Assessing Team-Based Instructional Design Problem Solutions of Hierarchical Versus Heterarchical Web-Based Hypermedia Cases

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For this study, we examined the cogency, comprehensiveness, and viability of team-based problem solutions of a Web-based hypermedia case designed to promote student understanding of the practice of instructional design. Participants were 14 students enrolled in a graduate course on advanced instructional design. The case was presented to students using two hypermedia structures, hierarchical (tree-like structure) and heterarchical (network-like structure). Results from analyses of four data sources revealed that problem solutions developed in response to the heterarchical case design were more cogent and convincing than problem solutions developed in response to the hierarchical case design. Specifically, the heterarchical case solutions provided evidence of a heuristic problem-solving process facilitating the identification of an expert-like solution to the case and the articulation of learners' understanding and application of grounded and engaging instructional designs.

The use of hypertext-hypermedia to represent ill-structured problems has been of primary interest to researchers because of its inherent nonlinear interlinking ability in representing a complex and interconnected body of information (Hemstreet, 1997; Jacobson & Spiro, 1995). Ill-structured (or ill-defined) problems are the kinds of problems or tasks encountered in everyday practice, requiring the integration of several content domains, and possessing multiple solutions or solution paths (Jonassen, 1997; Lesh & Doerr, 2003). Hypermedia problem-representation capabilities mirror the characteristics of ill-structured problems and could provide an efficient and effective medium to design cases for learning environments that are problem centered (Grissom & Koschmann, 1995). Additionally, hypermedia learning environments have the potential to enrich learners' understanding of complex topics by providing them with random, dynamic, nonlinear access to a wide range of information represented as text, graphics, animation, audio, and video (Azevedo & Cromley, 2003).

Although there is a critical mass of studies on learning with hypermedia, the results are often inconclusive or at best fragmentary, particularly concerning the effects of hypermedia case designs of ill-structured problems on students' problem-solving skills (Dillon & Gabbard, 1998; Tergan, 1997; Williams, 1992). In order to better understand the potential learning benefits of hypermedia systems, researchers need to understand the complex interaction between learning tasks and system features by examining both products and processes associated with achieving such tasks. In this study, we examined the

effects of two types of hypermedia case structures, hierarchical and heterarchical, on students' collaborative problem-solving skills, with the goal of informing educators and practitioners who utilize case-based or problem-centered teaching methods how to represent ill-structured problems using Web-based hypermedia technology.

THEORETICAL FRAMEWORK

Instructional design cases or problems are a classic example of ill-structured problems because they are design problems (Jonassen, 1997, 2000). Design problems "have ambiguous specification of goals, no determined solution path, and the need to integrate multiple knowledge domains" (Jonassen, 2000, p. 80). In approaching an instructional design problem, students must frame the problem through careful consideration of the problem context, their own knowledge and skills, and the nature and quality of the resources available (Dabbagh, Jonassen, Yueh, & Samouilova, 2000). Solutions to instructional design problems are unique, and often require a team-based approach and the integration of multiple perspectives and processes. Instructional design can therefore be characterized as a "problem-solving enterprise in which practicing professionals combine creativity with technical skills to solve complex, ambiguous problems" (Stepich, Ertmer, & Lane, 2001, p. 54).

Often, a structured or prescriptive approach to teaching instructional design, focusing on the acquisition of objective facts and features of the design process and the application of context-free rules of an instructional systems design (ISD) model, results in graduates who do not value the importance of observation and critical thinking skills required for the successful implementation of contextualized and engaging instructional solutions (Dabbagh et al., 2000). In order to address this critical issue, an increasing number of instructional design programs are implementing case-based teaching methods to help students develop the knowledge and skills commonly used by experts, and to bridge the gap between education and practice (Ertmer & Quinn, 1999; Julian, Kinzie, & Larsen, 2000; Quinn, 1994; Rowland, Parra, & Basnet, 1995; Stepich et al., 2001).

Case-based teaching methods use cases or problems as anchors for learning. Students are presented with complex and real-world problems or cases and asked to analyze and solve these problems through reflection and discussion (Allen, Otto, & Hoffman, 2000). According to Welty (1989), the key to case-based teaching is the discussion itself, through which students "learn to identify actual problems, to recognize the key players and their agendas, and to become aware of those aspects of the situation that contribute to the problem" (p. 5). Benefits of case-based teaching methods for instructional design students include helping students:

> (a) draw connections between their emerging knowledge of instructional design and the complex demands of practice, (b) reflect on relevant theory and methods as they explore a greater number of design issues in a broader array of contexts, and (c) broaden their knowledge base as they collaborate with colleagues to identify effective design solutions. (Stepich et al., 2001, p. 55)

Despite research evidence of the benefits of case-based teaching methods, research on case structure and its impact on the acquisition and transfer of complex knowledge is provisional. Sutyak, Lebeau, and O'Donnell (1998) argued that case structure may have a profound impact on knowledge transfer and student expectations of learning, and that case structure remains a fertile field of study. Additionally, Siegel et al. (2000) suggested that a high level of transfer might be attained through Web-based instructional designs that support case- and problem-based learning.

Sutyak et al. (1998) examined the impact of structured and unstructured cases on surgical domain-specific reasoning skills of third-year medical students having surgical and nonsurgical career orientations. Structured cases presented prototypical examples of a given diagnosis with all pertinent data embedded in the written scenario, whereas unstructured cases presented the same diagnosis but with a greater degree of uncertainty accomplished by leaving out pertinent data, therefore requiring students to seek this information through ques-

tioning and research. Results indicated that unstructured cases positively influenced surgical domain-specific reasoning for nonsurgical career students, thus supporting the hypothesis that unstructured case designs may lead to a higher degree of far transfer.

In terms of Web-based hypermedia case designs, Siegel et al. (2000) discovered that different hypermedia structures are required for different problem-solving contexts, and that users showed a preference for cross-referenced or conceptually indexed hypertext material in which multiple paths are available to reach a certain concept, and hyperlinks represent relations between ideas forming a conceptual network or relational structure. Additionally, there is evidence that hypermedia linking structures interact with learner characteristics (e.g., learners' prior knowledge and cognitive styles) and with the goal of the learning task (e.g., exploring vs. searching for specific information), and that the design characteristics of a hypermedia learning environment can enhance or limit user performance and affect the quality of independent learning (Last, O'Donnell, & Kelly, 2001).

