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The impact of a modified initial teacher education on challenging trainees' understanding of neuromyths

Abstract

Initial Teacher Education (ITE) offers an underutilised opportunity for bridging the gap between neuroscience research and educational practice. This article reports on innovations embedded within an ITE programme to support trainee teachers to recognise and challenge the persistence of neuromyths. Education researchers, neuroscientists and psychologists collaboratively applied design-based research to create, improve and reflect on original neuroeducational teaching/learning resources for university-based primary (elementary) ITE trainees. Encouragingly, pre and post surveys showed reductions in trainees' beliefs in neuromyths and a shift to responses showing uncertainty that suggested their beliefs became unsettled. The most persistent neuromyths were those regarding fish oils, left brain/right brain and learning styles/VAK. Trainees retained their initial interest in knowledge about the brain and education, gained confidence and became more critical about applying the Learning Sciences in educational contexts.

key words: neuromyth, initial teacher education, design-based research intervention

Introduction

The potential for educational neuroscience is being actively explored across the globe (Thomas, Ansari & Knowland, 2018). Over the past decade, there have been increasing calls for greater integration and collaboration between cognitive psychology, neuroscience and teaching, but also a recognition that this is problematic and that deliberate bridging is required (Goswami, 2006; Royal Society, 2011; Howard-Jones, 2014; Horarth & Donoghue, 2016; Sigman, Peña, Goldin, & Ribeiro, 2014). This study addresses how teachers are prepared to engage with scientific accounts of learning during their Initial Teacher Education (ITE) by recognising and challenging misconceptions about the brain and learning, known as 'neuromyths' (OECD, 2002), that are prevalent among trainee teachers (Howard-Jones, Franey, Mashmoushi, & Liao, 2009, Grospietsch & Mayer, 2019; Pasquinelli, 2012; Tardif, Doudin & Meylan, 2015; Papadatou-Pastou, Haliou & Vlachos 2017; MacDonald, Germaine, Anderson, Christodoulou & McGrath, 2017).

To date, little headway has been made in creating and evaluating practical tools for ITE that support trainee teachers in recognising and challenging neuromyths and evaluating recommendations for practice arising from the learning sciences. This article reports on the impact of a project in which resource materials were developed to engage primary trainee teachers in the learning sciences as relevant for their future work as professionals and to prepare them to critically evaluate the claims and packages they may encounter in their future careers.

We argue that educational problems should be identified and addressed from the different perspectives of relevant, rigorous disciplines; scientific approaches should be taken together with educational concerns with the aims of learning and social complexity. Thus we locate this design-based research (DBR) within the learning sciences as defined by the International Society of Learning Sciences (ISLS); '...interdisciplinary empirical investigation of learning as it exists in real-world settings and to how learning may be facilitated…' (https://www.iNewton and Msls.org/). A multidisciplinary team of neuroscientists, psychologists, education researchers and teacher educators collaborated to design and trial materials, integrating their perspectives through making decisions about the development of a robust product for ITE. (McMahon & Etchells, 2018). Specifically, we investigated 1) the neuromyths held by the trainees and the impact of the intervention on this, 2) whether trainees' prior experiences of brain-based training affected their responses and 3) the impact of the intervention on trainees' interest in, perceived value of and confidence in applying knowledge of the brain to education. The project is located in England where the government has recently introduced a new Education Inspection framework that is explicitly informed by the ‘learning sciences’ (Ofsted, 2019; 15), which gives the project particular current relevance.

