Relationship Between Small Group Problem-Solving Activity and Lectures in Health Science Curricula

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Abstract: Components of problem-based education, such as small group teaching, are being implemented in diverse health curricula. Implementation, however, is often motivated by the intuitive appeal of many problem-based learning components, when what is needed is the detailed examination of how these components support students' integration of knowledge as well as continuity of their learning experiences. This study presents an investigation of the relationship between lecture and small group teaching (SGT) in a medical curriculum. Four problem-oriented SGT sessions representing diverse topics in the first-year curriculum and their corresponding lectures were videotaped and analyzed using techniques of concept mapping, where the broad concepts from the lectures were identified and matched to the case-specific concepts in the small group sessions. The results show that lectures function as an anchor for the students' discussion of issues relevant to clinical problem-solving and interventions in small group sessions. These discussions extended to contextual aspects of clinical practice that were not dealt with in the lectures, such as ethical/cultural issues around the treatment of patients. Furthermore, small group environments were found to promote discussions that allowed the integration of information from different sources and encompassed concepts across a number of disciplines. These results suggest that carefully designed small group sessions serve the purposes of 1) illustrating broader concepts in lectures to case-specific, clinically relevant problem-solving and 2) promoting knowledge integration from diverse sources of information. The implications of these results for learning and reasoning in health science curricula are discussed.

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Conventional health science curricula in North America have traditionally separated biomedical teaching and clinical training, which led to the concern that health science education was becoming increasingly detached from clinical practice. In recent decades, many health professional schools have attempted to answer the concerns over the relationship of biomedical knowledge to clinical practice by developing clinically integrated curricula, based on problem-based learning (PBL). Dental education programs, like medical programs, have adopted components of PBL in North American dental schools.[1] PBL programs endeavor to satisfy three objectives: to organize biomedical and clinical knowledge around a patient problem; to develop the clinical reasoning process; and to enable self-directed learning.[2,3] A major advance in this direction was the development of small group teaching (SGT), a critical component in the PBL curriculum. In SGT, discussion of illustrative patient cases is a routine pedagogical tool. In particular, PBL instruction involves the introduction of clinically meaningful problems right from the start of the curriculum instead of the separate teaching of biomedical science and clinical topics.

The principal force in the argument for PBL derives from two convictions. First, the traditional curricular format does not prepare students for the collaborative nature of practice in clinical settings. Since many patient care tasks require the participa-

tion of teams of clinicians with different specializations, it can be said that many clinical tasks are truly cooperative.[4] However, traditional classroom teaching—which mostly takes the form of the lectures—does not reflect this cooperative nature because it provides little chance for interaction between students and between students and instructor. Second, scientific knowledge taught abstractly, as it occurs in lecture-based curricula, does not help students to integrate this knowledge with clinical practice because basic science is taught separately from the teaching of clinical disciplines.

The principal pragmatic advancement of PBL is the substitution of large lectures with a small group of students headed by a tutor, usually a practicing clinician or senior student, in which basic science topics are discussed in direct connection with clinical problems. Clinically integrated content delivery formats, such as small-group teaching, attempt to bridge the gap between biomedical knowledge and clinical practice.[1] Even though the effectiveness of PBL as an alternative to traditional clinical education remains inconclusive,[5,6] there is the need to investigate components of PBL to understand what these components contribute to the learning experience.[7] Dental education has recently seen an increase in PBL implementations in a number of schools.[8-11] Within the PBL format, SGT constitutes an important instructional device in promoting learning.

Integration of Biomedical and Clinical Knowledge

Although SGT seems to be a better instructional format than lectures for facilitating students' integration of basic science and clinical practice, the relationship between biomedical and clinical knowledge has been shown to be somewhat problematic.[12] Studies that delved into the characteristic nature of biomedical and clinical knowledge structures have found that these may be separate domains of knowledge. In an early study that compared the performance of students from PBL and CC curricula, Patel et al.[12] established a significant distinction between biomedical and clinical bodies of knowledge. Based on the results from the study, they argued that clinical problems cannot easily be embedded into a basic science context, whereas basic science can be embedded within the clinical context. In other words, biomedical knowledge is easily integrated into a clinical structure, and therefore is a necessary prerequisite to differential diagnosis and an understanding of clinical ailments, but the reverse does not hold true. That is, clinical understanding cannot be easily integrated into biomedical knowledge.

A study by O'Neil et al.[13] appears to support such interpretation. Using open-ended questions and focus groups, they investigated how medical students linked their problem-based learning experiences to their clinical experiences. They found that the students made use of their clinical experiences in two ways: 1) as a basis for elaborating their knowledge when encountering a patient, and 2) as a source of discussion in small group sessions. Given the distinction between clinical experience and biomedical knowledge, ensuring the effective integration of biomedical and clinical knowledge is a priority in the grand scheme of curriculum change and development.

Such interaction can be ensured by following two fundamental principles of effective and enriching education: meaningful interaction and continuity of learning.[12] Meaningful interaction refers to the degree to which students, their interests, and their energies are captured and invested in learning episodes. Continuity of learning refers to the extent to which present learning experiences build up from past learning experiences in a cumulative fashion. Clinical instruction through lectures emphasizes issues pertaining to the continuity principle, rather than the interaction principle, whereas small group teaching emphasizes the importance of meaningful interaction over continuity of learning. A viable reason behind the introduction of small group teaching is therefore to complement the lecture format in an effort to negotiate the coexistence of these two principles.

Research on Small Group Teaching in Medical and Dental Education

Small group instruction has been widely investigated in the last thirty years. The motivation for the interest in small groups in PBL derives from the increasing attention paid to active learning, where the student is viewed as constructing his or her knowledge through interaction with instructor and peers. A review of the effects of SGT conducted by Springer

et al.[14] provided evidence of the benefits of small group instructional interaction in various educational settings, including higher education. They argued that their evaluation of the research supports the implementation of SGT in higher education. However, in a reanalysis of Springer et al.'s reviewed data, Colliver et al.[15] questioned their results and concluded that SGT is not a better vehicle for knowledge acquisition than traditional lectures.

However, in medicine, the adoption of small group teaching as a component of PBL curricula has been supported by its contribution to gains in student satisfaction,[16] improved student performance,[17] promotion of students' knowledge structures,[12,18] enhanced self-directed learning skills,[14] and intrinsic interest in, and motivated learning of, the subject matter.[19,20] The primary role of SGT may be in consolidating knowledge rather than knowledge acquisition. PBL students have, for example, shown increased use of knowledge elaboration and backward reasoning (from the information to the hypothesis), in contrast to students of conventional curricula who mainly use factual knowledge and forward reasoning—from the hypothesis to the information.[12,20] Similarly, the use of small group teaching and PBL has been promoted in dental education for a long time.[21-24] Adoption of small group teaching in dental education is also predicated on the same benefits as in medicine.[25] Such promotion has been recently predicated on the importance of learning collaborative activities during dental instruction,[26,27] where it is argued that collaborative learning helps students integrate skills and knowledge and motivates them for learning.

Yet despite the increasing acceptance of small group teaching, there are surprisingly few empirical studies[28] that delve into the detailed characterization of problem-solving and learning activities that occur in small group sessions, as well as the relation of the dynamics of discussion to learning issues. There is some evidence,[12,20] however, suggesting that certain aspects of learning in small group teaching may be associated with differences in the reasoning processes of these students as compared to those observed in conventional instruction formats. To look at such processes in detail, a methodology is needed that examines the actual reasoning of students while engaged in representative tasks. Studies that have looked at group interaction processes in a detailed manner[28] have shown the usefulness of qualitative methodologies as tools for observing, identifying, and describing group activities that promote shared cognitive problem-solving and understanding.[29] Methodological tools that are based on the detailed exploration of students' discourse, such as propositional analysis,[30] can reveal how participants in an interaction construct their medical knowledge by evaluating their reasoning processes from the inputs and perspectives provided by group members.[29]

To this end, a theoretical framework that examines individuals as embedded in their social and cultural milieu is needed. A useful theoretical perspective is provided by the "distributed" approach to cognition,[28,31] which construes human cognition as distributed beyond the compass of the organism proper by involving other persons, relying on symbolic media, and exploiting the environment and artifact.[2,32] Research suggests that there are many benefits to be gained from this approach to group learning environments, including shifting the role of students from passive recipients to active participants in their own progress, by emphasizing interaction, co-construction of shared knowledge,[33-37] and advancing the promise of student-centered education in problem-based learning.[38]

However, studies using the distributed approach have yet to examine the characteristics of learning that occurs in small group environments. Questions such as how does the problem-solving process occur and how is knowledge built upon, if at all, need to be answered. The study of group interaction, where problems are solved by collaboration, has become an important source of data for the approach. The small group becomes an important vehicle for learning. A benefit of a small group is that it necessarily presents the learner with perspectives divergent from his or her own and, as such, the learner is encouraged to take other perspectives into account to build a more complex mental representation of the subject.[39] In this context, a shared understanding is believed to develop among the group members, each member benefiting from the others' contributions. While distributed cognition may be invoked to support the choice for small group teaching over classroom teaching, this perspective, while offering an interesting theoretical approach, has yet to provide a firm methodological framework for exploring learning and teaching in detail.

