

Accelerated learning at Masters' level: Problem Based Learning of Diagnostic Reasoning skills by Physician Associate Students

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Abstract

Physician Associates (PA) complete a two year postgraduate course, and are expected to graduate with diagnostic skills equivalent to those of newly qualified doctors who have completed a five year course. BSMS has utilised Problem Based Learning (PBL) in an attempt to accelerate the acquisition of these skills by PAs. Weekly PBL sessions were conducted during year 1 of the PA course, focusing on the 'top 20' core conditions within the curriculum. Alongside this, students had weekly clinical exposure in General practice. In order to assess the impact of this strategy the 'Diagnostic Thinking Inventory' (DTI) developed by Bordage et al. (1990) was conducted three times across year 1 and the results compared to standardised data for medical students and doctors. This found that PA students had a significantly higher baseline score in terms of *flexibility of thinking* (equivalent to newly qualified doctors engaged in foundation training) and *structure of memory* (equivalent to third year medical students). Results showed a statistically significant improvement in structure of memory across year 1: achieving an improvement in score which took over four years to achieve in medical students. This appears to suggest that PBL can facilitate increased assimilation of diagnostic reasoning skills within postgraduate learners.

Keywords: Physician Associate, Diagnostic Reasoning, Problem Based Learning, Postgraduate.

Introduction

A Physician Associate (PA) has been defined by the Department of Health as '...a new healthcare professional who, while not a doctor, works to the medical model, with the attitudes, skills and knowledge base to deliver holistic care and treatment within the general medical and/or general practice team under defined levels of supervision' (2012). The number of PAs is expected to increase substantially to meet the increasing demands on the National Health Service (NHS). Having trained in the medical model, PAs are able to undertake diagnosis, and this is seen as a key reason for the employment of PAs as opposed to other advanced healthcare practitioners.

Brighton and Sussex Medical School (BSMS) began delivering a postgraduate clinical diploma in Physician Associate Studies in September 2016. This is a two year postgraduate course and is delivered at masters level (level-7). Entrants are required to have gained a 2:1 or higher in a biomedical science or healthcare sciences degree. The PA curriculum is mapped against the Department of Health document ‘Competence and Curriculum Framework for the Physician Associate’ (2016), which outlines the skills expected of newly qualified PAs. This mirrors the mapping of medical school undergraduate curriculums to the General Medical Council’s ‘Outcomes for provisionally registered doctors with a license to practice’ (2015) and there is substantial overlap between these two documents.

The Competence and Curriculum Framework uses a model for categorising clinical conditions on the basis of the skills and knowledge required to diagnose them. Each clinical condition is assigned a category as shown in figure 1 (below). A PA is expected to be able to independently diagnose a ‘1a’ condition (examples include: hypertension, gout, depression, and migraine). For ‘1b’ conditions, PAs are expected to ‘identify the condition as a possible diagnosis’ (examples include: myocardial infarction, acute pancreatitis, thyroiditis and malaria).

