

Formative assessment as a learning aid for pharmacy calculations—a theory based design

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Abstract

Deficiencies in basic numerical skills exist amongst the general population and within healthcare professions. This paper shows how an application of education theory can be used to design an assessment tool to diagnose these problems in pre-registration pharmacists. The main component of this research is based on formative assessment, which acts both as an assessment method and learning aid. Theories such as Landa's Algo-Heuristic Theory and Vygotsky's Concept of Learning Development are incorporated directly into the tool's development. The designed assessment tool comprises three papers, developed around a sample Royal Pharmaceutical Society of Great Britain (RPSGB) exam paper. These papers are to be used at various stages throughout the pre-registration training year to aid progression to mastery. Preliminary validation of this research was carried out using qualitative analysis of an academic/practitioner pharmacist consensus group. The analysis showed that formative assessment is perceived to be difficult to implement and understand. It also showed this tool to be a novel method of addressing this important issue, worthy of further research.

Keywords: *Formative assessment, Landa, numeracy, pharmacy, Vygotsky*

Introduction

The Peppermint Water Case of March 2000 (Pharmaceutical Journal, 2000) highlighted an important issue regarding the undergraduate pharmacy course. It was declared by the prosecuting counsel and various experts who were called upon for evidence, that the undergraduate course did not fully prepare students for practice as pharmacists.

The prosecuting QC told Chester Crown Court that:

There was real doubt over whether [the student's] university and preregistration training would have left him fully appreciable of chloroform water in its concentrated and other forms (Pharmaceutical Journal 2000).

Using standard literature search techniques predominant groups of literature were identified. The first pertained to numeracy deficits and misconceptions in health care and the second concerned using formative

assessment to ameliorate these problems. Throughout this study, the following research questions were observed:

- (1) Can a learning and diagnostic tool be developed, that can identify numeracy misconceptions and deficits in pre-registration pharmacists?
- (2) Can formative assessment fulfill this task?

Formative assessment is a broad concept and is often defined in procedural terms as an application of a specific methodology to a testing process. It relies on the correct application of feedback to function as a learning aid. Ramaprasad (1983) defines feedback as "information about the gap between the actual level and the reference level of a system parameter which is used to alter the gap in some way". It is believed that there are two important functions of this feedback. The first is to allow the instructor to adapt their teaching methods to that of the student's needs and

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the second is to inform the student on what they can do to improve their learning.

Formative assessment is not, however, sensitive enough to identify any misconceptions that could interfere with learning (Smith, diSessa & Roschelle, 1993). Much like summative assessments, formative assessments tell us what the student knows and does not know, but it cannot tell us if they have any misconceptions about this knowledge. Misconceptions are flawed ideas that are defined as “a student conception that produces a systematic pattern of errors” and that these “are strongly held and interfere with learning” (Smith et al., 1993). Weeks, Lyne and Torrance (2000) argue that regarding numeracy assessments much documentation exists showing that students have misconceptions about basic mathematical operations which have stemmed from inadequate early learning.

Landa’s theory of Algo-Heuristic instruction (Landa, 1983) recognizes the importance of not only teaching a student factual knowledge but also the processes utilized by experts in applying this knowledge. The theory states that experts perform tasks using unconscious and intuitive processes. Landa (1983) suggests that for novices to use their knowledge and perform as experts these unconscious processes must be taught to students.

To apply Landa’s theory and convert the novice to the expert, these unconscious processes must be broken down into elementary operations. From these operations the teachers must design algorithms and heuristics which will direct the student to perform these processes. Landa also emphasizes repetition as an important method for turning the novice into an expert. For these processes to become intuitive to the novice they must practice and “recreate the expert level processes”.

Landa’s theory allows us to design algorithmic and heuristic models to teach students dosage calculations. However, this theory is only a general teaching theory, and lacks practical application. There are two other components needed in order to address the research questions outlined above. First, the effectiveness of how well learning occurs needs to be understood. Second, a more specific teaching method for dosage calculations is needed.

Addressing the first of these issues, Vygotsky (1978) offers a constructivist theory of development based on the idea of the zone of proximal development (ZPD). A practical application of this theory is ‘scaffolding’ as developed by Wood, Bruner and Ross (1976) in the area of childhood development. Scaffolding is defined as: “a form of adult assistance that enables a child or novice to solve a problem, carry out a task or achieve a goal which would be beyond his unassisted efforts” (Wood et al., 1976).

