How could undergraduate education prepare new graduates to be safer prescribers?

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This review examines the extent to which undergraduate prescribing education prepares graduates for the complexities of prescribing in the workplace context. In order to prescribe safely, it is important for medical students to acquire prescribing expertise. We have developed a theoretical model, based on theories of expertise development, which acknowledges the inherent complexity of the task itself, the social context and the relationship between the two. We have examined the empirical evidence on educational interventions for prescribing by reviewing the extent to which the interventions acknowledge the different components of our theoretical model. Fifteen empirical studies met our inclusion criteria and were reviewed in detail. All the studies were conducted between 2002 and 2010, six were controlled trials, six were before and after studies and three were prospective observational studies. We found that most studies focused on improving and evaluating students' knowledge and skills, although they used different approaches to doing so. These aspects of prescribing only constitute a small part of our theoretical model of prescribing expertise. Other important components, such as social context, metacognition and training transfer, were neglected. We suggest that educational interventions need to account for the integrated nature of learning to prescribe and take a more contextualized approach which considers the task as a whole, rather than isolated constituent parts. In doing so, prescribing education could equip graduates with the necessary expertise to judge and respond to situations, enabling them to prescribe safely, or seek the help to do so, in the unpredictable and complex context of workplaces.

Introduction

'"She's got a headache doctor, please do something," repeated the patient's son. My pen hovered over the drug chart. I broke out in a sweat. Eventually, I looked at the nurse and confessed what she'd already guessed: I didn't know how to prescribe paracetamol. My mum, for goodness' sake, with not a day's medical training in her life, could successfully give someone paracetamol. I knew what paracetamol looked like, I knew what you would prescribe it for – I even knew the pharmacology behind how it worked. But how to actually prescribe – the doses, what to write and where, how often it should be given, and so on – is something that doctors aren't taught at medical school.'- Trust me, I'm a (Junior) Doctor [1].

Research shows that graduates are not adequately prepared to prescribe safely [2–4] but it is unclear how under-

graduate prescribing education can effectively address the problem. In the UK, prescribing errors occur with 8.4% and 10.3% of medication orders written by Foundation Year 1 and 2 doctors, respectively [2]. More than one factor usually contributes to the cause of a single error [5] so educational interventions designed to minimize errors need to address the complexity of the prescriber, the inherent complexity of the prescribing environment and the interaction between them. The aim of this review is to consider the efficacy of current undergraduate prescribing education from the theoretical perspective of expertise development for complex skills. We have specifically evaluated the extent to which the empirical evidence on undergraduate prescribing education was arrived at from a clearly stated theoretical position about the nature of the prescribing task and how it is learned.

Ross *et al.* [6] conducted a rigorous systematic review investigating the extent to which educational interventions can improve graduates' prescribing ability. They

approached the problem by reviewing whether interventions were effective in improving prescribing performance. They found the evidence to be of insufficient quality to support meta-analysis and were not able to draw clear conclusions regarding the future of prescribing education. Ross *et al.* [6] suggested that the World Health Organization (WHO) Good Prescribing Guide is the most widely used educational development for improving prescribing. We chose not to review the guide itself, but did include studies of interventions which were based on it (identifiable in Table 2). Cook and colleagues [7] distinguished 'justification' research (i.e. 'does this intervention work?') from 'clarification' research (i.e. 'how does this intervention work, for whom and under what conditions?'). Since Ross and colleagues had already reviewed whether educational interventions work, we felt it would be appropriate to clarify what makes interventions successful or unsuccessful. We chose to review educational theory prior to reviewing the literature, in order to develop a theoretical model of learning to prescribe that we could apply to the papers we found.