For example, Jacobson, Maouri, Mishra, and Kolar (1996) found evidence that students' epistemic beliefs affected learning from conceptually indexed case-based materials with modeling-scaffolding support. Jacobson et al. found that students who regarded learning as an active process of constructing meaning performed at a significantly higher level on a knowledge synthesis task than students with a simpler set of epistemic beliefs. Dabbagh (2002) found evidence that a heterarchical (network-like or conceptually indexed) Web-based hypermedia design of an ill-structured case triggered significantly more collaboration and discussion between group members than a hierarchical (tree-like or top-down structure) Web-based hypermedia design, and that the time spent interacting with the heterarchical case design was one and a half times the time spent interacting with the hierarchical case design.

This sample of research studies suggests that relational or conceptually indexed hypertext representations of ill-structured problems or cases may be perceived as more effective in promoting advanced knowledge acquisition and collaborative problem solving. However, these results also indicate that there are several instructional and learner variables that could confound the effect of case structure on problem understanding and problem solution. These variables include the type of learning tasks in which students are engaged when interacting with a case, time on task, the degree of modeling and scaffolding provided, and the cognitive factors (e.g., epistemic beliefs) influencing knowledge acquisition and transfer. In addition, the research methods used to conduct these studies ranged from exploratory to experimental, making it difficult to generalize the results and ensure that if these studies were replicated, they would yield similar results. As Jacobson et al. (1996) contended, "There continues to be little rigorous empirical documentation of the educational efficacy of hypertext learning environments and the conditions under which significant learning outcomes with such systems are achieved" (p. 273).

Recognizing the need for further research on case structure, particularly with regard to Web-based hypermedia designs, the present study was designed to validate or confirm the hypothesis that relational or network-like hypermedia representations of ill-structured problems or cases are more effective than sequential or hierarchical representations in promoting advanced knowledge acquisition. Relational or network-like hypermedia representation of case material, referred to in this study as the *heterarchical case structure,* can be described as a linking structure or navigational metaphor in which hypermedia links are interspersed throughout the content, representing associations similar to knowledge representation in a memory model or network structure (Jonassen & Wang, 1993). A heterarchical case structure can be contrasted with a *hierarchical case structure,* in which case material is typically organized into logical sections, often by major topic area, resulting in several navigation levels with a top-down or tree-like structure (Last et. al, 2001; Oliver, 1996).

More specifically, in a hierarchical tree structure, a superordinate node (or root node) holding more complex information is connected to

subordinate nodes (leaves) holding simpler information. Recursively, each subordinate node could itself become a superordinate node when connected to new nodes, forming a tree-like structure without cycles (Melara, 1996). By contrast, in a heterarchical structure, any node can be connected to any node of information by segmentation or association, and multiple links among superordinates and subordinates are made, forming a network-like or relational structure (Melara).

Given that many print and Web-based case designs that support case- and problem-based learning tend to be hierarchical in structure and navigation of material (Siegel, et al., 2000), we sought in this study to examine the effects of hierarchical versus heterarchical Web-based hypermedia case structures on students' problem-solving skills, based on data gathered from team-based student solutions of an ill-structured instructional design case represented both hierarchically and heterarchically. The instructional design case was used in an advanced instructional design course as an anchor for learning in a case study assignment. The main research question investigated in this study was whether team-based problem solutions of a heterarchical Web-based hypermedia case design of an ill-structured problem are more cogent, comprehensive, and viable than team-based problem solutions of a hierarchical Web-based hypermedia case design.

METHOD

Course Description

The advanced instructional design course was taught in the spring of 2002 at a large mid-Atlantic university by the first author of this article. The course is a requirement for students enrolled in the Instructional Design and Development (IDD) track of the instructional technology master's program. The course provides students with the knowledge and skills of designing contextualized and engaging learning environments based on the principles of constructivism and situated cognition. Pedagogical models discussed in this course include anchored instruction, cognitive apprenticeships, cognitive flexibility hypertexts, and communities of practice, among others. Course activities include in-class discussions, in-class group activities and presentations, reflection journals, a case study assignment (which is the focus of this study), and a culminating instructional design project based on the pedagogical models discussed. All course activities are supported with a Web-based component using WebCT.

Participants

Course enrollees were 28 graduate students (24 females, 4 males). The 83:17 female to male ratio is a normal gender mix for students enrolled in instructional technology programs at large mid-Atlantic universities. The students were all seeking a master's degree in IDD and were in their second or third semester of coursework. All students had completed a basic instructional design course as well as two to five other courses in the program including a course on learning theory and a course on multimedia development. Student ages ranged from 26 to 52 years and all had a minimum of 4–6 years prior professional experience in K–12, government, military, or corporate settings.

At the beginning of the semester, students were asked whether they preferred an online or print-based format for the case study assignment. Fourteen (n = 14) out of the 28 students indicated a preference for the online format and were assigned to the Web-based hypermedia case investigated in this study. The rest of the students were assigned print-based cases selected from the *ID Casebook: Case Studies in Instructional Design* (Ertmer & Quinn, 1999).

The Case

The ill-structured problem selected for this study is an instructional design case concerning the issue of informed consent prior to surgery. The case places students in the role of instructional designers charged with solving a performance problem. The problem relates to preoperative instruction in which potential gall bladder disease patients learn enough about the surgical procedure to give informed consent.

Students interacting with this case are responsible for designing instruction and assessment that legally verifies that patients were fully informed of preoperative procedures and related side effects. If such instruction could be validated as effective, huge benefits could accrue to the medical profession, and certainly to the insurance companies, given the impending number of malpractice cases filed against physicians for either misinforming, or not informing, patients about possible risks of gall bladder surgery or alternative procedures to correct the disease (Dabbagh et al., 2000). The informed consent case is an example of an ill-structured instructional design problem (Jonassen, 1997).

The case material was initially compiled in print form and assembled based on Barrows's (1985) problem-based learning module (PBLM) for presenting clinical problems to medical students (see Dabbagh et al., 2000). The PBLM is a simulation of a patient problem presented to students, as it would be to a physician in actual medical practice. Patient information in a PBLM is arranged in a linear fashion, beginning with a statement of the patient's medical problem, followed by the patient's medical history, all relevant physical and laboratory tests, and associated documentation.

Similarly, the print-based informed consent case began with a statement of the problem of informed consent, followed by a history of the problem stemming from gall bladder surgery litigation, examples of real-world malpractice cases, samples of legal informed consent forms, legal definitions of informed consent from *Black's Law Dictionary,* samples of gall bladder patients' medical histories, related doctor and patient interviews, and relevant journal articles. The print-based case was later converted by the first author of this article to a Web-based hypermedia design reflecting the two types of hypermedia linking structures investigated in this study: hierarchical and heterarchical.

