Title:

IS THERE A RELATIONSHIP BETWEEN HOW MRI IS LEARNED AND KNOWLEDGE?

Name: Dr Catherine Westbrook EdD, MSc, FHEA, PgC (L&T), DCRR.
Affiliations: Anglia Ruskin University, Cambridge, UK
Email address: Catherine.westbrook@anglia.ac.uk
Correspondence address: Faculty of Medical Science, Anglia Ruskin University East Rd, Cambridge CB1 1PT

ABSTRACT

Rationale: The aim of this study was to discover whether a specialised undergraduate degree in magnetic resonance imaging (MRI) is a better way of educating MRI practitioners than experiential methods, and how necessary it is to first qualify as a radiographer to practice. This study compared the knowledge between individuals who qualify as a radiographer and then only learn MRI experientially (experiential practitioners), to those who learn only via a specialised undergraduate degree in MRI and enter practice directly without first qualifying as a radiographer (graduate practitioners).

Method: Forty-eight participants (graduate practitioners n=25, experiential practitioners n=23) from four different clinical sites in the United States of America (USA) were recruited. An objective, structured, clinical examination (OSCE) was used to compare knowledge on the key topics.

Results: Graduate practitioners consistently achieved a higher percentage of correct answers than the experiential group in all five sections of the OSCE. The total score in the graduate group was statistically significantly higher than for the experiential group (p=0.018). Means scores were graduate 63.18%, (SD 11.03), experiential 53.58% (SD 16.24) There was a correspondingly large Cohen's effect size (0.697) which indicated that the specialised undergraduate degree in MRI does have an impact on knowledge.

Conclusion: A specialised undergraduate degree may be a beneficial way of learning MRI and it may not be necessary to first qualify as a radiographer to practice competently.

Keywords: Magnetic Resonance Imaging (MRI), specialised undergraduate degree, knowledge, education, radiography.

INTRODUCTION

There is currently no cohesive policy on how to best educate Magnetic Resonance Imaging (MRI) practitioners [1]. A recent review of the literature suggested that the quality of provision is varied, that MRI practitioners lack knowledge and current educational methods are flawed [2]. In most countries, including the United Kingdom (UK), MRI scans are usually performed by practitioners who first qualify as a radiographer and then learn MRI experientially [1,2]. Undergraduate radiography curricula naturally focus on general radiographic imaging, and learning MRI is usually limited to basic theory and observing some routine examinations [3,4]. Consequently, when individuals first enter MRI practice they often require additional training, and this is commonly provided experientially by other MRI practitioners or manufacturer applications specialists [1,2]. However, research suggests that this educational method is flawed, because the learning does not follow a standardised curriculum and is not formally assessed [1,2,5]. Many who train new practitioners in the workplace have learned MRI experientially themselves and there is evidence that misunderstandings are cascaded and perpetuated [6].

Short taught courses and post-graduate programmes are available in some countries to supplement experiential learning but their effectiveness has not been tested [1,2,5]. In the Unites States of America (USA) and Canada, several higher education institutions have developed specialised undergraduate programmes in MRI. They allow practitioners who have not previously qualified as a radiographer to enter practice directly with a degree in MRI [1,2]. Most follow a standardised curriculum [7] and a similar model is used in Canada [8]. Weening, et al [9] suggest that these courses are beneficial but very little research exists on their effectiveness [2].

The aim of this study was to discover whether practitioners who enter practice directly with a degree in MRI are more knowledgeable than those who learn MRI experientially post-qualification as a radiographer. The purpose was to investigate how effective a specialised undergraduate degree in MRI might be in educating MRI practitioners in the future.

METHOD

Ethical approval for this study was sought and received from Anglia Ruskin University. Two groups of practitioners, who have learned MRI differently were identified (Table 1). The first were individuals who were educated exclusively in MRI via a specialised undergraduate degree and entered MRI practice directly without first qualifying as a radiographer (termed *graduate practitioners*). The second group were individuals who were educated initially in radiography and then went onto practice MRI post-qualification. Their learning in MRI was only experiential. None of these individuals had attended a short course or a post-graduate programme of study and they had learned MRI only “on the job” (termed *experiential practitioners*). Individuals in both groups were graduates (so the level to which they had been educated was the same), but in different subjects (graduate practitioners in MRI, experiential practitioners in radiography). The only difference between them was how they had learned MRI. To keep the comparison as clear as possible, practitioners who had learned MRI via other methods were excluded.

