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Problem-based Learning

The TRIPSE

A PROCESS-ORIENTED EVALUATION FOR PROBLEM-BASED LEARNING COURSES IN BASIC SCIENCES

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A process-oriented problem solving exercise is discussed that attempts to mimic the scientific process. This would be particularly useful for problem-based courses in the basic biomedical sciences.

Keywords: Problem-based learning, problem solving, student evaluation, teaching

Any educational system that does not involve the learner as an active participant is doomed to eventual failure, however successful it may appear in the short run. Problem-based learning (PBL)[1] seeks to promote active learning by providing students with an opportunity to direct their own learning within the constraints of overall goals set by the teacher. Learning and evaluation are inextricably linked, and students who are active participants in their own learning should be evaluated by a system that does not merely emphasize rote learning.

In framing any evaluation from the perspective of students it is important to keep the following three principles in mind. 1) Students must learn from the procedure. 2) The procedure must be consonant with the goals of the program. 3) Students must be given an opportunity to display not only their weaknesses but also their strengths.

PBL courses seek to meld process and content. Thus what is learned stems from how it is learned. Therefore any evaluation procedure that is consonant with the goals of a PBL program must measure both process and content.

Because PBL courses set an emphasis on analysis, information retrieval, and critical analysis it is important that these elements be tested. In the small group variant of PBL, emphasis is also placed on abilities to function effectively within the group. Thus most courses attempt to encourage and promote self- and peer assessment. Although this is not easy, it is imperative that it be done.

It is also important for both teachers and students to have some measure of the abilities of the students to function independently. To this end it is necessary to develop exercises that can assess individual performance but also preserve, to some extent, the open-ended nature of the learning process. In this essay, I describe an exercise that may be particularly suited for students in the basic biomedical sciences.

THE TRIPSE (TRI-PARTITE PROBLEM SOLVING EXERCISE)

The term TRIPSE refers to a tri-partite problem solving exercise. I developed it for an undergraduate course in introductory pharmacology taken by students in a biology-pharmacology cooperative education program. The course was run in the small group variant of PBL. This was based on the Triple Jump Exercises that had been used in the M.D. undergraduate program at McMaster University.

The original version was a three-component happening devised at McMaster University by a group of undergraduate medical students with their tutor [1]. The students wanted an individual assessment of their problem solving abilities. In the original formulation, the activity was divided into three stages. In the first stage (problem definition), students were given a clinical problem with a minimal amount of information. The students used the information to ask their tutors a series of questions to elicit more information that may or may not have been available. This enabled students to bring prior knowledge to bear on a novel problem and devise an educational plan to identify the items of information needed to solve that problem. They then went on to conduct an information search (stage two) for 2–3 h and returned for a third period (synthesis and feedback) with the information they had acquired, and a period of re-appraisal and synthesis followed. The students assessed their own performance, and the tutor gauged their abilities to ask questions, use prior knowledge, and seek and synthesize information within a limited time frame. Variations on this theme have been used by others [2–4]. The exercise was extremely useful for the tutor to obtain information about the learning styles of their individual students and for the students to acquire the confidence to deal with problems on an individual level. However, the procedure as used was extremely demanding of faculty resources, particularly time. Thus for a tutor who had six students to deal with, a full working day was required. This clearly became difficult as resources be-

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[1] The abbreviation used is: PBL, problem-based learning.