Research on collaborative interaction provides a new perspective on the subject. According to Patel et al.,[40] research into collaboration provides a window to observe the shared construction of understanding as it occurs in a small group context. Learning is constructed through conversations with group

members and involves the creation and interpretation of communication.[41] Conversations, particularly those that occur in groups, provide a common ground for students to construct mutual knowledge about beliefs and assumptions and engage in collaborative knowledge building.[42] Thus, one of the major issues facing designers of instruction is to help group members understand one another and create and maintain common ground. This process may involve the resolution of internal conflicts among the varying perspectives and the collective construction of shared meaning. This point has been made repeatedly in the literature. In their study of team navigation aboard a large naval vessel, for instance, Seifert and Hutchins[43] argue that the occurrence of errors in learning within a cooperative system provides opportunities for learning. In this context, the authors discuss how errors are likely to occur with novices and how they can make use of these instances as learning opportunities. The presence of errors or impasses in learning may be a source of meaningful learning (as opposed to rote learning) as long as there is possibility of error correction.

Given the importance of students' construction of a shared representation and overcoming errors for meaningful learning, it becomes necessary to understand how these occur in SGT and how the interaction in the small group context contributes to or hampers the construction of a common mental representation of a domain problem. What form does the collaboration in small group contexts take that enables the effective construction of a mental representation? What are the problem-solving activities that occur in small groups? How do group interactions characterize this collaborative effort? How do group interaction and problem-solving intertwine in the construction of group representations? Are small group sessions ideally suited to teaching all materials, or better only for some? What are some of the factors that may make small group teaching less effective? In this article, we report on a detailed investigation of the relationship between lecture teaching and small group teaching, the integration of biomedical and clinical knowledge across teaching formats, and how knowledge is built during SGT.

Method

Our research approach borrows from the situated approach in that it looks at teaching and learning as embedded into a cultural milieu and uses process measures of evaluation. We also make use of a methodology for the analysis of people's cognitive structures and processes in terms of the type of knowledge they bring to the task.[12,44] These perspectives permit us to assess what is being learned and how characteristics of the participants and the group as a whole aid or abet the accomplishment of learning objectives. Previous work on intensive care medicine[45] has employed a similar theoretical approach to explore the ways in which expertise is acquired in dynamic small group situations. This study is based on methodological approaches[12] that address issues regarding the teaching strategies used in small group contexts and the extent to which students integrate knowledge from different sources and situations in small group sessions.

Subjects, Materials, and Procedure

Four student cohorts ranging from seven to fifteen students from McGill University who participated in four lectures and corresponding small group teaching sessions were selected for the study. These cohorts were chosen from different areas of the curriculum to provide a broad cross section of subject matter. All participating students were in the preclinical stage of their medical degree (i.e., first eighteen months of a four-year program). This program requires that students attend lectures covering a variety of topics, which are then followed by small group sessions that apply the topics covered in lectures. The following lecture-small group sessions were selected for inclusion: Cancer and Oncogenes, Cardiac Physiology, Introduction to the Patient (ITP), and Tuberculosis. These topics were selected for analysis because they represented four varied types of subject matter exemplifying a cross-section of the curricular content. Fifteen students took part in the Cancer and Oncogenes session, thirteen students in the Cardiac Physiology session, seven in the ITP session, and fourteen in the Tuberculosis session. Participation was on a voluntary basis.

Each instructor and teaching assistant in charge of the four lecture-small group sessions were informed that one of their classes would be attended by members of our research staff, where consent to videotape the sessions was obtained. In the sessions, two video cameras, each operated by a member of the research staff, were placed at opposite sides of the classroom to capture all interactions of the participants. Each lecture-small group session was videotaped on one occasion. There was one faculty level

group leader in each of the three small group sessions, who prepared the cases with the students. After initial introduction of the cases by the faculty member, the students led the discussion by presenting the cases to their colleagues. The faculty acted as facilitators/moderators of the sessions, and the students presented the cases.

Teaching notes from the lectures were obtained either from the instructor or from the school (a record of lecture notes and small teaching sessions is kept in a web-based page). These notes contained the issues covered in each lecture-small group session and presented the rationale and objectives for the lectures and small group sessions. Following the small group sessions, teaching assistants were asked for copies of any notes or materials they brought with them or used during the sessions, including patient cases and corresponding questions, class notes, and group agendas.

Analyses

To effectively address the various issues surrounding the institution of small group teaching, the study was divided into sections where different cohorts were analyzed for different sections. Our decision to use this method of analysis stems from activity analyses developed in cognitive systems engineering.[46] In cognitive analyses of this sort, it is appropriate to do a more in-depth analysis of a limited number of interactions rather than a superficial analysis of many interactions.

All videotapes were first transcribed verbatim, using CVideo, a system that allows for computer-supported annotation of video data.[47] Video data were then indexed by means of time stamps, which allows for examinations of both the physical setting and the patterns of activity. Based on previous work involving the analysis of health science classes[48] and clinical reasoning,[49] a propositional analysis of the verbal data from the videotapes was performed. This method consists of listing all relevant concepts in the transcript, which include the statements, the concepts, and the relations between concepts. A concept here is defined as an abstract notion or explanatory principle used in the definition of a scientific system. For example, in the cardiovascular system lecture, basic explanatory principle of the cardiovascular system was described as follows: blood flow to the individual tissues is matched to tissue needs, cardiac output matches the total blood demand, and the arterial pressure is controlled. Two or more such concepts would be linked together by specific relations.

From this analysis, semantic networks were developed that represent the conceptual structures generated during the lecture and small group sessions. Also, the analysis served as a basis for the development of a coding scheme designed to identify the general characteristics of the group dynamics, the content and direction of discussions, and the use of teaching strategies, knowledge integration, and several components of problem-solving. Specifically, the coding categories were divided into three sections: a) conceptual continuity between lectures and small group sessions; b) integration of biomedical and clinical knowledge; and c) small group dynamic and problem-solving strategies.

Conceptual Continuity Between Lectures and Small Group Sessions. In order to evaluate the extent of crossover of information and concepts from the lecture material to the small group teaching sessions, the topics covered in the lectures and small group sessions were compared, based on the transcripts and course notes provided by the instructors and teaching assistants. Specifically, the lectures and small group sessions were broken down into subtopics in order to summarize the sessions according to the major points that were discussed. After this surface-level coding was performed, the propositions and concepts from each subtopic in the lecture were mapped onto the related concepts elaborated on in the small group teaching session to determine the conceptual relationship between the material covered in the lectures and small group teaching.

Integration of Biomedical and Clinical Knowledge. To assess the integration of biomedical and clinical knowledge in small group teaching, the transcripts from the small group sessions were coded for the utilization of biomedical and clinical concepts. Knowledge integration can be broken down into three aspects: concept utilization (the extent to which biomedical and clinical concepts are used in an explanation), conceptual coherence (the extent to which concepts used form a single conceptual structure), and explanatory coverage (the extent to which the explanation accounts for the data).

Utilization of biomedical knowledge was analyzed in terms of the number of propositions that refer to biomedical concepts and the source of such propositions, as determined by lecture topics. These propositions were coded according to general biomedical categories, such as physiology, anatomy, histology, and pathology concepts. Utilization of clinical knowledge was coded in terms of the number of propositions describing either the state of a patient (signs

and symptoms) or medical procedures and treatments, with no reference to underlying normal or pathology functioning.

Both integration and coherence were operationalized with the help of semantic network analysis, where concepts derived from the participant protocols were represented as graphs. In each graph, the number of biomedical concepts and clinical concepts is identified and tabulated. Integration occurs as the biomedical and clinical concepts are used in the same graph. Explanatory coverage was operationalized as the number of clinical data that are linked to the graph.

Small Group Teaching Dynamics. In order to describe the dynamics of the interaction among the small group teaching session members, the transcripts from the sessions were coded based on a number of pragmatic categories that aim to characterize the nature of participants' interactions during discussion. The major categories of analysis were *initiating interactions*, *problem-solving interactions*, *use of knowledge-based teaching strategies*, and the *provision of feedback*.

Initiating interactions were coded whenever a participant began discussion with another participant on a topic different from the one currently being discussed. These interactions were further coded according to the following categories of interaction: tutor-prompted comment by a student, student-prompted comment by the tutor, and student-prompted comment by a student.

Problem-solving interactions were coded whenever participants were engaged in an attempt to resolve an issue or answers to a question. These interactions were further coded according to the following categories: request for information/elaboration, introduction of hypotheses, presentation of findings, review of data, use of evidence, elimination of hypotheses, and directionality shifting. "Request for information or elaboration" was coded when a participant made a specific request for information concerning a topic of discussion. "Introduction of hypotheses" was coded when a participant presented a possible explanation related to the topic of discussion. "Presentation of findings" was coded when a specific piece of information relevant to the understanding of a patient case was given by one of the participants. "Review of data" was coded when a participant repeated a specific piece of information that was relevant to understanding the topic of discussion. "Use of evidence" was coded when a participant supported his or her reasoning by presenting evidence. "Directionality shifting" was coded when a sudden change in the flow of reasoning occurred.

Knowledge-based teaching strategies were coded when an attempt to make another participant understand a specific point of information was undertaken during the session. These interactions were further coded according to the following categories: analogy, reference, repetition, summary, description, and anecdote. "Analogy" was coded when a participant made reference to a similar process, event, or thing in an attempt to explain a concept in terms familiar to another participant. "Reference" was coded when a participant made a referral to another source of information for clarification. "Repetition" was coded when a participant repeated previous information to emphasize a particular concept. "Summary" was coded when a participant described the main concepts associated with a topic. "Description" was coded when a participant provided a more in-depth explanation of a concept. "Anecdote" was coded when a participant explained a concept using a story to emphasize certain points. The results of such strategies were then coded according to whether they led to an acknowledgment of understanding, further questions or attempts to enhance understanding, or the use of additional strategies to enhance understanding.