Teachers’ beliefs in neuromyths

There is a growing body of literature documenting the neuromyths found commonly and widely among in-service teachers with studies in the UK and Netherlands (Dekker, Lee, Howard-Jones & Jolles, 2012), East China (Pei, Howard-Jones, Zhang, Liu, & Jin, 2015), Greece (Deligiannidi & Howard-Jones, 2015), Turkey (Karakus, Howard-Jones & Jay, 2015), Latin America (Gleichgerrcht, Luttges, Salvarezza & Campos, 2015; Spain (Ferrero, Garairzar & Vadillo, 2016, Canada (Sarrassin, Riopel, & Masson, 2019), Switzerland (Tardif, Doudin, & Meylan, 2015), the USA (MacDonald et al., 2017) and South Korea (Im, Cho, Dubinsky & Varma, 2018). The most prevalent neuromyths have been remarkably consistent across countries, with widespread beliefs that teaching should be tailored according to a pupil’s learning style and that cerebral hemispheric dominance explains differences between learners. These neuromyths may be grounded in partial knowledge of the brain as having regionalised functions, without a deeper understanding of the interconnected nature of the brain, especially in higher cognitive functions (e.g. Tardif et al., 2015). Other myths, such as whether fatty acid supplements (omega-3 and omega-6) have a positive effect on academic achievement, may be sustained through claims in the media (Goldacre, 2009). The prevalence of some myths varies between countries, e.g. Dekker et al. (2012) found that the statement that ‘Environments that are rich in stimulus improve the brains of pre-school children’ was incorrectly seen as true by 95% of UK teachers surveyed, but only by 56% of surveyed teachers in the Netherlands. Researchers have recently sought to explore the hypothesis that gaining more knowledge of the brain would reduce beliefs in neuromyths.

Although there is some evidence that those with significantly more expert knowledge of the brain are less likely to believe in neuromyths (MacDonald et al. 2017; Howard-Jones et al.

2009), this is not a consistent finding. In their study of in-service teachers Dekker et al. (2012) found that an interest in the brain made belief in neuromyths more likely, possibly due to the increased likelihood of encountering more dubious claims. Dekker et al. (2012) proposed that incorporating neuroscience courses in to ITE could enhance neuroscience literacy and recommended that training should include the skills needed to evaluate research. These recommendations can be considered in the light of Weisberg, Keil, Goodstein, Rawson, and Gray's (2008) findings that participants who had undertaken introductory cognitive neuroscience classes were still as 'seduced' by superfluous neuroscientific explanations as the general population. It was only participants with significant expertise, such as a degree in cognitive neuroscience or related areas, who could identify where explanations were supported by false or irrelevant neuroscience. Im, Varma, and Varma (2017) specifically examined the seductive allure of neuroscience effect in relation to educational topics with participants from the general public (not teachers) and found that the addition of extraneous neuroscience text together with brain images led to participants finding explanations more convincing. Interestingly, a comparison between South Korean preservice elementary teachers taking an educational psychology course and a control group found that the course improved general neuroscience literacy but did not reduce belief in neuromyths (Im et al., 2018). Similarly, in Germany, Grospietsch & Mayer (2019) found that Biology trainee teachers held neuromyths in parallel with their neuroscientific understanding and suggest that sociocultural factors support neuromyths. However, in-service teacher professional development that focused on the neurobiology of learning, particularly exploring the concept of plasticity, was shown to increase teachers' neuroscience knowledge and to impact positively on classroom pedagogy (Dubinsky, Roehrig & Varma, 2013).

Rationale for the focus on Initial Teacher Education

ITE makes an important contribution to the values, beliefs and ideas that teachers carry with them through their careers (e.g. Brouwer & Korthagen, 2005). However, it is a relatively short period of time in a teacher's professional learning, and as such there is little systematic consideration of recent developments in the learning sciences, or how this may inform the future practice of trainee teachers. Recent research focused on trainee teachers has found similar patterns of interest in neuroscience, and belief in neuromyths to those seen among in-service teachers (Dündar & Gündüz, 2016; Grospietsch & Mayer, 2019; Papadatou-Pastou et al. 2017). As a result, targeting primary trainee teachers may provide a long-term, developmental solution to improving the way in which neuroscientific research may inform educational practice, by equipping teachers from the very outset with the ability to critically analyse claims from both robust and questionable research.