Table 1: Participant MRI educational profile

	Degree in radiography	Degree in MRI	Average experience in MRI in years	Standard Deviation
Graduate practitioners (n=25)	No	Yes	6.08	2.83
Experiential practitioners (n=23)	Yes	No	13.02	15.56

As most of the MRI undergraduate programmes are delivered in the USA, data were collected there. Forty-eight participants (graduate practitioners n=25, experiential practitioners n=23) from four different clinical sites, in four different states in the USA were recruited to the study. These sites were chosen because each are affiliated to four different institutions that deliver an undergraduate programme in MRI and therefore had good access to potential participants. All the participants practiced at ‘Tech 2’ level which means that they were qualified MRI practitioners, as opposed to students (Tech 1) or teachers (Tech 3). All the participants were registered to practice in their state. Participants in both groups worked together in the same clinical environment so that co-variates such as workplace culture, MRI equipment and patient demographics were minimised. Participants were purposively selected by gatekeepers at each site and placed into one of the two groups depending on the way they had learned MRI. It was not possible to obtain equal sample sizes as, after the data collection period, a different number of practitioners from each group had participated. To maintain anonymity, participants were asked to draw a numbered ball from a box to ensure that identifiers were randomly allocated. To enable instant category recognition, even numbers were used for experiential practitioners, odd numbers for graduates. The number was used to place each participant within one of the two groups but was not linked to the participant in any other way.

An objective structured clinical examination (OSCE) was chosen as the method of data collection and was designed to test the residual knowledge of MRI between graduate and experiential practitioners as objectively as possible. Residual knowledge was defined as working knowledge as applied to practice and was differentiated from knowledge recently acquired by rote or memorised for an examination [10,11]. This was regarded as more useful as it is the type of knowledge a practitioner is likely to use when scanning patients [12].

OSCEs are a means of objectively assessing the theoretical knowledge and practical skills of medical and nursing professionals [13] and have become widely accepted as a strategy for assessing underpinning theory and clinical competence across a range of allied health professions [14]. A typical OSCE involves participants progressing through several time-limiting tasks where skills on a variety of topics are assessed. The main characteristic of the OSCE is that compared to other assessment tools, objectivity is preserved by selecting questions and answers that are not open to interpretation or judgement [15,16]. This is achieved by a form of questioning that has a single correct answer established by a predetermined grading system. In addition, the standardised time-limitation of each task means that every participant has the same amount of time to complete the same set of questions. These strategies are thought to reduce subjectivity and therefore increase reliability [12, 17-19].

The OSCE was devised with regards to a database developed by the American Registry of Radiologic Technologists (ARRT) to inform its MRI certification programme [7]. The OSCE was divided into five sections of 20 answers each (total

100). Some questions required selection of more than one answer so not all sections contained 20 questions. These sections were divided into the following topics;

- Section 1: MRI safety, anatomy and pathology: (12 questions, 20 answers).
- Section 2: general principles: (15 questions, 20 answers).
- Section 3: image contrast and pulse sequences: (20 questions, 20 answers).
- Section 4: image production: (16 questions, 20 answers).
- Section 5: image optimisation: (14 questions, 20 answers).

Most of the questions were multiple-choice where the participant selected one or two answers, but some questions required a written answer. There was, however, only one possible correct answer. As part of these instructions, all participants were asked to tick a box or write down their assessment of the correct answer (depending on the type of question). They were also instructed to leave a question blank (not answer it) if they could not volunteer an answer. The purpose was to reduce guessing an answer correctly and to assess the number of questions participants did not volunteer an answer for. Unlike questions that participants believed they could answer (and answered either correctly or incorrectly), the questions left blank indicated where participants had identified a gap in their knowledge. Every participant was given a section to complete every eight minutes. This time-frame was chosen as optimal from a previous study using the same method [5]. At the end of each eight-minute period the participants were asked to stop writing. The completed section was removed and replaced with the next section with another eight-minute time limit. This process continued until the OSCE was completed (40 minutes in total).

All participants were provided with a participant information sheet and informed consent form before the OSCE. This form advised participants that they would be required to complete a timed multiple-choice quiz and that it was very important that they did not revise anything before the test. None of the participants had prior knowledge of the questions and none were informed of exactly what topics would be covered beforehand. The participants were not shown the OSCE before data collection and during the OSCE, participants were not allowed access to books or other resources. This was carefully monitored by the researcher and gatekeeper who acted as invigilators. These strategies were designed to ensure that the OSCE scores were as good a representation as possible of the residual MRI knowledge of each participant at the time of the test.

The OSCE scores for graduate and experiential practitioners were compared. Descriptive statistical analysis of the OSCE score for each section and for the total OSCE scores, normalised to account for the difference in sample size, was performed. Inferential statistical testing using the two-tailed t-test for two independent samples was performed on the total OSCE scores and for the number of questions participants did not volunteer an answer (DNA). The aim was to explore whether any differences between the OSCE scores in each group were statistically significant at a confidence level of $p<0.05$. Cohen's effect size was also applied to investigate whether the way in which MRI is learned impacts knowledge.