The provision of feedback refers to a response to a query or question for information. Feedback can take a number of different forms, where all feedback was further coded according to these subcategories: comment, prompt, explain, and acknowledge. "Comment" was coded when a participant provided a reaction to information that was not elaborated on in detail. "Prompt" was coded when a participant elicited additional information. "Explain" was coded when a participant provided a more in-depth account of his or her reaction to information. "Acknowledge" was coded when a participant provided a simple reaction indicating agreement or disagreement with a statement. The results of providing feedback were also analyzed according to whether it led to further discussion of the topic in question, a resolution to the topic in question, or further questioning related to the topic in question.

Results and Discussion

We studied four sets of lecture and small group teaching sessions in order to characterize and under-

stand the conceptual relationship between the material addressed in lectures and small groups and the nature of interaction during small group teaching. Results related to the conceptual continuity and integration of knowledge between the lecture and small group session for each topic will be presented first, followed by results describing the dynamics of small group teaching and then student evaluations of lecture and small group teaching methods.

Cancer and Oncogenes

Conceptual Continuity Between Lecture and Small Group Session. The analysis compared the lecture entitled "Cancer and Oncogenes" with its corresponding small group session, where the lecture material was considered to be the knowledge base that students would draw upon in the small group session when faced with patient cases. The lecture was broken down according to the major concepts presented by the lecturer. Specifically, the lecture material progressed from definitions of general terminology and cellular properties of oncogenes and the underlying causes of tumors, to reasons for genetic damage and mechanisms of DNA repair and treatment. The topics of discussion during the small group session included an introduction to the signs and symptoms of cancer, the diagnostic procedures, an evaluation of tumor cell properties, and causes of tumors, after which the discussion progressed into an ethical debate concerning the implications of genetic testing. The meeting continued with a review of techniques used for the isolation and repair of genetic disorders, a discussion of the types and causes of cancer, and a series of questions raised by the instructor to summarize the material.

Figure 1 presents the topics covered during the small group session for the Cancer and Oncogenes series, the concepts used during discussion in the small group session, and related concepts discussed during the lecture. The right-hand side of the figure shows the concepts introduced in the lecture, while the middle column outlines concepts that arose during the small group session. Overall, the results indicated that twenty-six concepts were addressed in the lecture, and thirty-nine concepts were discussed in the small group session. When the lecture was mapped onto the small group session, twenty-three concepts were carried over to and applied within the clinical context of the SGT session.

The results also indicated that the small group discussions tended to focus on the treatment of ethical issues pertinent to the patient cases. This suggests that the small group environment was conducive to ethical debates because the numbers of students in the small group discussions were few and an expert mediator (the instructor) was present. Debate in the Cancer and Oncogenes session occurred when the instructor encouraged the students to think about the implications of knowing in advance whether one is the carrier of a damaged gene. The students drew upon biomedical information to support their clinical opinions. They negotiated various alternatives as opposing points of view were put forth. For example, some students claimed that they would want to know if they were a carrier of a damaged gene and that they would be concerned about their children. Other students expressed concerns about telling a patient that they are a carrier without explaining to them the possibility of incomplete penetrance, as well as the idea that some polyps and tumors do not become malignant for years and may never become malignant. Another student argued that even if you have a certain gene that predisposes you to cancer, you may never develop cancer. Thus, the small group environment was an ideal setting for ethical discussions given that it was intimate, less formal, and supervised by an expert mediator.

Integration of Biomedical and Clinical Knowledge. Figure 2 illustrates the breakdown between biomedical and clinical subtopics that were discussed during the Cancer and Oncogenes lecture. Specifically, the results showed a greater number of biomedically oriented subtopics discussed versus clinically oriented subtopics.

In a further analysis of the Cancer and Oncogenes small group session dialogue, we examined the type of knowledge, biomedical and/or clinical, being employed by both the instructor and the students. Out of a total of 195 concepts used in the small group meeting, 133 were biomedical, and the remaining sixty-two were clinical. This finding indicates that the use of biomedical knowledge was consistently greater than that of clinical knowledge in the small group sessions.

In their discussion, both the students and the tutor elaborated on these concepts using information taken directly from the Cancer and Oncogenes lecture, as well as from other biomedical disciplines. Specifically, forty-five biomedical concepts were overtly drawn from the lecture material, while the remaining eighty-eight stemmed from other disciplines such as physiology, anatomy, histology, immunology, genetics, microbiology, and molecular

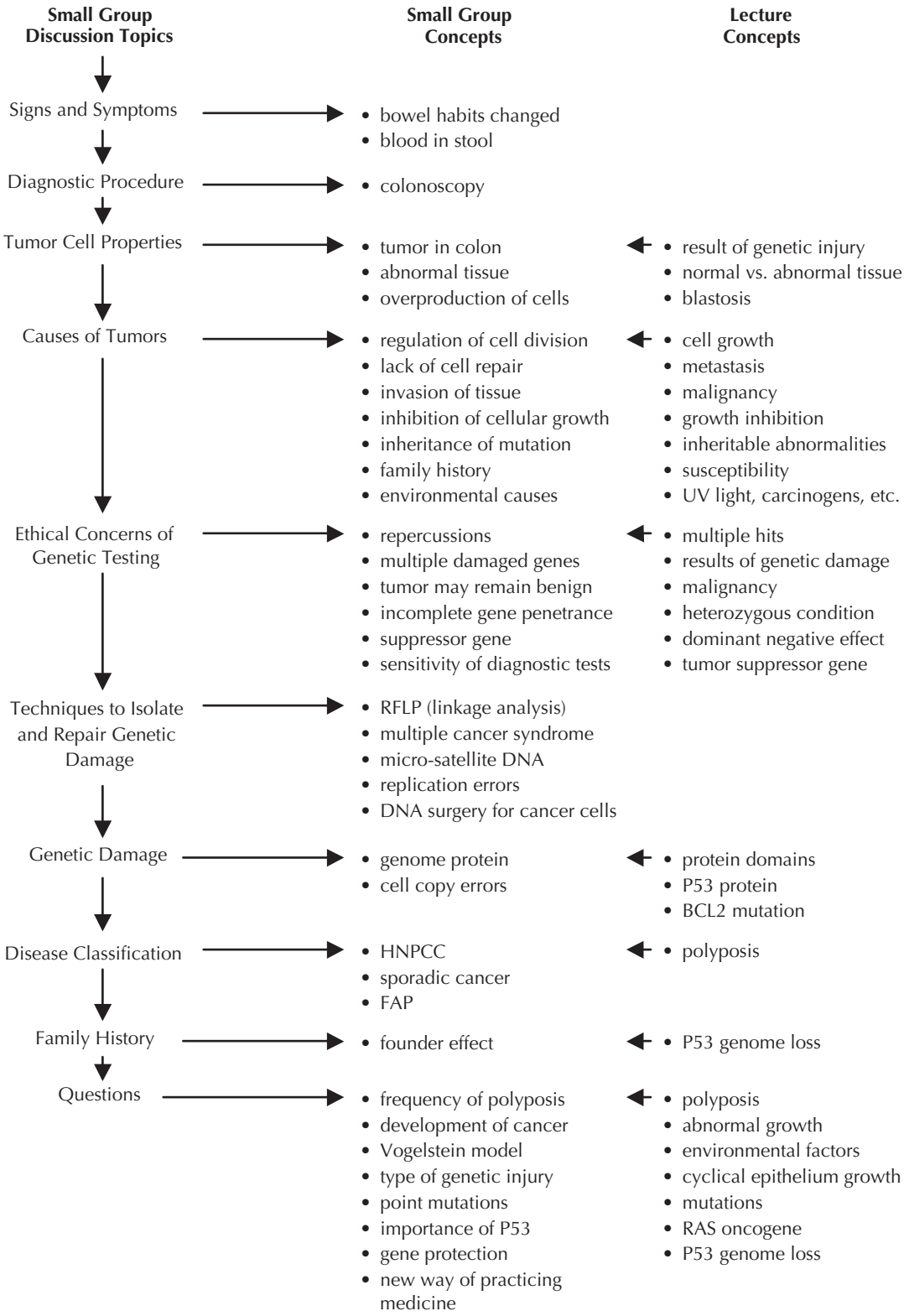

Figure 1. Conceptual mapping between Cancer and Oncogenes lecture and small group session

