Adapting SafeMedicate (Medication Dosage Calculation Skills software) For Use In Brazil

Samia Valeria Ozorio Dutra
University of South Florida, samiavaleria@mail.usf.edu

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Adapting SafeMedicate (Medication Dosage Calculation Skills software) For Use In Brazil

by

Samia Valeria Ozorio Dutra

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Nursing College of Nursing University of South Florida

Major Professor: John Clochesy, Ph.D.
Constance Visovsky, Ph.D.
Teresa Gore, Ph.D.
Keith Weeks, Ph.D.

Date of Approval:
June 6, 2018

Keywords: students, nursing, education, drug dosage calculations, virtual, and mathematics.

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DEDICATION

Every challenging work needs self-effort as well as guidance. This dissertation is gratefully dedicated to God, my parents, my godparents, my professors, and friends whose love, encouragement, and prays make me able to achieve such success and honor.


Be the change you want to see in the world.
ACKNOWLEDGMENTS

I acknowledge Dr John Clochesy and Dr Maureen Groer for supporting me on every step of my career development during my PhD program. These tutors are rare jewels.

I acknowledge the financial support from the Brazilian Federal Agency for Support and Evaluation of Graduate Education (CAPES) and National Institute of Health who through University of South Florida funded my studies, health insurance, and stipend.
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ABSTRACT

Medication related errors are a significant cause of morbidity and mortality. In Brazil, most errors are related to prescribing, preparing, and administering medications. One way to deal with this barrier to safe care is through assessment and education of medication calculation dosage skills. Considering the Brazilian reality, this dissertation is a context and language adaptation of an evidence-based intervention called safeMedicate, a program that reinforces learning synthesis in crucial elements of medication dosage problem solving and provides the foundation for development in remaining levels of the hierarchy of learning. A guideline for drug calculation skills development or improvement based on the seven research-based principles for smart teaching was developed. Teaching approaches are beneficial for multiple methods of learning by addressing cognitive, motivational, and developmental goals. Web-based software would be a strong ally on adopting those approaches by complementing the class practice and providing opportunities for practice learning. The two-phases of adaptation and preliminary evaluation of safeMedicate for use in Brazil were guided by the Participatory and Iterative Process Framework for Language Adaptation (PIPFLA) cross-cultural equivalence model. A triangulation method of face validity survey, journaling, and multiple focus groups was used. The focus groups were (1) language adaptation team, (2) panel of experts, and (3) student panel. In order to analyze focus group data, a systematic coding procedure was performed through an iterative process, solving any differences between coders in order to guarantee internal consistency. The main themes were language, visual, content, programing, and data while discussing necessary adaptations of safeMedicate for use in Brazil.
BACKGROUND AND RATIONALE

Failures in the medication-use processes significantly contribute to the reduction of patient safety. A medication error is defined as any preventable event that may cause or lead to inappropriate medication use or harm to a patient (Agência Nacional de Vigilância Sanitária, 2009). As such, it is important to identify the frequent medication errors, particularly in the Brazilian clinical practice.

A Drug Information Centre in Brazil reports that most errors are related to prescribing, preparing, and administering medications. The errors result in wrong dose/overdose (13.2%), wrong route of administration (11.4%), inadequate drug storage (11.4%), and wrong dosage form (ex. Tablets, capsules, ampoules, IV infusion crystalloid solutions, etc) (8.8%) (Dos Santos, Winkler, Dos Santos, & Martinbiancho, 2015). Of note, overdose is related to excessive administration of the drug, which may be related to the wrong prescription or the wrong dose preparation or a combination of these two factors.

Brazil does not yet have available death statistics related to medication errors (Brasil, 2013), but studies suggests that, in the US, at least one death per day can be attributed to medication errors and harm up to 1.3 million people a year (Partin, 2006). Medication errors were the primary source of death in Medicare patients, contributing to prolonged hospital stay (James, 2013). A study comparing the educational practices and perspectives related to the medication dosage calculation skills of providers reports that most academic educators in nursing, clinical educators in nursing and clinical nurses agree that dosage calculation skills are important for safe medication administration (Crawford, 2016).
Medication administration is an important and essential nursing function with the potential for dangerous consequences if errors occur. One way to minimize this threat is to provide competency-based education for personnel charged with any tasks related to medication administration. Considering the Brazilian reality, this dissertation is a context and language adaptation of an evidence-based assessment and educational system called safeMedicate that was developed through a translational research process spanning more than 20 years. The translational research process links basic research and application in clinical practice addressing two gaps: the knowledge/technology transfer and health professional evaluation (Young, Weeks, & Hutton, 2013).

The product developed from this sequential research process is now used by many education organizations worldwide to educate and support student nurses and midwives to develop their medicine management skills, particularly in medication dosage calculation problem solving (MDC-PS). The program is currently sold as safeMedicate North American English for the United States, Canada, another English version for United Kingdom, as well as French version for Canada and Switzerland.

In order to adapt safeMedicate for use in Brazil, it is necessary to address the health professional evaluation guaranteeing it meets the professional practice, professional regulation, and political requirements. The safeMedicate system is designed to support the learning synthesis and diagnostic assessment of cognitive competence in critical elements of medication dosage problem solving and underpin the application of further competence development and evaluation within each of the remaining levels of the hierarchy for learning (Authentic World, 2009). This web-based system had been exposed to rigorous evaluation and assessment of the outcomes in the professional practice (Holland, 2013).
Medication dosage problem solving consists of 3 interrelated elements: (1) conceptual competence which involves correctly interpreting a medication dosage calculation problem and accurately setting up a dosage equation; (2) calculation competence which involves correctly calculating an accurate numerical value for the dose or rate to be administered; and (3) technical measurement competence which involves selecting an appropriate measurement vehicle and accurately measuring the dose or rate to be administered (K. W. Weeks, Meriel Hutton, Coben, Clochesy, & Pontin, 2013; K. W. Weeks, Sabin, Pontin, & Woolley, 2013).

Different from teaching methods which consider students as passive recipients, safeMedicate provides a contextualized learning environment where students can actively engage. Students using safeMedicate achieve significant improvements in the construction of conceptual and calculation competence in medication dosage calculation problem-solving (MDC-PS) in both UK and USA programmes. The authentic learning environment supports a spectrum of learning styles in mathematics by offering opportunities to tailor and expand mathematical skills through mental computation, arithmetic, geometry/visual, and algebra (Keith W Weeks, Clochesy, Hutton, & Moseley, 2013).

In order to inform and guide the language adaptation process, it is required to use a combined emic (within-culture/insider’s perspective) and etic (similarities across cultures/outsider’s perspective) (Berry, 1999; Marínez-Lora, Boustani, del Busto, & Leone, 2016; Matías-Carrelo et al., 2003) – an approach that’s significance will further be explicated below.
Theoretical basis of safeMedicate

The safeMedicate system is rooted in Piagetian psychology as it is useful to look closely at the ways in which the individual builds particular mathematical ideas or concepts. This knowledge and learning process is based on experiential learning, a model described by David Kolb and credited to Kurt Lewin (Kolb, 2014).

Piagetian psychology

The program safeMedicate was designed using Cognitive Constructivist Learning Theory, which is based on individuals’ constructions of knowledge through experience. Constructivism is a theoretical stance on knowledge and learning that addresses an individual’s learning through interactions with the external world, physical and social. One branch, called radical constructivism, strongly derives from Piaget and is seen largely in mathematics education (von Glasersfeld, 1982; Von Glasersfeld & Smith, 1996). An alternative branch, called social constructivism, strongly derives from Vygotsky and sees individual construction of knowledge as being strongly related to social interaction, discourse and patterns in language (Abdulwahed, Jaworski, & Crawford, 2012).

As safeMedicate program regards the development of dosage calculation skills, which relates to mathematics education, its development occurred in the light of Piaget constructivism. Piaget emphasized the importance of cognition in the construction of knowledge through two processes: assimilation and accommodation (Piaget, 1966). Assimilation occurs when the student links new information with prior learning experiences, or schemata. Accommodation refers to the creation of new schemas to organize information that the student cannot assimilate into existing schemas. Therefore, the knowledge and learning process is based on student experience.
However, experience alone is insufficient to be called experiential education, the reflection process is crucial (Dewey, 1998; Joplin, 1981; Saudelli, 2015). The reflective abstraction is a concept introduced by Piaget to describe the logico-mathematical structures by an individual during the cognitive development. It begins at the very earliest ages in the coordination of sensory and motor structures and continues on up through higher mathematics (Dubinsky, 2002). Still, this perspective does not draw attention to the ways social factors impinge on individual’s consciousness as the Vygotskian perspective focus (Abdulwahed et al., 2012; Young et al., 2013).

Overall, the safeMedicate experimental research highlighted how the exposure to authentic learning environment is the first step in the development of conceptual and calculation competence and relevant schemata construction, which refers to the internal representations of the relationship between the features of authentic dosage problems and calculation functions (Keith W Weeks et al., 2013). This development of mathematical ideas or concepts is a process based on the experience of knowledge and learning process, which is grounded on experiential learning, a model described by David Kolb.

**David Kolb and experiential learning**

A prominent model of experiential learning was described by David Kolb. He believed all learners have a learning style preference among four styles (accommodating, diverging, assimilating and converging), that are connected to a four-phase cycle of progressive learning. While the “accommodating” style learner usually is connected to tactile and kinesthetic learning for preferring hands-on engagement, the “diverging” style is sensitive and appreciate considering things from various perspectives. In the “assimilating” style learners welcome logical, concise,
and systematic approaches. Lastly, the “converging” learners prefer problem-solving types of learning approaches (Kolb, 2014; Saudelli, 2015).

The Kolb’s “Experiential Learning Cycle” propose that educators create teaching and learning moments at each point, thereby experiencing, reflecting, thinking and acting in an ongoing cycle. The cycle points consists of experiential moments with (1) “immediate or concrete experiences” which provide a basis for (2) “observations and reflections.” These observations and perspectives are assimilated and refined to form (3) ‘abstract concepts’. The abstract concepts develop to form new implications that can involve (4) ‘active experimentation’, thus creating new experiences (Kolb, 2014; Saudelli, 2015).

**Dissertation overview**

Using these theoretical bases, this dissertation aims to adapt and evaluate Authentic World Medication Dosage Calculation software for use in Brazil. While assessing evidence-based research of medication calculation skills education, the suggestion of developing a guidance of instruction strategies for drug calculation skills was nurtured. Consequently, the first section of the dissertation proposes instruction strategies design for drug calculation skills development or improvement based on the seven research-based principles for smart teaching.

The second section describes a systematic and transparent method of adaptation and evaluation of an educational software. This was performed in two phases: (1) adaptation and (2) preliminary evaluation. This dissertation uses a formative research approach which is a kind of developmental research or action research which improves instructional-design theory (model), practices, and processes (Reigeluth & Frick, 1999), guided by the adapted model of the
Participatory and Iterative Process Framework for Language Adaptation (PIPFLA) (Maríñez-Lora et al., 2016).

Lastly, the third section explore adaptations and preliminary evaluation of the safeMedicate Portuguese materials for use in Brazil following the methodology described on the second section. It hypothesizes that major adaptations will relate to protocols, guidelines, and Brazilian students’ language accessibility needs.

References


SECTION ONE:
UNDERPINNING SAFEMEDICATE PEDAGOGY AND AUTHENTIC LEARNING AND ASSESSMENT ENVIRONMENT

Abstract: This manuscript proposes instruction strategies design for drug calculation skills development or improvement based on the seven research-based principles for smart teaching. Two strategies were used during the development of this integrative review: a methodological strategy specific for integrative review and PRISMA. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement was used to evaluate the methodological quality of included studies. From the total 1,549 articles, 25 studies met the eligibility criteria. This review contemplates the analysis and considerations reported towards 11,202 nursing students/nurses who participated in the studies. Regarding methodology, the majority adopted a quantitative approach (68%), followed by qualitative (20%) and mixed methodology (12%). Teaching strategies fit into the framework of multiple research principles, some recurring approaches are collect data about students/nurses, model expert practice, scaffolding complex tasks, and being explicit about objectives and expectations. These approaches address cognitive, motivational, and developmental goals. Web-based software would be a strong ally on adopting those approaches by complementing the class practice and providing opportunities for practice learning.

Keywords: “students,” “nursing,” “education,” “drug dosage calculations,” and “mathematics.”
Introduction

The risk of an error occurring during the medication preparation ranges between 27 and 60% (Walsh, Kaushal, & Chessare, 2005). Different medication preparation phases are potentially subject to errors, such as the reconstitution of drugs, titration, preparation of solutions, and the calculation made to less than unit dose. The most common errors in this phase are using a different drug from the one prescribed, wrong dosage or dilution, and setting the wrong speed of infusion (Grugnetti, Bagnasco, Rosa, & Sasso, 2014; Wright, 2010).

Nursing students often show poor math skills and have difficulty doing calculations without a calculator. Even though the use of calculators may improve basic mathematical skills (sums, subtractions, multiplications, and divisions), drug calculation requires complex skills (calculation skills, logic, deduction, reasoning, and understanding) (Bagnasco et al., 2016; Bliss-Holtz, 1994). Dosage calculation skills are usually assessed on written tests in formal educational settings. However, the use of written tests as a valid measure of dosage calculation skills in clinical settings has been questioned. As a matter of fact, educational qualifications do not impact on skills required to calculate drug dosages correctly (Bagnasco et al., 2016; Hutton, 1998). This happens because math skills are not learned for all time but need to be refreshed through constant exercise and application of math rules and principles in order to maintain calculation competence.

Background

Dosage calculation errors. The types of medication calculation errors are identified and classified into two categories because solving medication dosage calculations takes two different sets of knowledge. One category relates to mathematical skills which are the arithmetic ability to
add, subtract, divide, and multiply. The other category involves conceptual skills which are necessary to formulate proportions and solve equations correctly. In other words, to set up the problem correctly (Blais & Bath, 1992; Bliss-Holtz, 1994).

The most common arithmetic errors made by nursing students identified in various studies are related to (1) converting units of measure with students showing difficulties even with the multiplications and divisions by 10, 100, and 1000 or percentages (Arkell & Rutter, 2012; Bagnasco et al., 2016; McMullan, Jones, & Lea, 2010), (2) difficulty in multiplying, reducing, or transforming fractions (Bagnasco et al., 2016); (3) calculating infusion rate solutions administered intravenously (Arkell & Rutter, 2012; Bagnasco et al., 2016; McMullan et al., 2010).

Conceptual mistakes are even more common than arithmetic errors (Mackie & Bruce, 2016) because the latter be minimized with the use of calculators (Bagnasco et al., 2016; Bliss-Holtz, 1994). They relate to (1) interpretation of information (Bagnasco et al., 2016) and (2) the conceptualization of calculations (how to set up problems) (Bagnasco et al., 2016; Blais & Bath, 1992; Jackson & James, 2011). Furthermore, students also demonstrate problems with identifying the form of medication to administer the medication (Blais & Bath, 1992).