Although teachers are very interested in how cognitive psychology and neuroscience could inform education (Goswami, 2006), they are receiving ideas and information from other teachers and schools rather than through academic routes (Simmonds, 2014). Along with calls for more evidence informed approaches to teaching (Slavin 2002; Goldacre, 2013) there have been suggestions that, as professionals, teachers should know more about research processes in order to become critical consumers of recommendations for practice based on research findings (BERA-RSA, 2014; Childs & Menter, 2018; la Velle & Kendall, 2019). By providing research-based materials from neuroscience and psychology, in this project we extended the knowledge and understanding of learning with which ITE trainees engaged.

The intervention

The research team worked in collaboration with ITE tutors and trainee teachers, developing the design principles and evaluating the intervention (Anderson & Shattuck, 2012). A current feature of ITE in England is the limited time spent on postgraduate university-based training (typically 45 days compared with school-placements totalling 120 days), significantly constraining the time available for any intervention. The key element of the intervention, therefore, was a 90 minute workshop. The students took part in an informal reproduction of the experiment developed by Weisberg et al. (2008) that demonstrated the seductive allure of neuroscience. This was followed by a 10-minute overview of the anatomy of key brain areas and linked functions but with an emphasis on connections between the two brain hemispheres through the corpus callosum and how brain areas are networked. Problematic myths and associated approaches, such as visual, auditory or kinaesthetic (VAK) learning styles, Brain Gym©, and left brain/right brain learning styles were then challenged. Aside from the workshop, trainees were also provided with: a 10-minute science literacy session critiquing claims that fish oils improve academic achievement embedded in a science workshop and a brief overview of neuroplasticity in a lecture on educational theories of learning.

Methods

Participants and ethics

A total of 340 trainee teachers were invited to participate and were given information about the project, with 298 initially completing the pre-training survey in early September at the start of the nine month course. As this was administered during a tutor-led session the freedom not to participate was emphasized to avoid any feelings of coercion. The intervention took place two or three weeks after this. The post- training survey was administered the following April, approximately 8 months after the intervention. A total of 154 participants completed the survey both before and after the intervention. Adverse weather conditions had meant that the post-training survey had to be rescheduled to a point in the year when the trainees had high assessment burdens and low attendance, which led to a lower response rate. Of these, 24 participants did not provide a full set of data, and thus were excluded from further analysis, leaving a final total of 130 participants (Female=102, Mean age = 25.39 years old, SD = 5.93). Respondents were distributed across all teaching groups. The study was approved by the local ethics committee.

Design

The surveys contained both Likert-type scale questions for quantitative analysis and open-ended questions for qualitative analysis. The overall project takes a Design-Based Research (DBR) approach. DBR aims to develop both theory and practice though the development of an intervention (Anderson & Shattuck, 2012) with iterative phases of design, enactment, analysis and redesign, typically using mixed methods (Cobb, Confrey, diSessa, Lehrer & Schauble, 2003; Zheng, 2015). The pre-training survey therefore had the dual purpose of informing the development of the teaching and learning intervention as well as providing baseline data on trainees' views on neuromyths. The post-training survey contained additional questions to probe the key messages about the brain and learning that trainees encountered during their university and school placement experiences. Trainee and tutor responses to the teaching were also gathered and adjustments made; this micro-level of analysis will be reported elsewhere. This article reports on the macro-level analysis of the first cycle of an on-going DBR process.

Materials

The survey was based on that of Dekker et al. (2012) and was modified for this study. Information about the participants' sex, age, undergraduate degree subject, and teaching group was gathered. Participants were asked whether they had encountered 'brain-based' educational approaches such as Brain Gym©, VAK learning styles, multiple intelligences, or left brain/right brain learning. Next, participants were asked about their interest in, and opinion of the value of knowledge about the brain in terms of their future teaching. They were also asked about their confidence in reading scientific knowledge.