RESULTS

The key findings are illustrated in Tables 2 to 4. Graduate practitioners consistently achieved a higher percentage of correct answers and a lower percentage of incorrect answers than experiential practitioners in all five sections (Table 2). The section mean scores were higher for graduate practitioners in all five sections of the OSCE and mean total OSCE score of graduate practitioners was higher than that of experiential practitioners (Table 3). The standard deviation and variance was lower in the graduate group, reflecting more consistency in the OSCE scores (Table 3). Both graduate and experiential practitioner scores revealed a general decrease in the total score from Sections 1 to 5. The OSCE scores attained by participants in both groups were lower in Section 4 (image production) and Section 5 (image optimisation) than in other sections (Table 2).

The total OSCE score in the graduate group was statistically significantly higher than the total score for the experiential group ($p=0.018$) (Table 2). There was a correspondingly large Cohen's effect size (0.697) (Table 4), indicating that the effect being tested (the specialised undergraduate degree in MRI) did have an impact on the OSCE scores. Sections 2, 3 and 4 (general principles, image contrast and pulse sequences, and image production) yielded significant differences in the number of questions answered correctly between the groups, with the difference for Section 2 (general principles) being highly significant (p=0.001). The difference in the number of incorrectly answered questions was also highly significant in this section (p=0.001). Sections 2, 3 and 4 had a large Cohen's effect size. Although graduate practitioners did not answer fewer questions than experiential practitioners in all five sections there was no statistically significant difference between them (Table 2) indicating that participants in both groups identified a similar number of gaps in their knowledge.

Table 2: Percentage of questions answered correctly, incorrectly or not answered and p values.

		Section 1	Section 2	Section 3	Section 4	Section 5	Total
Graduate	Correct (%)	74.2	67.8	67.2	55.2	51.4	63.2
Experiential		69.3	53.7	56.5	43.5	44.3	53.5
	p value	0.203	0.001	0.046	0.004	0.182	0.018
Graduate	DNA (%)	6.6	9.0	9.8	10.0	16.6	10.4
Experiential		6.4	10.4	13.1	14.6	19.4	12.7
	p value	0.962	0.717	0.475	0.389	0.575	0.501
Graduate	Incorrect (%)	19.2	23.2	23.0	34.8	32.0	26.4
Experiential		24.3	35.9	30.4	41.9	36.3	33.8
	p value	0.095	0.001	0.074	0.133	0.296	0.017

Table 3: Summary of descriptive statistical analysis normalised to account for sample size difference

	mean	median	mode	SD	variance
Graduate	63.18	62	57	11.03	121.56
Experiential	53.48	54	57	16.24	263.70

Table 4: Cohen's Effect Size (OSCE Scores) (large = 0.5 to 0.8, medium 0.3.to 0.5)

	Section 1	Section 2	Section 3	Section 4	Section 5	Total
Cohen's (d)	0.369	0.971	0.586	0.587	0.389	0.697
effect size	medium	large	large	large	medium	large

DISCUSSION

The findings of this study suggest that learning MRI through a formal programme of study is beneficial as there was a significant difference in the OSCE scores between graduate and experiential practitioners. There was also a difference in consistency of knowledge between the two groups as evidenced by a smaller standard deviation in the graduate group. Sections 2, 3 and 4 account for the highly significant difference in scores between the two groups. Section 2 (general principles) was particularly responsible for this result and indicates that the fundamental theories that underpin MRI appear to be the key differentiator of residual knowledge. A sound grasp of fundamental principles is important as they support understanding of other topics. This could be one of the reasons why graduate practitioners out-performed experiential practitioners in other sections of the OSCE.

Although the sample size was small, it broadly reflected the recommendations for comparative studies of this kind [20]. The participants were representative of two distinct ways in which MRI was learned and there was no reason to believe that their OSCE scores were any different from those of other graduate and experiential practitioners, had they been tested. Co-variates such as how long ago MRI was learned, experience, learning styles and assessment were considered but after further analysis of the data were not thought to have influenced the findings. For example, it might be expected that maximal experience in MRI results in higher OSCE scores, because time in practice is an indicator of opportunities to learn [10]. However, in this study experiential practitioners, who had nearly twice as much experience as graduate practitioners (Table 1), had consistently lower OSCE scores. The highly significant difference in OSCE scores suggests that the way in which MRI is learned does have an impact on residual knowledge. Even if the sample size had been larger, the remaining participants would have had to perform particularly badly in the OSCE to overturn the significance of the result. The practice and education of MRI practitioners is diverse [1]. Although the educational systems in the USA and UK are in some respects different, the knowledge required to acquire MR images for diagnostic purposes is the same. The findings of this study, that tested the residual knowledge of MRI practitioners who work in the USA, should therefore be potentially transferrable to practitioners in the UK.