Conceptual mistakes occur regularly because students often fail to make a semantic connection between the words themselves in the formula and the actual medication orders and doses found in practice. In other words, the standard recipe approach of setting up math problems does not address the conceptual aspect of problem-solving (Revell & McCurry, 2013; Weeks, Lyne, & Torrance, 2000).

Cognitive style in mathematics. The cognitive style in mathematics refers to an individual preferred or natural approach to numerical data. Many researchers suggested two
styles of mathematics learning (John B Bath & Blais, 1993; Chinn, 2001; Krutetskii, WIRSZUP, & Kilpatrick, 1976) linked to clinical and experimental research about hemispheric dominance. Hemispheric dominance is the learner’s preferred hemisphere control.

Learners’ with a dominant left hemisphere often take sequential step-by-step reflective processing and is likely to use paper and pencil in solving problems. This learning style is described by the term “inchworm” (John B Bath & Blais, 1993; John B. Bath, Chinn, & Knox, 1986). In contrast, the learner with right hemisphere dominance uses all-at-once impulsive processing. Usually, the person resists using paper and pencil, preferring to make initial estimates of the answer, restricting possible answers, and attempting several methods almost simultaneously. This learning style is described by the term “grasshopper”.

Objective

This manuscript categorizes instructional strategies design for drug calculation skills development or improvement using the seven research-based principles for smart teaching (Ambrose, Bridges, DiPietro, Lovett, & Norman, 2010). In other words, this manuscript describes a practical application of the seven research-based principles to drug calculation skills teaching.

The main strength of the seven principles is how they are evidence-based research, exploring cognitive, developmental, social psychology, anthropology, education, and diversity studies. The principles are applicable (1) across subject areas as the factors that impact the way students learn transcend disciplinary differences (domain-independent); (2) to all educational levels and pedagogical situations from K-12 to higher education (experience independent), (3) considering the differences in pedagogical implications; and (4) considering the culture would
influence how the principles are applied, cross-culturally relevancy. The principles help instructors reflect on their approaches efficiency.

Here we provide guidance on math teaching for nurses using evidence-based research. This review can help both new and experienced instructors. While the new instructors may understand the components of effective course design and classroom pedagogy, the experienced instructors may adapt to effective evidence-based troubleshoot strategies as well as to efficiently suit new courses or student populations.

**Methods**

Two strategies were used during the development of this integrative review: (1) a methodological strategy specific for integrative review (Whittemore & Knafl, 2005) and (2) PRISMA (Moher, Liberati, Tetzlaff, Altman, & Group, 2009). The author used a methodological strategy specific for integrative review (Whittemore & Knafl, 2005) to enhance the rigor of this study. The steps were (1) specifying the review purpose, (2) searching the literature, (3) evaluating data from primary sources, (4) analyzing data (through data reduction and comparison) and (5) presenting the results.

The researcher conducted an electronic search to identify studies related to the development of medication calculation skills on nursing students or nurses in the following databases: CINAHL, PubMed, and PsycINFO. Using the Medical Subject Headings (MeSH®) recognized thesaurus of keywords, the search terms used were “students,” “nursing,” “education,” “drug dosage calculations,” and “mathematics.” Search was carried out between July 2017 and May 2018.
To qualify for inclusion in the review, the studies had to include nursing students or nurses. The PRISMA four-phase flow diagram (available at [http://prisma-statement.org/](http://prisma-statement.org/)) was used to depict the article selection process. PRISMA stands for Preferred Reporting Items for Systematic Reviews and Meta-Analyses which help authors to improve reporting of systematic reviews and meta-analyses and is also useful for critical appraisal of published systematic reviews, although it is not a quality assessment instrument (Moher, Liberati, Tetzlaff, & Altman, 2010). From the total 1,549 articles (1546 derived from the database search and 3 from a hand search of reference list), 457 duplicates and excluded 951 records without full text access. The remaining 111 articles were screened for eligibility and 86 excluded (see Figure 1). Reasons for article exclusion included: not relate or focus on medication calculations skills and publication before 2014.

**Figure 1.** Flow diagram of study selection for integrative review (PRISMA).
The oldest article on the topic dated from 1984. As nursing education guidelines changed throughout the years and many schools incorporated simulation and technology into their teaching methods, the author opted to limit the systematic review from 2014 to present date. This procedure was to ensure that the evidence presented was as current as possible. Also, an extensive literature review examining the literature available on effective education strategies for undergraduate student nurses on medication dosage calculations was published in 2014, including articles since 1990 (Stolic, 2014).

Summarizing, the four main types of pedagogy strategies before 2014 were traditional pedagogy, technology, psychomotor skills and blended learning. The studies focussing on traditional or conventional teaching had mixed results. The most common problem-solving technique in the traditional pedagogy was Dimensional Analysis (DA), also called a factor-label method, conversion factor method, unit analysis and quantity calculus, which is a systematic problem-solving method used to develop mathematical and conceptual skills and calculate medication dosage problems. Only five studies from this review used computer or technology aid as their main education strategy: two used learning software packages, one personal digital assistants, one used epackages and digital versatile disc (DVD), and focused at improving student’s anxiety or attitudes towards computers. Psychomotor studies included simulation, practice stations, and clinical settings off campus. Others blended the strategies above (Stolic, 2014).

The results suggested student nurses showed some benefit from the different strategies; however, the review raised the issue of poor performance of nursing students on medication calculation exams with the number of students able to attain 100% pass marks remaining disturbing low. Besides many studies have used medication calculation exams what raises the
issues of reliability and validity. The authors concluded more improvements are necessary and more rigorous research into this area is needed (Stolic, 2014).

**Quality appraisal**

The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement was used to evaluate the methodological quality of included studies (von Elm et al., 2014). STROBE provides recommendations on what should be included in an accurate and complete report of an observational study covering three main study designs: cohort, case-control, and cross-sectional studies.

**Data Extraction and synthesis of study findings**

A spreadsheet was used to collate data from each study. Also, the author developed a customized matrix relating the seven principles of learning with the evidence-based research as well as the STROBE criteria to assess the methodological quality of included articles.

The studies were heterogeneous. Therefore, the findings were integrative in a narrative synthesis as suggested by the Guidance on the Conduct of Narrative Synthesis. This approach allows synthesis of different study designs and methodologies, focusing on the effect of interventions and the factors shaping the implementation of interventions (Popay et al., 2006). See table 1.1.
<table>
<thead>
<tr>
<th>Citation</th>
<th>Purpose</th>
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<th>Method</th>
<th>Findings</th>
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<tr>
<td>(Ozyazicioglu et al., 2018)</td>
<td>evaluate the knowledge of nursing students about pediatric dosage calculations.</td>
<td>148 bachelors</td>
<td>cross-sectional: retrospective, quantitative.</td>
<td>The students failed mostly in calculating millimeter and decimal.</td>
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<td>(Bull et al., 2017)</td>
<td>Explore the impact of an international health partnership’s work and reflect upon the role of health psychologists in helping educators apply behavioral science</td>
<td>87 Portuguese-speaking nurses</td>
<td>Case-control (Case-series): prospective, mixed methods. Measures of participant confidence and intentions to make changes to healthcare practice</td>
<td>Interaction and educational games may encourage active learning and practice, encouraging deeper mental processing meaning participants may be more likely to remember and use new information in practice. Found possible social desirability bias among participants.</td>
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<tr>
<td>(Hurley, 2017)</td>
<td>Evaluate the effectiveness of an experiential teaching strategy</td>
<td>76 baccalaureate nursing students</td>
<td>Prospective cohort: quantitative. pretest-posttest design Randomly assigned.</td>
<td>The experiential strategy (student-centered approach. Clinical context, medication administration, and calculations were integrated) was more effective than the traditional method (t=-0.312, df=37, p=.004, 95% \text{ CI}) with a reduction in calculation errors.</td>
</tr>
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<td>(Kolberg, Holt, &amp; Klevan, 2017)</td>
<td>Examine the educational system through the lens of history and adding a dash of cultural theory</td>
<td>Review analyzing the contributing cause to the poor outcomes on drug calculation exams may be found in the Sputnik Crisis of the late 1950ies</td>
<td>The flipside of the Sputnik reforms was the alienation of large numbers of pupils and parents; the introduction of complex and abstract mathematics at an early stage created an exclusive subject that seemed both incomprehensible and meaningless for many. This may have contributed to a high degree of math anxiety culturally.</td>
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<td>(Karabag Aydin &amp; Dinc, 2017)</td>
<td>evaluate the effectiveness of Web-based instruction</td>
<td>63 nursing students</td>
<td>case-control (Case-series): prospective, quantitative.</td>
<td>The results demonstrated that Web-based teaching improves students’ arithmetic and drug dosage calculation skills. Web-based teaching operates independent of time and place. This motivates students to study more outside the classroom, lightens the burden on the teacher when managing increased numbers of students, and promotes independent study habits.</td>
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<td>Study</td>
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<td>(Bagnasco et al., 2016)</td>
<td>Explore where students had most difficulty and identify appropriate educational interventions to bridge their mathematical knowledge gaps.</td>
<td>726 undergraduate nursing students.</td>
<td>case-study: prospective. Mixed methods descriptive study</td>
<td>The majority had difficulty with basic math principles. Many of the students who declared to have good maths skills did not obtain high scores. Authors' suggested the use of two authentic virtual environments called safeMedicate and eDose™ (distributed by Authentic World Ltd.) as a very effective solution, both in terms of learning and assessing math skills in undergraduate nursing students.</td>
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<td>(Fernandes Pereira, Afio Caetano, Marques Frota, &amp; Gomes da Silva, 2016)</td>
<td>To evaluate the influence of the use of digital applications in medicament calculation education.</td>
<td>100 nursing students,</td>
<td>Prospective cohort: quantitative. Both groups were assessed before and after the application of the teaching strategy.</td>
<td>The strategy of using this application (app) positively influences learning and enables greater security in the implementation of medicament calculations.</td>
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<td>(Mackie &amp; Bruce, 2016)</td>
<td>determine areas of challenge for students in performing medication dosage calculations in order to design interventions to improve this skill.</td>
<td>65 nursing students and 8 faculty members</td>
<td>case-control (exploratory research): retrospective, mixed methods</td>
<td>An intervention that focuses on practice opportunities, online conceptual learning opportunities, and simulations that illustrate the impact of MDCs, had a positive effect on nursing students as assessed in the pre- and post-tests of this study. Conceptual and procedural errors occurred more commonly than the unit errors. Nursing students suggest categorizing students before entry into the program based on a test of general math ability.</td>
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<td>(Mills, 2016)</td>
<td>Identify the process of nursing students’ attainment of conceptual understanding when learning medication dosage calculations.</td>
<td>20 students</td>
<td>Grounded Theory of Conceptual Understanding.</td>
<td>Nurse educators need to identify teaching and learning strategies that promote conceptual understanding, helping students to get beyond memorization. An important implication of this study was that students and faculty need to be comfortable with confusion and the resulting critical thinking required for the attainment of conceptual understanding.</td>
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<td>(Ridling, Christensen, Harder, Gove, &amp; Gore, 2016)</td>
<td>Describe and compare nurse performance on a medication dosage calculation assessment tool</td>
<td>851 Registered Nurses</td>
<td>cross-sectional: retrospective. secondary analysis. Multiple regression</td>
<td>The work unit and the interaction between certification status and experience were significant in relation to score on the calculation assessment.</td>
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Table 1.1 (continued)

| (Roykenes, 2016) | Investigate previous learning experience | 11 narratives of nursing students | cross-sectional: retrospective. Qualitative. Thematic analysis of former experiences in learning math. | Analysis of the narratives showed that environmental factors other than significant others affected the students’ learning of mathematics. Class size and noise were two important environmental factors, especially for those who defined themselves as silent and anonymous. |
| (Van Lancker et al., 2016) | To evaluate the effectiveness of an e-learning course compared with a face-to-face lecture on medication calculation. | 411 nursing students | Prospective cohort: quantitative. Linear mixed model. | Medication calculation skills improved significantly more by the face-to-face lecture than e-learning course. No difference between e-learning and face-to-face group right after intervention. But difference 3 months later: e-learning showing worst outcomes. Another predictor was computer literacy, where having limited computer literacy was negatively significantly associated with medication calculation skills. Bias analysis: It is not specified whether the e-learning was complement to face-to-face or exclusively e-learning. |
| (Williams & Davis, 2016) | Examine the effects of math anxiety on ability to accurately calculate drug dosages | six articles | review | Four factors were identified as having an influence on a student's drug dosage calculation abilities: math anxiety, self-efficacy, teaching methods and numerical ability. |
| (Savage, 2015) | Conduct an educational audit on drug dose calculation learning. | 268 registered nurses and nursing students | cross-sectional: quantitative, prospective. | The majority of errors were those of calculation; largely multiplication and division. Targeted teaching may be highly effective in increasing classroom test performance; it is probably most effective when students are motivated by test scores “counting” towards their overall scores. |
Table 1.1 (continued)