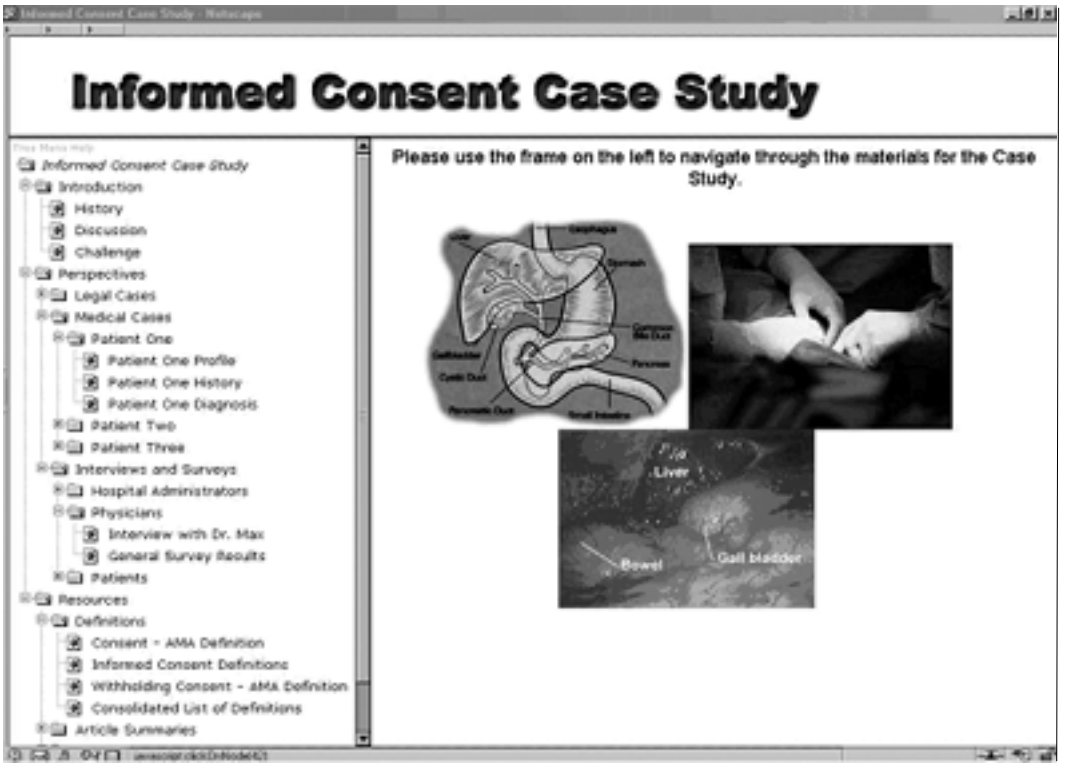
The Case Structure

The hierarchical Web-based design of the informed consent case retained the PBLM format of the print-based case in terms of organization and sequencing of the case material. Navigation in the hierarchical structure was implemented using a frame-based Web design illustrated in Figure 1. The left frame in Figure 1 displays a tree-like navigational structure organized by case topics and subtopics. When users click on the links in the left frame, the case information is displayed in the right frame using text and graphics. All navigation is enabled through the left frame. As is typical in a hierarchical structure, users browse deeper into the linking structure for more detail and return to higher levels in the hierarchical organization to change topics and subtopics. No horizontal or lateral associations between topics or ideas were implemented in this design.

By contrast, the heterarchical hypermedia structure was implemented using a single frame in which the case material is presented as a narrative simulating a patient who has just experienced a medical emergency resulting in the need for gall bladder surgery. Throughout the narrative, the patient is informed of all the administrative and surgical procedures including the issue of giving informed consent prior to surgery and its implications. All case information presented in the hierarchical design was included in the heterarchical design through embedded textual hyperlinks that embody the natural meaning of the narrative as it describes the patient's journey from diagnosis to surgery (see Figure 2). These hyperlinks were interspersed throughout the case narrative forming multiple links among case topics and subtopics in a cross-referential or associative fashion with no discernable hierarchy or repeatable paths, typical of a relational or network-like linking structure (Oliver, 1996).

The navigational metaphors adopted in these two Web-based hypermedia designs can be described as highly contrasting. As Larson and Czerwinski (1998) contended, hierarchical versus heterarchical hypermedia designs can be viewed as a "depth versus breadth" topology of linking structures. Although the heterarchical design in this study presented the case information through a patient's story, students interacting with each of these case designs in a previous study (Dabbagh, 2002) designed to conduct usability testing and examine students' overall

Figure 1 ☐ Hierarchical case structure.



perception of the informed consent problem, viewed the problem to be equally complex, ill structured, relevant, and meaningful, establishing that case structure is the distinguishing variable between the two Web-based designs.

The Learning Task

The case study assignment accounted for 25% of a student's final grade, and was implemented midway through the semester over a 3-week period. The instructor provided the following information in the syllabus regarding this assignment:

> In groups of 3–4, students will review and develop a written response to an instructional design case study. Case studies will be a mixture of web-based and print-based format. Time will be given in class to discuss and develop responses or solutions to the problems outlined in the case. Each group will post their formulated response to the course Web site and will present their solution (time permitting) to the class with appropriate rationale and reasoning based on issues covered in the course. Groups will be asked to critique each other's responses online through discussion forums.

Three case studies, the informed consent case and two other print-based instructional design cases selected from the *ID Casebook* (Ertmer & Quinn, 1999), were chosen for this assignment. Two groups of students were assigned to each case to facilitate the peer group critique process. The students who had elected to work with an online case (n =14) were randomly divided into four groups. Two groups (four students in each group) were assigned to the hierarchical design, and two groups (three students in each group) were assigned to the heterarchical design of the informed consent case.

In addition to the syllabus description of the case study assignment, a handout was provided to students that included the following suggested strategies for analyzing the case (Ertmer & Quinn, 1999): (a) Identify key issues in the case, (b) consider main issues from the perspectives of key players, (c) generate a list of poten-

Figure 2 □ Heterarchical case structure.

tial solutions related to each issue, (d) specify possible consequences of each solution, and (e) weigh the advantages and limitations to each solution and a recommendation for action. The handout also stated that groups were not required to follow these strategies and were free to collaboratively determine their own approach to analyzing the case. Either way, the groups were asked to articulate the problem-solving strategy adopted in solving the case in their solutions. The instructional approach for implementing this case study assignment is consistent with the methods and principles of case-based learning discussed earlier in this article.