The original survey consisted of a mixture of 32 items containing statements about general brain knowledge as well as statements about neuromyths, with participants responding using a 3-point scale (agree/disagree/do not know). In the present study, this was modified so that 31 items were used on a 7 point scale ranging from 1 (definitely false) to 7 (definitely true). This was in order to probe the extent to which trainees had confidence in their own ideas and to allow for a finer-grained distinction in strength of belief. One item referring to circadian rhythms in adolescence was removed, as primary school trainees might perceive it as irrelevant to them. Finally, in the pre-survey open questions asked what aspects of the brain and learning about which trainees would like to know more. In the post-survey, trainees were also asked what ideas about brain and learning they had gained from university and encountered on school placement. An example of the full survey presented to participants can be found in the Supporting Information (S1).

Analysis

Statistical analysis using SPSS was conducted to analyse the quantitative data in the following three steps, whilst qualitative thematic analysis to the written responses using NVivo (Version 11) was also conducted to support and illuminate the quantitative statistical results. Firstly, in order to explore the main effect of the teacher training on primary trainee teachers' certainty about prevalent neuromyths, descriptive statistics were used to identify 1) the differences of both general knowledge of the brain and neuromyths between pre-and post-training responses; and 2) the most prevalent neuromyths. In addition, a within-subject t-test was used to compare the difference in the percentage of uncertain responses between the pre and post survey. Thematic analysis was also applied to explore the key themes of improved understanding of the brain and neuromyths developed during the trainee teachers' teacher training experiences. Next, to explore the role of prior experiences of neuromyths on the effect of the teacher training, participants were split into two groups based on their prior experience of neuromyths (some vs. none) for further analysis using a mixed model ANOVA. Finally, the effect of the teacher training on the trainee teachers' interest in brain knowledge, its perceived value to their practice and their confidence in scientific knowledge was also explored using paired t-tests. Using thematic analysis, the written responses to the survey were coded based on: attention to the research foci of neuromyths; knowledge about the brain and becoming a critical consumer of brain-based claims; and the degree of openness to other trainee ideas. For each survey question codes were grouped and emergent themes were identified. An example of the full survey presented to participants can be found in the Supporting Information (S1). Anonymised raw data are available at the Open Science Framework (DOI 10.17605/OSF.IO/89ESR).

Results

Impact of the intervention on primary trainee teacher certainty of prevalent neuromyths

Descriptive statistics showing differences in pre- and post-training responses to the survey items on both general knowledge of the brain and neuromyths are shown in Table 1. They suggest that overall there was no impact on general knowledge of the brain and a slight reduction in belief in neuromyths.

Table 2 shows data on the most prevalent neuromyths reported in the pre-training survey, alongside data for the same neuromyths post-training. It shows that trainees' beliefs in the seven neuromyths were slightly reduced after the intervention.

In the case of the fatty acids myth (survey item 5), the reduction in responses at the 'true' end of the scale corresponded with more responses at the 'definitely false' end of the scale.

However, for the two items concerning the left brain/right brain myth, the pattern was of a shift in the direction of the correct response, but there were more ‘don’t know’ responses as well as more ‘definitely false’ responses. Similarly, the improvement in responses to the learning styles/VAK myth was composed partly of more correct responses and partly of more ‘don’t know’ responses. Overall there was a significant increase in the percentage of uncertain responses between the pre and post survey (Pre M=22.3% to post M=24.9%, t[129] = -2.08, p = 0.04, d = -0.18).

In the qualitative responses to the survey 24 of the 61 responses to the post-training survey question ‘What was the main message about the brain that you gained from your university-based teacher training?’ related to improved understanding of the brain and neuromyths. There were two predominant themes: understanding of neuroplasticity and awareness of neuromyths, for example:

> “The brain is a huge network of connections that is continually developing and changing to accommodate new information and retain existing knowledge.” and
>
> “Debunking common myths about the brain and learning”.

