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Safety in numbers 4: The relationship between exposure to authentic and didactic environments and Nursing Students' learning of medication dosage calculation problem solving knowledge and skills

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ABSTRACT

Advancing the art and science of education practice requires a robust evaluation of the relationship between students' exposure to learning and assessment environments and the development of their cognitive competence (knowing that and why) and functional competence (know-how and skills). Healthcare education translation research requires specific education technology assessments and evaluations that consist of quantitative analyses of empirical data and qualitative evaluations of the lived student experience of the education journey and schemata construction (Weeks et al., 2013a). This paper focuses on the outcomes of UK PhD and USA post-doctorate experimental research. We evaluated the relationship between exposure to traditional didactic methods of education, prototypes of an authentic medication dosage calculation problem-solving (MDC-PS) environment and nursing students' construction of conceptual and calculation competence in medication dosage calculation problem-solving skills.

Empirical outcomes from both UK and USA programmes of research identified highly significant differences in the construction of conceptual and calculation competence in MDC-PS following exposure to the authentic learning environment to that following exposure to traditional didactic transmission methods of education ($p < 0.001$). This research highlighted that for many students exposure to authentic learning environments is an essential first step in the development of conceptual and calculation competence and relevant schemata construction (internal representations of the relationship between the features of authentic dosage problems and calculation functions); and how authentic environments more ably support all cognitive (learning) styles in mathematics than traditional didactic methods of education. Functional competence evaluations are addressed in Macdonald et al. (2013) and Weeks et al. (2013e).

Introduction

In this fourth paper in the *Safety in Numbers* medication dosage calculation problem-solving (MDC-PS) series we focus on the 1997–2001 UK and USA proof of concept research (see Weeks et al., 2013a). This research first evaluated the relationship between exposure to traditional didactic methods of education, prototypes of the authentic environment illustrated in Weeks et al. (2013c) and nursing students' construction of conceptual and calculation competence for medication dosage problem-solving skills (see Fig. 1).

Within this framework we will explore:

a. An analysis of participating UK nursing students' baseline numeracy skills, GCSE mathematics grade and cognitive style in mathematics (CSM).
b. The outcomes of a UK college-based crossover experiment & series of clinical case studies.
c. The outcomes of a USA college-based experiment.

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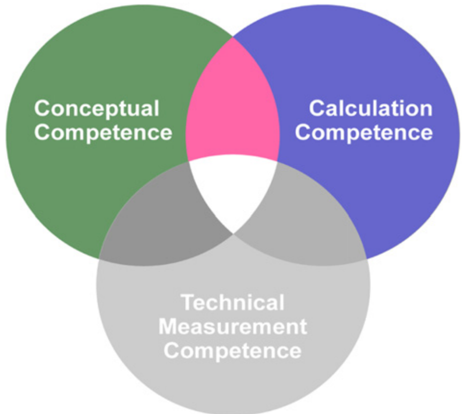

Fig. 1. Model illustrating the research programme emphasis on the construction of *conceptual and calculation competence* for medication dosage problem-solving skills.

Background & literature

This international programme of MDC-PS proof of concept research resulted as a follow-up to a five-year period of classroom and clinical practice based fieldwork described by Weeks et al. (2013b). This fieldwork defined and illustrated a MDC-PS competence model (Fig. 1) and classified three types of dosage errors (conceptual, calculation and technical-measurement). The outcomes from this fieldwork challenged the value of traditional classroom-based didactic teaching methods that focus solely on abstract information and that isolate the process of knowledge construction from its application in practice settings. Specifically the research suggested that these pedagogical approaches contributed to conceptual (problem set-up errors). Two types of calculation error were described: arithmetical operation errors (e.g., inappropriately dividing a fraction numerator into its denominator) and computation errors (e.g., basic errors of multiplication and division etc). Previous work in the field suggested that these errors stemmed from mathematical dropped stitches associated with absence from primary or secondary school at a critical time or failure to understand a key mathematical concept that resulted in missing a link in the learning process.

This paper focuses on the primary UK PhD and USA post-doctorate programmes of research that evaluated exposure to authentic and transmission education environments and nursing students' development of *conceptual and calculation competence* in MDC-PS skills. A third classification of competence and error, *technical measurement* (see Fig. 1), was not investigated in this original study. See Sabin et al. (2013) for an evaluation of the internal reliability and criterion-related validity of authentic assessment and OSCE environments for measuring technical measurement competence.

Methods

In both the UK and the USA proof of concept studies, the research hypotheses focused on exploring the relationship between exposure to authentic and transmission education environments and nursing students' learning of MDC-PS skills. Table 1 illustrates an overview of the investigation. This consisted of baseline assessments, a college-based experiment and in the UK a 16-week follow up clinical assessment and evaluation phase.

The UK study

As illustrated in Table 1 the UK study was undertaken between 1998 and 1999, as part of a PhD study of a pre-registration Diploma in Nursing Studies programme at a large UK university. It consisted of a two-phase college based cross-over experiment and a follow up clinical practice based series of student case studies and evaluations.

The college based cross-over experiment

The research method followed the classic experimental design described by Campbell and Stanley (1963), cited in McLaughlin and Marasculio (1990, p.60). The classic experiment has three components:

1. Random assignment of subjects to experimental conditions.
2. At least one control group.
3. Clear and unambiguous specifications of the manipulation of an independent variable.

Design of the crossover experiment

The experiment was designed to identify and compare the relationship between variation in exposure to two learning environments and the development of cognitive competence (knowledge) in novice pre-registration nursing students' medication dosage calculation skills. The essential features of the two environments consisted of:

a. *A computer-based prototype of the authentic environment* illustrated by Weeks et al. (2001) and Weeks et al. (2013c). This environment was developed via a recursive co-development programme involving the lead nursing lecturer who designed the program (KW), registered nurses and pharmacists and nursing students. The completed programme consisted of a CD-ROM based and technology enhanced interactive computer program that was populated with digital photographs of real world prescription charts, medication containers and their labels (ampoules, medicine bottles etc), and medication measurement and administration vehicles (tablets, capsules, medicine pots, syringes, IV infusion crystalloid solutions & administration sets etc) mapped onto appropriate equations for solving dosage and rate problems. Subsequently using the principles of cognitive apprenticeship described by Weeks et al. (2013c), participants were exposed to two 90 min supervised periods of:
   - Modeling of expert techniques for understanding and solving authentic medication dosage calculation problems;
   - Scaffolded support in strategies for setting up and solving dosage equations;
   - Formative assessments designed to articulate participants conceptual understanding of how to set-up and calculate dosage equations;
   - Abstracted replay reflection exercises that facilitated comparison of the participant's equation set-up and calculation performance with that of the expert solution expressed in both inchworm and grasshopper *cognitive (learning) style forms*.

b. *A classroom-based didactic transmission environment*. This consisted of the standard university method for teaching medication dosage calculation problem-solving. Experienced lecturers with 15–30 years of experience within the field presented a 90 min lecture and a 90 min tutorial consisting of:
   - Modeling of word and number based medication dosage calculation problems;
   - Drill and practice in the setting up and solving of dosage equations;