Procedure

Students were given two weeks to solve the case and were assigned discussion areas in WebCT to facilitate online collaborative problem solving and posting of case solutions. Case solutions were limited to the equivalent of 3–4 single-spaced word processing document pages to encourage concise expression of ideas. After all case solutions were posted, new discussion areas were created in WebCT to facilitate a one-week case solution critique process in which peer groups compare and contrast each other's solutions, and reflect on similarities and differences through online discourse. Peer groups were defined in this assignment as groups working on the same case. Therefore the two groups assigned to the hierarchical structure of the informed consent case were asked to critique each other's solutions, and the two groups assigned to the heterarchical structure of the informed consent case were asked to critique each other's solutions. All groups were required to revise their case solutions based on the peer critique and to post their revised solutions online for final evaluation by the instructor.

Measures

We used four different measures or data sources to assess the cogency, comprehensiveness, and viability of the four team-based solutions of the informed consent case: (a) a ten 3-point, Likert-

type item case solution evaluation rubric (CSER) applied to each of the groups' initial solutions of the informed consent case, (b) a content analysis of the case solutions based on the results of the CSER, (c) a content analysis of the transcripts captured from the peer group online discussion critique, and (d) an eight-item questionnaire that sought student perceptions about the case content and structure, and the problem-solving approach adopted by the group.

Case solution evaluation rubric (CSER). In developing the CSER, we considered previous guidelines and criteria suggested for evaluating case study solutions. Specifically, Ertmer and Quinn (1999) developed 12 questions that could guide the analysis of student performance on instructional design case studies. These questions addressed the viability and coherence of case solutions and examined whether students identified the key issues in a case and took into consideration relevant constraints. Similarly, Julian et al. (2000) identified 15 rating items used to judge team-based case solutions of The Chronicles of Rocket Boy, an instructional design case presented to seven student teams that participated in the 1998 ID case competition sponsored by the University of Virginia. These items focused largely on whether case solutions integrated instructional design knowledge and whether the team recommended an appropriate overall solution to the problem. Additionally, Jonassen (1997) identified both product and process criteria for evaluating solutions of ill-structured problems. Jonassen argued that because ill-structured problems have multiple solutions, the product, which is the recommended or proposed solution, can only be evaluated in terms of its viability or feasibility.

For the purposes of this study, we synthesized the above case evaluation guidelines into ten 3-point, Likert-type scale items focusing largely on process criteria in order to assess students' problem-solving skills and related activities as revealed by the team-based case solutions. For example, Item 4 on the scale (see below) addresses the viability of the assumptions that students made while working toward a resolution of the case. Making assumptions is an analytical thought process or activity in problem solving (Mayer, 1992), and evaluating the viability of an assumption can provide insight into the causal relations implied by the solution to a problem (Jonassen, 1997). As a result of the consideration of the above factors, the 10 items of the CSER evaluated the extent to which the group's proposed solution:

1. Clearly and coherently identified the key issues, questions, and concerns depicted in the case.
2. Represented the key issues in a way that can be supported by facts from the case.
3. Considered the relevant constraints presented in the case.
4. Did not contain any unwarranted assumptions.
5. Considered the interests and perspectives of the different stakeholders involved in the case.
6. Recommended a workable, practical alternative in light of the facts presented in the case.
7. Was specific and comprehensive.
8. Was coherent, cogent, and well reasoned.
9. Aligned with accepted instructional design practice.
10. Demonstrated the group's knowledge of instructional design principles and concepts.

The 3-point scale used to classify the above problem-solving activities or processes in the students' case solutions consisted of three categories: (a) Category 1 (denoted by 1) designated the presence of the problem-solving activity or process in the group's case solution; (b) Category 2 (denoted by -1) designated the absence of the problem-solving activity or process in the group's case solution; and (c) Category 3 (denoted by 0) designated the inability of the evaluator to make a judgment (i.e., to determine whether the problem-solving activity or process is present or not present in the group's case solution). Two graduate students independently evaluated each of the four teams' case solutions using the CSER. The student evaluators were asked to support their judgments with excerpts from the case solutions, or provide rationales explaining their classifications. The student evaluators were enrolled in the IDD program at the institution where the study took place and

were in their last semester of coursework. The case structure corresponding to the informed consent problem solutions and the identities of the participants were not revealed to the student evaluators. An expert (the first author of this article) also evaluated the four case solutions using the CSER.

The eight-item questionnaire. The eight-item questionnaire was used in a previous study (Dabbagh, 2002) to assess student perceptions of the informed consent case, both the hierarchical and heterarchical Web designs, in terms of structure, usability, complexity, real-world relevance, and usefulness of case information in supporting the formulation of a viable solution. The same questionnaire was used in this study to replicate previous results and provide an additional data source for triangulation purposes. The questionnaire items were posted via e-mail to the participants of this study (n =14) after the completion of the case study assignment. Responding to the questionnaire was not a component of the case study assignment grade, and no additional incentive was provided. Eight students (57% response rate) responded, four from the hierarchical groups (2 from each group) and four from the heterarchical group (2 from each group).

The questionnaire included the following items:

1. What did you think of the case in general? Was it simple, complex, ill-defined, well-defined?
2. What did you think of the topic (informed consent)? Was it relevant? Meaningful?
3. What did you think of the hypermedia structure of the case? Well structured, ill structured?
4. Was it easy to find what you were looking for?
5. Describe your general fact-finding and problem-solving strategy while navigating the case and interacting with your group members.
6. Do you think you had enough information to identify the main issues and problems in the case or to solve the case?
7. Do you think the information in the case was useful?
8. How would you change the case or present it differently to students?

RESULTS

Upon examining the two graduate student evaluators' classifications of the four case solutions using the CSER, we noticed that one of the student evaluator's (Rater 2) classifications were generally higher than those of the other student evaluator (Rater 1) and the expert evaluator. Further interviews with both student evaluators revealed that Rater 2 did not adhere to the agreed-upon approach of applying the CSER to the case solutions, which was to rate each case solution independently by looking for evidence (or absence of evidence) to support each item of the CSER and to provide a supporting rationale. Rater 2 stated that she used Barrows's (1985) hypothetico-deductive problem-solving process to guide her evaluation of the case solutions. Specifically, Rater 2 indicated that she "treated all case solutions as working hypotheses" and "expected the groups to use processes consistent with an ADDIE model, or a structured analysis consistent with Barrows's model (encountering the problem, analyzing it, organizing the facts–prioritizing, and developing a working hypothesis–solution)." Additionally, Rater 2 stated that she "considered the page-length restriction when looking at factors such as specificity of instructional solutions design, identifying assumptions, and justifying solutions" and "looked for evidence that teams had *considered* these aspects" adding that "in a 3–4 page paper, there is only so much you can do in these areas." Upon reflecting on her approach, Rater 2 explained that her ratings would have been lower in certain cases had she not treated all solutions as "working hypotheses," "the sort that would have evolved upon further problem analysis."