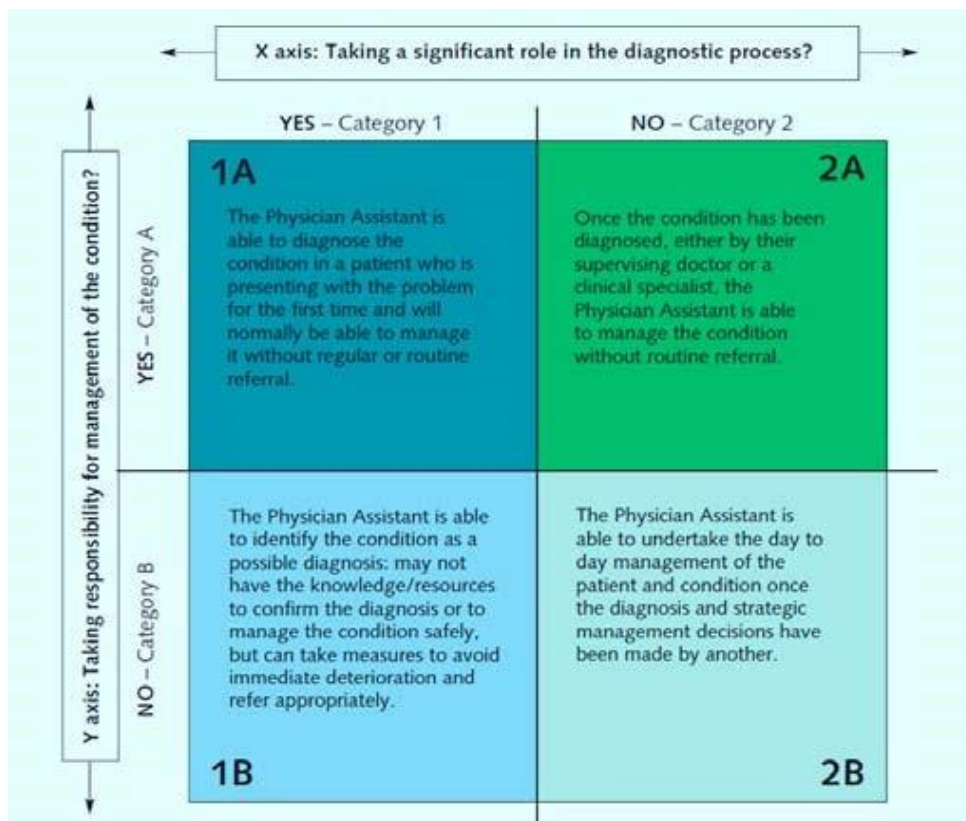
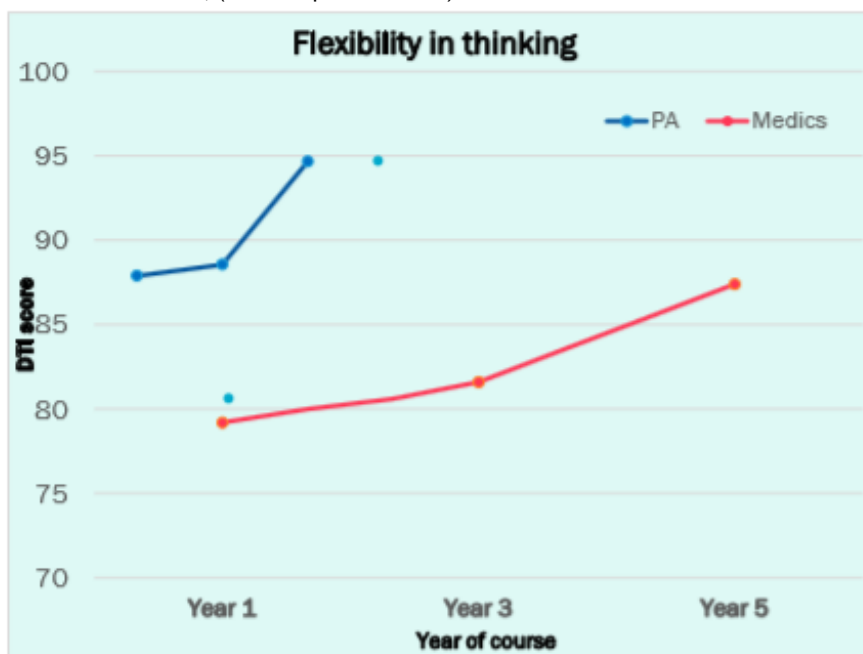


Figure 1: Matrix for categorising clinical conditions on the basis of required competence (R.C.O.P.F.O.P. Associates, 2016)

In order to achieve these outcomes PA graduates must assimilate the diagnostic skills that are arguably equivalent to those of newly graduated doctors. Given that the PA course lasts for two years (as opposed to five+ for doctors) these skills must be developed at an accelerated pace. To achieve this, BSMS must ensure that it is utilising educational pedagogies with a robust evidence base. Recognising this challenge, the BSMS PA course team adopted an explicit strategy to develop diagnostic reasoning within this cohort. This took the form of framework lectures exploring diagnostic reasoning and illness scripts, followed by weekly Problem Based Learning (PBL) sessions with a diagnostic reasoning focus.