Competency-based medical education is becoming the norm so it is worth considering its implications for clinical practice. While it has set a standard for competent performance, a major shortfall is that it defines adequacy rather than excellence. Another shortfall of competency-based education is that it takes an atomistic approach, breaking complex skills down into their constituent parts so they can easily be assessed. In doing so, the complexity and context of real professional practice is removed, making it an insufficient measure of professional aptitude. True competence is a socially situated concept which demands that learners are able to adapt to uncertainty, respond to the different contextual features of different workplaces, think strategically and monitor and control their own performance. From a cognitive psychology perspective, achieving true competence demands expertise, even when the task is as simple as prescribing paracetamol. Since new graduates are immediately involved in patient care, it is surely imperative that they have achieved expertise in the tasks they are responsible for, rather than adequate performance of their atomized component parts. We propose, therefore, that theories of expertise development provide a suitable theoretical framework for reviewing how undergraduate education could prepare new graduates to be safer prescribers.

Theories of expertise development

Batalden *et al.* proposed a five stage model of expertise development, whose stages are novice, advanced beginner, competent, proficient and expert [8]. This model has been applied to many different complex skills, including medical ones. It addresses the nonanalytic, or automatic, processes that develop as a person becomes expert, but largely neglects the need for effortful cognitive processing in the mind of experts.

Bereiter & Scardamalia, on the other hand, describe expertise development as an ongoing, effortful process, during which experts must constantly engage with the complex environment in which they function [9]. They suggest that, even though the outcome goal of a particular educational stage may not be for learners to achieve expert status, the aim must still be to direct them towards the development of expertise in the longer term [10]. Bereiter & Scardamalia's theory emphasises how important it is for experts to understand complex processes and their contexts. Furthermore, it emphasizes that experts have to be able to reflect on situations and achieve an appropriate balance between automaticity and conscious thought. This process of monitoring and controlling cognitive function is recognized in cognitive psychology as 'metacognition'. It is an important feature of self-regulated learning, which is essential for maintaining and improving skills.

Moulton *et al.* [11] expand on this view of balancing automaticity and effortful processing by recognizing 'slowing down when you should' as a feature of expertise. The phenomenon of 'slowing down' refers to a transition between automatic and effortful processing when an unexpected, unusual or difficult situation arises. 'Slowing down' is thought to be an important feature of expert judgement which allows experts to engage in more deliberate thinking when required. This theory supports the notion of expertise as a process and suggests that medical education should develop students as experts, rather than experienced non-experts.

Our review question was 'how does undergraduate education prepare new graduates to be safe prescribers and how could it be improved?' We would argue that, based on the theory above, achieving a predetermined standard of competence in isolated aspects of prescribing is unlikely to make new graduates safe prescribers, because the task, the contexts in which it has to be applied and the interaction between the two are very complex. We provide an alternative approach in Figure 1, therefore, which integrates various theories of expertise development. The diagram illustrates the different aspects of a complex skill which are involved in expert performance of it. An important feature is the outer circle, which represents the environment in which performance of the skill takes place. We refer to this as social context which, for prescribing, could include a variety of clinical circumstances. The white boxes represent internal cognitive processes, which must interact with the social context if expertise is to be achieved. The model emphasizes that knowledge, skills and attitudes need to be integrated and are involved in a continuous feedback loop with the social context. Self-regulation, which involves motivation and metacognition, enables an expert to adapt to the demands of the task within the workplace by determining the appropriate level of cognitive engagement required to complete the task successfully, or seek help if necessary. Every time the skill must be practiced within a new context, learning must be

Figure 1

Theoretical model based on theories of expertise development and instructional design theory for complex skills [9, 11, 28]

transferred, which is an effortful and error-prone process. Our diagram illustrates that learning must often be transferred to multiple situations and contexts. Failure to take an integrated approach to addressing the whole task of prescribing, within the social context of the workplace, hinders learning transfer, thereby increasing the potential for errors.