This concept of bridging the student’s knowledge gap and using a scaffold to teach places a greater

emphasis on the role the instructor must assume when teaching a student. The instructor must continually assess the student’s current state of knowledge to correctly locate the boundary of the ZPD. This means that the student’s learning goals are re-evaluated more frequently. The concept by Wood et al. (1976) of scaffolding also allows the instructor to adjust the level of guidance given to a student. When the student is successful the degree of control is decreased and conversely if the student makes a mistake the degree of control is increased.

The combination of Landa’s general theory of teaching and Vygotsky’s scaffolding interpretation creates Landamatics, a way of implementing a scaffolded learning process in an educational setting.

What is needed now is a specific method for teaching dosage calculations. For this purpose the 4 C approach was examined, which consists of four discreet areas: computation, conversion, conceptualization and critical evaluation (Johnson Johnson, 2002). This concept of instruction addresses the basic issues pertaining to dosage calculation. Each component is fundamental to dosage calculations and therefore, it is essential that the student have a firm grasp of the basics in order to become competent. The model allows for each component of dosage calculations to be addressed on an individual basis and can allow errors in certain areas to be highlighted and attributed to a specific aspect of the model.

This model is a specific teaching theory and could be considered a specific application of a broader Landa-style approach. The 4 Cs can be integrated into an assessment tool, which can drive formative assessment to assess and define the student’s knowledge.

This model recognizes the importance of being able to critically evaluate an answer. However, this approach does not include a method for assessing this accuracy of this critique, and for this purpose a confidence-based assessment can be used to identify any misconceptions held by the student. Gardner-Medwin and Gahan (2003) have utilized such a method that can be used in both formative and summative environments.

The confidence based assessment works by encouraging the student to become more reflective about an answer for a problem. In the scheme there are three levels of confidence ($C = 1/2/3$) from lowest $C = 1$, to highest $C = 3$. Students allocate a confidence level to each of their questions answered, which reflects their confidence of the answer. The marks awarded for correct answers are 1, 2 and 3, which reflect the level of confidence expressed. Incorrect answers are marked as 0, -2 and -6, again which reflect the level of confidence expressed. The negative marking has two functions. First, to identify any strongly held misconceptions, observed if the student expresses high confidence for an incorrect answer and

second to demonstrate to the student that guessing is not knowledge. This marking scheme is “properly motivating” (Gardner-Medwin & Gahan, 2003).

Confidence assessment has many potential benefits if used correctly. If used formatively, it can identify more aspects of the student’s knowledge than with summative assessment and when used immediately after the assessment the feedback can be more meaningful. It can be adapted to perform an important part in a component of the 4 Cs as it will allow the student to critically evaluate their answers. The negative marking will also motivate the student to become more reflective about their answers.

Detecting misconceptions is extremely beneficial when used with a Vygotskian framework as it defines the student’s current state of knowledge (i.e. their ZPD). The confidence based assessment allows us to adjust the amount of scaffolding offered and Landa’s concepts attempt to generate expert level performance.

Methods

A sample calculation paper provided by the Royal Pharmaceutical Society of Great Britain (RPSGB, 2004) was used as the foundation in generating an assessment tool.

A two step process was used. First, the sample exam questions were answered by the authors. This process was considered to represent the “expert level process”. The second step involved incorporating Landa’s concept and the need to break the process into the elementary operations. The operations used by the authors formed the basis of the scaffolding questions which would act as prompts for the student. It was decided to develop an assessment tool which had three levels classified as: beginner, intermediate and expert.

The actual RPSGB examination has a multiple choice format. This was kept in the designed assessment papers, however, the students would be asked to clearly show their workings. A confidence interval was added to the papers to act both as a component of the 4 Cs (to allow the student to demonstrate their ability to critically evaluate their answer) and as a means to highlight any misconceptions.

The assessment titled beginner contained the scaffolding questions which were considered to represent both the conscious and unconscious processes used when answering the problem. This was to ensure that the student would be guided through the assessment and that they would be recreating the expert level process. The beginner paper allows the tutor to gain insight into the student’s ability at the basic level. Confidence intervals highlight any misconceptions that the student may have at this basic level. From the results of this assessment feedback is generated to be used as part of the

formative assessment aspect. The feedback can be classified according to the 4 Cs. The tutor will allocate any errors from the paper to a component using the 4 Cs. Students can then use this feedback to develop their learning and become competent at this level. Once the student has demonstrated competence at this level it is time to remove some of the scaffolding support and progress to the next stage.