Given the above, we decided to exclude Rater 2's evaluation of the case solutions from the analysis. Table 1 presents the results for each item of the CSER as classified by Rater 1 (the first student evaluator) and the expert evaluator. Inter-Rater reliability between Rater 1 and the expert evaluator was r = .86 across all four case solutions, r = 1.00 across the two heterarchical

Table 1 ☐ Results of the case solution evaluation rubric.

Ten-Item, 3-point scale, Case Solution Evaluation Rubric	*Group1A Hierarchical Structure*	*Group 1B Hierarchical Structure*	*Group 2A Heterarchical Structure*	*Group 2B Heterarchical Structure*
1. The group's proposed solution clearly and coherently identified the key issues, questions, and concerns depicted in the case.	Rater 1 = 1 Expert = 1	Rater = 1 Expert = 1	Rater 1 = 1 Expert = 1	Rater = 1 Expert = 1
2. The group's proposed solution represented the key issues in a way that can be supported by facts from the case.	Rater 1 = 0 Expert = 1	Rater = 0 Expert = 1	Rater 1 = 1 Expert = 1	Rater = 1 Expert = 1
3. The group's proposed solution considered the relevant constraints presented in the case.	Rater 1 = 1 Expert = 1	Rater = 1 Expert = 1	Rater 1 = 1 Expert = 1	Rater = 1 Expert = 1
4. The group's proposed solution did not contain any unwarranted assumptions.	Rater 1 = 0 Expert = 0	Rater = 0 Expert = 0	Rater 1 = 1 Expert = 1	Rater = 1 Expert = 1
5. The group's proposed solution considered the interests and perspectives of the different stakeholders involved in the case.	Rater 1 = 1 Expert = 1	Rater = 1 Expert = 1	Rater 1 = 1 Expert = 1	Rater = 1 Expert = 1
6. The group's proposed solution recommended a workable, practical alternative in light of the facts presented in the case.	Rater 1 = 0 Expert = 0	Rater = 0 Expert = 0	Rater 1 = 1 Expert = 1	Rater = 1 Expert = 1
7. The group's proposed solution was specific and comprehensive.	Rater 1 = 1 Expert = 1	Rater = 1 Expert = 1	Rater 1 = 1 Expert = 1	Rater = 1 Expert = 1
8. The group's proposed solution was coherent, cogent, and well reasoned.	Rater 1 = –1 Expert = –1	Rater = 0 Expert = 0	Rater 1 = 1 Expert = 1	Rater = 1 Expert = 1
9. The group's proposed solution aligned with accepted instructional design practice.	Rater 1 = 1 Expert = 1	Rater = 1 Expert = 1	Rater 1 = 1 Expert = 1	Rater = 1 Expert = 1
10. The group's proposed solution demonstrated the group's knowledge of instructional design principles and concepts.	Rater 1 = –1 Expert = –1	Rater = 0 Expert = 0	Rater 1 = 1 Expert = 1	Rater = 1 Expert = 1

NOTE. 1 = presence of problem-solving acticity in case solution; 0 = unable to judge (whether problem-solving acticity is present or not present in case solution; –0 = absence of problem-solving activity in case solution.

case solutions (2A & 2B), and r = .86 across the two hierarchical case solutions (1A & 1B). Table 1 reveals that there were differences between the heterarchical and hierarchical case solutions on certain items of the CSER. Whereas 100% of the CSER classifications across the heterarchical case solutions (2A & 2B) were of Category 1 (presence of problem-solving process in case solutions), 18⁄40 (45%) of the classifications across the hierarchical solutions (1A & 1B) were of Category 3 (unable to judge) or Category 2 (absence of problem-solving activities in case solutions). More specifically, Rater 1 and the expert were unable to make a judgment on Items 4 and 6 of the CSER for Case Solutions 1A and 1B, and on Items 8 and 10 for Case Solution 1B. In addition, neither evaluator found evidence of problem-solving activities or processes for Case Solution 1A as depicted by Items 8 and 10 of the CSER. To examine the significance of these differences, we performed a qualitative analysis of Items 4, 6, 8, and 10 of the CSER using the case solution documents and the rationales of Rater 1 to triangulate our findings.

Item Analysis of CSER

Item 4: Solution did not contain unwarranted assumptions Rater 1 and the expert evaluator were unable to make a judgment on Item 4 of the CSER for the hierarchical case solutions (1A & 1B). This suggests that the hierarchical case solutions "may have included unwarranted assumptions based on the facts of the case." An example supporting this claim is provided from Case Solution 1B. Group 1B assumed that the problem stemmed from having no standards in place for informed consent, and that "physicians see no need for standard informed consent procedures, and in general see no problem with current procedures." Group 1B based this assumption on the results of an anonymous survey (the survey was part of the case information) administered to six physicians in one hospital in which there was one lawsuit involving gallbladder surgery. The survey questions were poorly constructed and the results were inconclusive. More data should be gathered before stating that the problem stemmed from a lack of standardization of informed consent procedures.

In terms of the heterarchical Case Solutions (2A & 2B), Rater 1 and the expert evaluator indicated that these solutions did not contain any unwarranted assumptions. An example supporting this claim is provided from Case Solution 2A. Group 2A clearly identified the need to gather more data, citing the inconclusiveness of the physician's survey as a primary reason for this need. Specifically, Group 2A's solution listed several issues that need to be investigated, such as How are informed consent procedures carried out at different hospitals? Who administers the informed consent form? and How do hospitals deal with "special cases" (emergency situations, under-age patients)? thereby demonstrating knowledge that further analysis is required before identifying the cause of the problem. Furthermore, Rater 1 stated, "Group 2A avoided making unwarranted assumptions and also identified multiple processes and tools that they would employ in order to gather the data required to draw valid conclusions."

