

ARTICLES

Use of Instructional Dialogue by University Students in a Distance Education Chemistry Course

Paul Gorsky, Avner Caspi, and Inbal Tuvi-Arad

Abstract

A distance education system may be viewed in terms of intrapersonal and interpersonal instructional dialogues that mediate the learning and instructional resources that enable such dialogues. Instructional resources include self-instruction texts, tutorial sessions, instructor availability, Web sites, and more. This study investigated the kinds of dialogues engaged in by Open University students and the kinds of resources they used while studying an intermediate-level chemistry course. Research objectives were to document (a) what study strategies if any, involving which resources and dialogues, were generally used by students; (b) what dialogue types, enabled through which resources, were specifically used by students to overcome conceptual difficulties; and (c) how the use of resources and dialogues in the chemistry course compared with students' experiences in other science courses. It was found that all students initially chose individual study characterized by intrapersonal dialogue. Only when individual study failed did students opt for interpersonal dialogue. This finding conflicts with the assumed importance often ascribed to interpersonal dialogue by some distance education theorists.

Résumé

Un système d'éducation à distance peut être vu en termes de dialogues pédagogiques intrapersonnels et interpersonnels qui servent d'intermédiaires entre l'apprentissage et les ressources pédagogiques qui rendent possibles de tels dialogues. Les ressources pédagogiques incluent les textes d'autoapprentissage, les sessions de tutorat, la disponibilité du professeur, les sites Web, etc. L'étude a examiné, dans le cadre d'un cours de chimie de niveau intermédiaire dans une université par correspondance, les types de dialogue qu'engagent les étudiants et le type de ressources qu'ils utilisent. Les objectifs de l'étude étaient de documenter (a) quelles stratégies d'apprentissage, si existantes, impliquant quelles ressources et quels dialogues, étaient généralement utilisées par les étudiants, (b) quels types de dialogues, rendus possibles par le biais de quelles ressources, étaient spécifiquement utilisés par les étudiants pour surmonter les difficultés conceptuelles, et (c) comment l'utilisation de ressources et de dialogues dans le cours de chimie pou-

vait-elle se comparer avec les expériences des étudiants d'autres cours de science. Les résultats ont montré que tous les étudiants avaient initialement choisi l'apprentissage individuel caractérisé par le dialogue intrapersonnel. Les étudiants ont opté pour le dialogue interpersonnel seulement quand l'apprentissage individuel n'avait pas réussi. Ce résultat de recherche entre en conflit avec les idées de certains théoriciens en éducation à distance qui, souvent, attribuent de l'importance au dialogue interpersonnel.

Introduction

Since Socrates (470-399 BC), dialogue has generally been assigned a fundamental position in Western views of education. Dialogue has been viewed from both philosophical and pedagogical approaches. Philosophical approaches to interpersonal instructional dialogue tend to emphasize either its epistemological advantages in the pursuit of knowledge and understanding (Socrates and Plato) or its moral and political foundations based on egalitarianism and mutual respect (Dewey, 1916; Buber, 1965; Bruner, 1966; Rogers, 1969; Freire, 1972). For example, regarding the moral aspects of educational dialogue, Buber (1965) wrote, "the basic movement of genuine dialogue, and thus of education itself, is a truly reciprocal conversation in which teacher and students are full partners" (p. 184). According to Buber, the relationship between teacher and students is based on honesty, equality, openness, and mutual respect. Genuine dialogue is not located within any one of the participants, but rather is found in their *betweenness*, in what Buber calls the reality of the "interhuman" (p. 184). Bruner (1966) and Rogers (1969) also emphasize the importance and necessity of dialogue between teacher and student. Bruner wrote that instructor and student should engage in an active dialogue (i.e., Socratic learning). He contended that the task of the instructor is to translate information to be learned into a format appropriate to the learner's current state of understanding. Rogers discussed the centrality of the interpersonal relationship in the facilitation of learning alongside the need to provide freedom in educational environments.