To illustrate our theoretical model using the example quoted at the head of this article, the junior doctor is attempting to apply knowledge learned outside of the workplace to his patient. He knows the pharmacology of and indications for paracetamol, but has not developed an understanding of how to apply this knowledge in the real context of practice. Although the doctor monitored the situation and correctly identified that he needed help, he did not have the ability to adapt his own knowledge and skills to the situation at hand. Assuming that the nurse taught him how to prescribe successfully for this particular patient, it is likely that he would still find it difficult to tackle the complexity of prescribing paracetamol for a different patient who had renal failure, for example. As a novice, all of his cognitive efforts would be directed to achieving the

basics, such as which boxes of the drug chart to write in. An expert would be able to process certain aspects of the task automatically, focusing his cognitive output on the parts of the task he judged to require more attention.

We set out to answer our review question by seeing how research to date fits our theoretical model of how prescribing education *could* work, in order to identify implications for practice and suggest a future research agenda.

Methods

Literature search

Whilst we did not set out to conduct a systematic review, we aimed to do a thorough review of primary empirical research on undergraduate prescribing education. We searched the following databases for articles from 2000–2011: MEDLINE, EMBASE, PsycINFO, CINAHL, Cochrane Trials Database and Scopus. We extended the search of MEDLINE, EMBASE, PsycINFO, CINAHL and the Cochrane Trials Database back to 1980, which added no informative

Table 1

BEME strength scale

Strength	
1	No clear conclusions can be drawn. Not significant
2	Results ambiguous, but there appears to be a trend.
3	Conclusions can probably be based on the results.
4	Results are clear and very likely to be true.
5	Results are unequivocal.

papers. Search terms included prescribing, prescriptions, education, teaching, learning, curriculum, medical education, medical student and undergraduate student.

Study selection

We only included literature on undergraduate medical student prescribing. Papers referring to the education of doctors or non-medical prescribers were excluded. Studies were only included if they evaluated an educational intervention or initiative. Studies that assessed the prevalence of prescribing errors without discussing the educational background were excluded. All study designs were considered but, pragmatically, the review was restricted to English language papers. LM applied these criteria to the citations identified by the search, selecting abstracts for further review. Abstracts were included or excluded according to the same criteria and the full text of the remaining citations was retrieved. TD and LM reviewed the full text of potentially relevant articles, categorizing each one as empirical research, opinion/review, or curriculum design, or excluding it. Only empirical research was included in the review, but other articles were considered appropriate background reading.

Reliability assessment

Each paper selected for inclusion was assessed for methodological reliability using the BEME strength scale (Table 1), as advocated by Yardley & Dornan [12]. Studies scoring less than 3 (the scale midpoint) were excluded.

Evaluation of data

TD and LM jointly reviewed the learning theories discussed in the introduction and developed the interpretive framework shown in Figure 1 which was used to formulate a coding sheet. This was refined by reviewing half the selected papers together. Once the coding sheet had been developed, LM formally coded the papers to it, discussing the interpretation with TD and MT as the study proceeded.

Data analysis and synthesis

We mapped interventions to the framework by pinpointing which aspects of the whole task had been considered in each study, either as part of the intervention itself or the

evaluation of it. Workplaces have very distinct sociocultural features, which makes it hard to transfer learning that was acquired in other contexts to them [2]. It should be noted that whilst we acknowledged the learning context of the intervention, 'context' as depicted in the framework refers only to real world prescribing contexts. We evaluated the extent to which it was included in intervention designs.

Results

Search results

The initial search identified 2473 papers. Two hundred and seven of them were identified by screening titles as suitable for further assessment. Forty-three of these articles, which appeared relevant, were retrieved in full text. Nineteen articles were excluded as they did not meet the inclusion criteria. Seventeen of the remaining 24 articles were empirical research and were therefore eligible to be included, whilst four descriptions of curricula or instructional designs and four opinion/review articles were ineligible. Two of the empirical articles were excluded because their BEME strength score was below 3, so a total of 15 empirical studies were reviewed in detail.