Item 6: Recommendation of a workable, practical alternative. Rater 1 and the expert evaluator were unable to make a judgment on Item 6 of the CSER for the hierarchical case solutions (1A & 1B). This suggests that the hierarchical case solutions "may not have recommended a workable, practical alternative in light of the facts presented in the case." An example supporting this claim is provided from Case Solution 1A. Group 1A's recommended solution was resource and time intensive, while the facts of the case indicated a need for a short-term, low-impact instructional intervention, and a long-term systemic reform process to address the larger issue of informed consent and its implications on medical practice. For example, Group 1A's solution recommended instructor-led training for all physicians to ensure effective communication and delivery of informed consent procedures. The facts presented in the case however, indicated that instructor-led training would not be the most efficient approach, given the nature of physicians' schedules at hospitals.

On the other hand, Rater 1 and the expert evaluator indicated that the heterarchical case solutions (2A & 2B) "recommended a workable, practical alternative in light of the facts presented in the case." An example supporting this claim is provided from Case Solution 2B. Group 2B's solution included a detailed outline of five potential plans of action, ranging from short-term solutions that are efficient and timely, to long-term solutions that are more comprehensive. The short-term solution included identifying physicians that perform gall bladder surgery at hospitals where litigation has recently occurred, conducting a review of informed consent procedures at those hospitals, and providing targeted training to those physicians to ensure that the risks of gall bladder surgery and alternative procedures are effectively communicated to patients.

Item 8: Coherency and cogency of solution. Rater 1 and the expert evaluator did not find evidence of problem-solving activities or processes in the hierarchical case solutions (1A & 1B) as depicted by Item 8 of the CSER. This suggests that the hierarchical case solutions "may not have been coherent, cogent, and well reasoned." An example supporting this claim is the expert evaluator's comment on Group 1A's case solution, which stated, "It was not clear though why there was a need for training—you jumped right

into it." Group 1A recommended a solution without appropriate justification, reasoning, and analysis. In terms of the heterarchical case solutions (2A & 2B), Rater 1 and the expert evaluator provided a rating of 1 on Item 8 of the CSER. Rater 1 reported that Group 2A "provided two potential solutions and explained each in great detail with references, objectives, expected outcomes, and potential limitations." The following excerpt from Case Solution 2A demonstrates the coherency and cogency of this group's argument in support of its recommended solutions:

> Informed consent is ultimately a communication issue. It cannot be entirely solved by the delivery of a training product, such as a computer-based training (CBT) or teacher-based training (TBT), especially when so many diverse stakeholders are involved. It can be facilitated by such products, but only if they are the result of a successful process of ongoing communications between medical providers and laypersons. We propose, therefore, a short-term, case-based, and a long-term, community of practice (learning community) process solution.

Item 10: Knowledge of instructional design. Rater 1 and the expert evaluator did not find evidence of problem-solving activities or processes in the hierarchical case solutions (1A & 1B) as depicted by Item 10 of the CSER. This suggests that the hierarchical case solutions "may not have proposed a solution that demonstrated [their] knowledge of instructional design." An example supporting this claim is provided by Rater 1's rationale on Item 10 for Case Solution 1A. Rater 1 stated, "The group's solution focused on the product rather than the process. It was not clear whether the recommended solution stemmed from instructional design practice." In terms of the heterarchical case solutions, Rater 1 and the expert evaluator agreed that Case Solutions 2A and 2B "demonstrated the group's knowledge of instructional design principles and concepts."

Evidence of Integration of Constructivist-Based Instructional Designs

To further examine the nature and degree of the heterarchical groups' knowledge and understanding of the practice of instructional design, we reexamined their Case Solutions (2A & 2B) and looked for evidence of application of constructivist-based instructional designs as discussed in the advanced instructional design course in which the students were enrolled. The following excerpt from Case Solution 2A reveals how students integrated their knowledge of instructional design based on the course content:

> [Group 2A] In a traditional ISD model, the designer would use multiple sources of data, including people, to formulate a solution. In our model, instead of using people as just sources of data, we intend to actively involve them in analyzing the problem and specifying a solution. Informed consent is a complex communications issue, and is best addressed by empowering representatives from all affected groups to actively problem-solve. That is the point of our learning community long-term approach. It is not a program, and it does not preclude training. It does emphasize that training take place in context, and in the practice of the profession, and not necessarily just as an in-service.

Similarly, Group 2B's long-term solution suggested a train-the-trainer model, using real-world best practice scenarios of conducting informed consent proceedings, with ongoing support from exemplar volunteer doctors acting as mentors to novice doctors. They labeled this approach a minicognitive apprenticeship demonstrating the identification of a constructivist-based instructional design training solution.

Evidence of Expert Versus Novice Problem-Solving Behavior

The above qualitative analysis suggests that the solutions associated with the heterarchical case design were more cogent and convincing than the solutions associated with the hierarchical case design. The analysis also revealed that the heterarchical case solutions included explicit links among multiple factors in the case and focused on building from what was known. These solutions also included explicit consideration of implementation or effects of recommendations. In terms of the hierarchical Case Solutions (1A & 1B), the analysis suggests that these solutions may have included unwarranted assumptions and may not have recommended a practical and well-reasoned solution in light of

the facts presented. Recommendations were described in definite terms, and are unlikely to change as additional information becomes available. Additionally, there was little apparent consideration of implementation or effects of recommendations. These differences in problem-solving processes can be characterized as expert-novice differences (Stepich et al., 2001). To address this emergent theme in our analysis, we added new problem-solving characteristics that differentiate between expert and novice-like behaviors, and examined the peer critique online discussion transcripts in light of this new pattern of problem-solving behavior.

Content Analysis of Peer Group Critique Online Discussion Transcripts

Stepich et al. (2001) identified five problem-solving strategies that can be used to differentiate expert-novice behavior when examining student case solutions. These included (a) conceptualization of the issues, (b) search for information, (c) attention to relationships among factors, (d) level of commitment to solutions, and (e) consideration of implications of recommendations (p. 56). In the first problem-solving strategy, for example, experts tend to interpret case issues in light of previous experience, whereas novices tend to report issues as given. When searching for information (the second problem-solving strategy), experts focus on building from what is known, whereas novices focus on filling in what is not known. Additional expert-novice differences were listed for the other problem-solving strategies. Stepich et al. used these five problem-solving characteristics to code student case study responses, classifying each response as either expert-like or novice-like.