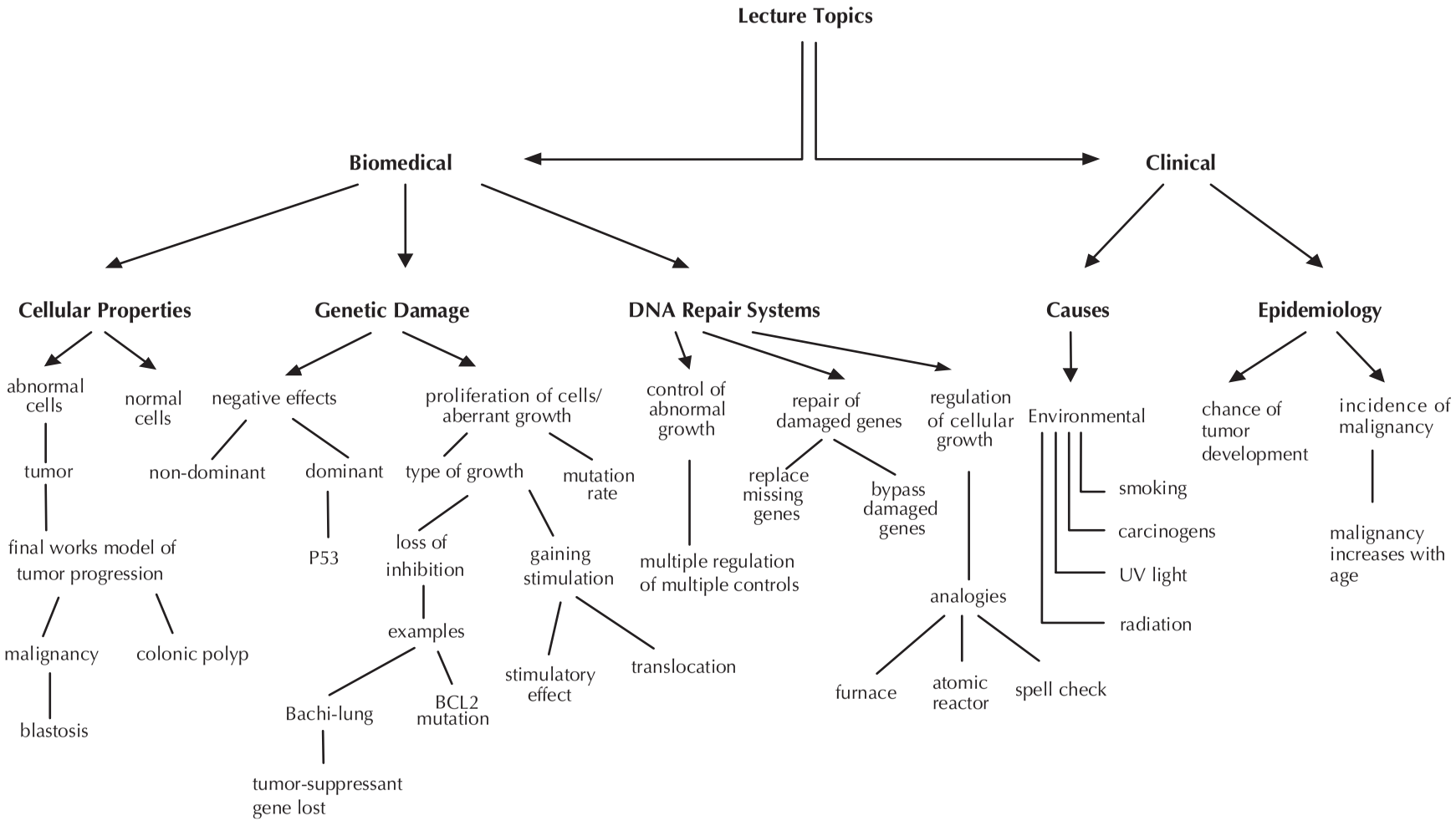

Figure 2. Schematic representation of biomedical and clinical concepts used during Cancer and Oncogenes lecture

biology. The following is an excerpt taken from the Cancer and Oncogenes lecture in which the lecturer introduced biomedical concepts related to tumors and their properties:

> Tutor: . . . damage or injury to a cell of some kind results in a tumor where you see thousands and thousands or millions of cells, all of them sharing the abnormal property. One of the abnormal properties you see here immediately, they grow out their age, they look different from one another . . . they are not nicely organized the way normal cells are. And really those are a number of the hallmarks of malignancy. If it starts this way, with damage to a cell, that results in a whole bunch of offspring cells including genetic damage, then we can say that the damage of the original cell, that was present in the daughter cells, then we can conclude that the damage that generates the abnormality is inheritable. . . . If the damage to the genes doesn't involve some vital function, well what kind of genetic damage will lead to this. . . . with these growth rates there must be either stimulation to grow or loss of inhibition to grow.

Similarly, when students described how tumors develop during discussion of a patient case in the small group meeting, they used a number of concepts that were introduced in the lecture. To illustrate, the following is a transcript of a dialogue among students and the instructor during a small group session:

> Tutor: . . . Does it look like cancer to you?
>
> Student 1: It looks abnormal.
>
> Tutor: It looks abnormal, you are absolutely right. Why is it not normal?
>
> Student 1: Irregularly growing tissue.
>
> Tutor: Yes, if you were to look from that side, what would you see?
>
> Student 1: Raised.
>
> Tutor: Raised, yeah, there is too much tissue. Does it have to be cancer?
>
> Students: [no answer]
>
> Tutor: Could it be a benign tumor? So there are too many cells, I am producing too many cells. How do I do that?
>
> Student 2: There has been a mutation in the gene.
>
> Tutor: Which gene? Here? Or everywhere in my body?
>
> Student 2: Well, it depends if you have inherited it or if you just got a mutation by environmental processes.
>
> Tutor: I tell you about my family, but I don't know this, there might be a problem. And what does this mutation in my gene—how can you explain that?
>
> Student 3: Well, you have too much activity going on, and then you have, you don't have any inhibition of that . . .
>
> Tutor: Activity, I don't understand activity. I am just a patient. Do you want to help her out?
>
> Student 4: Well if you have a normal growth of tissue, whereas you said you have too many cells. So, uhm, the reason why you have too many cells is because they are growing too many cells. So the activity she is referring to is the activity that produces the growth of tissue. And when you talk about the growth of cells, uhm, if you trace your way back through all the science, uhm you find that the growth of tissue ultimately originates in something that is called genetics, and that is sort of your blueprint, which is, uhm, handed down.

Specifically, in this dialogue, the students used lecture concepts such as "irregularly growing tissue," "normal growth of tissue," "mutation in the gene," "inheritance," "mutation by environmental processes," "too much cellular growth," and "inhibition" to elaborate on their answers in the small group session. Thus, concepts from the lecture on the generic topic of Cancer and Oncogenes functioned as a conceptual background for the students' discussion of a clinical case in the small group meeting.

Tuberculosis

Conceptual Continuity Between Lecture and Small Group Session. The same method of analysis was applied to the Tuberculosis lecture and small group series. The Tuberculosis (TB) lecture started with a general introduction and background on TB in present-day society, proceeding to the types and characteristics of mycobacteria, the pathogenesis of TB, its detection, and the circumstances surrounding reactivation. The lecture also addressed methods for diagnosis, strategies for controlling TB, and treatment with drug regimens. For the small group session, students were provided with objectives and an assigned reading on tuberculosis prior to attending the session. Students were also given two clinical cases to read, with accompanying questions pertaining to each. The first case dealt with the primary infection of a three-year-old boy with miliary tuberculosis, as well as the reactivation of his father's tuberculosis. In discussing the boy's case, the conversation progressed from an evaluation of his signs and symptoms and an interpretation of his lab results, to a diagnosis and a contemplation of diagnostic procedures. An investigation of the father's condition began with an assessment of his signs and symptoms, as well as a discussion of resistance and reactivation. The discussion continued with another look at diagnostic procedures, means of infection, and ethical concerns. The second case of an elderly woman with spinal tuberculosis was only addressed near the end of the session and was used primarily to make the point that tuberculosis can infect a broad range of patient types.

Figure 3 presents the topics covered during the small group session for the Tuberculosis series, the concepts used during discussion in the small group session, and related concepts that were discussed during the lecture. The right-hand side of the figure shows the concepts introduced in the lecture, while the middle column outlines the concepts that arose during the small group session. As indicated, there was a crossover of concepts when the lecture material was mapped onto the small group session. Both the students and the instructor referred to a number of lecture subtopics in their treatment of the patient cases. For example, the concept of "resistance" was introduced in the lecture in the context of a discourse on "multiple drug regimens." In the small group session, the students drew upon their understanding of "resistance" to distinguish between "primary infection" and "reactivation" during their discussion of the father's case. It can be assumed that the students understood the concept of "resistance" since they were able to apply it in a context different from which the concept was initially introduced to them.

The small group setting was conducive to evaluating clinical issues related to the patient cases. The case studies lent themselves to an examination of the signs and symptoms common to tuberculosis. Six subtopics dealt with signs and symptoms. The tutor spent a considerable amount of time reviewing them with the students, suggesting that it is important to be able to recognize these signs and symptoms to effectively diagnose and treat tuberculosis: "blood-tinged sputum," "insidious onset of fever," "night sweats," "weight loss," "cough," and "rales/crackles in the lungs." Signs and symptoms were not addressed in the lecture material to the same extent. The results also indicated that three concepts in the small group session were related to ethical issues pertaining to the child's case.

Integration of Biomedical and Clinical Knowledge. Figure 4 depicts the split between biomedical and clinical topics used by the instructor in the TB lecture. Specifically, the breakdown of topics shows a greater number of clinically oriented topics that were discussed when compared to biomedically oriented topics.

A total of 275 concepts were used in the discussion of Tuberculosis during the small group meeting. Of those 275 concepts, 173 were identified as clinical concepts, while the remaining 102 were identified as biomedical concepts. Both the students and the instructor elaborated on these concepts using information from the lecture as well as from other biomedical disciplines. However, only fourteen of the 102 biomedical concepts were overtly borrowed from the Tuberculosis lecture material, while the remaining 88 were drawn from other biomedical disciplines such as physiology, anatomy, histology, immunology, pathology, biochemistry, and molecular biology. Three other categories were created—"physiology/anatomy," "pathology/immunology," and "microbiology/immunology"—as certain biomedical references were inextricably related to two disciplines. This finding indicates that the use of clinical knowledge was consistently greater than that of biomedical knowledge during the lecture and small group session.