The main features of the studies can be seen in Table 2. All were conducted between the years 2002 and 2010, eleven of them after 2005. Six of the studies were controlled trials. The number of participants receiving the intervention ranged from nine to 98. Six studies were before and after studies with the number of participants ranging from 21 to 79. The three remaining studies were prospective observational studies. One study observed a whole year group over 3 years, one invited participants from the 1300 students in the whole medical school and the other introduced a curriculum intervention for all students in years 2 to 4.

Most studies focused on improving students' knowledge and skills and used a variety of approaches to do so. Only one intervention was implemented predominantly in the workplace [13] whilst students were taught outside the workplace in others. Two of the studies were entirely web-based [14, 15], concentrating on developing students' pharmacology knowledge and some skills, such as dose calculations. Other studies took more integrated approaches, using problem-based learning [16, 17], combining different teaching methods and/or using simulated scenarios [14, 18–21]. Most papers acknowledged the complexity of learning to prescribe, but none rigorously analyzed the prescribing task in order to develop an intervention that took account of all the components of complex skill acquisition. The majority of interventions targeted the central box of Figure 1, whilst largely neglecting the importance of practice contexts and the problem of training transfer. Similarly, the evaluation of interventions

Table 2
Study details and framework mapping

	Participants (n)	Year group	Intervention (description)	Framework mapping										Strength (BEME)				
				Intervention			Evaluation											
				K	S	A	M	C	T	R	K	S	A	M	C	T	R	
Controlled trials																		
Celebi <i>et al.</i> [16]	74	5	Teaching module on prescription errors	✓	✓	✓			✓		✓	✓						4
De Vries <i>et al.</i> [25]	I1 = 94, I2 = 98, C = 191		WHO Good Prescribing Guide, with (I1) or without (I2) personal formulary.	✓							✓	✓					✓	4
Degnan <i>et al.</i> [14]	I = 9, C = 35	5	Online module, emergency medicine. Simulated context.	✓	✓						✓	✓	✓		✓		✓	4
Sandilands <i>et al.</i> [13]	I = 50, C = 28	5	Doctor and pharmacist led. Practical teaching and bedside teaching.	✓	✓			✓			✓	✓	✓	✓			✓	4
Scobie <i>et al.</i> [18]	I = 40, C = 40	5	Pharmacist facilitated teaching	✓	✓						✓	✓	✓	✓			✓	4
Tonkin <i>et al.</i> [19]	I = 73, C = 71	6	Tutorial for prescription writing	✓	✓						✓	✓	✓				✓	4
Before and after																		
Garbutt <i>et al.</i> [26]	28	3	Educational meetings focusing on avoiding errors	✓							✓	✓		✓				3
Karaalp <i>et al.</i> [20]	79	5	Problem-based pharmacotherapy course based on WHO Good Prescribing Guide.	✓	✓		✓				✓	✓				✓		4
Naritoku <i>et al.</i> [24]	61	4	Pharmacology teaching delivered by a pharmacologist and clinical physician	✓													✓	4
Shankar <i>et al.</i> [17]	64	1	Problem-based pharmacology session	✓	✓						✓						✓	3
Wells <i>et al.</i> [22]	21	3	Teaching session with pharmacist and elderly patient.	✓	✓						✓						✓	4
Zgheib <i>et al.</i> [23]	78	2	Case-based discussions, team-based learning. Pharmacology course.	✓	✓	✓					✓	✓						3
Prospective observational																		
Flockhart <i>et al.</i> [21]	All year 4	4	Core curriculum for 4 th years – combination of teaching methods	✓	✓						✓	✓		✓				4
Maxwell <i>et al.</i> [15]	1300	All	Web based. Student formulary, pharmacology, access to lecture notes.	✓													✓	4
Richir <i>et al.</i> [38]	292	2–4	Context-learning pharmacotherapy program. Role-play/OSCE.	✓	✓	✓					✓	✓	✓	✓		✓		4

Participants (n): C, control; I, intervention. Intervention/evaluation: K, knowledge; S, skills; A, attitudes; M, metacognition; C, sociocultural context of workplaces; T, learning transfer; R, student/teacher reactions.

focused predominantly on knowledge and skills, depicted in the central box of the diagram.