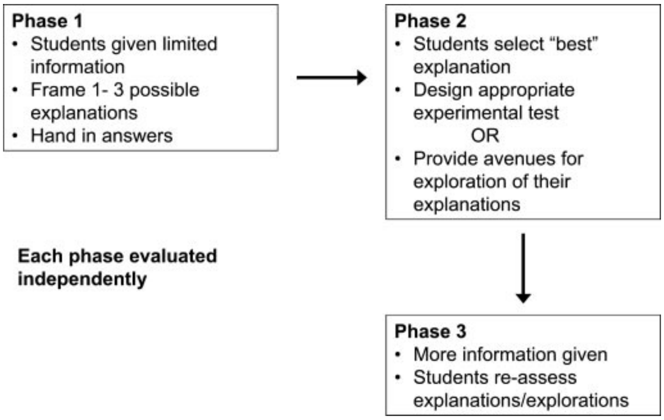

FIG. 1. **Flowchart showing the three phases of the exercise.**

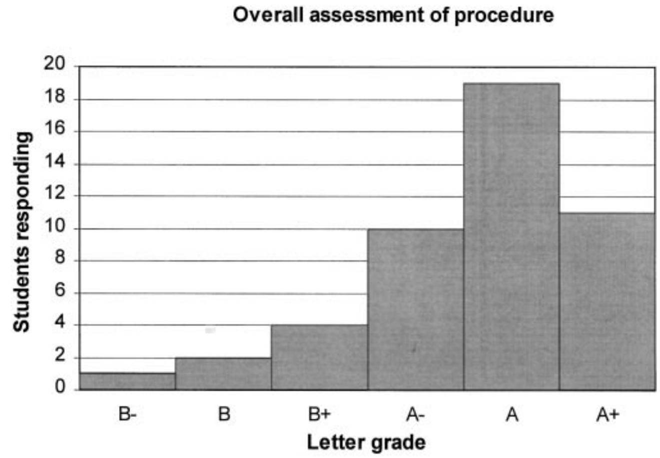

FIG. 2. **Results of students asked to grade the exercise on a standard University scale (D to A+).**

came strained. In addition, it became difficult to obtain standard information.

I modified the Triple Jump for the above-mentioned course in Pharmacology in 1989. The reasons for the change were 2-fold; the initial class had 14 students, and I was the sole tutor. It became logistically impossible to do the conventional Triple Jump. Further I wanted to model the scientific process and include a component that enabled me to assess how students looked at their approaches in light of new information.

The exercise was initially termed a Group Triple Jump [5], but that did not convey fully the greater emphasis on problem solving that this activity demanded. Further some students who were familiar with the medical model were confused about the expectations of this exercise.

In practice, the TRIPSE proceeds as shown in the diagram (Fig. 1) and as described below.

Phase 1, hypothesis generation (30–45 min). Students are given limited data from an experimental study. Using the available information, the students frame 1–3 possible explanations for the data. The answers are handed in.

Phase 2, design of experimental tests (30–45 min). Students are expected to choose one of their explanations and design a suitable test or tests to confirm or deny their expectations.

Phase 3, re-assessment (variable length). Students are given more information (usually the original paper on which the TRIPSE is based or a set of references) and asked to re-assess their original explanations/tests in view of the new information. This third component is often done as a take home exercise so that students can consult other resources if need be.

Each phase is evaluated separately. When the exercise is completed, the students are given an outline describing the essential factors that needed to be explained, as well as individual written comments.

An example of a TRIPSE and feedback given to students is provided in the Appendix.

COMMENTS

The exercise described above gives students an opportunity to explore novel areas using their prior knowledge and tests their abilities to transfer learning to novel situations. It also provides the teacher with some insight into the abilities of an individual student to function under time constraints.

Many different variations can be incorporated into the basic design. The issues to be considered are class size, faculty and library resources, and the level of the students when they take the courses. Under optimal conditions, the individualized Triple Jump is perhaps the most useful. Faculty can readily gauge the capacities of the students and can give individualized attention. Although the exercise is consonant with the goals of PBL and does model clinical practice, it appears to have low psychometric properties and is resource-intensive [6]. Under such conditions, the TRIPSE variant is useful. However it is important to emphasize to the student that there is really no one correct answer, only sets of answers ranging in credibility. Therefore teachers should provide individualized comments (see Appendix). Although it is ideally suited for basic sciences, because it models the practice of modern science, the format can be quite easily adapted to clinical scenarios, as well. It is important to have a trial run of the procedure with the students so that they get some practice. This serves to dispel anxiety.

The problems to be used can be drawn from a wide variety of sources. Articles published in scientific journals are particularly useful. Other sources could include data gathered by the teachers themselves in their own research pursuits. A particularly interesting opportunity is provided by posters presented at research meetings, because these often represent works in progress, and the answers to questions asked may not be entirely clear to the researchers themselves. Thus the students have much freer rein to speculate. On occasion, I have also used data presented in seminars by visiting speakers who are quite happy to share their information. This also provides an added interest, because students feel that they, too, are participating in the scientific process.

The student evaluations of this exercise have been generally positive. In an end of term questionnaire, students were asked to indicate on a 5-point scale (1 = low to 5 = high) the strength of their agreement with the following statement defining the expectations of the teacher:

"Students will use a novel problem to frame hypotheses (explanations), devise experimental tests, and re-assess their answers in light of new information. This exercise was designed to simulate the scientific process in practice."