The problem with such philosophical approaches to dialogue, however, is that they are highly idealized. They tell us little about what real dialogues look like and how they work, or fail to work, in real situated learning environments. Pedagogical viewpoints of interpersonal instructional dialogue tend to emphasize actual discursive practices. That is, various kinds of dialogues are defined, each with its own educational objective grounded in theory, either instructivist or constructivist. For example, Burbules (1993) lists four types of dialogical engagement: inquiry, conversation, instruction, and debate. These four dialogue types do not provide an exhaustive typology; rather, they illustrate the diversity of form and the diversity of aims that dialogic processes may assume. Some converge toward predetermined answers and conclusions (instructivism),

whereas others are open and divergent (constructivism); some are friendly, some antagonistic. All, however, are dialogues, and all are generally recognizable as such.

Over the past 25 years, the concept of dialogue has been expanded in order to accommodate intrapersonal dialogue, the internal process or processes through which learners construct understanding. This viewpoint enables the assumption that all learning is mediated through dialogue, sometimes interpersonal and other times intrapersonal. Modern distance education systems include a diverse array of resources for intrapersonal dialogue such as self-instruction texts, instructor-led tutorial sessions, Web-based instructional systems, audio- and videocassettes, television and radio programs, computer-based simulations and tutorials, and so forth. In addition, there are many and diverse resources for interpersonal dialogue such as Web sites for synchronous and asynchronous interaction, teleconferencing, audioconferencing, telephone, e-mail, face-to-face meetings, and so forth. Given this diversity, we suggest that students' study strategies and practices might usefully be investigated in terms of the dialogues chosen and the resources used.

This article reports on a small-scale research project aimed at exploring individual accounts of the process of learning university chemistry by focusing on the instructional resources and dialogues used by students. It responds to a need to find out more about the complexity of real situated learning experiences and to create new ways of thinking about factors and influences, especially instructional technologies, that may be crucial in determining the success or failure of distance education courses.

To carry out such an analysis, however, a need exists for a broad conceptual framework of distance education systems that recognizes the centrality of instructional dialogue and views the resources of an instructional system in terms of the kinds of dialogue each resource supports. Such a framework was proposed by Gorsky and Caspi (in press). A brief review of the framework follows.

The Framework of Resources and Dialogues: A Model for Distance Education Systems

The underlying assumption of the framework is that learning is mediated by two types of dialogue, intrapersonal and interpersonal (instructor-learner or learner-learner). Distance education systems (e.g., a university program, course, or lesson) may be analyzed along two key dimensions: *instructional dialogues* and the *instructional resources* that make them possible. The framework is discussed in general terms only; a specific, detailed analysis of each variable may be found in Gorsky and Caspi (in press).

In the framework, two types of instructional dialogue, intrapersonal and interpersonal, are defined because the learning mechanisms involved in each are so different. Two categories of instructional resources, human and structural, are defined. Human resources are the players, instructors, and learners who directly engage in dialogue, or not, for whatever reasons. Structural resources influence the extent of interaction and dialogue that may occur. Learners may use the resources of a distance education instructional system as they see fit in accordance with their goals, abilities, and needs. A discussion of dialogue types follows.

Intrapersonal Instructional Dialogue

Intrapersonal instructional dialogue is defined as an internal process through which learners construct understanding. Vygotsky (1978) viewed concept formation as resulting from processes that occur between people (inter-psychological) and from processes that occur within the individual (intra-psychological). Holmberg (1989) characterized internal dialogue as a special and limited form of conversation directed toward learning that he called “an internal didactic conversation.” Such conversations occur when learners “talk to themselves” about the information and ideas they encounter in texts, lectures, or elsewhere. In a study conducted by Entwistle and Entwistle (1992) adult students described their study methods for understanding difficult information and material as requiring active engagement with the concepts and issues not only by discussion with others, but also through *internal debate*. Donovan, Bransford, and Pellegrino (1999) describe metacognition as an *internal dialogue* that individuals develop in order to build skills for predicting learning outcomes and monitoring comprehension.