Cardiac Physiology

Conceptual Continuity Between Lecture and Small Group Session. The Cardiac Physiology lecture started with the general structure of the cardio-

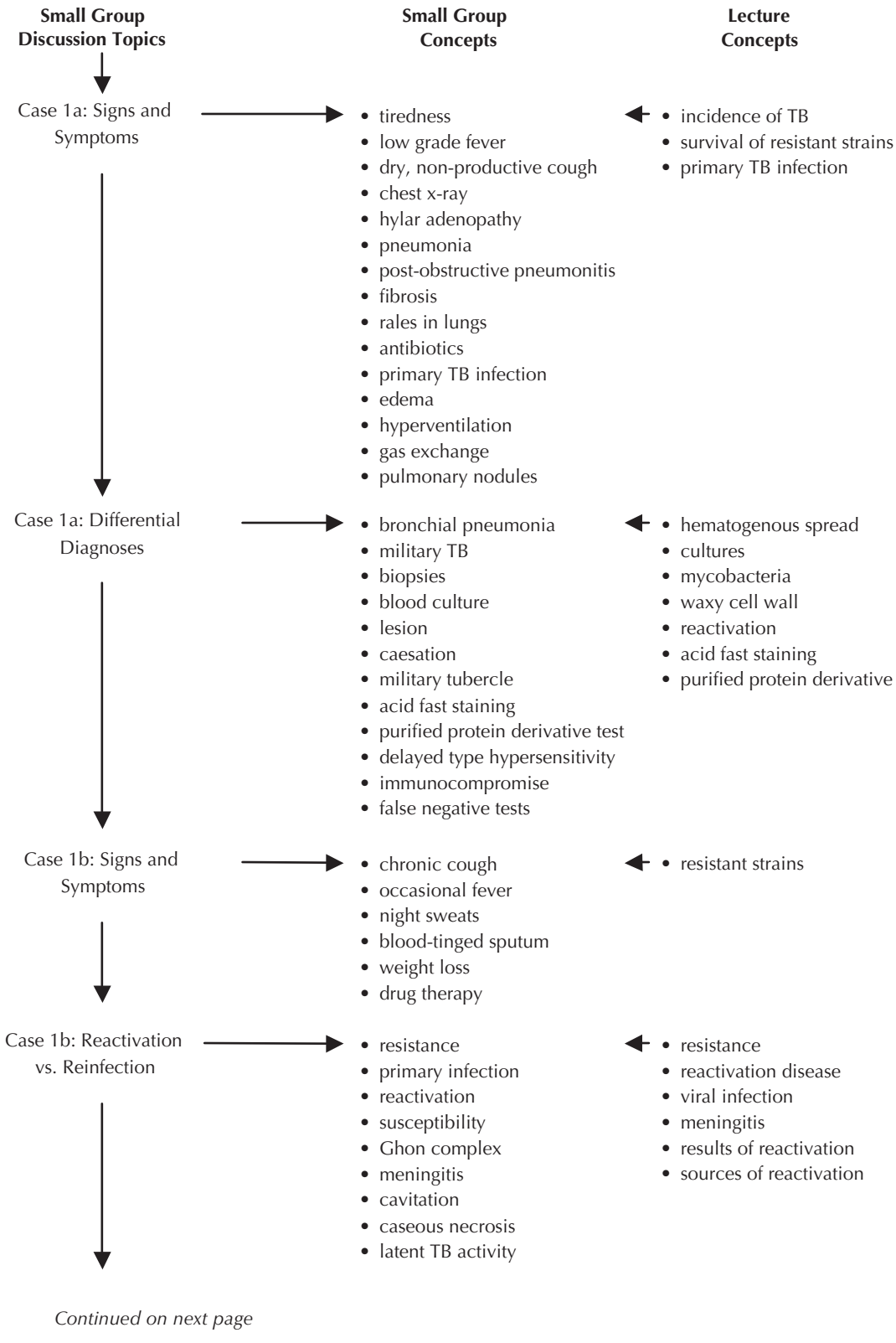

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Figure 3. Conceptual mapping between Tuberculosis lecture and small group session

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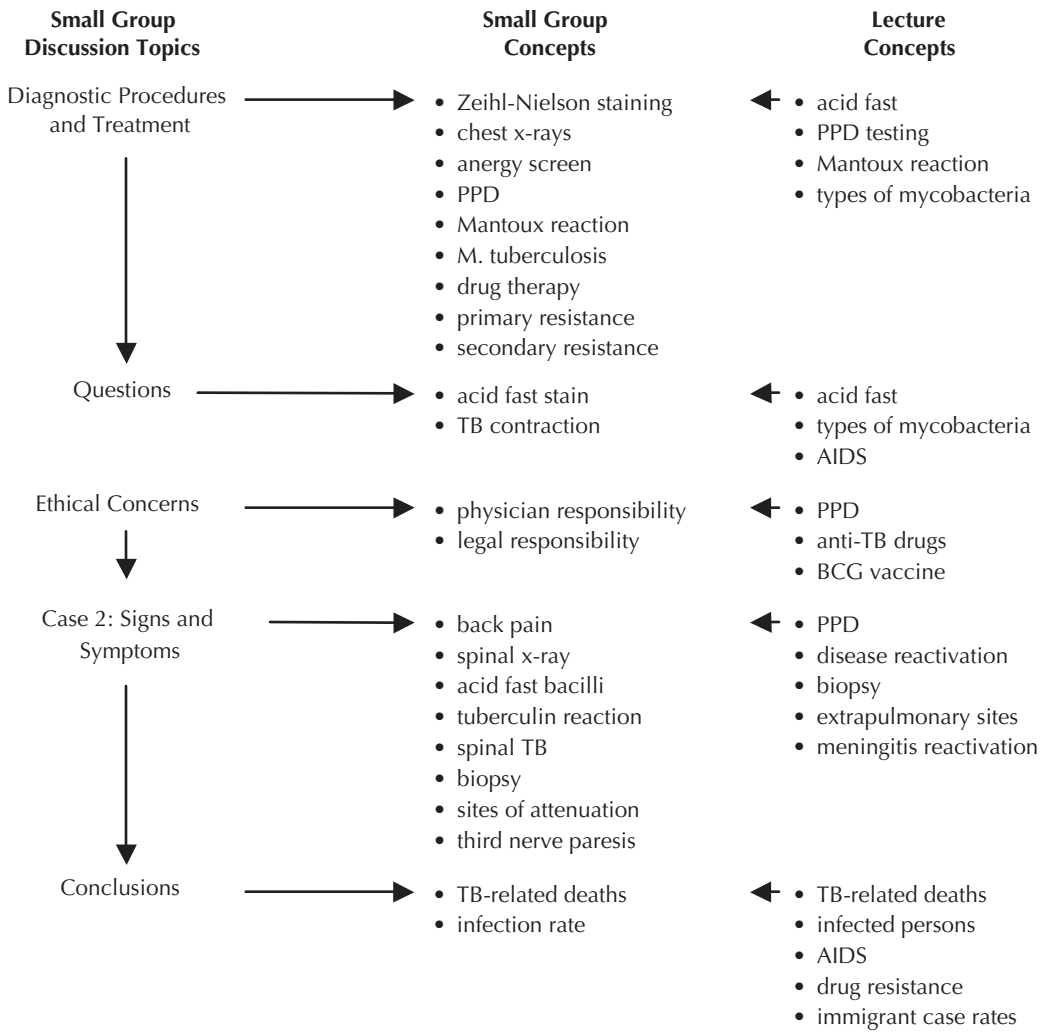

Figure 3. Conceptual mapping between Tuberculosis lecture and small group session *(continued from previous page)*

vascular system and progressed to the activation sequence of the heart and finally to action potential and excitability and refractory periods. Illustrations describing the cardiac cycle, parts of the electrical and ventricular system, phases of action potential, and refractory periods were also used in the process of explaining these topics. The small group session began with a description of the patient's problems, labeling of electrocardiographic complexes, and calculating the ventricular rate from the rhythm strip taken one year earlier. It then progressed to calculating the atrial and ventricular rate from the present rhythm strip of the patient and raised questions regarding the reasons behind the ventricular complexes being wide and the slow average rate. Finally, the reason behind the conduction problem in the young patient was also discussed. At times, questions not directly related to the case were also asked. As an example, one student asked a personal question about whether the tutor had seen patients with Lyme disease. During the lecture, material concepts were introduced that were used later in the small group session for elaboration purposes. Specifically, four topics with a total of twenty-five concepts were introduced during the lecture. For the small group session a total of twenty-three concepts were discussed. Seven of the twenty-five concepts introduced to the

students in the lecture were later used in the small group session.

Integration of Biomedical and Clinical Knowledge. In the small group session, a total of five questions were discussed. There were two topics for the first question: one of labeling the electrocardiographic complexes, and the other of calculating the ventricular rate from the patient's rhythm strip taken one year earlier. For labeling the electrocardiogram strip, the concepts of electrophysiology of the heart and the characteristics of QRS complex introduced in the lecture mapped onto the small group discussion. For interpreting ventricular rate, the students used the illustration of Wigger's cycle along with their prior information related to the topic. The tutor also introduced a new strategy of counting the number of beats per minute in the session, which was based on counting the number of large squares in the segment and not discussed earlier in the lecture. The second question also had two topics: one of calculating the atrial rate (inverse of PP interval) and the ventricular rate (inverse of RR interval), and the other topic related to the relationship between atrial and ventricular activity. The answer to the first question was based on the formula of counting the large squares as earlier explained by the tutor. To explain the relationship between atrial and the ventricular activity, the students used the concepts of arrhythmias and illustrations of parts of specialized electrical and ventricular conduction system, explained previously in the lecture, to conclude the independence of the two. For the third question, which involved discussion for the ventricles being wide, students used the concept from the lecture about action potential to point out that conduction velocity is much slower in the ventricular muscle than in the Purkinje fiber and there is blockage in the conduction system. For the reason of average rate being slow, which was asked as a fourth question, there was a mapping from the concept of phases of action potential in the lecture and their prior knowledge on the subject to the concepts of nodal conduction abnormality and inflam-