This study questions the value of learning MRI experientially and suggests that learning via a formal programme of study is beneficial. Educational research often emphasises the benefits of experiential learning [21,22]. It is argued that experiential educational methods allow the learner to discover, process and apply knowledge to their practice. This stimulates deep learning, as it encourages connections between theory and practice [23,24] and develops a strong ownership of what is being learned. Dewey's model [25] identifies knowledge and content organisation as being key components of successful experiential learning because this determines how individuals can apply theoretical knowledge to practice. However, these important phases of Dewey's model are not usually in place for experiential practitioners. Practitioners in the experiential group had little underpinning theory to support their practice and there may have been few opportunities for them to bridge the gap between theory and practice in the workplace. Their learning may have been ad hoc and acquired from other experiential practitioners, whose knowledge and teaching skills were untested [6.] Graduate practitioners, however, were more likely to be able to connect the knowledge they had acquired in the classroom with their practice because they learned via formally developed curricula that permitted standardisation of content, delivery and assessment [5].

However, participants in both groups did not perform well in some sections of the OSCE. For example, in Section 1 several participants in both groups were unable to label major anatomical structures and identify the common examples of pathology that they should see in everyday practice. Furthermore, 40% of graduate practitioners (10/25) and 42% of experiential practitioners (10/23) could not identify four safety contraindications to MRI. In Section 5 both groups answered fewer questions correctly and more questions incorrectly than any other section in the OSCE. The most poorly answered questions in each group related to an understanding of the consequences of altering the time to repeat (TR) and phase matrix. Whilst most could provide some answers, no-one could list all the consequences, and one graduate and four experiential practitioners could not provide any correct answers. These results imply that neither learning method is reinforcing knowledge, and questions how these subjects are taught and applied. Although the undergraduate programme seems to be beneficial, there are areas that may need further development.

According to the Skills for Health national occupational standards in MRI, competent MRI practitioners must demonstrate a sound understanding of theoretical knowledge and this must be applied in a range of clinical situations.[26] The topics tested in the OSCE focussed specifically on theoretical concepts and how they are applied in practice. The educational theory of Eraut and the Dreyfus' skills acquisition model were used to establish the most appropriate topic areas. These models link knowledge with the development of professional expertise and practical competencies, particularly in the early stages of a practitioner's career. [27, 28] Eraut explores learning that involves the conscious use of knowledge and how this relates to the application of practical skills. The initial stages of professional development and progression into a competent practitioner require standard routines and explicit rules and the individual learns to link these to different scenarios. [28] In the context of MRI this means developing a sound understanding of physical principles and being able to apply them to some basic task-orientated procedures.[29] For example, a competent MRI practitioner is expected to understand the theoretical principles behind parameter selection within pre-defined protocols and then apply those principles in routine clinical examinations.[26]

MRI is traditionally viewed as a core skill of a radiographer [30, 31] but the fact that none of the graduate practitioners first qualified as a radiographer but consistently scored more highly in the OSCE than experiential practitioners, suggests that acquiring the core technical knowledge and skills of a radiographer may not be important to practise in MRI. It is even possible that first qualifying as a radiographer sends practitioners on an unhelpful educational pathway into MRI, because after qualifying as a radiographer they are more likely to learn MRI experientially than to be given the opportunity to complete another undergraduate programme.

There are several professional implications to direct entry into MRI practice via an undergraduate degree in MRI, but data about these were not collected in this study as the purpose was to quantitatively compare knowledge with how MRI is learned. However, qualitative data about professional issues were collected in another strand of a mixed methods study. These showed, for example, that graduate practitioners were paid higher salaries than experiential practitioners because they were more likely to have passed the ARRT MRI certification examination. Most undergraduate programmes aim to enable their graduates to pass this examination at the first attempt.

CONCLUSION

The intention of this study was to start a new conversation on how best to educate educating imaging specialists. It advocates that being a graduate in MRI rather than in radiography results in higher levels of residual knowledge, as evidenced by the significantly different OSCE scores. A relationship might exist between how MRI is learned and knowledge. A formal programme of study that follows a standardised curriculum seems beneficial and first qualifying as a radiographer may not be as important as the way in which MRI is learned. However, further research linking residual knowledge and technical competency is needed to fully understand how best to educate MRI practitioners. The introduction of direct-entry into MRI is controversial and raises important questions about scope of practice and professional registration. Further research is needed to assess the impact and feasibility of such an intervention on the imaging profession.

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