However, two responses illustrated how neuromyths were held by some trainees at the end of the course and possibly were even introduced during the course, for example:

> “The different 'parts' of the brain and how all people receive information in different ways, whether that is learning style or using different 'sides' of their brains.”.

A further theme was that brain knowledge is useful to teachers (N=9). There was also evidence that the intervention provoked a critical, or possibly sceptical, view of brain-based claims with responses (N=12) such as:

> “Don't believe everything you read about the brain just because they have a picture of a brain scan and tell you that scientists say.....” and

"Don't believe anything you read/hear in the media!! (without asking at least some questions!)."

Trainee experiences in school during their training course may also have had an impact. The post-survey question: 'What ideas about the brain and learning were evident on your school placements?' elicited 45 responses. Many (11) of the trainees reported that they saw no evidence of brain-based practice in schools. Learning styles/VAK featured (N=8), for example:

"We use audio, visual and kinaesthetic learning quite a bit",

but conversely 6 responses emphasised the individuality of children, e.g.

"Individual differences between learners, changing the approach for teaching".

Other responses varied considerably and included reference to Growth Mindset, mindfulness, working memory and exercise breaks. Two trainees reflected critically on brain-based claims and interventions they had encountered in their school placements. One identified common neuromyths:

"Many common misunderstandings still exist e.g. brain gym (sic), belief that we are types of learners.".

Another wrote:

"There was a focus on growth mindset. Schools often discuss scientific research, from training etc., as if it is fact. They do not question the research or critically analyse it. This then impacts things within the school."

This trainee was apparently identifying the lack of critique by the school, not rejecting Growth Mindset, nevertheless, it raises the concern that the intervention may have led some trainees to dismiss all brain-based teaching interventions.

Differences in survey accuracy depending on prior brain-related training experience

More than a third of trainees declared pre-course experiences of some form of brain-related training, which may have contributed to their beliefs in neuromyths (Table 3). During the intervention workshop some trainees reported doing Brain Gym© as pupils themselves and recalled being categorised as a visual, auditory or kinaesthetic learner at school. Tutors reported that some trainees were visibly shocked and expressed anger at having been subjected to these as pupils.

To explore the role of prior experience, correct response scores were further analysed using a 2x2x2 mixed-model ANOVA. The two repeated measures factors were test point (pre- vs. post-training) and knowledge type (general brain knowledge vs. neuromyths). The between-subjects factor was prior experience of neuromyths (some vs. none). The results showed a significant main effect of test point ($F[1,128] = 15.20$, $p < .001$, $\eta^2 = 0.11$) suggesting that overall, participants were more likely to provide answers tending towards being more correct in the post-training survey. There was also a significant main effect of knowledge type ($F[1,128] = 380.49$, $p < .001$, $\eta^2 = .75$), suggesting that participants generally provided answers that tended towards being more correct to statements concerning general brain knowledge as opposed to neuromyths. There was no significant between-subjects main effect of prior experience ($p = 0.082$). In addition, there was a significant interaction between test point and knowledge type ($F[1,128] = 19.70$, $p < .001$, $\eta^2 = 0.13$). Post-hoc tests revealed that participants became better at judging neuromyths post-training ($M = 4.143$, $SD = .514$) compared to pre-training ($M = 3.878$, $SD = .387$; $t[129] = 5.993$, $p < .001$, $d = .526$). There were no differences in terms of judging general knowledge pre-training ($M = 4.938$, $SD = .459$) versus post-training ($M = 4.896$, $SD = .471$; $p = .256$). Participants were better at judging general knowledge than neuromyths both at the pre-training stage ($t[129] = 20.312$, p

$<.001$, $d = 1.781$) and post-training ($t[129] = 13.199$, $p < .001$, $d = 1.158$). There were no significant interactions between test point and prior experience ($p = .341$), knowledge type and prior experience ($p = .899$), nor was the three-way interaction between test point, knowledge type and prior experience significant ($p = .348$).