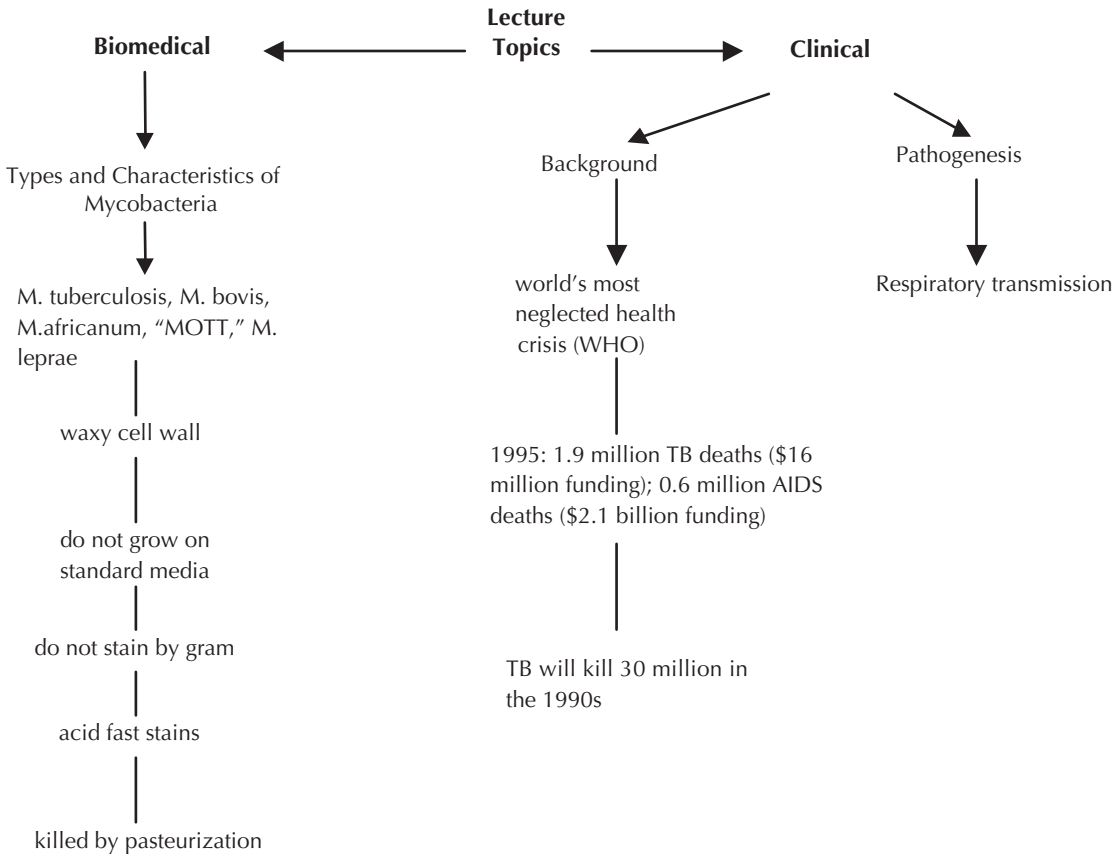

Figure 4. Schematic representation of biomedical and clinical concepts used during the Tuberculosis lecture

mation to the conduction system and pacemaker activity in the small group session. For finding the conduction problem in the young patient, students correctly pointed to Lyme disease, which was not mentioned in the lecture. To conclude the session, the tutor also gave a brief description of Chaga's disease, its signs and symptoms, to further broaden students' knowledge on the subject.

Introduction to the Patient

Conceptual Continuity Between Lecture and Small Group Session. To determine how well concepts were carried over from the "Introduction to the Patient" (ITP) lecture to the small group session, two separate excerpts of dialogue from the small group session were compared to the lecture: the first pertained to a suicidal patient, and the second pertained to an elderly patient. This method of analysis was used for the ITP lecture since psychiatry topics are taught differently than others, where the small group sessions took place in a more informal atmosphere at the instructor's home.

In the first dialogue, the concepts of suicide and depression were touched upon during the small group meeting. Indirectly related to suicide, and more directly related to doctor-patient relationships, were the concepts of discomfort/comfort, relationships, rights, entitlement, and obligations on the part of the medical student/physician. In the lecture notes, the concept of suicide was present throughout. The concept of suicide was related to every topic discussed; thus, the students had adequate prior knowledge, which was carried over into the small group sessions. The concept of depression was also addressed in the lecture/class notes. Specifically, it was found that the concept of depression was touched upon explicitly fourteen times during the lecture. For example, depression was named as a "significant factor in 50-70 percent of all suicides . . . suicide rates 30X higher in depressives." In the small group session, this type of information was useful when the tutor asked the students, "When a patient walks into your office and they are depressed, do you think it is a problem asking them: 'Are you thinking of killing yourself?'" One of the students responded, "Well, from our ITP lecture, it seems to be that you should ask them." It is very explicit, in this case, that the student carries over the information acquired from the lecture into the small group discussion. As far as the concepts related to doctor-patient relationships were concerned, only one concept, obligations, was touched on in the lecture/course notes pertaining to suicide. The concepts of discomfort/comfort, relationships, rights, and entitlement did not come up explicitly in any of the lecture/course notes.

In the second dialogue on the elderly, the concept of personal relations was discussed, under which the concepts of attachment, distancing, and dependence were included. One concept that was raised, but was not directly related to the elderly, was that of "standing" (the role, rank, position of the health care professional). This concept would have been covered in the section on doctor-patient relationships. In the lecture notes on the elderly, personal relations was touched upon explicitly six times. Falling within those six were three related to distancing and two related to dependence. Attachment, however, was not touched upon at all. The effects of this were seen in the small group session, when the tutor asked the students, "Why do you think it is that you, who are relative strangers to the patients, are playing such an important role for the elderly?" The students, although speculating as to what the reasons might be, were not certain about any one of their suggestions. In this case, it seems as though the students would have been able to apply this knowledge in answering the tutor's query had it been presented in the lecture material. Thus, the lack of continuity between material covered in the ITP lecture and small group session hindered the students' understanding of the concepts addressed during small group teaching.

Small Group Teaching Dynamics

Characterization of Interactions. Table 1 presents the percentage of total interactions that were characterized as being either initiating, problem-solving, knowledge-based teaching, or feedback interactions for each of the small group sessions that were studied. For all small group sessions, most interactions were dedicated to initiating discussion on a particular topic (30 percent for Cancer, 28 percent for Tuberculosis, 20 percent for Cardiac Physiology, and 42 percent for ITP) or providing others with feedback concerning a given piece of information that was presented (38 percent for Cancer, 38 percent for Tuberculosis, 38 percent for Cardiac Physiology, and 39 percent for ITP). Furthermore, a similar number of interactions were related to knowledge-based teaching strategies across the groups, although these interactions were more prominent during the Cardiac Physiology session (28 percent). Problem-solving interactions were more common during the Can-

cer, Cardiac Physiology, and Tuberculosis sessions (17 percent, 13 percent, and 14 percent respectively) than during the ITP session (2 percent). Thus, the small group discussions involved similar processes across all topics, although problem-solving played a more important role in the discussion of the biomedically oriented topics (Cancer, Cardiac Physiology, and Tuberculosis) than for the discussion of patient issues.

Initiating Interactions. In terms of initiating interactions, the tutor was responsible for the majority of interactions that involved the presentation of a new topic for discussion during the Cancer (58 percent) and Tuberculosis (70 percent) small group sessions, while the students initiated the majority of these interactions during the Cardiac Physiology (60 percent) and ITP (51 percent) small group sessions. However, there were relatively equal contributions from the tutors and students to the discussions. These results suggest that the tutors involved in small group teaching are an important factor in the initiation of these discussions, but that students also provide important contributions to the direction the sessions take. Given that lectures tend to have minimal interaction between the lecturer and students, this suggests that the interactions between tutors and students made possible in small group sessions can lead to a fostering of new ideas, which would not be possible in a lecture.

Problem-Solving. Table 2 presents the types of interactions that characterized the problem-solving activities that occurred during the small group sessions. Specifically, problem-solving during small group teaching mainly consisted of requests by the participants for further information or elaboration. Additionally, students during the Cardiac Physiology session engaged in a number of interactions in which they reviewed previous data or information in attempts to solve a problem. Students were almost exclusively responsible for initiating problem-solving interactions across all four sessions, where students initiated 90 percent of these interactions during the Cancer session, 82 percent during the Tuberculosis session, 95 percent during the Cardiac Physiology session, and 100 percent during the ITP session. Thus, these results suggest that problem-solving during small group teaching is mainly a student-driven process consisting of the introduction and elaboration of hypotheses.

Figure 5 presents a schematic representation of the problem-solving process used by tutor and students in the ITP small group session. The session started with a description of a clinical case of a three-year-old child who shows signs and symptoms suggestive of pneumonia. After the instructor presented the first portion of the clinical case, he asked a specific question that focused the students' attention on specific information, rather than asking the students' views on the case. He encouraged them to look at the results from the X-rays (given in the case) followed by a question on the consequences of lymph nodes on the bronchus. This strategy of focusing on specific information will be found in subsequent portions of the teaching sessions.

Although there was ample participation in the SGT session by students, it was evident from Figure 5 that the session was highly directed towards obtaining the correct information. The instructor kept a highly visible role as leader of the session and focused students' attention on the identification of the correct diagnosis and treatment.