Similarly, we coded the peer group critique online discussion transcripts of all four team-based solutions of the informed consent case using four of the five expert-novice problem-solving strategies described above (see Appendix A). We decided that the second problem-solving strategy (search for information) was not relevant to our study because students were not instructed or required to search for additional information to solve the case. Additionally, this study was not designed to track (technically) student trajectories through the hypermedia cases to determine what specific case information was sought. We wanted to focus on the cogency, comprehensiveness, and viability of the case solutions, so we examined the extent to which the following problem-solving characteristics were expert- or novice-like as evidenced in the peer critique online discussions: (a) conceptualization of issues in the case, (b) attention to relationships among factors, (c) level of commitment to solutions, and (d) consideration of implications of recommendations.

In coding the transcripts, we separately examined a randomly selected transcript from the four peer group critique online transcripts, and classified each student posting as either expert- or novice-like based on Stepich et al.'s (2001) characterizations. We then discussed our individual coding results, identifying statements that seemed to clearly illustrate expert and novice characterizations. These examples were then used to guide our coding of the rest of the transcripts. This process provided convergence on data to ensure that any inferences were valid and viable (Winegardner, 2001).

Results of this emergent analysis revealed that the heterarchical groups consistently demonstrated expert-like problem-solving behavior on all four problem-solving strategies, whereas the hierarchical groups demonstrated more novice-like problem-solving behavior (see Appendix A). Briefly, we found that the students in the heterarchical groups made several assumptions based on personal experience with medical practice, and consistently referred to their prior experience and knowledge of instructional design when critiquing each other's solutions, demonstrating expert-like behavior. Additionally, the analysis of the transcripts revealed that students in the heterarchical groups compared and contrasted multiple case information before making recommendations, and carefully considered the effects of their recommendations. For example, Group 2B reflected on the implications of why doctors may not be the best candidates to communicate to patients the risks involved in gall bladder surgery. Similarly, Group 2A reflected on why nurses should not be solely responsible for administering the informed con-

sent form. Both groups proposed the intervention of a third party (a hospital social worker) as an alternative solution in case patients did not understand what they were consenting to when being informed of the risks of surgery by a doctor or nurse.

Content Analysis of the Eight-Item Questionnaire

Next we proceeded to examine student responses to the eight-item questionnaire. Because of space limitations, we will not provide a comprehensive analysis of the responses to all items. Overall, the responses confirmed previous results in terms of student perceptions of case complexity, relevance, and ill structuredness (Items 1 & 2). The responses also confirmed that the hypermedia case designs were distinct and highly contrasting. Students who interacted with the hierarchical case indicated that the hypermedia structure was well structured and that it was easy to find information (Items 3 & 4), whereas students who interacted with the heterarchical case indicated that the hypermedia structure was ill defined, and that it was difficult to find information in a systematic and predictable manner. We acknowledge, however, that the 57% response rate is a limiting factor in generalizing the results. Next, we focused on student responses to Item 5 (Describe your general fact finding and problem-solving strategy while navigating the case and interacting with your group members) because these responses were particularly relevant to this study in terms of revealing the problem-solving strategy adopted by each group. Simultaneously, we examined the case solutions, because groups were required to articulate their problem-solving strategy in them.

Hierarchical groups student responses. The four hierarchical groups' student responses to Item 5 indicated that their groups (1A & 1B) adopted the five strategies for analyzing a case, suggested in the case study assignment handout, as their problem-solving strategy. Their case solutions also confirmed the adoption of this strategy. Both case solutions used tables to organize the case information into (a) key issues of the case, (b) consideration of the main issues of the case from the perspectives of key players, (c) a list of potential solutions related to each issue, (d) possible consequences of each solution, and (e) advantages and limitations to each solution.

Heterarchical groups student responses. The four heterarchical groups' student responses to Item 5 were not as conclusive. The first student response from Group 2B suggested that the general fact-finding and problem-solving strategy adopted by her group was "constant communication and revisiting the information." The second student response from Group 2B was inconclusive in terms of identifying a unique problem-solving strategy.

Upon examining Group 2B's case solution, we found the following excerpt describing their problem-solving strategy:

> We approached the problem from a slightly different angle in the beginning and took a big picture look at the case as a whole, which helped us in gathering information and presenting our analysis. We took considerable time gathering facts, then revisiting them over and over before we started to pull them together to think of a solution. We found that the case can be more easily understood if divided into 3 parts: 1) what is known, 2) what is not known, and 3) possible solutions (plans of action).

The above excerpt suggests an iterative or recursive problem-solving strategy, supporting the first student response from Group 2B to Item 5 (constant communication and revisiting the information). The iterative nature of Group 2B's problem-solving strategy and their application of what is known, what is not known, and plans of action to facilitate their understanding of the case can be perceived as similar to Barrows's (1985) hypothetico-deductive problem-solving approach, which guides students to identify an initial set of hypotheses about the problem, what they know about the problem (the facts), what they need to know (the unknowns or learning needs), and how they plan to acquire new information (action plan). This process is repeated multiple times enabling reexamination and hence continuous adjustment of the initial problem hypotheses based on new learning.

Within Group 2A, the first student response to Item 5 was inconclusive in terms of identifying a unique problem-solving strategy. The sec-

ond student response (below) revealed a fact-finding strategy that is clearly different from the suggested strategies for analyzing the case provided in the case study assignment handout:

> First I just tried to identify the players and their perspectives. Then I tried to understand the nature of gallstones, and the risks of surgery/nonsurgery. I then wanted to find out more about how the medical community (not just those in the hospital)—so I searched the Web. What I saw on the Web gave me the idea that we should design our training in the same spirit that practicing professionals design their own continuing education—that a "learning community/community of practice" approach might be more acceptable to them and would work best.

Upon examining Group 2A's case solution, we found the following excerpt describing their problem-solving strategy:

> Coming from the Mager-school-of-instructional-design, our team first approached the problem in a traditional manner, but then we decided we would try the constructivist approach as we envisioned it in this case. We understood that the aim of constructivism is to build a learning environment that fosters the growth of ideas, but does not determine how or what will flourish (emergent and generative).

The above excerpt can be perceived as an elaboration of what the second student response from Group 2A reported as a problem-solving strategy, namely, a situated or contextualized approach that involves focusing on building from what is known, searching for additional information, and interpreting the findings in light of prior knowledge and experience. This problem-solving strategy is also consistent with expert-like behavior (Stepich et al., 2001).