Interpersonal Instructional Dialogue

Interpersonal instructional dialogue is seen as a discursive process through which learners’ understanding may be increased. Ultimately, all learning occurs through intrapersonal processes, even learning mediated by interpersonal dialogue. However, given the direct effect of interpersonal learning on concept acquisition, it is useful to distinguish between the two types of dialogue.

Interaction is a necessary condition for the creation of instructional dialogue. Interaction may or may not lead to dialogue. Given an instructional system, for each interaction type (instructor-learner and learner-learner) there exists a potential for interaction derived from a particular constellation of variables both structural (e.g., group size) and human (e.g., learner autonomy). For each interaction type, a variable named *potential interaction* may be estimated. The potential for interaction may be actualized to greater or lesser degrees through dynamic interplay between

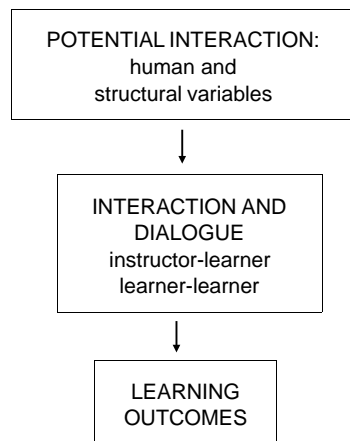


Figure 1. The model of interpersonal instructional dialogue.

instructor and learner or between learners. Figure 1 is a schematic representation of the model of interpersonal instructional dialogue. Formal definitions of the model's constructs and variables follow.

Potential Interaction

Potential interaction is defined formally as a variable that measures a potential for creating interpersonal interaction in an instructional system. Potential interaction is determined by structural variables. Two distinct values of potential interaction, one for each dialogue type (instructor-learner, learner-learner), may be estimated or measured for any given instructional system.

Gorsky and Caspi (in press) found that certain structural variables (instructional design, group size, instructor accessibility, and learner accessibility) determine to a large degree the extent of interpersonal interaction that may occur. The collective effect of these variables on a given instructional system determines the value of potential interaction. Other structural variables may influence the potential for interaction and the resulting dialogues; however, as far as is known their effect if any is minimal or yet to be studied.

Dialogue

Interpersonal instructional dialogue is defined as a discursive relationship between two or more participants characterized by thought-provoking activities such as questioning, hypothesizing, interpreting, explaining, evaluating, and rethinking issues or problems at hand. A dialogue is said to have occurred if one or more of the activities listed above is manifested

in an interaction, either instructor-learner or learner-learner. This is a judgment based on a qualitative analysis of data from sources such as observations, videos, transcripts, interviews, and questionnaires.

There are various kinds of dialogue with various specific aims that in turn derive from varying philosophical stances. Dialogue may be used as a means to increase learners' understanding or to sharpen learners' analytic skills or even as an evaluation tool. It may be either instructor-learner or learner-learner. The instructor, characterized by facilitation skills, plays a critical role in creating and maintaining dialogue, both in traditional and in distance education programs (Dewey, 1916; Bruner, 1966; Rogers, 1969; Moore, 1993). The learner, characterized by "autonomy" (Moore) and personal need, will participate in interpersonal dialogue in accordance with these characteristics.

Learning Outcomes

Two learning outcomes, achievement and learner satisfaction, are included in the model. It has been shown that dialogue leads to more satisfactory learning outcomes as perceived by the learner (Moore & Kearsley, 1996; Chen, 2001a, 2001b). The relationship between dialogue and achievement is unclear and requires further research as not all dialogues result in increased learner understanding. Burbules (1993) has shown that although some dialogues may serve educational purposes, others have deleterious and even anti-educational effects.

Summary

This conceptual framework of distance education systems associates every resource in an instructional system with a specific dialogue type. In so doing, it provides a description of the mechanisms at play in distance education systems and proposes relationships between varying constructs that may be tested by empirical research. It is the theoretical basis on which this research is grounded.