To assess the effectiveness of PBL in developing diagnostic reasoning among the year 1 cohort (n=9). The course team used the Diagnostic Thinking Inventory (DTI) developed by Bordage et al. (1990). This is a validated 41 question inventory designed to quantitatively measure two aspects of diagnostic thinking: 'flexibility in thinking' and 'knowledge structure' of memory. This produces a score which can be compared to standardised groups at different levels of medical training. The DTI was conducted at three points across year 1 of the PA course in order to map the development of diagnostic thinking among PAs, and compare it with the pace of development amongst medical students, (see Graphs 1 and 2).



Graph 1. Flexibility in thinking

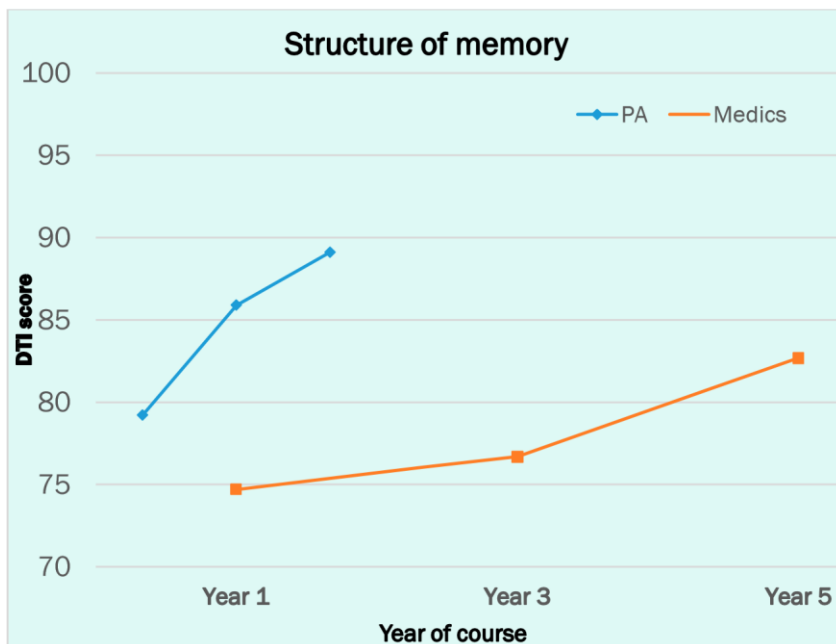
Medical education has a strong culture of research and critical appraisal of literature when considering appropriate learning pedagogies, therefore it is important to explore what is known about how healthcare professionals develop diagnostic reasoning skills, and appraise the evidence-base for using PBL to foster this skills acquisition.

Clinical and diagnostic reasoning

Cervero (1988) defined clinical reasoning as ‘the sum of the thinking and decisionmaking processes associated with clinical practice; it is a critical skill in the health professions, central to the practice of professional autonomy and it enables practitioners to take ‘wise’ action, meaning to take the best judged action in a specific context’. Clinical reasoning is an umbrella term used widely in the literature to encompass a number of different aspects outlined in table 1 (over).

The research described in this paper specifically seeks to examine the *diagnostic* reasoning of the PA cohort. However, theoretical accounts of its development in the literature often fail to distinguish diagnostic reasoning from clinical reasoning as a whole. It is important to be mindful of this important distinction when analysing or interpreting the evidence base.

Interest in the diagnostic reasoning process has been recently renewed in an attempt to reduce error within the diagnostic pathway. The most recent proposal is the ‘dual process theory’ (Croskerry, 2009). This describes two modes of processing. In system 1, reasoning is proceeded by a fast, unconscious retrieval process. This is viewed as inherently error prone. System 2 is a more deliberate, conscious and logical process. The



Graph 2. Structure of memory

level of complexity of the case determines which system is utilised. It is theorised that increasing one’s reliance on system 2 can improve diagnostic reasoning and reduce errors. This theory was the subject of a best-selling book by Kahneman entitled *Thinking, fast and slow* (2011).