Differences of trainee teachers' interest in brain knowledge, its perceived value to their practice and their confidence in reading scientific knowledge after the intervention

A final question that we were interested in concerned whether there were differences in trainee teachers' interest in scientific brain knowledge, their perception of its value to them in their future teaching practice and their confidence in reading scientific knowledge before and after the intervention. Table 4 shows the descriptive statistics for three questions that we asked relating to these factors.

A series of paired t-tests were conducted. No significant differences were found in terms of the interest in brain science that participants held pre- and post-training ($t[127] = 1.07$, $p = .287$). Perceived value was lower post-training ($t[128] = 5.56$, $p < .001$, $d = .489$), whereas confidence levels in reading scientific knowledge increased ($t[129] = -4.01$, $p < .001$, $d = -.351$).

Discussion

This study investigated changes in teachers' beliefs over the course of a modified initial teacher education programme that included a novel intervention designed to challenge primary teachers' beliefs in neuromyths and in doing so, to support their development as future critical consumers of neuroscience in education. As in previous studies of pre-service teachers (Howard -Jones 2014, Grospietsch & Mayer, 2019; Im et al. 2018, Papadatou-Pastou et al., 2017), we found significant evidence of neuromyths with the Learning styles/VAK myth and left brain/right brain myth being held by trainees. Also, the ‘rich environments’ myth and ‘fish oil’ myth were particularly prominent, which is in line with previous findings in the UK (Dekker et al., 2012). The design of the intervention responded to the pre-survey findings by focussing on these neuromyths, although the ‘rich environment’ myth was not addressed as there was insufficient time for unpacking the nuances of its meaning. Undertaking the pre-survey approximately a week before the workshop effectively acted as part of the intervention for this cohort of students by activating their awareness and prior knowledge. The high loss rate restricts the generalizability of the findings; it is likely that those who fully completed both pre and post surveys were particularly conscientious trainees and/or those with an interest in the brain. In this study the changes were introduced across the ITE programme with no control group. Further work would be needed to examine the specific impact of this novel intervention targeting neuromyths by comparing it with standard ITE.

Unsettling trainee’s neuromyths

Combined with the overall ITE and school placement, the intervention had a positive impact in that it somewhat reduced belief in the neuromyths it addressed. However their persistence confirms that trainee teacher neuromyths may be resistant to education (Grospier & Mayer, 2019) and the reasons for this need further exploration. The main effect of the teacher training was to ‘unsettle’ trainee beliefs in brain-based claims, making them more uncertain of what ideas to trust. Arguably, this is a desirable outcome that may indeed make them less susceptible to false claims as future teachers and contribute to their scientific literacy (Laugksch, 2000). It is encouraging to see that trainee confidence in reading scientific knowledge increased. However, confidence in reading about science does not necessarily equate to accuracy in understanding and may actually contribute to neuromyths (Dekker et al. 2012). There may be a fine line between promoting a critical view and a sceptical view and the next iteration of the intervention will consider this carefully. Also, from a practitioner point of view a critical approach to brain-based claims without specific recommendations for practice is frustrating (Goswami, 2006; Howard-Jones, 2014). The intervention will be redesigned both to examine the validity of brain-based pedagogical strategies from a scientific perspective and also to stimulate reflection on the possible sociocultural origins of trainees' pre-existing ideas (Leach & Scott, 2002).

Although the teacher training decreased belief in neuromyths, it did not increase their general knowledge of the brain, which arguably would be more useful in preparing trainees to critique future brain-based claims (Dubinsky et al, 2013). It is possible that education tutors were not sufficiently secure with teaching the neuroscience. Future iterations of the intervention will continue to focus on reducing the level of belief in neuromyths that trainees hold through new strategies to support learning of basic neuroanatomy.