The median, mode, and range of 52 responses, collated over a period of 4 years, were 4, 4, and 3–5, respectively. Students were then asked to grade the exercise on a standard University scale (D = poor to A+ = outstanding). Fig. 2 shows the answers of the 47 students, from the same 4 years as above, who responded to this particular question.

APPENDIX

TRIPSE Problem—It has been observed that viral respiratory infections exacerbate bronchial asthma. Investigators at the Cardiovascular Research Institute in San Francisco sought to use *in vitro* approaches to define the underlying mechanisms.

They set up isolated tracheal rings from ferrets in conventional organ baths and recorded changes in isometric tension in response to added agonists. They infected tissues with human influenza A virus by incubating them with solutions containing supernatants from infected rhesus monkey kidney cell monolayers. Control segments were incubated with supernatants from uninfected cells. They tested the responses of the segments to acetylcholine and the neuropeptide Substance P (see Fig. A1). Data were taken from their paper (D. B. Jacoby, J. Tamaoki, D. B. Borson, J. A. Nadel (1988) *J. Appl. Physiol.* **64,** 2653–2658). Reproduced with permission.

Contractile response of ferret tracheal rings to acetylcholine (*A*) and Substance P (*B*). *C*, control; *V*, virus-infected; *Th*, thiorphan-treated. From D. B. Jacoby, J. Tamaoki, D. B. Borson, J. A. Nadel (1988) *J. Appl. Physiol.* **64,** 2653–2658.

Outline Given to All Students—The essential points in this problem are the following. 1) Responses to Ach remain unaffected by exposure to the virus. 2) Responses to Substance P are greater in virus-infected tissues. There is a clear increase in maximal response. 3) Thiorphan treatment produces a much higher maximal response and eliminates the differences between the control and virus-treated tissues. 4) Many different hypotheses can be given; however the above features must be explained.

Representative Comments to Individual Students—

Student 1

Hypothesis Generation (10): 8

Design of Experimental Test (10): 7

Re-Assessment (10): 9.5

Total (30): 24.5

Comments—You had several hypotheses. You realized the distinctions between the responses to Ach and Substance P and the significance of the thiorphan effect. You noted that the response to Substance P was dependent on thiorphan and even noted the possibility that thiorphan may be inhibiting an inactivating enzyme. You also proposed that the contraction seen in the absence of thiorphan was because of endogenous Ach and that Substance P was playing an inhibitory role. Thus thiorphan was acting as an antagonist to an inhibitory receptor. Intriguing idea, that! The problem was that there was a contraction at the higher concentrations. If this was because of endogenous Ach, it implies that Substance P has two effects, the release of endogenous Ach being seen at higher concentrations. This was not stated explicitly. The last hypothesis was that Substance P does not readily penetrate the ferret tissues and that thiorphan permits it to do so. This was actually an interesting idea, and your rationale based on the concentration-response curves was plausible (within limits).

In the second phase, I was not really sure which hypothesis you were testing. Perhaps all! You listed number 3 at the outset, but that was a test of number 4. The saponin idea was reasonable. This presumably came from your laboratory project on skinned muscles. To test the involvement of Ach in the response to Substance P, you proposed to repeat the experiments with atropine; fair enough. To test the hypothesis that Substance P activated an inhibitory receptor, you proposed adding Substance P and Ach together. You argued that the effects of Ach would be nullified. However, as I noted above, the contractions seen with the higher concentrations of Substance P would have to involve another receptor.

Your re-assessment was superb. I really liked the thoughtful way in which you re-considered your original hypotheses in light of Jacoby's paper. Well done.

Student 2

Hypothesis Generation (10): 3

Design of Experimental Test (10): 6

Re-Assessment (10): 8.5

Total (30): 17.5

Comments—You proposed three explanations. However none were reasonable. For instance, you began the first by noting that there was an increase in the presence of thiorphan, which was true, but then you went on to talk the temporal course of degradation of Substance P in the presence of thiorphan. This was a good test of your hypothesis. Unfortunately, your hypothesis was wrong! Your re-assessment was accurate. You realized that the experiment that you proposed could in fact yield the needed information.

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