<p>| (Sulosaaari et al., 2015) | Evaluate the theoretical, practical and decision-making competence and to identify factors associated with medication competence | nursing students at the beginning (n=328) and at the end of their education (n=338). | cross-sectional: quantitative, retrospective, descriptive, correlational study | Students’ learning style is associated with medication competence. At the beginning of their education, students’ previous academic success had a stronger association with medication competence. However, at the end of the education students’ abilities in self-regulated learning and study motivation were more significant factors. |
| (S. Fleming, A.-M. Brady, &amp; A.-M. Malone, 2014) | Evaluate the drug calculation skills of registered nurses on commencement of employment. | registered nurses (n=124) | cross sectional survey design, retrospective. | The most frequent type of drug calculation errors are attributed to conceptual errors and participants identified ward based education on drug calculation as a pathway for improving the drug calculation skills of registered nurses. |
| (Grugnetti et al., 2014) | Evaluate the effectiveness of a Clinical Skills Workshop on drug administration | 77 nursing students | cohort: prospective, quantitative, descriptive pre-post test design. Simulation center. | Study results showed a significant improvement between the pre- and the post-test phases, after the intervention. Bias analysis: provided general means of scores. It would be interesting to see each student development |
| (Harris, Pittiglio, Newton, &amp; Moore, 2014) | Examined simulation methods to improve nursing students’ medication calculation and administration abilities. | 158 nursing students (beginning of the second year of a BSN program) | cross-sectional: quantitative, retrospective. quasi-experimental pilot study. | The students who participated in a medication administration simulation scored significantly higher (m = 95 percent, sd = 6.8) on the Math Exam than who attended a didactic medication review session (m = 90 percent, sd = 12.9) at the p = .004 level. |
| (Mettiainen, Luojus, Salminen, &amp; Koivula, 2014) | Investigate the efficacy of web course in increasing self-evaluated competence on medication administration. | 244 students answered the questionnaire before and 192 after the web course. | cross-sectional: quantitative, prospective, quasi-experimental. online self-evaluation questionnaire | It is necessary to revise medication administration before graduation and web-based learning can be used in it. Prior to the education most defects were found in matters concerning compatibility and adverse effects of pharmaceuticals and solutions and in epidural medication competency. |</p>
<table>
<thead>
<tr>
<th>Study Reference</th>
<th>Research Question</th>
<th>Methodology</th>
<th>Results/Findings</th>
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<tr>
<td>Ramjan, et al. (2014)</td>
<td>Identify strategies and potential predictors that may assist nurse academics to tailor their drug calculation teaching and assessment methods.</td>
<td>405 nursing students in their final semester, cohort: prospective, quantitative.</td>
<td>The study reinforced that nursing students preferred a ‘hands-on,’ contextualized approach to learning that was ‘authentic’ and aligned with clinical practice. Some of the strongest predictors for numeracy skill performance included (1) being an international student, (2) completion of an online practice quiz, scoring 59% or above and (3) students' self-reported confidence.</td>
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<td>Roykenes, Smith, &amp; Larsen (2014)</td>
<td>Investigate the test anxiety experiences of students faced with such a high-stakes test.</td>
<td>203 freshman nursing students, cross-sectional: quantitative, retrospective, mixed methods.</td>
<td>44.3% of the students reported high mathematics test anxiety in the months before the drug calculation test. More than 12% of the high-anxiety students reported a low mathematics self-concept.</td>
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<td>Simonsen, Daehlin, Johansson, &amp; Farup (2014)</td>
<td>Compare the medication knowledge, certainty and risk of error</td>
<td>243 graduating students and 203 registered nurses, cross-sectional: quantitative, retrospective, multiple choice test in pharmacology</td>
<td>Result underlines the importance of pharmacology as a core subject. The weakest knowledge and highest mean risk of error was in the discipline of drug management.</td>
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<td>Sowan &amp; Idhail (2014)</td>
<td>Describes the design and students’ response to an interactive web-based course</td>
<td>102 first-year undergraduate nursing students, cross-sectional: quantitative, prospective, mixed-methodology design.</td>
<td>Data showed a significant correlation between student satisfaction, self-efficacy and achievement in the virtual course. Significant predictors of satisfaction were ease of access the course and gender. Nearly 40% of the students believed that the virtual course is a sufficient replacement of the lab demonstration.</td>
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<td>Stolic (2014)</td>
<td>Examine the literature available on effective education strategies</td>
<td>20 papers with a total of 5206 nursing students, review</td>
<td>Four types of strategies; traditional pedagogy, technology, psychomotor skills and blended learning. Studies focusing on traditional or conventional teaching had mixed results.</td>
</tr>
<tr>
<td>van de Mortel, Whitehair, &amp; Irwin (2014)</td>
<td>Assess the efficacy of a whole-of-curriculum approach in improving applied numeracy skills.</td>
<td>1035 second and third year nursing students, cohort study: prospective, quantitative.</td>
<td>Whole-of-curriculum approach improved numeracy mastery rates by offering scaffolded learning supported by the consistency of regular assessment with the clear goal of achieving 100% mastery at each point.</td>
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Results

Study Characteristics

Twenty-five studies met the eligibility criteria for this review. This review contemplates the analysis and considerations reported for 11,202 nursing students/nurses who participated in the studies. Regarding methodology, majority adopted a quantitative approach (68%), followed by qualitative (20%) and mixed methods (12%).

From the total of twenty-five studies, four reviews (Kolberg et al., 2017; Stolic, 2014; Williams & Davis, 2016) and one ground theory development manuscript (Mills, 2016) were excluded from STROBE scoring. Considering STROBE classification, cross-sectional leaded the method (n=11, being 8 retrospective and 3 prospective), trailed by cohort (n=6, all prospective), and case-control (n=4, being 2 retrospective and 2 prospective).

Discussion: Evidence-based nursing teaching strategies for medication calculation skills

The educational strategies reported in the literature overlay the framework of seven research-based principles, by pursuing corresponding outcomes. This review focuses on the recommendations of effective pedagogy approaches to build practical, evidence-based guidance bridging teaching/learning strategies reported in the literature. The research-based principles of learning may overlap some strategies and outcomes.

Math anxiety and drug dosage calculation is studied worldwide and widespread, this review includes studies from United States of America, Brazil, Italy, United Kingdom, Norway, Tanzania, Jordan, and Australia; indicating that patient safety and numeracy skills are not a localized concern (Fernandes Pereira et al., 2016; Savage, 2015; Sowan & Idhail, 2014; Williams
& Davis, 2016). However, it is imperative to expand this concern to other healthcare professions such as medicine, midwifery, pharmacy, and paramedicine (Williams & Davis, 2016).

**Prior knowledge can help or hinder learning**

Mathematics competence is highly associated with positive or negative mathematics experiences. Therefore, an early diagnostic assessment is essential to reveal common mathematical misconceptions and psychological effects, whether in academic or hospital settings (Bull et al., 2017; van de Mortel et al., 2014). Multiple articles mentioned that math anxiety hinders math learning but did not necessarily include an anxiety assessment.

Math anxiety is explored under multiple perspectives from a broad historic-political influence to students experience during school years. Considering the macro viewpoint, Sputnik Crisis and the shortage of science and mathematics teachers in Tanzania are perceived as events that influence generations of math competency (Kolberg et al., 2017; Savage, 2015). On the other hand, considering the micro viewpoint, teachers, parents, classmates, and siblings were found to be significant persons, both as positive and negative contributors. (Ozyazicioglu et al., 2018; Roykenes, 2016). An early diagnose of general math ability was the most common suggestion from nursing students to improve teaching of medical dose calculations (Mackie & Bruce, 2016).

Some examples of early diagnose assessments considering previous school years of math incompetence, math anxiety, self-confidence, and preferred methods of learning (Kolberg et al., 2017) are Math Anxiety Scale (MAS) (Williams & Davis, 2016), Math Test Anxiety (MTA) (Roykenes et al., 2014), Numerical Ability Test (NAT) (Williams & Davis, 2016), Learning Style Inventory (ILS) (Sulosaari et al., 2015), Maths Self-Concept (MSC) (Roykenes et al., 2014),
and self-confidence test (Bagnasco et al., 2016; Mettiäinen, Luojus, Salminen, & Koivula, 2014; van de Mortel et al., 2014).

Self-confidence relationship to medication calculation skills have shown mixed results, some with a positive relationship (Mettiäinen et al., 2014) others negative (Bull et al., 2017). One possibility is this may be related to the fact that even students with high and medium math self-concept also experience high test anxiety (Roykenes et al., 2014).

Pay attention to patterns of errors (in academia or hospital environment) and develop a concept inventory are important, while minimizing distractions and time pressure (Bull et al., 2017; Mackie & Bruce, 2016): Be sure to differentiate declarative (knowing what and knowing why) from procedural knowledge (knowing how and knowing when).

Identify conventions and expectations for the teaching/learning experience in order to help override misconceptions. A study showed that an important core subject for continuous teaching and training during nursing bachelors’ degree is pharmacology (Simonsen et al., 2014).

**Knowledge organization influence how students learn and apply what they know**

We should also consider that being novice or expert on the topic changes how the knowledge is organized in one’s mind, which deeply influences teaching/learning strategies. For example, when assessing medication competence, a study showed a strong association with student’s previous academic success at the beginning of their education, but not at the end. At the end of the education, students’ abilities in self-regulated learning and study motivation were more significant factors (Sulosaari et al., 2015). This shows how student learning modify throughout their education years, indicating need of different teaching/learning strategies.
Therefore, instructors need to differentiate between novice (superficial) and expert (deep) organization (Sulosaari et al., 2015) because while expert organization relate to how they solve problems organizing around meaningful features and patterns, novice organization tend not to have as many alternative organizations to tap into.

Instructors should provide an integrated clinical context, medication administration, and calculations: approximates to real life-learning experiences helping to organize knowledge in a interconnected structure (concepts, facts, skills), This increases one’s ability to access that information when needed (expert knowledge organization) (S. Fleming, A. M. Brady, & A. M. Malone, 2014; Grugnetti et al., 2014; Harris et al., 2014; Hurley, 2017; Mettiäinen et al., 2014; Sowan & Idhail, 2014; Sulosaari et al., 2015).

The instructor should engage students on closer to real-life learning experience, bridging the theory-practice gap, provides opportunity for students to encounter a multidimensional learning experience. The experience of visual, motor, emotional, and tact memory increases one’s ability to re-access the knowledge of medication calculations skills when needed due the multiple organizations paths to tap, which is how experts access and organize their knowledge (Hurley, 2017). This way an integrated and comprehensive medication education support students’ competence development (Sulosaari et al., 2015). Bridging the theory-gap experience may be done through hospital streaming videos of nursing practice, simulations, and interactive virtual environment (S. Fleming et al., 2014; Grugnetti et al., 2014; Harris et al., 2014; Mettiäinen et al., 2014; Sowan & Idhail, 2014).

Instructors that provide a set of principles or propositions that provide a cognitive structure guidance to the incorporation of new information: monitor and develop problem-solving ability (Karabag Aydin & Dinc, 2017; Mettiäinen et al., 2014; Mills, 2016; Stolic, 2014).
This is done by: giving problems that are already solved and ask to explain the solution; present and analyze contrasting cases; develop concept maps (skeletal outline of each lecture/discussion; identify students prior knowledge organization and monitor in an ongoing manner how that organization changes with time and experience); introduce a new concept explicitly connecting with others; ask students to categorize a set of items according to more than one organizational schema.

Favor proper knowledge organization matching the requirements of the task which provides support for future learning and performance: patient vignettes (Sulosaari et al., 2015) and work unit practice (Ridling et al., 2016), for example. Beyond the beginning of learning, monitor revision to actively identify issues that affect patient safety (Savage, 2015).

Also, problem-solving ability supports the process of attainment of the conceptual understanding because questioning is an important part to develop students’ arithmetic and drug dosage calculation skills (Karabag Aydin & Dinc, 2017; Mettiäinen et al., 2014; Mills, 2016). This may also explain why work unit and the interaction between certification status and experience were significant in relation to score on the calculation assessment of registered nurses, who should be engaging into periodical revisions to identify issues that affect patient safety (Ridling et al., 2016; Savage, 2015).

Bigger the theory-practice gap, harder for students visualize and develop critical thinking skills. Active learning with the use of online resources and interactive software involving learner participation and engagement has proven effective across educational settings (Stolic, 2014). However, it is important to assess and support the level of computer literacy necessary to use these resources to enhance learning.
Student’s motivation determines, directs, and sustains what they do to learn

In general, studies recommend clarity and specifying learning goals at any education environment. Beyond the perception of aligning professors and students goals, instructors need to be aware that students usually undertake two types of behaviors to reach the learning goals (normative standards). They either attain competence by performing towards normative standards, called performance-approach goals; or avoid incompetence (do the minimum necessary) by meeting standards, performance-avoidant goals. Performance-avoidant behavior is more context related, bringing the importance of adapting the teaching strategy by embracing student learning type. (Ambrose et al., 2010).

Self-confidence was the most relevant factor regarding forming an attitude towards math; hence, the importance of focusing in its development. However, the start level self-efficacy may be related or not to performance on drug calculation math test. If starting with a low level, self-efficacy ends up being highly related to performance on a drug calculation math test. However, if starting with high level of self-efficacy, it ends up not being related to performance on a drug calculation math test(Williams & Davis, 2016). This may be related to social desirability bias as it does happens of high self-rated confidence among nurses be rated high before and after training, even though participants struggled with questions reflecting into confidence-competence gaps (Bull et al., 2017).

Instructors need to work on the three types of levers that changes student motivation and thus alter their behaviors: value, efficacy expectancies, and the supportive nature of the environment.

- In regards of value: Align professors and students goals by keeping insight on which value the student will likely be motivated: gaining levels of mastery, satisfaction from
doing the task, an activity which helps to accomplish other important goals (benefit student’s professional life) (Bull et al., 2017; Mackie & Bruce, 2016; van de Mortel et al., 2014).

- In regards of efficacy expectancies: show enthusiasm to raise students’ curiosity; and, align what is valued with assessments and course objectives. i.e: allow students to choose among options consistent with their goals and activities they value because flexibility lends a sense of control.

- In regards of environment: A supportive learning environment in which students and professors are comfortable with confusion and the result critical thinking is required for the conceptual understanding on math skills development(Mills, 2016; Sulosaari et al., 2015).

It is important to be aware of the two goal-directed behaviors, conscious that future performance are influenced by past experiences. In order to deal with work avoidance goals (“student does the minimum necessary to reach the normative standards”): Guide by learning goals, instead performance goals; Give opportunity for reflection: “What did you learn from this assignment?” or “What was the most valuable feature of this project” as it helps students identify the value of their work.

To work through courses known as “high-risk” and for students that come with anxiety for whatever reason: incorporate early shorter assignments that account for a small percentage of the final grade. The purpose is to provide a sense of competence and confidence before a larger assignment(Williams & Davis, 2016). Furthermore, discuss effective study strategies helps students to identify and include appropriate study strategies, good time management, and hard work (i.e.: how munch, when, the nature of study habits).
To develop mastery, students must acquire component skills, practice integrating them, and know when to apply what they have learned.

As students gain mastery over time, the knowledge and procedures required for complex tasks become automatized and thus require fewer cognitive resources. However, the cognitive load for complex tax may easily exceed what novice students can manage. This may happen when experts instructors are not aware of the learning needs of novice students, known as expert blind spot. In order to avoid it, professors need to keep in mind that students must acquire component skills, practice integrating them, and know when to apply what they have learned. Some steps may be followed:

First, focus on students’ acquiring component skills: beyond dividing the task into component parts, focused practice on key components has a profound effect on overall performance (i.e. professional updates). In addition, decomposing tasks help instructors pinpoint skills to develop, diagnosing weak component skills (i.e. “learn by doing”) (Bull et al., 2017; Hurley, 2017; Roykenes, 2016).

Second, stimulate practice integrating them: a reliable and sustainable learning model like medication dosage calculation problem-solving (MDC-PS) is suggested as it develops relation between conceptual competence (dosage problem-understanding), calculation competence (dosage-computation), and technical measurement competence (dosage-measurement)(Ozyazicioglu et al., 2018). Also, the integration of clinical context, medication administration, and calculations provides and experiential strategy reducing calculation errors(Hurley, 2017).
And third, assure understanding of when to apply what they have learned: Provide contrast cases, specifying the context and asking students to identify relevant skills or knowledge (i.e. in this phase, it is not always necessary for students to do, but rather to think) or, inversely, ask students to identify which contexts they would apply that particular skill or knowledge.