Diagnostic reasoning	Reasoning which aims to reveal the clients' impairment(s) disability(ies) and handicap(s) and the underlying pathobiological mechanisms.
Interactive reasoning	Occurs when dialogue in the form of social exchange is used deliberately to enhance or facilitate the assessment/management process. This reasoning provides an effective means of better understanding the context in which the patient's problems exist while creating a relationship of interest and trust.
Narrative reasoning	Involves the use of stories regarding past or present patients to further understand and manage a clinical situation.
Collaborative reasoning	Shared decision making that ideally occurs between practitioner and patient. Here the patient's opinions as well as information about the problem are actively sought and utilised.
Predictive or conditional reasoning	Part of the practitioner's thinking directed to estimating patient's response to treatment and likely outcomes of management, based on information obtained through the patient interview, physical examination and response to management.
Ethical or pragmatic reasoning	Alludes to those less recognised, but frequently made decisions regarding moral, political and economic dilemmas which clinicians regularly confront, such as deciding how long to continue treatment.
Teaching as reasoning	Occurs when practitioners consciously use advice, instruction and guidance for the purpose of promoting change in the patients understanding, feelings and behaviour.

Table 1. Domains of Clinical Reasoning (Adapted from *Clinical Reasoning in the Health Professions*, Higgs, 2008)

Whilst we recognise that a medical school must produce able diagnosticians, little is certain regarding *how* a student develops this vital skill, and therefore how best to foster its acquisition. In seeking to address this problem, Schmidt and Boshuizen (1992; 1993; 2008) proposed a staged theory, whereby knowledge acquisition and clinical skills are developed hand-in-hand. They recognised that diagnostic competence develops not only through knowledge expansion, but through knowledge restructuring as outlined in table 2 (over).

Stage 1: Knowledge network	Students acquire large volumes of knowledge regarding basic biomedical sciences linked together in a knowledge network. This is a constant process of adding new concepts, strengthening connections between items. Lines of reasoning consist of small chains of small steps commonly based on underlying biomedical concepts.
Stage 2: Knowledge encapsulation	As direct lines of reasoning between concepts are activated more often, these concepts cluster together, and students become able to make direct links between first and last concept, skipping intermediate concepts. Biomedical knowledge has been encapsulated with clinical knowledge; students tend to make direct links between patient findings and clinical concepts such as a diagnosis. However, if there is a complex clinical problem biomedical knowledge can be drawn on.
Stage 3: Illness scripts	<p>Illness scripts are a structure of knowledge organisation with three components:</p> <ul style="list-style-type: none">• Enabling conditions of disease: Personal, social, medical, hereditary and environmental factors which effect health and/or a specific disease• Fault: Pathophysiological process which is occurring• Consequences of fault: Signs and symptoms of a specific disease <p>Unlike novice knowledge networks, Illness scripts are activated as a whole. No active small step search within that script is required.</p>

Table 2. Staged theory of the development of medical expertise (Higgs, 2008)

Problem Based Learning

Problem based learning (PBL) is a student-centred pedagogy in which students learn through the experience of solving a problem found in trigger material. Students are encouraged to define their own learning outcomes based upon the material. Barrows (1986) states: 'The increasingly popular term 'problem-based learning' does not refer to a specific educational method. It can have many different meanings depending on the design of the educational method employed'. This statement is certainly reflected in the literature, where a wide range of different setups are all included and discussed under the heading 'Problem Based Learning'. This occurs both within healthcare and wider educational domains (Koh et al., 2008; Savery, 2015).

Many medical schools within the UK and abroad have adopted a PBL curriculum, or utilised PBL to some degree. In 2004, the European Network of Occupational Therapy in Higher Education (ENOTHE) declared PBL the learning method of choice, however the evidence to support this claim is far from robust.