Knowledge-Based Teaching Strategies. Table 3 presents the types of interactions that characterized the knowledge-based teaching strategies that occurred during the small group sessions. The majority of these strategies took the form of summarizing the main points of discussion and providing more in-depth descriptions to clarify information across all four sessions. Explanations made by reference to

Table 1. Percentage of total interactions across major coding categories for Cancer, Tuberculosis, and ITP small group sessions

Interaction	Cancer	Tuberculosis	Cardiac	ITP
Initiating	30	28	20	42
Problem-Solving	17	14	13	2
KBTS*	15	20	29	17
Feedback	38	38	38	39

*Knowledge-Based Teaching Strategies

Table 2. Types of interactions as a percentage of total problem-solving interactions for Cancer, Tuberculosis, and ITP small group sessions

Interaction	Cancer	Tuberculosis	Cardiac	ITP
Elimination of Hypotheses	0	0	2	0
Introduction of Hypotheses	17	12	39	33
Request for Information	83	88	23	67
Review	0	0	36	0

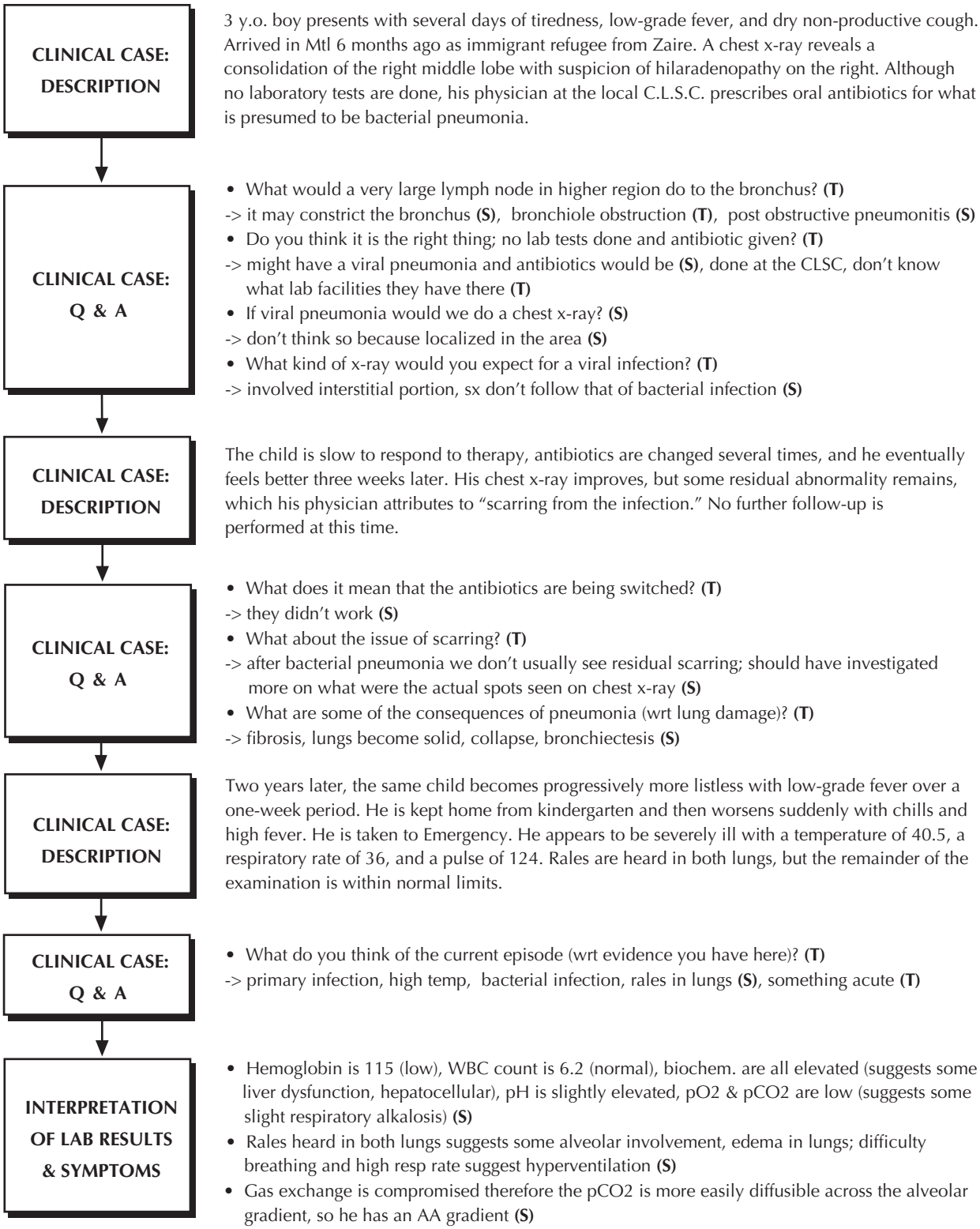

Figure 5. Schematic representation of problem-solving during the ITP small group teaching session (S=student, T=tutor)

similar situations through the use of anecdotes or analogies were less common during the discussions. Thus, these results suggest that knowledge-based teaching during small group discussion was grounded in a medical context, whereas the participants drew few parallels to similar processes outside of the medical domain.

The dynamics of the interaction demonstrate that the tutor was responsible for the largest percentage of knowledge based-teaching strategies across all four sessions. Specifically, the tutor initiated 86 percent of these interactions during the Cancer session, 77 percent during the Tuberculosis session, 95 percent during the Cardiac Physiology session, and 95 percent during the ITP session. Thus, these results suggest that knowledge-based teaching during small group discussion is mainly an instructor-driven process whereby information is summarized and described in further detail to the students. The majority of these interactions resulted in further questioning from the students to enhance their understanding of a concept (74 percent for the Cancer session, 76 percent for the Tuberculosis session, 80 percent for the Cardiac Physiology session, and 87 percent for the ITP session).

Feedback. Table 4 presents the interactions that characterized the types of feedback given during the small group sessions. The majority of feedback took the form of further explanation of a main point of discussion. The tutor initiated 65 percent of these interactions during the Cancer session, 73 percent during the Tuberculosis session, and 58 percent during the Cardiac Physiology session, while students initiated 79 percent of these interactions during the ITP session. Thus, these results suggest that both students and instructors were involved in the provision of feedback during small group discussion. The majority of these interactions resulted in further discussion from the students to enhance their understanding of a concept (83 percent for the Cancer session, 84 percent for the Tuberculosis session, 85 percent for the Cardiac Physiology session, and 86 percent for the ITP session).

Nature of Interactions. From the coding categories elaborated above, it is possible to define a cycle of action through which each group progresses. This cycle is illustrated in Figure 6. Beginning with the initiation of an interaction, information was relayed to the group. Individual students provided feedback in terms of their reactions to the information presented or asked questions of the instructor or each other. This sometimes resulted in the instructor using a knowledge-based teaching strategy to try to explain the context in greater depth or relating it to the students in some way that could be understood by them. In some instances this resulted in ideas or hypotheses being advanced by students with respect to very specific aspects of the course content.

Table 3. Types of interactions as a percentage of total knowledge-based teaching strategy interactions for Cancer, Tuberculosis, Cardiac, and ITP small group sessions

Interaction	Cancer	Tuberculosis	Cardiac	ITP
Analogy	2	1	1	3
Reference	12	16	12	9
Repetition	17	20	4	3
Summary	28	23	34	43
Description	37	31	38	31
Anecdote	4	9	11	11

Analogy: referred to a similar concept to explain in familiar terms.

Reference: referred to another source of information for clarification.

Repetition: repeated previous information to emphasize a particular concept.

Summary: described the main concepts associated with a topic.

Description: provided a more in-depth explanation of a concept.

Anecdote: explained a concept using a story to emphasize certain points.

Table 4. Types of interactions as a percentage of total feedback interactions for Cancer, Tuberculosis, Cardiac, and ITP small group sessions

Interaction	Cancer	Tuberculosis	Cardiac	ITP
Explain	81	73	74	72
Acknowledge	16	17	14	24
Prompt	3	10	12	4

Figure 7 presents an example of these processes during small group teaching. Looking at the coded dialogue, we observed that students were able to build ideas off of one another. This led to a more precise and detailed analysis of the topic. For instance, when describing a situation, one student may forget or omit a key point or idea. Another student, who may have had a similar experience or idea, can contribute to the group's understanding of the situation/idea. With increasing interaction, there seemed to be increasing clarity. For instance, when students 1 and 2 tried to describe their patient's history with suicide, each bit of information that each of them added to the dis-

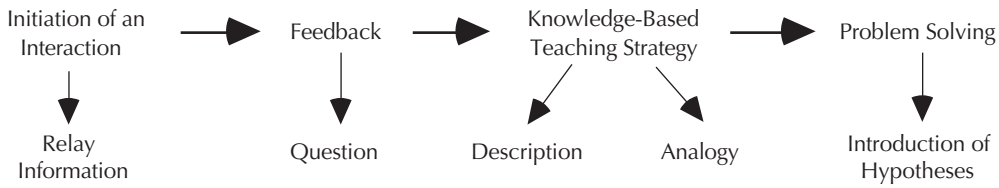

Figure 6. Characterization of small group teaching cycle of action

course seemed to build a story, which eventually elicited responses from both the tutor and fellow students, leading to a full discussion on the physician's role in the suicidal patient's care. This discussion led to several key questions that were of importance and needed to be answered.

We also observed that students were able to discuss feelings with regards to certain aspects of doctor-patient interaction with both the tutor and each other. This interaction between students and tutor enabled the students to get feedback regarding certain issues/situations that the tutor had experienced as a medical student (the tutor was a physician). The interactions occurring between students, on the other hand, allowed for students to tell their "stories" and to learn from one another. For instance, one student may think they are alone in feeling a certain way about some aspect of doctor-patient relationships; however, through interaction, they may find they are not alone and can talk each other through their personal learning experiences.

Student Evaluations of Small Group Teaching

During the small group sessions, the group's tutor asked students for their feedback concerning the curriculum. More precisely, tutors asked the students to explain what they liked and what they didn't like about the lectures and small group sessions and what they felt should be changed about both the lecture and small group components of the course. The two components were compared by mapping the "cons" of one component onto the "pros" of the other and looking at the ways in which they complement each other (i.e., what could be done in the small group that seemed to be lacking in the lectures).