A study indicate that nurses may mature their medication knowledge only during the first year of practice (Simonsen et al., 2014), what may explain why offering scaffolded instruction helped to improve numeracy mastery rates (van de Mortel et al., 2014). Scaffolding refers to the process by which instructors give students instructional supports early in their learning and progressively remove these supports (Ambrose et al., 2010). Therefore, further than repetition, scaffolding allows and incentives independence.

Learning and performance are best fostered when students engage in practice that focuses on a specific goal or criterion for performance, targets an appropriate level of challenge relative to students’ current performance, and is sufficient quantity and frequency to meet the performance criteria (Ambrose et al., 2010).

In addition, the instructor should keep in mind to explore available educational material: blended learning is able to attend different learning needs (Stolic, 2014).

**Goal-directed practice coupled with targeted feedback enhances the quality of students’ learning**

Overall, it is acknowledged that feedback on performance is important. However, it is more effective when it identifies particular aspects of students’ performance they need to improve rather than providing a generic evaluation. In addition, a proper timing of how soon
feedback is given (sooner the better) as well as how often (more frequently better) helps to optimize the development of the skills (Ambrose et al., 2010).

In addition to providing opportunity to ask more questions and offer a tailored review to each individual student’s need, group feedback has shown a positive relationship between drug dosage calculation scores and mathematical skills (Karabag Aydin & Dinc, 2017; Williams & Davis, 2016). Finally, because learning accumulate gradually with practice it is important to build opportunities for practice, particularly on deficient skills (Mackie & Bruce, 2016).

The instructor needs to keep in mind to set challenging but achievable goals so students may explain their poor performance in terms of controllable and temporary causes, while progressing to increasingly complex problems. i.e.: ask students to explicitly note how a piece of feedback impacted their practice or performance helps them to see and experience the “complete” learning cycle (Mills, 2016; Williams & Davis, 2016).

Identify the most common errors and discuss those mistakes at the group level (Bull et al., 2017) is crucial, besides articulating your expectations by providing rubrics (standard criteria) and a targeted feedback, prioritizing towards the essential components of the skills (Van Lancker et al., 2016). Also, provide repetition not only focused on improving deficient skills, but to students internalize understanding of a concept favors math competence development (Mackie & Bruce, 2016; Mills, 2016).

Student’s current level of development interacts with the social, emotional, and intellectual climate of the course to impact learning

Additionally, the social and emotional gains that students make during college are considerably greater than the intellectual gains over the same span of time. Therefore, it is
essential to provide a positive learning experience by addressing tensions and class climate early(Ambrose et al., 2010; Mills, 2016; Roykenes, 2016; Sulosaari et al., 2015). Build a model of inclusive language, behavior and attitudes is meaningful to make uncertainty safe. i.e.: Establish and reinforce ground rules for interaction(Mills, 2016; Roykenes, 2016; Sulosaari et al., 2015).

If an activity satisfies more than one type of goal, the motivation is likely to be higher. For example, games may satisfy affective and social goals encouraging active learning or peer mentoring by faculty. This stimulates behavior change through capability, opportunity, and motivation (Bull et al., 2017; Mackie & Bruce, 2016; Mills, 2016).

To become self-directed learners, students must learn to monitor and adjust their approaches

Instructors need to provide opportunities for self-assessment and peer review assessment, so the students reflect on their performances (Bull et al., 2017; Mackie & Bruce, 2016). i.e.: ask students to assess their own work against a set of criteria that the professor provide. As well as stimulate self-learning skills. i.e. allocate time for students to set goals and make a specific action plan about where and when they would use their calculator (Bull et al., 2017; Ozyazicioglu et al., 2018).

Lastly, but not least, web-based learning motivates students to study more outside the classroom, lightens the burden on the teacher when managing increased numbers of students, and promotes independent study habits. This positively influences learning and enabling greater security in the implementation of medicament calculations. (Fernandes Pereira et al., 2016; Karabag Aydin & Dinc, 2017; Sowan & Idhail, 2014; Williams & Davis, 2016).
After all, homework and time spent in class verifying its completion may be considered too onerous for students. In other words, e-learning provide practice opportunities without consuming class time (Mackie & Bruce, 2016).

Correspondingly, e-learning packages would allow students to progress at their own speed and practice particular sections until mastery is reached by allowing multiple opportunities for practice, students being able to ‘learn from mistakes,’ availability of the resource, to refresh skills at own pace and help students to gain insight into their strengths and weaknesses (Ramjan et al., 2014; Savage, 2015).

Taking those e-learning considerations, the instructors should use web-based learning as strong ally(Fernandes Pereira et al., 2016; Karabag Aydin & Dinc, 2017; Mackie & Bruce, 2016; Ramjan et al., 2014; Savage, 2015; Sowan & Idhail, 2014; Williams & Davis, 2016). Supplementary to discuss knowledge about information and communication technologies as its deficit may generate greater resistance to using these resources to enhance learning, even though active learning through online sources and interactive software have been proven effective across educational settings (Fernandes Pereira et al., 2016; Sowan & Idhail, 2014; Stolic, 2014; Van Lancker et al., 2016).

**Conclusion**

Safe medication administration is an international goal as safe and quality care is a paramount concern for healthcare organizations and consumers. Teaching strategies are beneficial for multiple research-based principles, some recurring approaches are collect data about students/nurses, model expert practice, scaffolding complex tasks, and being explicit about objectives and expectations. These approaches address cognitive, motivational, and
developmental goals. Web-based software would be a strong ally on adopting those
approaches by complementing the class practice and providing opportunities for practice
learning. Teachers should take advantage of the potential of technology for the benefit of an
education and more creative, autonomous, collaborative, and interactive learning. Lastly,
nurse calculation skills are only one factor affecting medication errors and medication safety
as a whole; hence, the importance of managing other medication safety skills when trying to
mitigate the risks associated with medicines.

**Limitations**

The results obtained in the studies were variable, perhaps suggesting the need for more
empirical study designs. The majority opted for a purposive convenience sample, suggesting that
results should not be generalized beyond the sample characteristics. Also, some study findings
may have been influenced by students/nurses knowing they were in a study, increasing their
motivation to study. Finally, the Hawthorne affect may have been introduced as well for not
having adequate control over instructor’s teaching styles and attitudes.

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Mathematical calculation skills required for drug administration in undergraduate nursing
students to ensure patient safety: A descriptive study: Drug calculation skills in nursing


SECTION TWO:
CROSS-CULTURAL TRANSFORMATION REQUIREMENTS AND PROCESS

Abstract: This study aimed to describe a systematic and transparent method of adaptation and evaluation of an educational software. This method of adaptation was developed by coupling the rigor of systematic reviews, research synthesis, empirical research analysis, and consulting translational sciences in regards of back-translation’s purpose. The author developed an adaptation of the PIPFLA framework. The adapted model followed five dimensions that should be considered during the comprehensive cross-cultural equivalence model, considers the evaluation methods used to prepare language adaptations, added triangulation of research methods to strength the validity of the adapted framework as well as to presented a detailed reasoning for approaches and components choices. A suggestion of recruitment strategy, coding process, and data analysis is offered. The adapted process of PIPFLA proposed in this paper uses a standardized and transparent documentation, including expert judgment. Neither systematic reviews nor empirical researches currently published describe the methodology used with enough details to allow methodology replication or improvement. To uptake systematic and transparent cross-cultural adaptation processes allows not only to optimize education research resources worldwide but favors the spread the outcomes of effective evidenced-based trainings.

Keywords: research methodology, research design, software validation, education, cross-cultural comparison.
**Introduction**

There is an unmet need to shorten the time of translation and adapting effective educational tools across languages and cultures. The process presented in this paper was developed for a dissertation whose proposal was a Brazilian context and language adaptation of an evidence-based software called safeMedicate. Translational research was used on the development of SafeMedicate in a process spanning more than 20 years to link basic research and application in clinical practice. (S. Young, Weeks, & Hutton, 2013).

SafeMedicate is designed to support the learning synthesis and diagnostic assessment of cognitive competence in critical elements of medication dosage problem solving and underpin the application of further competence development and evaluation within each of the remaining levels of the hierarchy for learning (Authentic World, 2009). This tool had been exposed to rigorous evaluation and assessment of the outcomes in the professional practice (Holland, 2013).

Different from teaching methods which consider students as passive recipients, safeMedicate provides a contextualized learning environment where students can actively engage. Students using safeMedicate achieve significant improvements in the construction of conceptual and calculation competence in medication dosage calculation problem-solving (MDC-PS) in both UK and USA programmes. The safeMedicate experimental research highlights how authentic environments are more able to support all cognitive learning styles in mathematics(Weeks, Clochesy, Hutton, & Moseley, 2013) than traditional didactic methods of education. The authentic learning environment supports a spectrum of learning styles in mathematics by offering opportunities to tailor and expand mathematical skills through mental computation, arithmetic, geometry/visual, and algebra (Weeks et al., 2013).
Language adaptation generally includes more than a simple word-for-word translation. It is an interpretation of meaning. Moreover, in order to adapt safeMedicate for use in Brazil, it is necessary to address the health professional evaluation guaranteeing it meets the professional practice, professional regulation, and political requirements.

This moves translation beyond grammatical rules and writing conventions to an interpretation informed by socio-cultural and contextual factors (Alegría et al., 2004; Bravo & Woodbury-Farina, 1993). In order to inform and guide the language adaptation process, it is required to use a combined emic (within-culture/insider’s perspective) and etic (similarities across cultures/outsider’s perspective) (Berry, 1999; Maríñez-Lora, Boustani, del Busto, & Leone, 2016; Matías-Carrelo et al., 2003) – an approach that’s significance will further be explicated below.

Therefore, this research follows the theoretical base used for safeMedicate development as well as the theoretical base guidelines for the language adaptation process.

Theoretical base of language adaptation

Emic and etic perspectives. A series of repeated translations and back-translation exercises have been done by a team of bilingual translators blind to the previous translation (Brislin, 1970). Nevertheless, when different languages are involved, translation and back-translation techniques are not sufficient to achieve cultural equivalency. In other words, cultural insensitivity usually arises when experts transfer concepts across cultures uncritically and develop translations that conform exactly to the original standardized versions without needed adaptations for the population for which it is being developed (Matías-Carrelo et al., 2003). In
order to avoid this, cross-cultural studies have been approaching the *emic-etic* paradigm to consider multiple linguistic and socio-cultural factors.

Initially, *emic* and *etic* were considered two different research approaches. The *emic* perspective is related to the attempt to explicate the phenomena’s significance from inside the system/culture, aiming to describe the internal logic or singularity of a culture. The *etic* perspective is a viewpoint from outside the system, fundamentally comparative, aiming to identify and compare equivalent phenomena across different cultural contexts (Alegria et al., 2004; Matías-Carrelo et al., 2003).

However, this dichotomy limits the cross cultural research based on the *emic* approach, which is limited by observation bias and lack of generalizability and the *etic* approach, which is limited by over-emphasis on reliability by standardizing the conceptualization at the expense of validity (Alegria et al., 2004). Therefore, some researchers aim to integrate both approaches, not viewing them as opposites, but as complimentary approaches, which provide the same data from two points of view (Berry, 1999; Helfrich, 1999; Pike, 1967). This process is operationalized by first elaborating an *imposed etic* perspective, which serves as the starting point for comparative research, followed by the *emic* exploration of the phenomena, aiming to understand it in local cultural terms; and concluding the adaptation by utilizing the *derived etic* perspective, which can be discerned by following extensive use of *emic* approaches in a number of cultures (possibly leading to “universals”) (Berry, 1999).

**Objective**

This study aimed to describe a systematic and transparent method of adaptation and evaluation of an educational software.
Research Plan

This method of adaptation was developed by coupling the rigor of systematic reviews, research synthesis, empirical research analysis, and consulting translational sciences in regards of back-translation’s purpose. Features of systematic reviews encompass specifying and explicit question, conducting a comprehensive search, and rating the quality and strength of the quality of the evidence.

During the search, the author located the theoretical framework of cross-cultural equivalence model which aims to combine emic and etic perspectives on a Participatory and Iterative Process Framework for Language Adaptation (PIPFLA) (Maríñez-Lora et al., 2016). The Participatory and Iterative Process Framework for Language Adaptation (PIPFLA) is a cross-cultural equivalence model which aims to combine emic and etic (Maríñez-Lora et al., 2016). The Participatory and Iterative Process Framework for Language Adaptation (PIPFLA) is a modified 10-step process of the Principles of Good Practice: The Cross-Cultural Adaptation Process for Patient-Reported Outcomes Measures, considering the unique needs of intervention versus measurement like time, resource constraints, and additional harmonization steps. The PIPFLA includes back-translation, however, after consulting translational sciences in regards of back-translation’s purpose, the author developed an adaptation of the PIPFLA framework.

The adapted model followed five dimensions that should be considered during the comprehensive cross-cultural equivalence model: Semantic, Content, Technical, Criterion, and Conceptual (Matías-Carrelo et al., 2003) and considers the evaluation methods used to prepare language adaptations which are Informativeness, Source Language Discrepancy, Security, and Practicality (Behling & Law, 2000; Maríñez-Lora et al., 2016). Also, the author opted to add triangulation of research methods to strength the validity of the adapted framework as well as to
present a detailed reasoning for approaches and components choices. A suggestion of recruitment strategy, coding process, and data analysis is presented.

**Discussion**

**The cross-cultural equivalence model**

Even though back translation has been a common step in the cross-cultural adaptation of instruments (Beaton, Bombardier, Guillemin, & Ferraz, 2000; Borsa, Damásio, & Bandeira, 2012) and is included in the 11-step process of PIPFLA, the back translation benefit of providing information about semantic and conceptual equivalence has been questioned in the translation science (J. Harkness et al., 2010; J. A. Harkness & für Umfragen, 1998; J. A. Harkness, Van de Vijver, Mohler, & für Umfragen, 2003). Moreover, the International Medical Interpreters Association does not recommend back-translation.

The argument is that comparison of an original source text and a back-translated source provide only limited and potentially misleading insight into the quality of the target language text. This happens because many adaptations made by the translator which perfectly convey the meaning of the original are lost in the back translation giving the appearance of an inaccurate rendition (Harkness, 2013; Txabarriaga, 2008). It is recommended that instead of looking at two source language texts, it is much better in practical and theoretical terms to focus attention on first producing the best possible translation and then directly evaluating the translation produced in the target language, rather than indirectly through back translation (Harkness, 2013).

Consequently, the dissertation author adjusted the process of translation and adaptation of the PIPFLA model according to the recommendation of producing the best possible translation
and directly evaluating the translation produced in the target language, than through back translation (Harkness, 2013).