In 2012, Thistelwaite et al. (2012) performed a systematic review of PBL for health professional education. For inclusion, papers were required to have outcome data regarding the effectiveness of PBL. An important consideration when appraising evidence is what outcomes are being assessed and therefore the strength of evidence this represents. Kirkpatrick's hierarchy (Kirkpatrick, 1967; figure 2) offers a structure for appraising interventions in medical education. This systematic review required included papers to adopt outcome measures at level 2 or above of Kirkpatrick's hierarchy. 104 papers were included in the review, of which 23 per cent were judged as having higher quality and significance (although arguably this was a subjective assessment). The researchers concluded that PBL is enjoyable for students, and that students believe that it enhances their learning. However, it was inconclusive with regards to the *effectiveness* of PBL compared to other types of activity. When considering Kirkpatrick's hierarchy, this only represents level 1 evidence (participant reaction and/or self-reported learning). There are many limitations to this study. The authors themselves state: 'We decided to have wide inclusion criteria and not limit this review to medical education'. Whilst arguably this will allow more studies to be included, it will mean that the data may be less applicable and therefore the evidence less robust in relation to my population of interest.

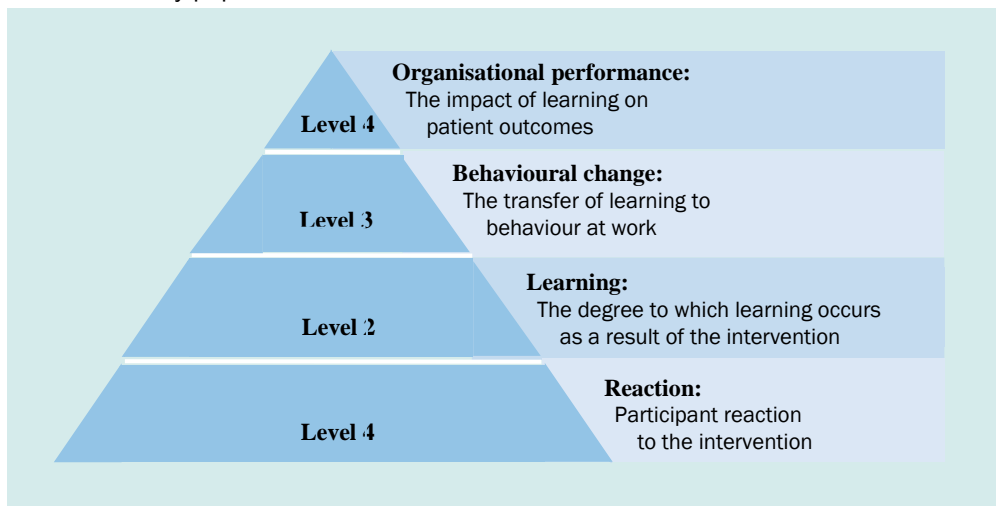


Figure 2: Kirkpatrick's Four-level training evaluation model

In 1987, Schmidt et al. (1987) sought to review studies that examined the learning outcomes of doctors who had experienced a PBL curriculum compared to a traditional curriculum. This is an important paper as it seeks to collate outcomes at level 2 of Kirkpatrick's hierarchy, which the previous systematic review was not able to demonstrate. With regards to academic achievement, Saunders et al. (1989)

administered a multiple choice knowledge test to final year students at The University of Sydney (traditional curriculum, n=243) and The University of Newcastle, Australia (PBL curriculum, n= 45). They found a small but statistically significant difference in scores in favour of the traditional curriculum (Sydney = 71 per cent, Newcastle = 67 per cent). However, it was recognised by the researchers that the Newcastle students had not previously undertaken assessment using multiple choice assessment format. This is likely to have had a substantial impact on their overall scores, and call into question the validity of the study results.

Friedman et al. (1990) sought to investigate performance at work after graduation in those who had completed both types of curriculum. This sought to look at level 3 of Kirkpatrick's hierarchy: behavioural change. They examined the performance of a group of Canadian medical school graduates via reports from supervisors where they had to rate performance against the average intern in their programme. They found that 26.1 per cent of graduates from McMaster University (which adopted a PBL curriculum) were rated as performing much better than the average intern, 38.3 per cent as performing better, 28.7 per cent as average and just 6.9 per cent as weaker than the average intern. However, there are many methodological flaws with this study. The question 'how does this graduate compare with the average intern?' is entirely non-specific and may be judged according to different criteria by different supervisors. The study was not blinded, which may have led to confirmation bias depending on the supervisor's personal opinion on PBL.