A comparison between negative aspects of the small group sessions and how they were complemented by positive aspects of the lectures was also performed. Only one negative aspect of the small group sessions was mentioned, but it was not agreed upon by all members of the cohort. Specifically, one student claimed the interactions that occur during the small group sessions have a tendency to level off a group of students. The student claimed that the interactive nature of the small group sessions requires that students participate and that, if a student has nothing to say regarding a particular topic or if certain students are more knowledgeable about a certain topic, those students participating in the session may not include all members of the cohort. The only aspect of the lecture that could complement this problem is the fact that the lectures are not interactive. However, in light of what was seen in the previous analysis, this seems counterintuitive. The overall consensus seemed to indicate that what made the small group sessions so popular was the fact that there was interaction, so the concern of this one student can be seen as deviating from the norm.

Discussion

This study investigated the relationship between lecture-based and small group teaching, including the integration of biomedical and clinical knowledge across teaching formats, with a focus on how knowledge is constructed during small group sessions. The results indicate that, first, lecture material functions as a conceptual source of information for students in their discussions during the small group meetings. Whereas the lecture is geared to expose the students to a large, basic body of biomedical information, the small group setting provides an opportunity for the participants to discuss more clinically oriented issues, such as clinical procedures and treatments, ethical issues, and signs and symptoms. It is therefore reasonable to assume that there will be an overlap of concepts, as the students are given the opportunity to apply materials from the lecture to their clinical analysis of patient cases dur-

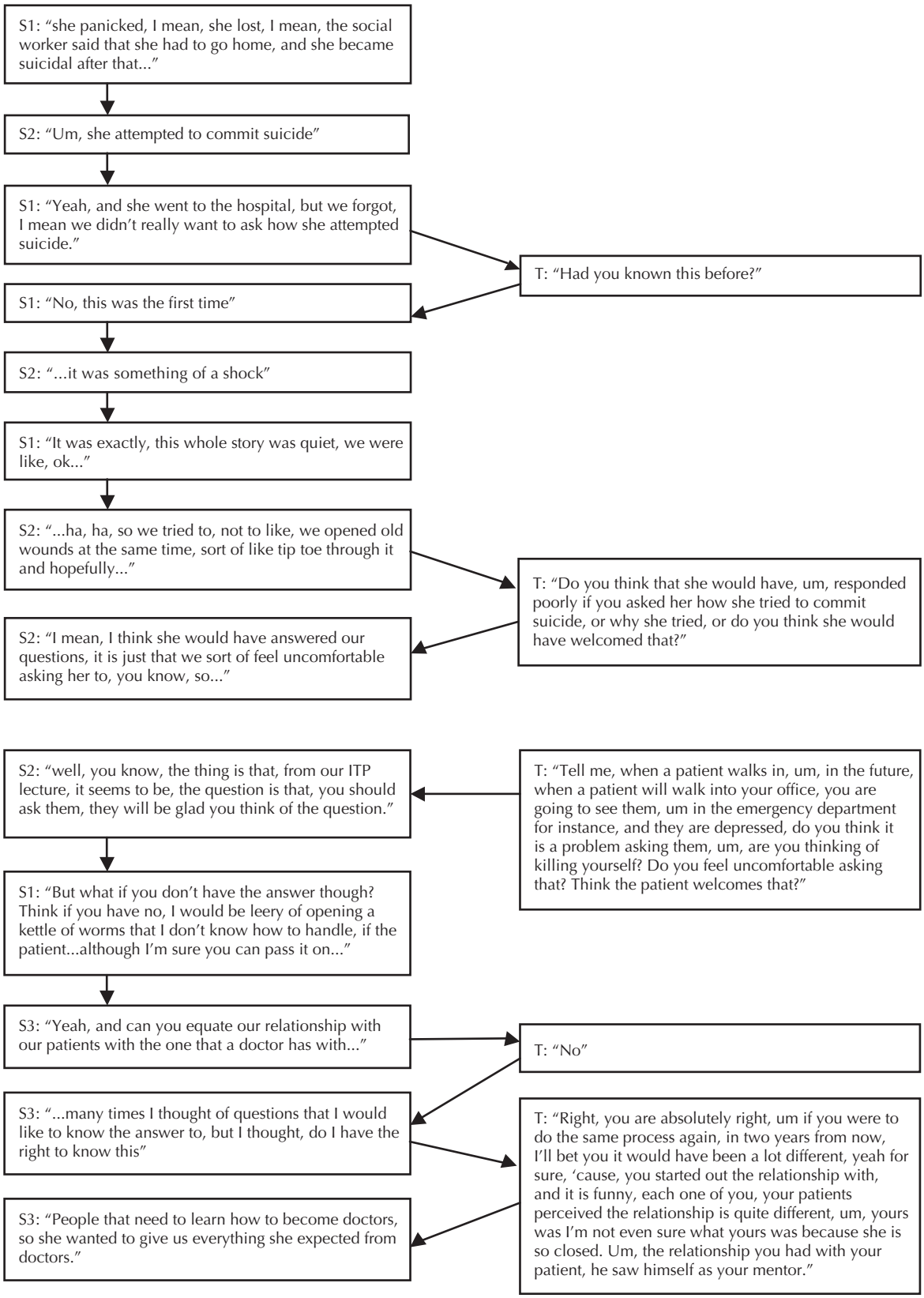

Figure 7. Schematics representation of small group teaching dynamics during the ITP small group teaching session

ing small group teaching. Thus, lectures function as an anchor for the students' discussion of issues relevant to clinical problem-solving and interventions in small group teaching, where the contextual issues surrounding the topics can be dealt with in some depth, for instance, by presenting the main concepts and leaving the details for the small group sessions. In this regard, knowledge acquired during lectures could be later discussed in SGT sessions.

Small group sessions were found to promote discussions that allowed an integration of information from different sources. These discussions integrated concepts across a number of disciplines, including physiology, anatomy, histology, immunology, genetics, microbiology, and molecular biology. This integration took place in an environment that was more intimate and less formal than lectures, although similarly supervised by an expert mediator. This suggests that small group sessions can serve the function of examining lecture concepts in several contexts allowing the students to relate them to relevant concepts in other disciplines. In this regard, small group teaching could be used as a vehicle that allows consolidation of what students have learned in lectures and information gathered from other settings.

Third, although the objective of small groups was to discuss patient cases in clinical terms, topics grounded in biomedical concepts and explanations—as is the case with "Cancer and Oncogenes"—resulted in the discussion of biomedical rather than clinical issues. The reason for this may be that these topics require a solid grounding in biomedical knowledge to be understood, in which case lectures would be more important. In these cases, small group teaching may not be the best vehicle for instruction. Instead, SGT may serve a better function once the topics of interest are addressed extensively in the lectures. With a solid background from lectures, the students have the opportunity to expand their knowledge of the issues discussed in the lecture.

Fourth, small group sessions also seemed to be an ideal forum for discussing ethical issues. Ethics is an area where personal concerns are significant; in SGT sessions, the students could explore their concerns. When necessary, the tutor intervened, providing students with the ethical norms of contemporary medicine. Such interventions cannot be meant to dismiss other opinions raised, but merely to educate students as to what other views exist in the medical community. Whereas, in a lecture, the instructor is more likely to briefly discuss different issues and opinions regarding each of these topics, in a small group the students are able to first express their ideas and then receive input from the group, allowing them to have discussions of unbiased ideas.

Fifth, when compared to lectures, which tended to allow for little interaction, if any, small groups allowed for in-depth discussions of the issues or concepts that were raised. The students were able to discuss their thoughts and feelings about things in a "controlled" environment in which there was immediate feedback. In the small group component of the ITP curriculum, the students are required to visit patients on several occasions. Being in a relatively new position, students are bound to have questions concerning doctor-patient protocol, ethics, and other such issues that one might come across as a first-year medical student on his or her first patient visits. These questions could arguably be answered in the lecture context. However, with classes of over one hundred students, one cannot expect each of those students' concerns to be addressed. In a small group format, students tend to be less timid, more open to asking questions, and more likely to discuss issues of personal concern.

In voicing their opinions, the students made it clear that small group sessions were the favored method of instruction. Not only did they praise the small group sessions as having been challenging and interactive, they went so far as to claim that they were the "highlights of the year." In contrast, lectures did not have the same popularity with the students; they noted lower attendance, presumably due to lack of interaction, tedious repetition, and lack of elaboration. However, small group sessions and lectures seem to complement each other quite effectively: lectures are needed to learn the basic concepts, while small group sessions are needed to provide an atmosphere in which students and group leaders can interact, leading to a more interactive, challenging, and arguably better learning environment.

We believe that a combination of lectures and small group sessions seems to offer the student the most appropriate means of education. If the curriculum consisted only of lectures, learning might be superficial and less applicable to the practice of medicine, but if it were limited to small group sessions, students would lack a common core of basic knowledge that allows them to engage in abstract and more advanced discussions. With this in mind, it is quite clear that an integrative approach to instruction for the health disciplines is a step toward more effective education.

Through our investigation, we have found that SGT may serve to integrate knowledge previously acquired in lectures and through readings. To this end, as dental education programs adapt problem-based learning strategies,[11,51-55] it is important that curricular reformers be knowledgeable of what has worked and what has not in medical schools. Despite the acceptance of PBL in many medical settings, its shortcomings in some aspects of learning are being increasingly acknowledged. Thus, an investigation of what is actually done in PBL environments may be necessary for a proper assessment of what types of activities are critical to what learning outcome.[27] The use of small group teaching sessions may not be the best instructional strategy for all forms of education. The key is that these components become integrated in such a way that they serve to increase the kinds of learning experiences that support optimal learning; that is, each format should be used for the educational and training task where it is most effective.

Acknowledgments

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