In addition, throughout the years measurement tools and interventions have been translated and adapted (Borsa et al., 2012; Sousa & Rojjanasrirat, 2011). However, not all programs describe the translation and adaptation process in detail (Bauermeister, So, Jensen, Krispin, & El Din, 2006; Collado, Castillo, Maero, Lejuez, & MacPherson, 2014; Pekmezi et al., 2012). Although studies incorporate systematic approaches of language adaptation process in various degrees, the source is not often cited (Maríñez-Lora et al., 2016). As such, a strength of the dissertation is the transparent nature in which safeMedicate was adapted. Specifically, Figure 2.1 illustrates the adaptation and evaluation process that were used in the dissertation, representing an adaptation of PIPFLA. That is, the back translation steps were removed as previously described.

![Figure 2.1 Process to adapt safeMedicate from English to Portuguese](image-url)
There are five dimensions that should be considered during the comprehensive cross-cultural equivalence model: Semantic, Content, Technical, Criterion, and Conceptual (Matías-Carrelo et al., 2003). In order to strengthen methodology, this process’s results were based on the triangulation of three methods (focus groups, interview, and face validity surveys) and considered the evaluation methods used to prepare language adaptations which are Informativeness, Source Language Discrepancy, Security, and Practicality (Behling & Law, 2000; Maríñez-Lora et al., 2016), each described below:

While Informativeness relates to the semantic and conceptual equivalence of the language adaptation, Source Language Discrepancy disclose discrepancies and translations ambiguities that need to be addressed. Both will be addressed in the process of forward translation (step 2) as well as at each harmonizing step (steps 3, 5, 7, and 9), which includes the language adaptation team.

While Security consists of mechanisms used to increase confidence in the quality, usability, and experiential equivalence of the language adaptation, Practicality refers to the feasibility and affordability of the process. Both criteria will be assessed during the harmonizing steps (steps 3, 5, 7, and 9) and during reviews done by the panel of experts (step 4), student panel (step 6), and face validity by target group (step 8).

Informativeness, Source Language Discrepancy, Security, and Practicality will also be evaluated during proof reading (step 10) and consolidation of the final language adaptation (step 11).
Strengthening the quality of the evidence: Triangulating research methods

Triangulation is when more than one method is used to collect data on the same topic through a mixed-methods approach. It is a powerful technique for facilitating a cross verification of two or more sources from the same phenomenon (Jick, 1979). The dissertation triangled two methods: face validity survey and focus groups. The focus groups were comprised of language adaptation team, panel of experts, and student panel.

In addition, it was used journaling. Journaling helps to gain a more in-depth perspective beyond the initial understanding of the research question (Ulin, Robinson, & Tolley, 2005). By identifying and documenting motivations, interests, and perspectives initially and throughout the research process, the principal investigator consciously compared the final interpretation with what first expected to find, building trustworthiness of the data.

Focus groups. The focus group is a particular form of group interview whose advantage is being inexpensive, flexible, stimulating, assistive in information recall, and capable of producing rich data. The disadvantage is groupthink, when stronger members have major control or influence the verbalization of other members, which can be overcome by focusing on the potential for learning about both the focus and the group. In general, the advantages as a data collection strategy outweigh the disadvantages (Speziale & Carpenter, 2011).

The primary investigator conducted a semi-structured group interview guided by safeMedicate sections (Appendix A). This way members of the focus group were able to provide simultaneous feedback towards each part of the educational sections. If items come up in the focus group that were not consistent with the guide (Appendix A), the guide was adapted as necessary. The focus group members of this dissertation (language adaptation team and panel of
experts) were perceived as partners on the adaptation process of SafeMedicate for use in Brazil instead of a human subject research.

The group meetings occurred through synchronous communications (videoconference calls) according to members’ availability, which was recorded. A poll were made to discover when most are available. After the meeting, data was synthetized and a cross-checking of recommendations was performed (D. R. Young et al., 2006).

There are three criteria of reliability for a focus group: stability, equivalence, and internal consistency (Speziale & Carpenter, 2011). In regard to stability, the consistency of issues over time, the researcher identified members that committed availability to the entirety of the project, maintaining consistency of experts. Equivalence emphasized the need for consistency of moderators. As such, the primary investigator acted as the moderator for all groups and communicated with team members of the language adaptation team and panel of experts regularly. In order to guarantee internal consistency of the analysis, the primary investigator assumed the primary responsibility for conducting the analysis which results were discussed with a second coder. The content validity of the focus group referred to the researcher assess if the shared information was valid and consistent among group meetings.

This method was used for the language adaptation team and panel of experts.

**Language Adaptation team.** The language adaptation team merged two translations from the source language version to target language (English-Portuguese). One of the translations was produced by the primary investigator, a Brazilian nurse, and the other by a professional translator. The translation produced by the primary investigator included doing first a cultural adaptation while doing the language translation of safeMedicate. This occurred because there are medications and prescriptions label differences between safeMedicate US version and Brazilian
practice. Hence, the investigator consulted government agencies and protocols to ensure proper Portuguese labels for prescription types and medication forms. Performing this cultural adaptation first while doing the language adaptation proved to be beneficial because it optimized the Portuguese language tailoring done by the focus groups. The language adaptation team included a project staff member, as is described in Table 2.1.

**Table 2.1. Language Adaptation Team**

<table>
<thead>
<tr>
<th>Role</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Translator 1:</td>
<td>Primary investigator; female; born and graduated nursing school in Brazil; worked as a professor in a Brazilian university; current doctoral candidate at University of South Florida, USA.</td>
</tr>
<tr>
<td>Translator 2:</td>
<td>Professional translator certified by the International Medical Interpreters Association (IMIA); prior experience translating medical information from English to Portuguese.</td>
</tr>
<tr>
<td>Project staff:</td>
<td>Female; born and graduated nursing school in USA; earned masters and doctoral degree at Texas Woman's University, USA; professor in a Brazilian university for 30 years until current date.</td>
</tr>
</tbody>
</table>

**Panel of experts.** The panel of experts evaluated the translations produced in the target language providing constructive feedback and suggestions, justifying them through sources like governmental and professional guidelines, articles, standardized medical language guides, etc. The Panel of experts characteristics are described on Table 2.2:

**Table 2.2 Panel of Experts**

<table>
<thead>
<tr>
<th>Professional</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Professional 1</td>
<td>MSN, RN; Brazilian nursing working in the market for 16 years, 8 years as clinical supervisor of nursing students, and 11 years as nursing professor.</td>
</tr>
<tr>
<td>Professional 2</td>
<td>MSN, RN; Brazilian nursing working in the market for 15 years, 10 years as clinical supervisor of nursing students, and 12 years as nursing professor.</td>
</tr>
<tr>
<td>Professional 3</td>
<td>PhD, RN; Brazilian nursing working in the market for 11 years, 11 years as clinical supervisor of nursing students, and 11 years as nursing professor (started as substitute professor becoming full professor for the last 3 years).</td>
</tr>
<tr>
<td>Professional 4</td>
<td>Nursing specialist, RN; Brazilian nursing working in the market for 23 years and 10 years as a nursing professor. This professional worked as nursing coordinator of various nursing programs for 19 years.</td>
</tr>
</tbody>
</table>

*Note: Brazilian professors are chosen through a selection process based on curriculum, didactic skills, and market experience.*
Even though the meeting was scheduled with seven professionals, three cancelled at the last minute, resulting in the focus group with four members who followed up with subsequent contact and meeting. In general, a group with six to ten members is recommended, as a larger group may preclude everyone from interacting, and a smaller group may make members feel as they cannot speak freely or have to speak when they have nothing to offer (Speziale & Carpenter, 2011). However, in this study, due the professionals diverse and strong experience in the Brazilian nursing market and comfortable level showed during the videoconferences, it was clear the professionals had no inhibition on contributing to the discussions.

The Portuguese version of safeMedicate achieved by the Language adaptation team was presented to the Panel of experts who provided feedback of adaptations necessary. The adaptations suggested were presented to software developers and the feedback was presented for panel of expert. Subsequent versions would be created and presented again (following a cycle), until the panel reaches consensus.

It is uncertain the number of versions that will be drafted for the adaptation process until the panel of experts reaches a consensus. Therefore, the primary investigator expected to spend six to twelve months on this dissertation. Consequently, the panel of experts was selected, in part, based of their commitment to the project. If consensus cannot be reached about a certain adaptation to the instrument, that adaptation would be decided through vote of the panel of experts. In the study, the panel reached consensus at the second videoconference as the software developers abided to the suggestions.

**Student Panel.** The student panel consisted of one nursing students and one professional nurse seeking update who provided through individual conference calls a general evaluation of safeMedicate providing critics and suggestions. The semi-structured interviews was guided by
safeMedicate sections (Appendix A). The participants were draw from a list of the names indicated by the panel of experts: each expert indicated three students and one professional nurse. The 18 students and 6 nurses were invited to the student panel. The remaining students and nurse professionals who committed to participate were allowed access to the safeMedicate Brazilian version and receive the face validity survey (Appendix C).

**Face validity survey.** Face validity refers to the degree to which a test appears to measure what it purpose to measure. A face validity survey was presented to the target group (nursing students and professionals seeking an update) as an opportunity to reflect and evaluate implementation of the instructional-design as a whole. The survey (Appendix C) is an adaptation of a System Usability Scale which has shown a strong face validity (Bangor, Kortum, & Miller, 2009). The survey focused on what they like about the various elements; what is helpful or not; if the materials and activities are appropriate to their needs; if they could which changes they would do; and, if they feel they attained the objectives.

Lastly, the researcher invited the students and professionals to participate in further adaptation/researchers of the software as well as references of colleagues. Through a snowballing strategy, this dissertation was able to build a contact database favoring future large-scale studies and adaptations.

**Establishing trustworthiness of data**

The fundamental criteria for trustworthiness of data in qualitative research is credibility, dependability, confirmability, and transferability.

In order to guarantee credibility, the principal investigator explored the correct operational measures for the concept being studied (Holloway & Galvin, 2016; Ulin et al., 2005)
through the triangulation of methods (journaling, focus group, and face validity survey) resulting in contextually rich interpretations.

Dependability relates to find logically consistent patterns of response that remain reasonably stable over time (Holloway & Galvin, 2016; Ulin et al., 2005), this is guaranteed by having a second independent coder helping to offset the subjective bias of the researcher. In addition, journaling contributes to this criteria by describing detailed decisions steps of methods change, questions revision, and so forth.

In regards to confirmability, which goal is to confirm the data reflect as accurately as possible the participants’ perspectives and experiences (Holloway & Galvin, 2016; Ulin et al., 2005), the principal investigator allowed the audition of the trail (audit trail). The journaling, focus group guides, list of codes, and reports enable to track the process that has led the investigator conclusions. Consequently, they allowed opening the study process to outside inspection and verification, in other words, the audition of the process.

Transferability in qualitative research refers to produce data that are conceptually, not statistically, representative of people in a specific context (Holloway & Galvin, 2016; Ulin et al., 2005). In pursuance of transferability, the partners of safeMedicate adaptation were carefully selected to represent viewpoints and experiences that reflect key issues in the research problem. For this reason, the snowball sampling method was performed guaranteeing an intensity (professionals with particular experience in the topic) and heterogeneous sample (the inclusion of professors and clinical nurses in the focus groups highlights the variation perspective of the phenomena).
**Recruitment strategy**

The recruitment strategy occurred through snowballing sampling method. The snowballing sampling is a technique for locating informants by asking others to identify individuals or groups with special understanding of a phenomenon. This technique tends to provide a rich pool of resources for exploring the research question because informants with special expertise can likely identify other knowledgeable people (Biernacki & Waldorf, 1981; Marcus, Weigelt, Hergert, Gurt, & Gelléri, 2016; Ulin et al., 2005).

The partners for safeMedicate adaptation were selected according to their role in the process. For the language adaptation team, the inclusion criteria was the fluency in English and Portuguese so all members may understand and discuss the Portuguese and English content simultaneously, the language barrier or lack of availability are the exclusion criteria.

For the panel of experts, it was included only nursing professionals that have been in the job market for at least four years performing as professors, supervisor of nursing students and/or clinical nurse. In the study, the professional had a diverse and long experience at those different practice areas. Professionals who had not been involved in the teaching medication calculation dosage, had been in the job market for less than four years, without access to internet connection, or not available for skype meetings were not included in the research.

The student panel was draw from a list of the names indicated by the panel of experts: each expert indicated three students and one professional nurse. The 18 students and 6 nurses invited to the student panel. The students and nursing professionals committed to participate were allowed access to the safeMedicate Brazilian version.
Coding process

The systematic coding of text is one of the key elements in qualitative data. Codes are the foundation of an analyst argument based on building blocks for theory or model building. The codebook development strategy standardized structure and dynamic process typifies the project undertake at CDC, where coding is generally done by two or more persons who may be located at widely dispersed sites (MacQueen, McLellan, Kay, & Milstein, 1998).

The CDC project work frame aligns with the process of adapting an educational software internationally. Therefore, considering that a structure codebook provides a stable frame for the dynamic analysis of contextual data, can improve intercoder agreement among multiple researchers, and take into account the value of team-based codebook developing and coding, the researcher opted for the codebook development strategy.

The codebook development strategy starts with the principal investigator developing the initial code list reflecting the researcher’s implicit or explicit research questions, which forces the researcher to place his or her assumptions and biases in plain view (MacQueen et al., 1998). The codebook structure includes six basic components: the code, a brief definition, a full definition, guidelines for when to use the code, guidelines for when not to use the code, and examples. The codes become coordinates on the map frame, linking features in the text to the analyst’s constructs. The adequacy of answers to research questions can then be assessed in terms of the sensitivity and specificity of the codes, the richness of the text, and the validity and reliability of the links established among them (MacQueen et al., 1998).

The coders examined patterns and possible relationships in these themes, contradictory responses, or gaps in understanding. The important were coders be guided by what is most useful as they organize and make sense of the text, documenting coding decisions and keeping in mind
The coding scheme is never rigid, but evolve over time. The process of continuous coding imposes a systematic approach and keeping track of gaps is important as they suggest new questions for further explanation: leading to adapt the study design, seek different sources, or modify discussion guides to explore new topics (Ulin et al., 2005). Therefore, the interview guides were discussed based on continuous data analysis which have undergone minor changes to produce the most accurate description of the phenomenon being studied: the adaptations necessary in safeMedicate for use in Brazil. Though the structure is simple and stable, the process of building is complex and dynamic as the codebook is reviewed and refined according to data analysis. The Figure 2.2 illustrate the coding process diagram, which is subject to review in case of inconsistencies.

**Figure 2.2.** Coding flow diagram. Source: (MacQueen et al., 1998).
The codes derive from a priori and emergent themes. A priori reflects what the researcher expect to encounter from the research questions and the emergent themes are codes that emerge after data collection. Table 2.3 shows the final codes’ themes and subthemes.