The Study

The Open University of Israel is a distance education university designed to offer academic studies to students throughout Israel. Established in 1974, the university offers a home study system based on textbooks, tutors, and study centers throughout the land. Enrollment for the academic year 2003-2004 was more than 38,000 students. Each university course offers "regular" instructor-led, face-to-face tutorials held every two or three weeks. Some courses offer "extended" instructor-led, face-to-face tutorials held weekly. In addition, instructors are available for telephone consultations; an open line was accessible for two hours per week at specified days and times. The classic text-tutor system was enriched in 1999 with the

introduction of a Web-Based Instructional Environment (WBIE) wherein each course has its own Web site. These sites are intended to enrich students' learning opportunities and to increase interpersonal interaction, both instructor-learner and learner-learner. Web site use is optional, non-mandatory, so that equality among students is preserved (at the time the study was conducted, only about 42% of the students had home access to the Internet). The WBIE does not replace textbooks or face-to-face instructor-led tutorials that are the pedagogical foundations of the Open University. The WBIE enables asynchronous instructor-learner and learner-learner interactions as well as a synchronous forum for chat between and among all logged-on participants, including the instructor.

The chemistry course from which participants were surveyed is an intermediate-level course required of all chemistry and life science majors. It includes 11 self-study text units, nine theoretical and two laboratory. It accounts for six credits of a total 108 needed for graduation. Table 1 lists the human and structural instructional resources for each of the dialogue types that were available to students.

Students received the written course materials, mailed to their home addresses, about six weeks before the start of the semester. Written materials included self-instruction texts and a booklet of problems to be solved and submitted by certain deadlines. In addition, they received a password that granted access to the course's Web site. Before the course began, students chose between one of two kinds of tutorials, either hour-long tutorial sessions held once every two weeks (regular) or hourly sessions held once a week (extended). In this study *instructor* is the term used for the person who communicated with students in tutoring sessions by e-mail, by telephone, or in person.

Table 1
Human and Structural Resources Available to the Open University Students

| <i>Dialogue Types</i> | <i>Human Resources</i> | <i>Structural Resources</i> |
|-----------------------|---------------------------|---|
| <i>Intrapersonal</i> | Learner | <ul style="list-style-type: none"> • Self-instruction texts • Tutorial sessions • Web site materials • Recommended texts |
| <i>Interpersonal</i> | Instructor; Learner(s) | <ul style="list-style-type: none"> • Web site discussion groups, synchronous and asynchronous • Telephone • E-mail • Personal face-to-face meetings |

Research Aims

The objectives of the research were to document (a) what study strategies if any, involving which resources and dialogues, were generally used by students; (b) what dialogue types, interpersonal and/or intrapersonal, enabled through which resources, were specifically used by students to overcome conceptual difficulties; and (c) how students' use of resources and dialogues in the chemistry course compared with their experiences in other courses.

Methodology

Because no other studies have been carried out, this is a small preliminary study to begin to test the viability of the model through naturalistic methods. These methods provide rich data that can then be used to design a more comprehensive study. Participants were interviewed in a natural, open, and nonthreatening context. Personal learning practices and processes described in the participants' own words provide a range of data for understanding their experiences, perceptions, and beliefs about varying dialogue types and the resources through which these dialogues were mediated.

Participants

One hundred, twenty-eight students completed the course "Pathways in Chemistry" during the spring semester of 2003. Ten participated in the study. It was decided that participating students would meet the following two criteria: the successful completion of at least two science courses in previous semesters and a willingness to explore their own learning processes. The former criterion ensured that students had amassed enough experience in distance learning so that dialogue preference would be the result of conscious decision-making and not the result of random trial and error. That is, they had acquired a sense of knowing how to learn based on direct personal experience. Furthermore, previous experience would enable a comparison of practices used in the chemistry course with other science courses. It was established from university records that of the 128 students, 88 met the first criterion. The search for volunteer participants was done randomly by telephone. The names of the participating students have been changed to ensure anonymity.