Trainee experiences beyond the university-led intervention

Little is known about how teachers come to hold neuromyths and the role of initial teacher training in this, although in-service teachers have identified university training along with intuition and perceptions based on teaching experience as sources of their belief in learning styles, hemispheric dominance and coordination exercises (Sarrasin, Riopel & Masson, 2019). In our study, trainees who declared pre-course experience of 'brain-based' packages (Learning styles/VAK, Brian Gym©, multiple intelligences or 'other') did not significantly differ in their responses to the survey questions pre or post. However, during the intervention some trainees remembered doing Brain Gym©-like actions as pupils or recalled being categorised by learning style at school. Thus the intervention seemed particularly pertinent to this generation of new teachers in order to avoid them reproducing this personal experience in their own teaching.

Furthermore, some trainees encountered VAK/Learning styles on the school placement they undertook during the course after the intervention had taken place, which is unsurprising given that the VAK myth is widely held (e.g. Tardif et al., 2015). This indicates a need to develop the partnership with schools in which trainees are placed, so that as a minimum they know that the university will be offering an alternative view and ideally to reduce the presence of such ideas within partnership schools. The brain-based claims and interventions trainees encountered in school do not all have the same status in the literature. So while teaching according to an assessment of pupil learning style is a neuromyth (Coffield, Moseley, Hall & Ecclestone, 2004; Howard-Jones, 2014), there is evidence for the impact of interventions based on Growth Mindset (Dweck & Leggett, 1988; Dweck, 1999) although its replicability has been contested (Yu & Bates, 2017) and research is ongoing (Dweck, 2019). In the next cycle of design we aim to help trainees to interrogate prevalent neuromyths and also to critique current research evidence for potential applications of neuroscience and cognitive psychology such as Growth Mindset (ibid) and retrieval practice (e.g. Karpicke, Blunt & Smith, 2016; Agarwal, Bain & Chamberlain 2012).

Neuromyths as a way into engaging ITE with the learning sciences?

As in any educational endeavour, we would expect the knowledge encountered by trainee teachers to be an accessible version of current expert understanding of learning, not false accounts. Also, we wish teachers to draw on the best available ideas to support their practice. However, the implicit assumption that the prevalence of neuromyths has a negative impact on teaching quality has been challenged by Horvath, Donoghue, Horton, Lodge, Hattie (2018), who found no difference in neuromyth acceptance between trainee teachers and award-winning teachers. We found that the consideration of neuromyths offered a way of engaging trainee teachers with the need for critical, reflective thinking about the application of the learning sciences to their teaching, as they enter a professional environment in which neuroscience research is increasingly likely to be seen as relevant to education (Brookman-Byrne & Thomas, 2018).

In an environment in which evidence-based practice is being strongly advocated (Goldacre, 2013; la Velle & Kendall, 2019), we need to recognise that any educational research, 'cannot provide certainty of outcome. What it can achieve is to provide reasonable warrant for decisions that must be taken by teachers' (Winch, Oancea & Orchard, 2015: 210). It follows that teacher education should enable teachers to engage with findings from the learning sciences thoughtfully as they exercise professional judgment, which in turn may necessitate an increasing requirement for them to engage critically with problematic research (Winch et al. 2015). The learning sciences are an emerging 'integrated knowledge tradition' committed to finding ways of relating disciplinary knowledge to policy and practice (Furlong & Whitty, 2017). In England it is anticipated that government inspection of ITE will follow the direction of school inspection and be underpinned, at least in part, by the 'learning sciences' (Ofsted, 2019; 15). As the Learning Sciences become a coherent and influential community of practice (Sommerhoff, Szameitat, Vogel, Chernikova, Loderer & Fischer, 2018), ITE needs to establish a place within that community. In the present study, the critical examination of neuromyths in the context of learning more about the brain provided an opportunity for opening up questions about the relationship between the learning sciences and trainee teacher learning in ITE.

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