For any study attempting to compare outcomes between two different curriculums, there are many more variables to consider than purely PBL or traditional curriculum. Students are not randomly assigned to each curriculum; a requirement for a pure experimental research design. There are a wide range of confounding factors, which make it difficult to associate any differences in outcomes purely to the use or otherwise of PBL. Differences in student selection, attrition rates, and other aspects of course design and clinical exposure will all effect outcomes, and mean studies looking at these elements cannot conclusively prove the impact of case based learning outcomes.

Can PBL facilitate the development of diagnostic reasoning skills?

Now we have considered the evidence for the development of diagnostic reasoning skills and the use of PBL we must consider if one can be used to foster the other.

Goss et al. (2011) sought to compare the diagnostic reasoning skills of students who engaged in PBL compared to a traditional curriculum. They performed a cross-sectional study at the University of Melbourne whilst the transition from a traditional to a PBL curriculum was occurring, and used the DTI to quantitatively score participants (n=431) diagnostic reasoning skills. As one may expect, they found that DTI scores were higher on completion of the course than they were in the early clinical stages. However, they also found that students completing the traditional curriculum had higher DTI scores at the end of year 1 and at the end of the course, compared with those completing the PBL curriculum (p=0.<001). There are several limitations to this study. The structure of the curriculum changed considerably during the study. In particular, the PBL curriculum included an additional, research-focused year before students entered their clinical years. This period away from immersion with clinical cases may have led to a

degradation in their diagnostic reasoning. Moreover, in the traditional curriculum, clinical placements were three years in duration compared to two and a half years in the PBL curriculum. These wide differences in structure mean it is impossible to say with any certainty that the differences in DTI scores can be directly attributable to the PBL component of the new curriculum.

As previously discussed, PBL is a broad term which encompasses a variety of 'delivery' methods. So it is important to consider whether specific types of PBL are better at developing diagnostic thinking skills in the context of the theories outlined above.

When discussing 'dual process' theory, Kahneman suggests three methods which may reduce errors and improve performance: 'slowing down', 'reflection' and 'cognitive forcing'. Cognitive forcing involves giving participants a set of warnings with regards to cognitive biases in order to encourage metacognition (an increased awareness of one's own thought processes). This is derived from an idea that diagnostic error is a result of multiple cognitive biases, and if one is able to reduce these they would thereby reduce diagnostic error. These strategies may all be employed by a skilled PBL facilitator; encouraging participants to think slowly and systematically during discussions within a CBL session. This assumption is at odds with a study performed by Sherbino et al. (2012) who found increased diagnostic accuracy with faster response times. However, this latter study was performed on 75 medical graduates and faster response times may simply reflect the fact that they know the correct answer via either pathway, rather than simply indicating that system 2 thinking is less error-prone.

Schmidt and Boshuizens' stages of development of clinical reasoning have formation of illness scripts as the most advanced form of 'mental model'. Some have therefore, theorised that using illness scripts in a PBL session may facilitate the development of this type of mental model in learners and advance diagnostic reasoning skills. Ho et al. (2010) performed a study to assess if providing students (n=53) with a three hour workshop using illness scripts had an impact on students' DTI scores or subsequent performance on a clinical reasoning problem task. They found no change in DTI score between the two group's pre-and post-workshop. However, when looking at performance on a clinical reasoning task, they did find a statistically significant increase in scores in the intervention group (mean improvement = 14 per cent, 95 per cent CI = 8 per cent-21 per cent). Whilst this may suggest that using illness scripts has little effect on diagnostic thinking, it is important to note that the study was rather small. The clinical reasoning task was completed by individuals as a computer based assessment, which cannot replicate the complexities of a group PBL setting. During first-hand experience of conducting PBL using illness scripts, students say they have found this useful in their revision and are creating revision notes on a condition based on an illness script.