**Table 2.3. Adaptation process codebook**

<table>
<thead>
<tr>
<th>Theme</th>
<th>Brief Definition</th>
<th>Definition</th>
<th>When to use</th>
<th>When not to use</th>
<th>Example:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Language</td>
<td>Language adaptations</td>
<td>Language adaptations that favor the ability to understand the content</td>
<td>Apply this code to all language/wording change whose focus is to increase the capability of a target-audience to understand the content</td>
<td>Do not use this code if the language change suggestion do not focus on increasing the capability of a target-audience to understand the content</td>
<td>Change &quot;Injectable&quot; to &quot;Injectable (ID, SC, IM)&quot;.</td>
</tr>
<tr>
<td>Visual</td>
<td>software visualization</td>
<td>Changes suggested to favor software image</td>
<td>Apply this code to all suggestions that favor software visualization/image by the user</td>
<td>Do not use this code if the suggestion do not focus on a better software view.</td>
<td>Example: &quot;font size looked small&quot;</td>
</tr>
<tr>
<td>Content</td>
<td>software content</td>
<td>Changes or additions to software material that favors content comprehension</td>
<td>Apply this code to all ideas that add or change software material to favor target audience comprehension by aligning to protocols, guidelines, or clinical terms.</td>
<td>Do not use this code if the suggestion does not target audience comprehension</td>
<td>&quot;Add the nine rights of medication administration because students learn this way in class&quot;</td>
</tr>
<tr>
<td>Programming</td>
<td>Software programming and changes from users perspective of utilizing the software</td>
<td>Suggestions about software programming, adding new functions and regarding users' action of using the software</td>
<td>Apply this code to all ideas that add new functions to software as well as to suggestions related to software usage</td>
<td>Do not apply this code to ideas that changes only software visual of a function already presented or to comments not related to explicit manipulation of the software</td>
<td>&quot;is it possible to include a smart assessment?&quot; or &quot;needs to scroll up and down to view the entire page&quot;</td>
</tr>
<tr>
<td>Data</td>
<td>Data report</td>
<td>Data derived from users of the software</td>
<td>Apply this code to ideas that are related to software content.</td>
<td>Do not apply this code to ideas that are related to software content.</td>
<td>&quot;is there a final report with percentage of mistakes?&quot;</td>
</tr>
</tbody>
</table>
In addition, the principal investigator noted the ideas in the field journal, recording any topics that the research has not adequately addressed up to present and ones that emerged unexpectedly in the transcripts, allowing the audition of the trail.

**Data Analysis**

To explore the evaluation of safeMedicate and identify the adaptations necessary in the software for use in Brazil, transcripts from the group conference calls were subjected to content analysis. A confederate name to protect the confidentiality of the partners of the conference calls was created. In order to reach internal consistency of the analysis, a systematic coding procedure to produce reliability is essential.

After the primary investigator developed the codebook, the primary investigator and a second coder independently coded the transcript of the first conference call. The second coder was a doctoral student trained in qualitative research with experience in cross-cultural research for five years. Both identified and sorted the statements referred to the research question (which are the adaptations necessary in safeMedicate for use in Brazil?). In cases where disagreement exists about a statement placement, both recoded referencing to Brazilian legal documents regarding medication training information. When no consensus is possible, the statement was placed into a residual category. In the study, both coders coded all videoconferences transcripts.
Descriptive statistics was used to analyze and report the face validity survey data, calculating frequencies, measures of central tendency, and standard deviations.

**Conclusion**

Neither systematic reviews nor empirical researches currently published describe the methodology used with enough details to allow methodology replication or improvement. The adapted process of PIPFLA proposed in this paper uses a standardized and transparent documentation, including expert judgment. In other words, contributes to reduce bias and provides a systematic and rigorous approach. Shortening the adaptation time of an effective evidenced-based training is important and necessary worldwide. To uptake systematic and transparent cross-cultural adaptation processes allows not only to optimize education research resources worldwide but favors the spread of outcomes from effective evidenced-based trainings.

**Limitations**

A limitation of the adapted PIPFLA method is how challenging may be reaching consensus on risk of bias for human observational studies. Exploring the outcome differences according to different research designs is also important as the quality rating varies according to methodology (i.e., case-control studies, cross-sectional studies, case series reports, cohort, nested case-control studies). The application of the adapted PIPFLA process may be poorly executed by other researchers as generating questions relevant to decision making throughout the adapted PIPFLA process is crucial to cover pertinent information. However, publishing a detailed step-by-step instruction may be helpful to avoid methodology fallout. Finally, there are many other puzzling nonscientific, social, and political barriers to cross-cultural adaptation processes.
Future directions

Assess the average time necessary for total process completion is important to future researchers and intervention developers. The recruitment and data analysis suggestion allows flexibility for future adaptations. This flexibility was deliberately proposed as improved statistical tools for data analysis and integration may contribute to advance the application of this adaptation process, favoring the ongoing development of research synthesis. Therefore, the broad applicability of the adapted PIPFLA process support efforts by businesses, governments, and researchers.

References


APPENDIX A:

SafeMedicate Feedback

Please answer the following questions regarding each section of safeMedicate Essential Skills. Please, keep in mind that safeMedicate software objective is to improve calculation dosage skills of nursing students and health professionals as a software to complement education.

Section 1: Introduction

<table>
<thead>
<tr>
<th></th>
<th>Strongly agree</th>
<th></th>
<th></th>
<th></th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The content was organized and easy to follow</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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<tr>
<td>2. The content met the learning objectives</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. The content reflected the Brazilian guidelines for medication administration</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4. I would change some things in the product if I could.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

What aspects of this slide you would change?

(*notes of the major points to send to the researcher and as a reminder to yourself for the group conference call: remember to indicate the slide to make it easier)
# APPENDIX B:

## General project development:

<table>
<thead>
<tr>
<th>Sections</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
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</thead>
<tbody>
<tr>
<td>1. Introduction</td>
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<td>2. Prescriptions &amp; S.I. Units</td>
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<td>3. Tablets and Capsules</td>
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<td>4. Liquid medicines</td>
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<td>5. Injections</td>
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<tr>
<td>6. IV infusions</td>
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</table>

## Panel of experts’ cycle development:

<table>
<thead>
<tr>
<th>Phase</th>
<th>Versions</th>
<th>Final version reached:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 2 3 4 5</td>
<td>6 7 8 9 10 11 12</td>
</tr>
<tr>
<td>Under analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feedback</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conference call</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under adaptation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX C

Face validity of safeMedicate

Please check the box that reflects your immediate response to each statement. Don’t think too long about each statement. Make sure you respond to every statement.

<table>
<thead>
<tr>
<th></th>
<th>Strongly disagree</th>
<th></th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The product helped me to improve my mathematical skills</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>2. I think that I would like to use this or similar product (online trainings) frequently.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3. I found the product unnecessarily complex.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>4. I thought the product was easy to use.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>I think that I would need the support of a technical person to be able to use this product.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>6. I found the various functions in the product were well integrated.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>7. I thought there was too much inconsistency in this product.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>8. I imagine that most people would learn to use this product very quickly.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>9. I found the product very awkward to use.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>10. I felt very confident using the product.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>11. I needed to learn a lot of things before I could get going with this product.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>12. The training experience will be useful in my work.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
SECTION THREE:
EVALUATION OF THE BRAZILIAN VERSION OF SAFEMEDICATE, WITH RECOMMENDATIONS FOR FURTHER DEVELOPMENTS

Abstract: This paper aims to identify and provide knowledge on the adaptations in safeMedicate for use in Brazil, taking into consideration professors, nurses, and students perspectives of the training software. The methodology followed the adapted PIPFLA version using n explorative, qualitative design with online focus groups. Transcripts from the group videoconference calls were subjected to content analysis. A confederate name to protect the confidentiality of the partners of the conference calls was created. After the primary investigator developed the codebook, the primary investigator and a second coder independently coded the transcripts. Both identified and sorted the statements referred to the research question (which are the adaptations necessary in safeMedicate for use in Brazil?). The main themes were language, visual, content, programing, data, and strength. Beyond reporting safeMedicate as acceptable in Brazil, members perceived it would be welcomed as a way to answer current teaching and practice gaps. Finally, it is important to consider cultural and political barriers when adapting material between different nations.

Keywords: nursing, education, drug dosage calculation, safemedicate, virtual.

Introduction

Medication administration is an important and essential nursing function with the potential for dangerous consequences if errors occur. One way to minimize this threat is to
provide competency-based education for personnel charged with any tasks related to medication administration.

A Drug Information Centre in Brazil reports that most errors are related to prescribing, preparing, and administering medications. The error causes include wrong dose/overdose (13.2%), wrong route of administration (11.4%), inadequate drug storage (11.4%), and wrong dosage form (ex. Tablets, capsules, ampoules, IV infusion crystalloid solutions, etc) (8.8%) (Dos Santos, Winkler, Dos Santos, & Martinbiancho, 2015). Of note, overdose is related to excessive administration of the drug, which may be related to the wrong prescription or the wrong dose preparation or a combination of these two factors.

Considering the Brazilian reality, this dissertation is a context and language adaptation of an evidence-based training software called safeMedicate that was developed through a translational research process spanning more than 20 years. The translational research process links basic research and application in clinical practice addressing two gaps: the knowledge/technology transfer and health professional evaluation (Young, Weeks, & Hutton, 2013).

By providing a contextualized learning environment, students using safeMedicate achieve significant improvements in the construction of conceptual and calculation competence in medication dosage calculation problem-solving (MDC-PS) in both UK and USA programmes. This happens because the authentic learning environment supports a spectrum of learning styles in mathematics by offering opportunities to tailor and expand mathematical skills through mental computation, arithmetic, geometry/visual, and algebra (Weeks, Clochesy, Hutton, & Moseley, 2013).
Language adaptation generally includes more than a simple word-for-word translation. It is an interpretation of meaning. Moreover, in order to adapt safeMedicate for use in Brazil, it is necessary to address the health professional evaluation guaranteeing it meets the professional practice, professional regulation, and political requirements.

This moves translation beyond grammatical rules and writing conventions to an interpretation informed by socio-cultural and contextual factors (Alegría et al., 2004; Bravo & Woodbury-Farina, 1993). In order to inform and guide the language adaptation process, it is required to use a combined emic (within-culture/insider’s perspective) and etic (similarities across cultures/outsider’s perspective) (Berry, 1999; Maríñez-Lora, Boustani, del Busto, & Leone, 2016; Matías-Carrelo et al., 2003).

Therefore, the qualitative study described in this paper aims to identify and provide knowledge on the adaptations in safeMedicate for use in Brazil, taking into consideration professors, nurses, and students perspectives of the training software.

**Study Aims**

To identify the adaptations necessary in safeMedicate for use in Brazil
To explore Brazilians’ target group (professor, nurse, and student) perspective of safeMedicate software.

**Methods**

**Design**

An explorative, qualitative design was used with online focus groups. The author chose online focus groups rather than traditional face-to-face because it provides the ability to
participate at a time most convenient to participants considering worldwide time zones differences. An advantage valued on online focus groups is the possibility of participating from home (Zwaanswijk & van Dulmen, 2014). The methodology followed the adapted PIPFLA version.

The author chose Zoom Video Communications for the online focus group because it provides an affordable, easy-to-use, video, voice and screen sharing platform, including mobile app access. It was named a 2018 Gartner Peer Insights Customers’ choice for meeting solutions. Gartner is the world’s leading research and advisory company who vets the reviews to ensure there’s no vendor bias or hidden agendas, but the real voices of enterprise users. In a growing number of markets, Gartner collects enough data to provide a top-level synthesis of which vendor products are the most valued by customers in a given market (Gartner, 2018).

Given the iterative process of qualitative research, the interview guide could be adjusted based on new insights from data analysis. Besides, the semi-structured interview guideline varied according to focus group characteristics (language adaptation team, panel of experts, and student panel), but all focused on identifying the changes necessary in safeMedicate system for use in Brazil as well as participants general perception about the system. Tables 3.1 and 3.2 shows the interview guides for the different focus groups.
Table 3.1. Interview guide for language adaptation team.

<table>
<thead>
<tr>
<th>Questions</th>
<th>Remarks/rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction: Hello everybody, my name is Samia Dutra and I will conduct</td>
<td>Before starting the focus group discussion, all participants will be informed about the purpose of the discussion, confidentiality and practical issues</td>
</tr>
<tr>
<td>the discussion. Thanks everyone for being here interested in this project.</td>
<td></td>
</tr>
<tr>
<td>We invited you all to adapt and evaluate safeMedicate software for use in</td>
<td></td>
</tr>
<tr>
<td>Brazil. This first meeting assess safeMedicate acceptability for use in Brazil.</td>
<td></td>
</tr>
<tr>
<td>Are there any questions regarding the project purpose?</td>
<td></td>
</tr>
<tr>
<td>During this meeting, I will ask several open questions. Your opinions and</td>
<td></td>
</tr>
<tr>
<td>view are very important for us. There are no right or wrong answers.</td>
<td></td>
</tr>
<tr>
<td>Please feel welcome to express yourself freely during the discussion.</td>
<td></td>
</tr>
<tr>
<td>This video-conference will be recorded on zoom software. This is only for</td>
<td></td>
</tr>
<tr>
<td>purpose of the research, only the research team will listen to the tape.</td>
<td></td>
</tr>
<tr>
<td>No names or personal information will be used in the report.</td>
<td></td>
</tr>
<tr>
<td>Some practical issues: the discussion will last for about three hours.</td>
<td></td>
</tr>
<tr>
<td>We ask you to please switch off your mobile phones. Please give everyone</td>
<td></td>
</tr>
<tr>
<td>the chance to express their opinion during the conversation. As a</td>
<td></td>
</tr>
<tr>
<td>moderator, my role is to make sure everyone has a chance to participate.</td>
<td></td>
</tr>
<tr>
<td>In every group there are people who talk more and people who talk less.</td>
<td></td>
</tr>
<tr>
<td>So, do not feel offended if I ask you to speak little more or a little less.</td>
<td></td>
</tr>
<tr>
<td>You can address each other when expressing your opinion, I am only here</td>
<td></td>
</tr>
<tr>
<td>to assist in the discussion. I will often check for clarification of</td>
<td></td>
</tr>
<tr>
<td>what is recorded and consensus when necessary. Is everything clear about</td>
<td></td>
</tr>
<tr>
<td>the course of the focus group discussion?</td>
<td></td>
</tr>
<tr>
<td>Mod: Please share your name and your study subject?</td>
<td>For acquaintance with the participants and to break the ice</td>
</tr>
<tr>
<td>Do you believe safeMedicate is acceptable for use in Brazil? Why?</td>
<td>Evaluate how acceptable would the software be in Brazil.</td>
</tr>
<tr>
<td>Mod: Have you had the opportunity to observe similarities and differences</td>
<td>Validate and obtain more specific information from participants.</td>
</tr>
<tr>
<td>in the material?</td>
<td>To evaluate positive and negative aspects of the website</td>
</tr>
<tr>
<td>Let's start with the translation of the images from the problems. Based</td>
<td>These sub-questions will be used to further explore the positive and negative</td>
</tr>
<tr>
<td>on the differences, what is the best translation for the images?</td>
<td>impressions of the website by the participants.</td>
</tr>
<tr>
<td>Now moving on to the differences in the documents in Word. What is the</td>
<td></td>
</tr>
<tr>
<td>best translation for the documents?</td>
<td></td>
</tr>
<tr>
<td>Following this discussion, do you believe safeMedicate is acceptable for</td>
<td>Refresh the question in order to gather any lingering ideas or comments.</td>
</tr>
<tr>
<td>use in Brazil? Why?</td>
<td></td>
</tr>
<tr>
<td>Does anyone has any further comments or questions?</td>
<td>Give opportunities to add remarks and suggestions</td>
</tr>
<tr>
<td>Thank you everyone for your contribution and time. You may contact me by</td>
<td>Conclude focus group.</td>
</tr>
<tr>
<td>e-mail in case you have any further questions. Hope we will be in touch.</td>
<td></td>
</tr>
</tbody>
</table>

