brain and Learning website. 48 responses were received between September 2005 and June 2006 from around the world (US = 19, UK = 8, Australia = 3, Germany = 3, Netherlands = 2, and one response each from Sweden, Spain, Mexico, Canada, China, Sudan, Ukraine, Malaysia, Greece, Poland, Singapore, Saudi Arabia and Italy. Analysis of the data revealed no notable differences from the UK survey results, suggesting the trends reported above may be reflected globally.



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The Innovation Unit is one of the country's leading organisations for innovation in education. We act as a catalyst for change, drawing on talent from both the public and private sectors, to improve education and other related services. We have extensive experience in school leadership, education system reform, policy making, universities, the BBC, local authorities and the private sector. We also draw on a network of thought leaders from the UK and around the world. Our goal is to improve education by combining the expertise of people who work in schools with the ambition of policy makers.

We have a range of projects in our portfolio, the largest of which is our Next Practice Education Programme, in which we support schools and local authorities as they take forward their own cutting-edge ideas to improve education. Next Practice is disciplined innovation — a new approach to stimulating, incubating, and accelerating innovation, which is strongly driven by users' needs. The current programme covers system leadership, resourcing personalisation, communities for learning, and parents and carers.

We also support the web-based Research Informed Practice Site (TRIPS) and the National Teacher Research Panel (NTRP), as well as promoting teacher discussion about research in the online Innovation Community. The Innovation Unit is also working with partners on a project for the Cabinet Office looking at Innovation in the Third Sector.

www.innovation-unit.co.uk

Neuroscience and Education Network, University of Bristol

The report is authored by members of the Neuroscience and Education Network (NEnet), an interdisciplinary group of researchers based at the Graduate School of Education, University of Bristol. Researchers within NEnet seek to answer questions involving the interrelation of concepts about the brain, mind and education. Research projects include consultation, practitioner-based studies and experimental neuroimaging projects.

www.bris.ac.uk/education/research/networks/nenet

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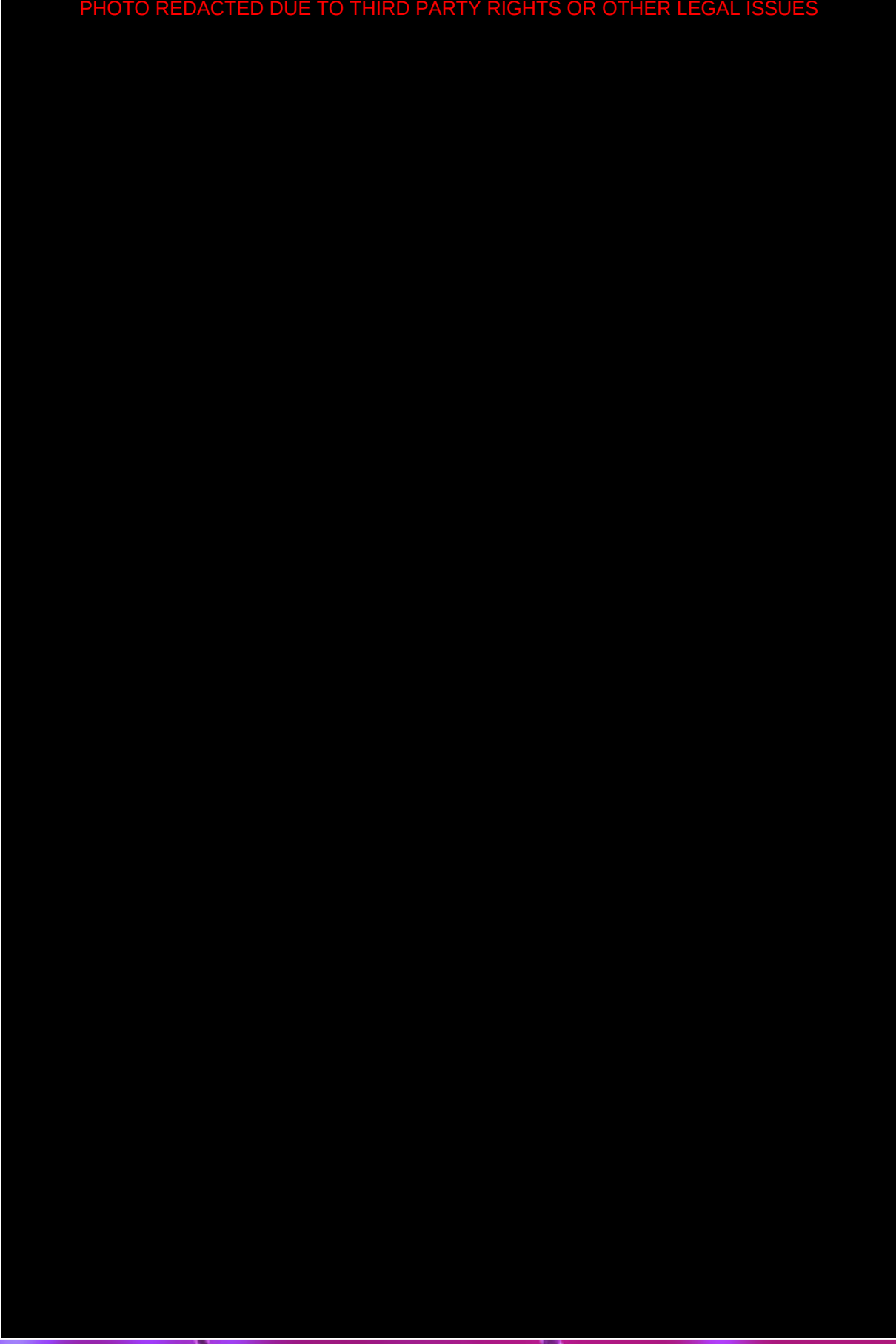
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