Chamberland et al. (2015) explored the use of self-explanation in the development of diagnostic reasoning skills. Self-explanation is an active learning process which requires the learner to generate explanations to oneself whilst working through a clinical case. They also sought to assess the impact of the student hearing a more experienced clinician's example self-explanation, and the addition of prompts to this self-explanation to encourage the processing of the example in a specific structured way. These prompts may be used to link biomedical knowledge with clinical knowledge. 58 Year-3 medical

students who took part in the study were randomised into three groups. All completed 12 clinical cases with a diagnostic focus. For all groups the first four cases were 'training cases', in which students were asked to use self-explanation after a brief demonstration. After these first cases, Group 1 were able to listen to examples of a clinician's self-explanation with prompts. Group 2 listened to clinician's self-explanation without prompts. The Control Group solved word puzzles. All Groups then completed eight further cases (four familiar, four unfamiliar). The researchers found that the diagnostic accuracy of all three Groups improved between the training and assessment phase, but Group 1 showed a statistically higher diagnostic performance score in the assessments than the Control Group ($p=0.037$). When looking at the unfamiliar cases alone, Group 1 showed an even greater improvement in diagnostic performance score compared to the control group ($p<0.001$) and compared to Group 2 ($p=0.018$). This study supports the use of self-explanation, particularly if this is able to be combined with examples of a more experienced clinicians thought process presented in a structured way via prompts. The principle of self-explanation is commonly applied within PBL, with students having to justify their thought processes to the group. It is also possible for the facilitator to demonstrate their own 'expert' thought processes; however, this does require a degree of expert knowledge which is not strictly necessary in order to facilitate a PBL session.

Despite the broad uptake of PBL within medical education the literature is divided and unclear with regards to its effectiveness as a pedagogy. Whilst it seems clear that students enjoy PBL, evidence at higher levels of Kirkpatrick's hierarchy is lacking, and when studies attempt to address this gap, methodology and confounding factors make the results difficult to interpret and apply more broadly. There is clear need for further, more robust, research into this area.

However, there are a number of strategies which do show promise in maximising diagnostic reasoning acquisition within a PBL setting, and specifically that have been utilised within the PBL sessions at BSMS. These include encouraging self-explanation in the participants, as well as giving examples of clinicians thought processes, and the use of an illness script approach.

Current research

Results are currently available from the first year of this study in Year 1 PA students ($n=9$). These results demonstrated that PA students began the course with higher DTI scores in both domains compared with medical students. This may reflect the fact that PA students are postgraduate with greater life experiences, and it could be argued that they should be more fairly compared with fourth year medical students from a school entry programme. Even using this as a comparator, the PA students are performing better in terms of flexibility of thinking, and at a similar level in terms of structure of memory.

There are a number of possible explanations for these results. It may be that students who are naturally skilled in structure and flexibility of thought are self-selecting into the PA course. It is possible that PA students' first degrees are equipping them with skills which can be quickly applied to diagnostic reasoning. Conversely it is possible that the medical school curriculum is not fostering these skills in its undergraduate

students, however, this is difficult to assess further due to a wide variety in practice across UK medical schools, as well as a lack of clarity with regards to how the standardised DTI data was derived.

Conclusion

These early results suggest that as well as entering the course with better diagnostic thinking skills than undergraduate medical students, PAs are subsequently developing these skills further at an accelerated trajectory. Whilst one can argue there may be confounding factors other than simply a PBL curriculum, this study appears to support the use of PBL and the current BSMS PA curriculum format.

However, when considering the implications of these findings it is important to recognise that weekly PBL sessions are labour-intensive, requiring a high level of facilitator input. Even if this methodology was to demonstrate clear benefit, it may be practically challenging for a medical school with a large numbers of students.

There are a number of significant limitations to this research. A small cohort means the results may not necessarily be transferrable to the PA student population. BSMS has higher entry criteria than some UK universities offering PA courses, and this may reflect in their DTI scores.

This does support the need for further research into this rapidly emerging area of medical education. This study will continue into the 2017-18 cohort in order to increase numbers, as well as follow the current cohort through into the second year of their course. Qualitative research will also be undertaken to try and understand in more depth how PA students are using PBL to further their diagnostic reasoning skills.

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Biographies

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