70
<table>
<thead>
<tr>
<th>Questions</th>
<th>Remarks/rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Introduction:</strong> Hello everybody, my name is Samia Dutra and I will conduct the discussion. Thanks everyone for being here interested in this project. We invited you all to adapt and evaluate safeMedicate software for use in Brazil. This first meeting assess safeMedicate acceptability for use in Brazil. Are there any questions regarding the project purpose?</td>
<td>Before starting the focus group discussion, all participants will be informed about the purpose of the discussion, confidentiality and practical issues</td>
</tr>
<tr>
<td>During this meeting, I will ask several open questions. Your opinions and view are very important for us. There are no right or wrong answers. Please feel welcome to express yourself freely during the discussion. This video-conference will be recorded on zoom software. This is only for purpose of the research, only the research team will listen to the tape. No names or personal information will be used in the report. Some practical issues: the discussion will last for about three hours. We ask you to please switch off your mobile phones. Please give everyone the chance to express their opinion during the conversation. As a moderator, my role is to make sure everyone has a chance to participate. In every group there are people who talk more and people who talk less. So, do not feel offended if I ask you to speak little more or a little less. You can address each other when expressing your opinion, I am only here to assist in the discussion. I will often check for clarification of what is recorded and consensus when necessary. Is everything clear about the course of the focus group discussion?</td>
<td></td>
</tr>
<tr>
<td><strong>Mod:</strong> Please share your name and your study subject?</td>
<td>For acquaintance with the participants and to break the ice</td>
</tr>
<tr>
<td><strong>Do you believe safeMedicate is acceptable for use in Brazil? Why?</strong></td>
<td>Evaluate how acceptable would the software be in Brazil.</td>
</tr>
<tr>
<td><strong>Mod:</strong> At first, we will focus on “How to Access a safeMedicate Assessment” video and feedback. What was your general impression of this video? Considering the answers to the safeMedicate form, most of you strongly agree that the content was organized and easy to follow. However, how do you think the content may be more organized and easier to follow? Considering the answers to the safeMedicate form, most of you strongly agree that the met the learning objectives. However, how do you think the video may meet better the learning objectives?</td>
<td>Validate and obtain more specific information from participants. To evaluate positive and negative aspects of the website These sub-questions will be used to further explore the positive and negative impressions of the website by the participants.</td>
</tr>
<tr>
<td><strong>Table 3.2. (continued)</strong></td>
<td></td>
</tr>
<tr>
<td>---------------------------</td>
<td></td>
</tr>
<tr>
<td>Considering the answers to the safeMedicate form, most of you strongly agree that the content reflected the Brazilian guidelines for medication administration. However, how do you think the video may meet better reflect the Brazilian guidelines?</td>
<td></td>
</tr>
<tr>
<td>Considering the answers to the safeMedicate form, some of you agree that changes are necessary in the video. What would be the changes that you recommend?</td>
<td></td>
</tr>
<tr>
<td><strong>Now we will focus on “How to carry out a safeMedicate Practice Assessment” video and feedback.</strong></td>
<td></td>
</tr>
<tr>
<td>What was your general impression of this video?</td>
<td></td>
</tr>
<tr>
<td>Considering the answers to the safeMedicate form, most of you strongly agree that the content was organized and easy to follow. However, how do you think the content may be more organized and easier to follow?</td>
<td></td>
</tr>
<tr>
<td>Considering the answers to the safeMedicate form, most of you strongly agree that the content reflected the Brazilian guidelines for medication administration. However, how do you think the video may meet better reflect the Brazilian guidelines?</td>
<td></td>
</tr>
<tr>
<td>Considering the answers to the safeMedicate form, some of you agree that changes are necessary in the video. What would be the changes that you recommend?</td>
<td></td>
</tr>
<tr>
<td><strong>Follow-up discussion, do you believe safeMedicate is acceptable for use in Brazil? Why?</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Refresh the question in order to gather any lingering ideas or comments.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Does anyone have any further comments or questions?</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Give opportunities to add remarks and suggestions.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Thank you everyone for your contribution and time. You may contact me by e-mail in case you have any further questions. Hope we will be in touch. Bye.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Conclude focus group.</strong></td>
<td></td>
</tr>
</tbody>
</table>
Participants and recruitment

Participants were eligible for inclusion if they met the following criteria:

1. To participate in the bilingual committee: Bilingual professionals with experience with healthcare material.

2. To participate in the Panel of Experts: Professionals working in the labor market for at least 4 years work as a university professor, preferably in medication calculation dosage; and/or (b) Clinical Practice supervisor; and/or (c) clinical nurse.

3. To participate in the Student/Nurse panel: Students who already undertook medication calculation dosage classes or nurses working on clinical practice.

Participants were recruited through convenience sampling, by using the network of university deans and the professional network of the principal researcher, as well as through “snowball sampling”. Social media was also used to extend opportunity of participation through a google form where professionals and students could answer questions and provide a link to their lattes curriculum of the Lattes platform in case they were interested in participating of safeMedicate adaptation process.

The lattes platform represents CNPQ's experience in integrating curriculum databases, research groups and institutions into a single information system. The lattes curriculum has become a national standard in the record of the former and current life of the students and researchers of the country. The platform is now adopted by the majority of the institutions of fomentation, universities and research institutes of Brazil (CNPQ, 2018).

This recruitment resulted in an initial sample of 22 nurses and professors that they were potentially interested in participating in the panel of experts and 45 students/nurses potentially interested in participating in the Students panel.
In regards of the Panel of experts, after form responses and curriculum evaluation for inclusion criteria, 15 e-mail invitations were sent out to nurses and professors followed by an e-mail screening members availability for videoconference dates. Seven members indicated common availability, which is when the videoconference was scheduled. Considering last minutes cancelations, four members participated in the Panel of Experts focus group. English fluency was not required for this group.

In regards of the Student Panel, the participants were draw from a list of the names indicated by the panel of experts: each expert indicated three students and one professional nurse. The 18 students and 6 nurses were invited to the student panel. The three first students and one professional nurse who committed to participate were allowed access to the safeMedicate Brazilian version. Considering last minute cancelations, two members participated (one student and one recent graduated nurse). English fluency was not required for this group as well.

For the bilingual committee, six bilingual members were invited: four professional translators and two bilingual nursing professors. One English-Portuguese professional translator and one bilingual nurse professor committed to participate in safeMedicate adaptation process.

**Data collection**

The principal investigator allocated the participants according to the focus groups purpose. The bilingual committee objective was to produce the best possible translation (English to Portuguese) by merging the professional translator and nurse translation documents and prioritizing an adaptation to the target language (Portuguese) considering the socio-cultural Brazilian factors. The Panel of Experts objective was to evaluate the translation produced in the target language (Portuguese) by providing critics and suggestions, justifying through sources
such as governmental and professional guidelines, articles, and standardized medical language.

The panel of students/nurse who provided a general evaluation of safeMedicate providing critics and suggestions.

Previous research recommends six to ten members in the focus group, so the principal investigator invitations followed the recommendation. Even though the final participants number was smaller, all focus groups showed productive results with members showing a comfortable level of interaction.

Focus groups discussions were organized between December 2017 and May 2018. Participants received link to zoom videoconference, link to safeMedicate material for analysis, and instructions for participation. The principal investigator acted as moderator, ensuring participation of the multiple members and often stimulated feedback or further explanation by asking additional questions to clarify and validate participants comments. Paraphrasing was used throughout the videoconferences to ensure the data reflect as accurately as possible the participants’ perspectives.

**Data Analysis**

Transcripts from the group videoconference calls were subjected to content analysis. A confederate name to protect the confidentiality of the partners of the conference calls was created. As the adaptation of a training software is to ensure nurses develop medication calculation skills to establish patient safety, the primary investigator chose flowers as confederate names as blossoming denotes to develop in a promising way.

After the primary investigator developed the codebook, the primary investigator and a second coder independently coded the transcripts. Both identified and sorted the statements
referred to the research question (which are the adaptations necessary in safeMedicate for use in Brazil?). In cases where disagreement exists about a statement placement, both recoded referencing to Brazilian legal documents regarding medication training information.

The codes derive from a priori and emergent themes. A priori reflects what the researcher expects to encounter from the research questions and the emergent themes are codes that emerge after data collection, leading to reviews of the codebook. Table 3.3 shows the final codes’ themes and subthemes.

**Table 3.3.** Adaptation process codebook

<table>
<thead>
<tr>
<th>Theme</th>
<th>Brief Definition</th>
<th>Definition</th>
<th>When to use</th>
<th>When not to use</th>
<th>Example:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Language</td>
<td>Language adaptations</td>
<td>Language adaptations that favor the ability to understand the content</td>
<td>Apply this code to all language/wording change whose focus is to increase the capability of a target-audience to understand the content</td>
<td>Do not use this code if the language change suggestion do not focus on increasing the capability of a target-audience to understand the content</td>
<td>Change &quot;Injectable&quot; to &quot;Injectable (ID, SC, IM)&quot;.</td>
</tr>
<tr>
<td>Visual</td>
<td>software visualization</td>
<td>Changes suggested to favor software image</td>
<td>Apply this code to all suggestions that favor software visualization/image by the user</td>
<td>Do not use this code if the suggestion do not focus on a better software view.</td>
<td>Example: &quot;font size looked small&quot;</td>
</tr>
<tr>
<td>Content</td>
<td>software content</td>
<td>Changes or additions to software material that favors content comprehension</td>
<td>Apply this code to all ideas that add or change software material to favor target audience comprehension by aligning to protocols, guidelines, or clinical terms.</td>
<td>Do not use this code if the suggestion does not target audience comprehension</td>
<td>“Add the nine rights of medication administration because students learn this way in class”</td>
</tr>
</tbody>
</table>
Table 3.3 (Continued)

| Programming | Software programming and changes from users perspective of utilizing the software | Suggestions about software programming, adding new functions and regarding users' action of using the software | Apply this code to all ideas that add new functions to software as well as to suggestions related to software usage | Do not apply this code to ideas that changes only software visual of a function already presented or to comments not related to explicit manipulation of the software | "is it possible to include a smart assessment?" or "needs to scroll up and down to view the entire page"
|-------------|---------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|--------------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| Data        | Data report                                                                      | Data derived from users of the software                                                                 | Apply this code to comments related to users data showed in the software       | Do not apply this code to ideas that are related to software content.          | "is there a final report with percentage of mistakes?"
| Strength    | software strengths                                                               | Comments regarding positive aspects of the software                                                   | Apply this code to comments related to positive                                 | Do not apply this code to changes requested                                     | "I like that it shows.."

**Ethical considerations**

The project was conducted in compliance with the principles of Not Human Subjects Research (NHSR) policy. Particularly because the participants were partners, not research subjects, and would receive confederate names, the Institutional Review Board (IRB) concluded the activities presented involved methods of program evaluation, quality improvement, and/or needs analysis. The anonymity of the participants was strictly safeguarded on reports and no further ethics approval of this study was required under the University of South Florida Institutional Review Board (USF IRB) (Appendix D).

**Results**

The main themes were language, visual, content, programing, data, and strength are discussed in the next sections.
Language.

The translation language used varied between a more succinct format to a more detailed (using more words) using technical healthcare words. The option to use a diversified bilingual committee to choose the appropriate wording was suitable to reach the best translated Portuguese version with the professional translator recognizing Portuguese as a dynamic language and that translations differences did not interfere on the content comprehension.

The translator is more succinct and more direct, [but the nurse] had some technical words and a tendency to explain more detailed (Tulip)

It has to be translated by the word that conveys the necessary understanding, so it's correct. Does not change in anything the meaning of the phrase, it just gets elegant […] It got more concise, but it didn't change. I grant to you [both], because you have the knowledge of the practical language (Violet)

The video material available from software developers contained the video in Portuguese, but started showing how to access the assessment through icons in English. Participants of all videoconferences mentioned language adaptation of the website and its icons as crucial for safeMedicate usage in Brazil.

Possibility of translating this material into Portuguese altogether. I think it's suitable the way it is. With the exception of that issue of the translation of the [website to] Portuguese (Sunflower)

Until these icons are translated. I see a bit difficult at first by having many sectors in English. (Lily)

Language subtheme: translation. The analysis and choices of specific terms for translation, focusing in a wording fitting to the Brazilian reality of teaching and practice was expected in the videoconferences. The principal investigator was important to clarify meaning, differences, and the content at the original material.

change those names "domain" "ability" (Betony)
I'm confused about "injectable" and "IV infusions" (Sunflower)

Also, the concern in including medical terms used on healthcare daily practice was raised in the discussions. It was acknowledged multiple times that the translated material was not perceived as a wrong translation, but that it was important to tailor the language for public comprehension and practice context.

She [professional translator] uses the term “medication request”. I would follow more the translation by the nurse who says “medical prescription”. [...] I agree more with “measuring device”. I like it better. Not that it’s wrong, but “instrument” is general. [...] Yes, “no rounding required”. I liked the way the nurse put it, because she used the language she uses in her everyday life [in the healthcare environment]. [...] I would suggest putting “routine medicine”. To be clear the translation is not wrong, it is only the use of language. (Tulip)

Expand language comprehension to technical nursing students was also a concern as well as use a language that would follow technology development.

here there is the technical level of nursing that also works with medications. So the clearest and simplest so everyone can understand. [...] More the “take the cursor” [...] I guess “pass the mouse” will be obsolete. (Tulip)

**Visual.**

Participants provided a general visual perspective of safeMedicate videos regarding content visualization requesting better video quality or more information on the content showed.

Even placing in full screen, it was hard to read (Coneflower)

replacing the color with symbols or numeric categories (Sunflower)

Oh... how cute... very interesting [When seeing the syringe plunger move] (Violet)

We do not see the question to know how really is. [...] What is the style of the question. [...] He did not bother to show us the question, but rather the operation as a whole (Jasmine)
An overview of the results allowing to see which part of the problem was wrong (calculation, device choice, or device measurement) in the same screen was also recommended.