The generation of the intermediate paper involved removing some of the scaffolded questions which were deemed too direct. Remaining scaffolded questions represent the conscious part of the answering process as classified by Landa (1983). Scaffolded questions still required the student to demonstrate competence in the 4 Cs, with computations and conversions as part of the questions. Questions still acted as a guide but also assessed the student’s ability to perform some of the unconscious operations allowing the student to demonstrate their ability to conceptualize problems.

The intermediate assessment paper is presented as per the beginner paper, with multiple choice answers and a confidence interval and the information generated should again be used in a formative assessment manner to enhance the student’s ability. The paper still requires the student to demonstrate their basic skills and the confidence interval will again highlight any misconceptions about the student’s ability to critically evaluate their answer. Once students have demonstrated competence at this level they progress to the expert level.

At the expert level there are no scaffolding questions, because it is now important for the student to demonstrate the knowledge and competence gained from the previous levels. This paper allows the student to fully demonstrate their ability to conceptualize the problems. Like the previous two papers, this level assesses all the skills required to perform dosage calculations. Confidence intervals are still used in this paper to validate the student’s performance at the expert level.

For these papers to be used correctly and to aid learning the instructor must appreciate all the concepts that were adapted in the design of the paper. Information generated from the assessments is to be used as feedback, to address the student’s learning needs.

A consensus group was held to gather opinions regarding the assessment tool. Four pharmacists were asked to partake in the consensus group discussion. Two pharmacists were teacher practitioners at the University of Brighton. The other two were academic pharmacists who lecture on the pharmacy undergraduate course. Although not a representative sample of pharmacists expected to use this tool, it was anticipated that this sample would be able to generate valid critical comments based on their experiences of practice and teaching.

Each participant was allocated a number for anonymity and an audio recording of the consensus

