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Safety in numbers 2: Competency modelling and diagnostic error assessment in medication dosage calculation problem-solving

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ABSTRACT

Accurately defining and modelling competence in medication dosage calculation problem-solving (MDC-PS) is a fundamental pre-requisite to measuring competence, diagnosing errors and determining the necessary design and content of professional education programmes. In this paper we advance an MDC-PS competence model that illustrates the relationship between conceptual competence (dosage problem-understanding), calculation competence (dosage-computation) and technical measurement competence (dosage-measurement). To facilitate bridging of the theory–practice gap it is critical that such models are operationalised within a wider education framework that supports the learning, assessment and synthesis of cognitive competence (the knowing that and knowing why of MDC-PS) and functional competence (the know-how and skills associated with the professional practice of MDC-PS in clinical settings).

Within the context of supporting the learning and diagnostic assessment of MDC-PS we explore PhD fieldwork that challenges the value of pedagogical approaches that focus solely on abstract information, that isolate the process of knowledge construction from its application in practice settings and contribute to the generation of conceptual errors. We consider misconceptions theory and the concept of mathematical 'dropped stitches' and offer an assessment model and program designed to diagnose flawed arithmetical operation and computation constructs.

Introduction, background and aims

Past, present & future challenges in medication dosage calculation problem-solving (MDC-PS) education

When children are presented with information that is divorced from their experience, they strive to connect it with the most approximate reality with which they are familiar. Eric Midwinter gives a memorable example of this,

> *Some time ago I inspected a child's drawing of 'Silent night; Holy night'. As well as the traditional complement of holy family, wise men, shepherds, oxen and asses, there was also a cheerful, stout fellow in a brown jerkin gazing benignly into the crib. "Who is that?" we asked… 'Round John Virgin', said the artist.*
>
> Excerpt from '*The Irrelevance of the Curriculum*' (Midwinter, 1972, p. 278).

Some people who read this extract immediately understand the child's misconception, while others ironically fail to '*see*' the meaning in Midwinter's description ('*see*' Fig. 1 for an artist's impression to support the textual description). In this paper, we explore an analogous problem associated with nursing curricula that divorce the classroom from the real world of clinical nursing practice. We argue that such curricula perpetuate a theory–practice gap that negatively affects the learning of MDC-PS knowledge and skills. This gap is evident when nursing students fail to '*see*' the meaning embedded in the language and symbols of medication dosage calculation word problems and/or the actions of registered practitioners performing dosage calculation problem-solving in the practice setting.

This theory–practice gap is significant because a failure to effectively learn MDC-PS knowledge and skills can contribute to medication errors in clinical nursing practice. Medication errors are

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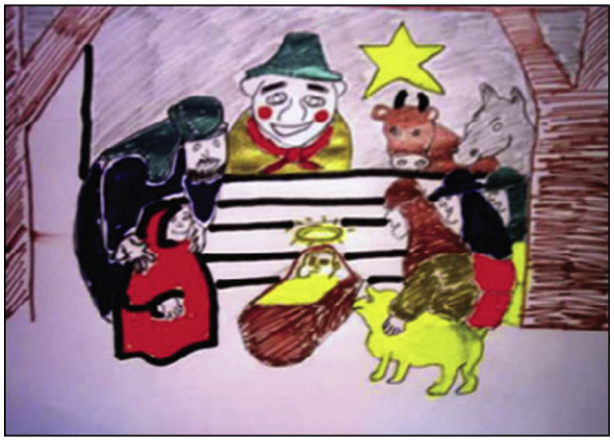

Fig. 1. (© K.L. Weeks 2012) Artist's impression of 'Silent night, Holy night'.

the most prevalent type of medical/nursing error recorded worldwide. Reported incidences of dosage calculation errors in clinical nursing practice average 5% of all errors, with reported rates of up to 14% (Dean et al., 1995; Lesar et al., 1997; Taxis and Barber, 2003). Rates of up to 33% have been cited for incorrect dose administration to patients (Røykenes and Larsen, 2010). In the UK, 25% of the UK National Health Service (NHS) litigation bill involves cases of drug error and the UK Department of Health (2000, 2004) has prioritised making the NHS safer for patients. A significant proportion of these errors have been blamed on inadequate staff training and assessment. The most common contributory factors are miscalculation, failure to titrate doses to patients' needs, miscommunication and all team members failing to check doses before dispensing, preparing or administering medication (NPSA, 2009, p. 19). Medication dosage calculation errors are highlighted as an aspect of clinical governance and as a key target for remedial action (Wright, 2006; Jukes and Gilchrist, 2006; NPSA, 2006a,b, 2009).