In order to evaluate the interventions, several studies attempted to replicate an authentic workplace prescribing task by setting OSCE stations [18–20] or asking students to prescribe for a simulated case scenario [14, 16]. None of the studies, however, actually assessed students' ability to prescribe within a real workplace context and, therefore, did not evaluate the whole task of prescribing that has been illustrated in Figure 1. Others used question based evaluation [22, 23], one study combining multiple choice exam questions with problem-based oral exams [21]. As well as assessing outcomes objectively, most studies evaluated students' opinions of the intervention and reported positive student feedback. Some studies chose to evaluate student satisfaction alone, without any assessment of prescribing ability [15, 17, 24].

Most of the studies that assessed performance evaluated students soon after the intervention, making it unclear whether expertise improved in the longer term. All the before and after studies lacked control groups, making it difficult to ascertain whether any improvement in performance was directly related to the intervention. Others included a variety of different teaching methods in their intervention making it unclear which part of the intervention might be effective [16, 21, 23]. Some of the studies evaluated aspects of prescribing expertise that the intervention had not specifically targeted [14, 25, 26].

Discussion

Principle findings and meaning

The methods of teaching prescribing that we have reviewed in this article have focused mainly on improving students' knowledge and skills. The context sensitive nature of learning medicine has been well described and documented [27]. Yet, whilst it is undoubtedly an important aspect of learning to prescribe, the context in which knowledge and skills need to be applied has been largely ignored in the studies we have reviewed. Whilst some studies acknowledged the problem of transfer and context, none aimed to integrate all the components of the prescribing task that we have outlined in our theoretical model. Just as prescribing errors arise out of complex situations [5], interventions to minimize errors must also take account of this complexity. It is clearly important to provide students with the knowledge and skills they require to become successful prescribers but it is the ability to apply those proficiencies in the workplace context that will determine whether they can prescribe safely as new graduates. Whilst there may be some benefit to practicing constituent skills in isolation, we suggest that prescribing education needs to avoid leaving the constituent parts fragmented and, instead, take a more integrated and contextualized approach. Van Merriënboer & Kirschner

have suggested how that might be done for complex skills by combining four-component instructional design and cognitive load theory [28]. This systematic approach to complex learning places value on authentic learning tasks and the co-ordination of constituent skills in order to improve the transfer of learning to different contexts. They reason that declarative, procedural and affective learning must be integrated into a holistic instructional design approach.

Strengths and limitations

While we do not claim to have carried out a systematic review, we have conducted a thorough review of the current literature on prescribing education. One of the main strengths of our review is the theoretical perspective from which we have viewed the literature. Our theoretical framework of prescribing expertise has allowed us to evaluate the studies from a unique position, one that offers greater insight into which aspects of prescribing education need to be addressed if interventions are to be successful in improving the safety of new graduates. We have placed importance on the learning context and have highlighted the issue of transferring expertise between contexts. Another strength is the range of expertise in the research team. Together we represented the perspectives of medical student, pharmacist, doctor and educationalist.

The conclusions of our review were limited by the small number of papers that were ultimately relevant to our research question. While we have been able to theorize the necessary components of a successful educational intervention, none of the studies took a sufficiently integrated approach to demonstrate how that might work in practical terms. As mentioned above, more research will be required to design and evaluate an effective intervention for safer prescribing. A limitation of our work is the extent to which the literature is an authentic representation of reality. This is a review of published literature so we have not been able to review all prescribing education. We have explored how and why interventions work (or do not work) by reviewing the published literature from a well-theorized perspective on expertise development. This makes our findings highly relevant to the progression of future research and educational interventions.