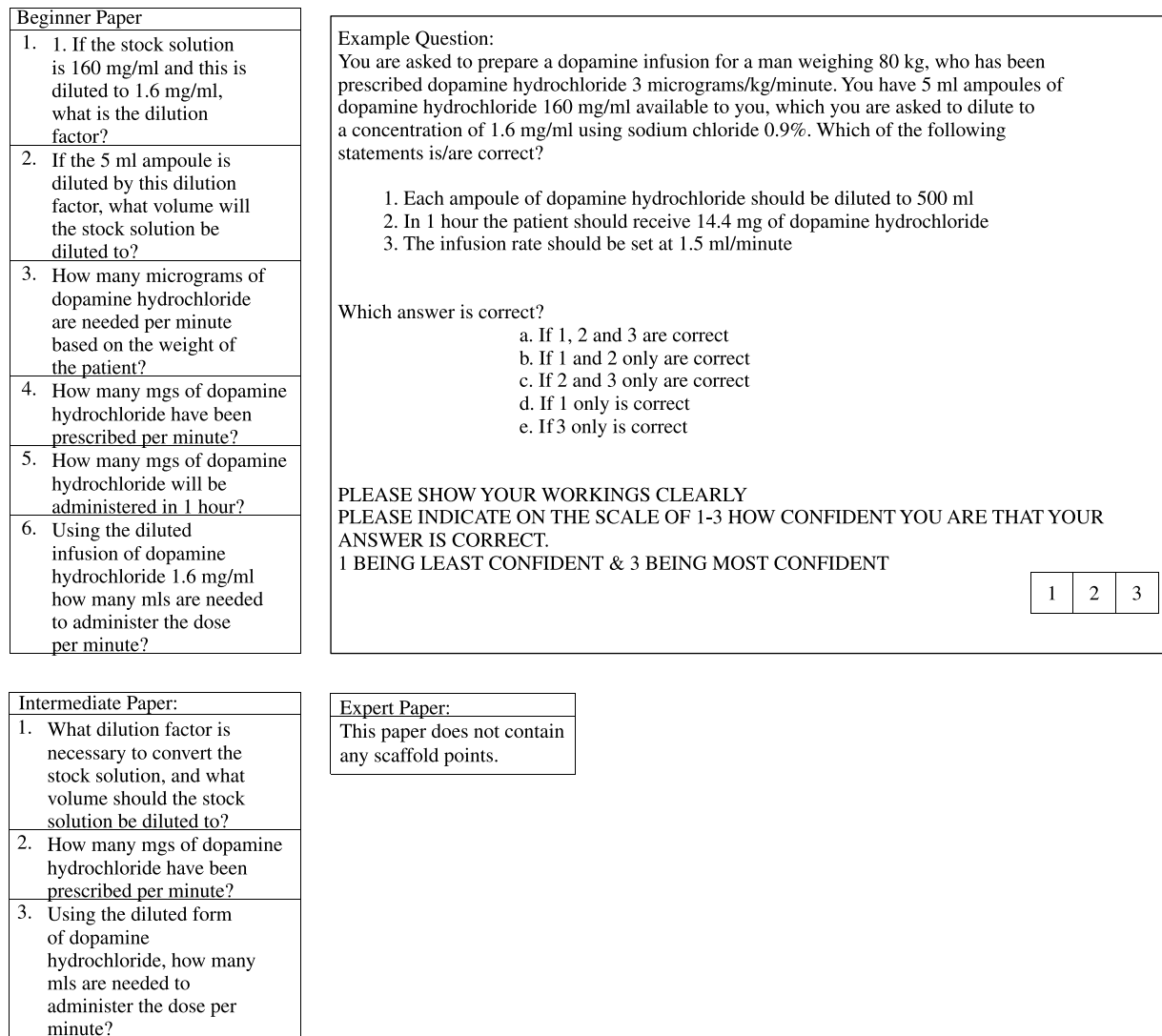


Figure 1. The logical progression of the scaffolding technique. An example question in the beginner, intermediate and expert level papers.

group was transcribed by the authors verbatim. A single document was produced containing the raw material to be used in a qualitative analysis.

The transcript was read several times and the coding process was divided into three stages. First, an open coding process was undertaken. This involved classifying the data into similar categories. Second, from these categories axial codes were developed which connected the categories from the open-coding process. Third, concepts were generated from the axial codes, which described the themes from the consensus group discussion.

Results

The learning and diagnostic tool

Figure 1 shows an example question which illustrates the logical progression of scaffolding in each paper and how this correlates with student ability.

Discussion

Five broad themes were generated from the consensus group discussion. The first was developed from the criticisms that arose from the beginning of the discussion. Criticisms were focused on the tool and the approach the authors adopted in designing it. It was thought that the authors were being too prescriptive with the scaffolded questions. During the deconstruction process, the main points of the question are identified, then the question re-constructed around these points, which form scaffolds. The group thought the “main” points could have been identified differently by different instructors, therefore, introducing the problem of variability in developing scaffold questions. However, the theoretical basis of the deconstruction was not discussed with the group, and it was felt that this criticism was borne out of a lack of information, rather than a true reflection of the tool. When discussing the formative assessment aspect of the tool the pharmacists had

reservations regarding the credibility and reliability of this method. These reservations were due to past experience with formative assessment and the difficulty of developing pro-active knowledge development amongst students.

The second and third themes focused on the knowledge development of undergraduates and pharmacists. The focus group debated how best to inculcate the importance of knowledge development in the undergraduate course. It was agreed that summative assessments had a negative impact on knowledge development and that as pharmacists it was important to recognize and address knowledge gaps. To be able to emphasize this in the undergraduate course would require a complete overhaul of all aspects of the course.

The fourth theme focused on formative assessment. Reservations noted earlier were even more apparent here. The pharmacists did recognize the benefits of this assessment and learning tool, but from past experience with formative assessment found that it did not encourage students to learn. Discussion then progressed onto the topic of exam culture. Here the focus group agreed that what drove students to learn were the summative exams. It was recognized that this was an inappropriate approach undertaken by the students and a poor basis from which to encourage professional knowledge development. The changes in the exam culture were discussed and it was felt that these could not be fully integrated into the current MPharm course. Although competency assessments have been introduced at the University of Brighton, the reliability of these assessments was debated. Some of the pharmacists argued that this was too vigorous a method, whilst others disagreed because of the anticipation and anxiety it caused students to experience.

Finally, the fifth theme observed related to the design of the assessment tool. The focus group found that after further discussion the scaffolded questions, together with the confidence interval were a novel approach in addressing numeracy problems in the pre-registration year.

Future work

Future work must include a robust investigation of the tool in use. Investigations should concentrate on the integration of the tool within the pre-registration year and the impact the tool has on the pre-registration pharmacists and their tutors. Studies should also concentrate on the formative assessment aspect of the tool, how the feedback is generated, how the feedback is used, any substantial improvements observed, eradication of misconceptions and whether students better understand dosage calculations. Due to the ability to generalize this tool, and the similarities with dosage calculations in other health care sectors those investigations do not need to be limited to the pharmacy arena.

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