In the light of these issues we wish to question the value of mechanistic and teacher-centric practices that have traditionally treated students as passive recipients of decontextualised and symbolic (word- and number-based) knowledge. We argue that these practices isolate the process of knowledge construction from its application in clinical practice, and perpetuate a theory–practice gap. In this paper we:

1. Explore *competence in MDC-PS.* We illustrate the design of a MDC-PS competence model that articulates the relationship between the conceptual, calculation and technical measurement facets of MDC-PS competence. It also allows for diagnosis of errors in these three competence domains.
2. Describe how the traditional classroom-based transmission models of education, as well as the proceduralisation of the medicines management process in clinical practice generate a theory–practice gap and contribute to MDC-PS *conceptual errors.*
3. Explore the origin of calculation errors and offer an assessment tool to assist diagnosis of errors in calculation that manifest as MDC-PS *arithmetical operation* and *computation errors.*

The ideas, analysis and frameworks described in this paper are a precursor to the other papers in the series that explore the development and evaluation of authentic environments that have been designed to bridge the theory–practice gap and develop nurses' MDC-PS competence.

Methodology

In this paper we explore the *problem assessment and framing phase* of a 20-year programme of medication dosage calculation problem-solving (MDC-PS) education action research. In Weeks et al. (2013a) we explain the basis of the education action research process, and here we describe the fieldwork that preceded a PhD research programme undertaken at a large UK university. This work took place in the early years of the programme and describes the work with nursing students who had mostly been school educated in the late 1970s to early 1990s period.

The fieldwork investigated MDC-PS competence requirements and addressed university nursing students' medication dosage calculation errors. It began with a five-year period of action research fieldwork punctuated with episodes of ethnographic study, elements of which have been reported in detail previously (Weeks, 2001; Weeks et al., 2000,2001; Lowes and Weeks, 2006). By gaining entry to the students' world via an *emic* perspective (Pike, 1967), it explored and attempted to empathize with the way students perceived the teaching and learning methodologies used in classroom and clinical practice environments when they were learning dosage calculation problem-solving skills. Participant observation, field note recording and post-experience interviews took place during classroom-based theoretical preparation, and clinical placements where medication dosage calculation problem-solving formed a part of wider medicine and patient care management. Detailed student evaluations of these experiences are reported in Weeks et al. (2013d).

We begin our exploration of the problem assessment and framing process with an analysis of the design features of a MDC-PS competence model.

Defining competence in MDC-PS

Facilitating the construction of professional knowledge and its application to professional competence development, performance, assessment and evaluation is a key mission of professional healthcare education and lies at the heart of professional registration and maintaining patient safety in clinical practice. However, in nursing education we have traditionally made a distinction between the teaching and assessment of knowledge and the teaching and assessment of competent and skilled performance. Thus in a traditional education system we have created not only a theory–practice gap, but also a knowledge-performance gap that separates 'knowing that' from 'knowing how'. This problem is exacerbated when we attempt to *define* and *describe* the requirements of competent performance through propositional language. Lum (2004) on questioning whether competence can be described and communicated via language in accurate and unequivocal terms, concluded that,

> *Ultimately, the essentially non-discursive nature of human capability can be seen to have important ramifications for both curriculum design and assessment in vocational education and training. It certainly raises serious doubts about the wisdom of an approach based on the assumption that it is possible to describe competence in precise detail. It would seem that in the last analysis present arrangements can only provide us with an impoverished and insufficient account of the educational enterprise and a mode of assessment which inevitably falls short of what it sets out to do (p. 496).*

More recently Wright (2012) and Weeks et al. (2013b) have called for a review and rethink of both the traditional method for