Relation to other publications

We are in agreement with Ross *et al.* [6] in concluding that there is insufficient evidence in the literature to inform curriculum design for prescribing skills. Whilst we would agree that outcome measures should be based on real life practice as far as possible, we would also suggest that the interventions themselves need to be grounded in real-life context. Ross & Maxwell have recently provided an informative overview of the challenges involved in developing effective strategies for prescribing education, the desired learning outcomes for medical graduates and some suggestions for enhancing undergraduate curricula [29]. We

believe that our review of learning theory has gone some way in addressing the need for a consensus on the cognitive skills required for safe prescribing, whilst our theoretical model of prescribing expertise provides a suitable background on which to consider the design and evaluation of future developments in prescribing education. Similar theoretical models have proved to be informative when considering specific aspects of prescribing, such as decision making [30] and therapeutic reasoning [31]. Medical decision making within clinical practice is certainly relevant to our work [32] but we have concentrated solely on prescribing expertise, in order to explore the whole task in as much depth as possible.

Our previous research (EQUIP) [2] showed how learning to prescribe is a social process, during which students actively engage with the sociocultural learning environment as they develop cognitive expertise [33–35]. Prescribing is a task which is embedded within the culture and values of the workplace [36], making it inappropriate to teach it predominantly outside of this context.

Van Merriënboer & Kirschner emphasise the importance of cognition, metacognition and transfer in education [28]. The studies examined in this review primarily concentrated on cognition, whilst neglecting the concepts of metacognition and transfer. Four-component instructional design theory emphasizes the importance of dealing with complexity by addressing the relationship between different aspects of the task, including the socio-cultural context. Value is placed on whole-task practice, which encourages learners to view the task holistically and build expertise that is grounded in context. The overall aim is for students to accumulate cognitive strategies which enable them to apply successfully their learning to a variety of situations. Learners are also encouraged to develop metacognitive skills, which are essential for self-regulated learning, successful learning transfer and achieving balance between automaticity and cognitive engagement as expertise develops [11].

Wider implications

The results of our review suggest that the shortfall in current prescribing education could be a result of insufficient integration of all the necessary aspects of prescribing expertise. Based on our findings, we suggest that medical schools consider evaluating their undergraduate prescribing education based on a framework of expertise development. Practically, this could involve observing and evaluating students within the context of workplaces.

However, before assumptions can be made regarding the practical solutions for prescribing education, it seems necessary to conduct further research to develop a better understanding of students' learning. We have now defined the expected outcome of an educational intervention (expertise), and the aspects of the prescribing task it must address (shown in Figure 1). However, the question of how students actually learn complex skills remains to be

answered. While deficiencies in prescribing education are evident, students still acquire a certain level of skill in prescribing prior to graduation, albeit lower than the standard demanded by professional practice. It seems necessary to evaluate students' learning, during formal teaching and informal learning in the workplace, in order to develop an understanding of what works, for whom and under what conditions. Our next study will explore this by asking students to record audio diaries of their prescribing-related learning experiences and take part in qualitative interviews. We propose that by combining this insight with instructional design theories for learning complex skills, it should be possible to design an educational intervention that encourages expertise development. Our focus will be on the self-regulation aspect of our theoretical model, with the aim of encouraging learners to improve their ability to monitor and control their cognitive functioning. We anticipate that our intervention could be implemented alongside other developments in prescribing education [29], such as pre-prescribing [37], e-Learning and student formularies.

Conclusion

This review has highlighted the complexities involved in educating medical students to become safe prescribers. We have explained why it is necessary for undergraduate education to encourage the development of expertise, as opposed to focusing on competency. Our theoretical model illustrates the necessary aspects of a complex skill which must be addressed in order to achieve expertise. If graduates are to be safe prescribers, their knowledge, skills and attitudes must be integrated into the complex social context of the workplace. The articles we reviewed show that prescribing education does not currently attend to all the features of our model, often breaking the skill down into constituent parts, rather than focusing on the whole task. We suggest that taking a whole task approach to developing educational interventions for prescribing could help to educate graduates who possess the necessary expertise to prescribe safely in the workplace.

Competing Interests

There are no competing interests to declare.

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