For him to know the point he missed, not need to open...at the first view, he would know where the error is (Marguerite)

Content.

Further pharmacology information in safeMedicate was requested in order to align to Brazilian professional practice guidelines as well as to respond to professional development need in Brazil.

Both in undergraduate and specialization, we perceive a fragility in pharmacology training. [...] Add an informative balloon of pharmacology. (Coneflower)

Having a baloon that the student clicked, stating the indication. [...] The indication of the medication as an extra option. [...] is he [the student] wants he watches, if he already dominates the content: he goes into the calculation. (Marguerite)

Also, add extra materials for consultation in the software was mentioned as beneficial for safeMedicate users’ reminder of guidelines as well as to the public perceive how safeMedicate align with Brazilian guidelines. Particularly, materials related to concepts thought in class such as the nine rights of medication administration.

I thought on when start the software have an introductory video listing protocol, only as a reminder to the student. (Coneflower)

Is there any part of the software that could have these protocols? [...] it's not a fundamental thing, but it would be a plus [...] because if he [the student] has a doubt, he goes there [click in the material] and studies. (Marguerite)

We use the international protocols anyway [...] including the right nine [in safeMedicate system], would be closer to the reality of our students here in Brazil (Sunflower)

Not clear to us [whether the software follows] the Brazilian guidelines. (Jasmine)
Programming.

The partners indicated the importance in adapting safeMedicate in an appealing manner to future users, making multiple suggestions to reach this objective

we need to think about leaving the product attractive to the student so that he walk in the processs and this does not get tiresome, boring. [...] increasing the numbers of problems and the degree of difficulty (Coneflower)

inteligent test. That will increase the difficulty and stay on top of the mistakes to test you [test the user of the software].(Marguerite)

The flexibility to resources usage of safeMedicate was mentioned in all videoconferences to align with the diverse technological contexts existed in universities and healthcare facilities.

Hospital units [are] more accessible in terms of resources available because there are already computers [in the site]. Diversification to be acceptable depending on the university situation for teaching. (different technology platforms favors access) (Tulip)

As expected, concern on peoples’ ability with technology was raised throughout videoconferences. However, the solution indicated for this issue was the suggestion to integrate the software as a mobile app, which was an interesting outcome considering the concern’s nature. The reasoning is explained by the videoconference participant:

But not everyone has facility in technology [deal with technology easily]. By cell phone would be something…easier to access. A more portable way. [...]computer is much more complex and involves a lot more system stuff than software as an app. having the software on the cell phone would help these people who don’t have this technological handling because it’s an easier tool to use. We live in a totally technological era. And tends to increase. So even people who are not adept at technology end up having to undergo technology [use] even for their own survival, either for academic or work reasons. People with smartphone use that technology every day to call a child or husband (Jasmine)

I have some doubts about the software not accompanying the smartphone (Lily)

The principal investigator explained the possibility of accessing the software through the web browser of the cell phone, which raised the speed and data usage concerns.
There is no way to pick up a software and reduce it in a short time, but it would be a very valid option. [...] We know that it can be accessed through the internet by the smartphone, but we also know that the internet of the smartphone is not as effective as an app regarding data usage [...] ... is completely different. Even because if it is something very heavy you take a lot of time to download and etc. So this question has to be well studied, because it runs the risk [of software coming] and not be so accessed or well accepted by the difficulty that would have in accessing it. Even because not everyone has a computer under the arm, not everyone has a data package [on the smartphone] with a reasonably accessible speed to sites that size. Among other things. (Jasmine)

Considering data usage and charges in Brazil, this concern is extremely valid to safeMedicate be successfully accessed and used by the target population. Another suggestion was reduce the amount of tabs or provide a more intuitive menu with images as well as to avoid the “pass the mouse, open the menu” function, as it may be annoying for the user.

There are so many tabs in the menu...if it didn’t have so many subfolders. I believe that even being in Portuguese still would have some difficulty. Implementation of images to the menu get more didactic and easy. Be something more objective so that you can access what is your goal faster [reach the tab you intends to access faster]. [...] this software is coming to be a facilitator, so this needs to be quick and easy to reach the goal more effectively. sometimes we can have ten links, but if they are focused it turns out well without difficulty (Jasmine)

In some applications [programs] this part of you just passing the mouse over gives some bugs [problems] [...] being unnecessary stress (Lyli)

Data.

The software display of performance received suggestions to align with comprehension and expectation of users along with easy follow-up on main needs.

In the Brazilian reality, the Brazilian students are stuck to the grade(Coneflower)

I wouldn't put as color, I would put as a numerical scale from zero to ten. [...] either in percentage or numerical scale. as much feedback to the student and to us [the teacher]. We have to know "this student is having difficulty at this point" (Marguerite)
Strength.

A frequent emerging theme in analysis was strengths and positive perspectives of safeMedicate, a theme incorporated in the codebook after coders review. The pattern of video format to present content was positively perceived as beneficial to users’ comprehension aligned with the authentic virtual environment for syringe choice and usage.

    found the entire tool [safeMedicate] easy to access (Coneflower)

    good visualization of [syringe] graduation number. I think [the video] is very clear, very explanatory, the voice of narration is good, the diction is good. […] The same observation of the other video because one complements the other (Marguerite)

    technology being used much more often in the classrooms. This tool [safeMedicate] can be even an ally of the teacher within the classroom. […] It seems you are handling the syringe. (Betony)

    I really liked the appearance, the syringe, the plunger, the ease of you seeing the syringe units, choosing the ideal syringe, the medication, the dosage and all (Sunflower)

    I really liked [safeMedicate] I think it will be very useful. (Tulip)

    [safeMedicate] was very well thought out and planned aiming at the study of [drug calculation] skills (Jasmine)

    But the [opportunity to] practice generates the possibility of performing with a greater ease to improve customer service and avoid mistakes. Used within the institutions as a new discipline […] along with semiology and semitechnical (Lyli)

    The availability of problem and tools in one screen was also mentioned

    can see everything that will be necessary for the realization of the calculation (Betony)

    The product suitability to Brazil was mentioned multiple times, particularly regarding the advantage of learning opportunities in spaces beyond the classroom allowing repetition of calculation skills. Opportunity for repetition was validated as a positive safeMedicate
characteristic in all videoconferences. Furthermore, the use of technology for teaching medication calculation skills was perceived as an opportunity to fulfill current gaps of teaching methods. Particularly when considering Brazilian nursing practice is considering implementing pharmaceutical prescription to nurses.

suitable for use in Brazil, it is a tool that facilitates learning not only in the classroom as other spaces (Betony)

we are seeing that [our classroom, traditional teaching methods] are not responding to the problems of our students, they feel the need to build their own knowledge and I think the arrival of these applications [software] only tends to enrich our methodology (Sunflower)

I think showing the necessity here […] the gap exists. Especially that nursing that is planned to install in Brazil requires the pharmaceutical prescription. So knowledge in the area of pharmacology and medication calculation only comes to add. (Tulip)

We only pay [register in discipline] that has this calculation in one or two disciplines of the university […] then it becomes vacant, because whether you want or not everything that involves mathematics is practical…you have to be there practicing daily (Jasmine)

Stimulate independence for knowledge development was perceived as a secondary gain the safeMedicate usage would bring to users. However, it is important to introduce the virtual aid tool concept to teachers and students.

also to make our students become more independent is the search for their own knowledge and we really work and participate as facilitator of this process (Sunflower)

I already see a very strong viability, but it’s because I’m already getting to know how to use it. […] there’s a certain lack of notion what a virtual aid is. (Tulip)

Finally, it is acknowledged safeMedicate importance to different healthcare professionals

Very good teaching and practice tool for those who are working in that area. Be it doctors, residents, nurses, nursing assistants… people who need to practice something and have no opportunity to do it firsthand. (Violet)
Discussion

Due participants vast experience in nursing practice and teaching, it was considered suffice their comments for the focus group. At the second videoconference of professors, the saturation of suggestions was reached by either their suggestions be accepted by software developers or agreeing safeMedicate functions explained would suffice that change requested. For example, the participants suggested a numerical value to indicate students’ performance which would serve as guidance to student and professor. The software provides a final percentage as a final report in which students and professor has access to how many calculations were made and the most frequent type of calculation error. The partners agreed this functionality fulfills the “percentage, numeric” need on assessment data report.

A necessary approach throughout videoconferences was to clarify the videos purpose to the student learn how he will access the safeMedicate system, to see the assessments. A moment in which the user has not finished the evaluation yet. Semantic and cultural modifications are common on cross-cultural studies with commonly performing psychometric analysis (Silveira et al., 2018). Psychometric analysis is not necessary in this study because it is not an adaptation of an assessment scale, but a content analysis exploring the changes necessary for safeMedicate usage in Brasil.

A negative possible outcome of focus group reported in the literature is groupthink, when stronger members have major control or influence the verbalization of other members, which can be overcome by focusing on the potential for learning about both the focus and the group (Speziale & Carpenter, 2011). However, throughout the videoconferences, the participants portrayed consciousness on mutual collaboration towards other participants, allowing each other to speak. It was clear all partners perceived it as a collaborative process where all voices should
be heard, indicating when another member raised the hand. When debriefed the perspective of using videoconference for the focus group asking explicitly on flaw areas where improvement would be necessary, there was a very positive method validation from participants.

No. I thought it was pretty good. It was the first time I used this software and it gives to interact well, see several things at the same time, the chat, the person...I have not used before and I thought it is fantastic. No specific detail... You were extremely thoughtful, when I entered you were already online in the room.... I opened the doors with you. It was very quiet [smooth]. I have nothing to suggest. (Betony)

Conclusion

The main themes were language, visual, content, programing, and data while discussing necessary adaptations of safeMedicate for use in Brazil. The emerging theme strength was perceived throughout videoconferences with every partner indicating positive aspects of the system. Beyond reporting safeMedicate as acceptable in Brazil, members perceived it would be welcomed as a way to answer current teaching and practice gaps. Finally, it is important to consider cultural and political barriers when adapting material between different nations.

Study Strengths and limitations

There were technical difficulties while doing the videoconference with one of the participants not able to turn on the microphone due computer technical problems. However, the viability of sending voice messages to the principal investigator which was continuously shared with the group ensured his participation and opinions to be heard. Provide access to video prior translation of written documents is important for proper word choice applicable to the software. Hence, the importance of alignment with software developers.
Acknowledgement

Acknowledgment of the financial support to Samia Valeria Ozorio Dutra from the Brazilian Federal Agency for Support and Evaluation of Graduate Education (CAPES).

Conflict of interest

No conflict of interest has been declared by the authors.

References


Zwaanswijk, M., & van Dulmen, S. (2014). Advantages of asynchronous online focus groups and face-to-face focus groups as perceived by child, adolescent and adult participants: a survey study. *BMC research notes, 7*(1), 756.
APPENDIX D:

7/14/2017

Samia Valeria Ozorio Dutra
College of Nursing
Tampa, FL 33620

RE: Not Human Subjects Research Determination
IRB#: Pro00030441
Title: Adapting safeMedicate (Medication Dosage Calculation Skills software) for use in Brazil

Dear Ms. Ozorio Dutra:

The Institutional Review Board (IRB) has reviewed your application. The activities presented in the application involve methods of program evaluation, quality improvement, and/or needs analysis. While potentially informative to others outside of the university community, study results would not appear to contribute to generalizable knowledge. As such, the activities do not meet the definition of research under USF IRB policy, and USF IRB approval and oversight are therefore not required.

While not requiring USF IRB approval and oversight, your study activities should be conducted in a manner that is consistent with the ethical principles of your profession. If the scope of your project changes in the future, please contact the IRB for further guidance.

If you will be obtaining consent to conduct your study activities, please remove any references to "research" and do not include the assigned Protocol Number or USF IRB contact information.

If your study activities involve collection or use of health information, please note that there may be requirements under the HIPAA Privacy Rule that apply. For further information, please contact a HIPAA Program administrator at (813) 974-5638.

Sincerely,

E. Verena Jorgensen, M.D., Chairperson
USF Institutional Review Board
Summary of dissertation

This dissertation followed the adapted version of the PIPFLA model according to the recommendation of producing the best possible translation and directly evaluating the translation produced in the target language, than through back translation. Considering safe medication administration is an international ambition for patient safety, in the first section of the dissertation was concluded that research-based principles would be beneficial to address cognitive, motivational, and development goals. Those may be achieved through collection of data about students/nurses, model expert practice, scaffolding complex tasks, and being explicit about objectives and expectations. Web-based learning was often referred as a strong ally to complement class practice by providing repetition opportunities to practice medication calculation skills. Also, it is important to consider that nurse calculation skills are only one factor affecting medication errors and medication safety, what enforces the need to simultaneously attempt to reduce other risks associated with medicines.

While exploring the adaptation methodology of previous studies, the primary author concluded in section two that neither published systematic reviews nor published empirical described the methodology with enough details to allow methodology replication or improvement. Hence, the choice to develop a standardized and transparent process, focusing in reducing bias by including expert judgement. It is important to develop methods which optimize the dissemination of evidence-based trainings.
The third section presents the main themes that portrays the changes necessary in safeMedicate system. Those were language, visual, content, programing, and data. Strength was an emerging theme throughout videoconferences indicating the advantages and positive aspects of the software. The partners concluded safeMedicate would be welcomed in Brazil by corroborating with the changes discussed as it would answer current teaching and practice gaps.

This dissertation reflects on international collaboration dynamic, a method of work aimed and continuously seek worldwide with different products, but with the same objective: improvement.

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ABOUT THE AUTHOR

Samia Dutra is a Brazilian woman who lived in different Brazilian regions. She earned her BSN and MSN in the Federal University of Rio Grande do Norte, Brazil and became a nurse professor in Potiguar University, Brazil. She was invited by the US Government to the 2011 International Visitor Leadership Program to represent Brazil. Her Godmother and Godfather inspired her to explore opportunities abroad.

Selected by LASPAU - affiliated with Harvard University and funded by the Brazilian government-CAPES, she started her Ph.D. studies. During her doctoral program, she worked as a USF College of Nursing research assistant on a National Institutes of Health grant and became the president of the Doctoral Nursing Student Organization. She collaborated in many oral and posters presentations as well as co-authored peer-reviewed publication. The Ph.D. Program Committee also selected her to represent USF College of Nursing at the Rising Stars of Research and Scholarship 2017 invited poster session other than being recognized as having the Best College of Nursing Presentation during USF Health Research Day in 2017 and 2018.

Interested in participating in humanitarian efforts, she volunteered to aid hurricane victims in Puerto Rico which led to further opportunities: sharing experiences at the American Psychiatric Nursing Association 2018 State Conference, become the Health Director at USF Community Emergency Response Team (USF CERT), and participate of the USF Health Disaster Relief Committee.

Samia’s vision is a world connected with exploring nursing excellence, peace, and care. She believes there is a place in the sun for everyone and aims for future global collaborations.