Evidence of a Heuristic Problem-Solving Process

Group 2A adopted a constructivist approach in solving the informed consent case. Constructivism is an established learning theory that emphasizes the design of learner-centered environments that are authentic, collaborative, complex, generative, and problem based. According to Hannafin, Hannafin, Land, and Oliver (1997) "theory-based approaches provide designers with powerful heuristics that guide design processes and procedures rather than provide explicit prescriptions" (p. 102). Group 2A used constructivist theory as a heuristic to guide their case analysis and address the ambiguities inherent in the case resulting in a grounded instructional design solution. Grounded design is the systematic implementation of processes and procedures that are rooted in established theory, ensuring that methods are linked with foundations and assumptions (Hannafin et al., 1997).

Similarly, Group 2B adopted a theory-based approach to problem-solving. Barrows's hypothetico-deductive problem-solving method is based on the pedagogy of problem-based learning, which is rooted in constructivist epistemology. Students in problem-based learning environments use this method as a heuristic to guide their solutions to ill-structured problems. This iterative problem-solving process eventually led Group 2B to recommend five potential solutions, ranging from short-term to long-term. For each solution the team identified a product outcome and a process with which to achieve this outcome.

Alternatively, Groups 1A and 1B (hierarchical case solutions), adopted the five items listed under the analyze-the-case strategy provided in the handout of the case study assignment as their problem-solving strategy. Although this approach is a viable case analysis method, it is not explicitly rooted in an established instructional or learning theory. Additionally, the hierarchical group solutions were more product- than process-oriented and did not overtly demonstrate the application of grounded or contextualized instructional designs.

CONCLUSION

We conducted this study to examine the cogency, comprehensiveness, and viability of team-based problem solutions of an ill-structured Web-based hypermedia case designed to promote student understanding of the practice of instructional design. We began with 10 problem-solving processes or activities designed to characterize the differences in four team-based

solutions of the case: two in response to a hierarchical case structure, and two in response to a heterarchical case structure. Throughout the data analysis process, we continued to refine our understanding of these problem-solving processes as we examined more data sources, using the constant comparison method (Lincoln & Guba, 1985). Analysis of multiple data sources revealed additional problem-solving characteristics, further clarifying and informing our understanding of the differences in student collaborative problem-solving behavior as it relates to hierarchical and heterarchical hypermedia case designs.

The results revealed that problem solutions developed in response to a heterarchical hypermedia case structure were more cogent, comprehensive, and viable than problem solutions developed in response to a hierarchical hypermedia case structure. Additionally, the results revealed that problem solutions developed in response to the heterarchical hypermedia case structure demonstrated expert-like problem-solving behavior, and the use of a heuristic problem-solving process that facilitated the identification of a contextualized solution to the case and the articulation of learner understanding of engaging and grounded instructional designs. The hypothesis that relational or network-like hypermedia representations of ill-structured problems or cases are more effective in promoting advanced knowledge acquisition and transfer was supported in this study.

However, the results need to be interpreted relative to the study's limitations. First, external validity may have been compromised by the small sample size, few groups in each treatment, and lack of random sampling from an identified population. Second, internal validity may have been compromised because of uneven group sizes, low response rate to the eight-item questionnaire, and the consideration of only one student rater's evaluations. Therefore the results should be interpreted with caution. Nevertheless, the results of this study suggest that heterarchical case structures can help promote student understanding of expert instructional design practice. With the increased emphasis on problem solving in the field of instructional design (Jonassen & Hernandez-Serrano, 2002), the results of this study should encourage educators and practitioners who utilize case-based or problem-centered teaching methods to further examine the effects of heterarchical hypermedia case designs of ill-structured problems on students' problem-solving skills.

The research literature has consistently reported that there is a relationship between the structure of information and the tasks being performed in hypermedia learning systems (Azevedo & Cromley, 2003; Last et al., 2001; Smith, Newman, & Parks, 1997). In particular, the research cited by Smith et al. reported that exploratory tasks, which require users to find related items of information within the structure, are best supported by a relational or network-like information structure, whereas searching tasks, which require users to find information from one place in the structure, are best supported by a hierarchical information structure. The results of this study confirm those findings. The heterarchical case structure facilitated more exploratory-type tasks, which put students in control of problem solving, encouraging them to try out different strategies and hypotheses and observe their effects (Collins, 1991). However, more experimental research is needed to empirically validate these findings. In addition, future studies should examine the interaction between learner characteristics (e.g., prior knowledge, cognitive styles, and self-regulatory skills) and hypermedia case designs, and the extent to which individual group members interact with a case to determine whether different learning tasks are performed by different group members in relation to case structure. We hope others in the field will continue to explore the complex interactions between learning tasks and hypermedia system features, to examine their effects on students' problem-solving skills and advanced knowledge acquisition. □

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Appendix A ☐ Sample of expert versus novice problem-solving behavior from the peer critique online discussion transcripts.

1. Conceptualizations of Issues	
Expert-like behavior: Group 2A (heterarchical case) interprets issues in light of previous experience	Novice-like behavior: Group 1B (hierarchical case) claiming that Group 1A (hierarchical case) reports issues as given
I want to address the question of why we [Group 2A] made assumptions and created detailed solutions. We realize that there are a lot of unknowns in this case. We considered that the task team would be in place to work toward answers to these questions. Our solutions were our brainstorming effort to predict somewhat what the team may develop. We made a lot of assumptions based on personal experience that we have had with doctors.	Before we begin discussing specific points we [Group 1B] wanted to ask you a couple of questions to give some context to your [Group 1A] recommendations. What were your team's underlying assumptions? What did you base your recommendations on? It seemed that your recommendations did not stem from an instructional design perspective but rather just on the facts of the case.
2. Attention to Relationships Among Factors	
Expert-like behavior: Group 2B (heterarchical case) makes explicit links among multiple factors	Novice-like behavior: Group 1A (hierarchical case) claiming that Group 1B (hierarchical case) lists issues without apparent consideration for how they might be related
While the administrator survey and the interview with the CEO of Tyrone Hospital provided insight into the concerns surrounding informed consent, as a team we felt that this information did not directly relate to the informed consent problems that the doctors at McGee Hospital were having with gall bladder surgery patients. Therefore, we looked to the five forms provided by the U.S. Health Department as a guide for providing effective informed consent for different medical proce-	(Student 1 from Group 1A) The issue of developing a standardized list of facts on gall bladder surgery seems to me to be more of the same with regard to problems with the "standardized" informed consent forms. Because there is no national standard, there can be no individual standard. I see a problem with [Group 1B's] solution because no outside resource exists that can determine what is standard. This solution puts the patient right back where they started.

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