Two instructors of a total of three who led the tutorials also participated in the study. The third instructor was ill on the day when the group discussion took place. Instructors are faculty members of the Open University.

Data collection and analysis

Data were gathered from semistructured interviews; each student was interviewed personally while both instructors met together with the authors. A constant comparative method (Silverman, 2001) was used in which provisional hypotheses were tested in a series of interviews with various students until no more new knowledge was gathered. Initial phases of data analysis involved classifying data in accordance with the research questions. Data generated by each student were analyzed in terms of the three research questions for purposes of tentative hypothesis validation. Hypothesis validation involves seeking patterns in the thoughts and actions of the participants (Ericsson & Simon, 1984; Hill & Hannafin, 1997).

Interviews with students

Student interviews were carried out by the first author, a research associate at the Open University who is not a faculty member in the Department of Natural Sciences. This affiliation and the goal of the study (understanding how each student learned) were emphasized so that students would not be reticent or apprehensive about offering information. Complete confidentiality was assured. The interviewer did not know any of the students who were interviewed.

Each student participant was interviewed once, alone, at the end of the course in a semistructured interview that took about 40-60 minutes. The interviewer made brief notes during the session and extensive notes immediately on completion of the interview. Interviews sought participants' accounts of their communicative behaviors, both internal and interpersonal, and of their reflections on their learning experiences. Participants were asked questions aimed to be as neutral and open-ended as possible while probing for particular idiosyncratic aspects of experience. For example,

- How did you learn (continuously or by “cramming”)?
- Did you personally communicate with the instructor or with other students?
- Did you post messages on the Web site?
- What did you do when you couldn't solve a problem?
- How did your study practices in chemistry compare with how you studied in other courses?
- Were these other courses simpler or more difficult than the chemistry course?

Because this is a preliminary, exploratory study, no special procedures (e.g., recording the sessions) were adopted to ensure data reliability beyond those described above.

Interview with instructors

In this case, all three authors participated in the interview together with both instructors. The third author and the instructors are established faculty members in the Department of Natural Sciences and, of course, know each other well. The group interview took place after completion of the course, after students' final grades had been recorded, but before the interviews with students. It seemed clear to the researchers that the instructors spoke freely and without reservation about the course. They explained and discussed their perspectives about the course. They were asked to express perceptions of and opinions about the quality of the self-instruction materials, the relative difficulty of assignments and tests, the tutorial sessions, and the quality and amount of interactions and dialogues that occurred with students.

Findings

Six categories of findings are presented: instructors' overall perceptions of the course; students' overall perceptions of the course; students' initial study strategies; overcoming conceptual difficulty; comparing the use of resources and dialogues in chemistry with other courses; and general patterns. These categories respond to the research questions and show goodness of fit between the findings and the tentative hypotheses on which the framework is based.

Instructors' Overall Perceptions of the Course

Both instructors felt that a majority of students were "not really interested" in the subject matter and were just interested in achieving a passing grade. These perceptions were based on several observations. First, the course is a requirement for all science majors, and many of the participants were biology students with little real interest in chemistry. Second, the material was both unfamiliar and difficult. Difficulty, they believed, emerged from the fact that the course included a large number of basic concepts, some of which may have been perceived by students as being unrelated. The fact that many of the concepts were represented mathematically added to the perceived difficulty.

From their past experience with the course, both felt that they knew where and when students experienced special difficulties. Tutorial sessions focused on the specific conceptual difficulties being experienced by the learners as well as on problem-solving. They felt that students used the weekly telephone session to its fullest extent and that students also used the course Web site as a means of communicating with them.

Students' Overall Perceptions of the Course

From the data gathered and analyzed in the study, several commonalities regarding the course "Pathways in Chemistry" were identified by the student participants. First, the course was difficult, even for good students. Two sources of difficulty were cited. The first seemed to be a lack of connection between theory and problem-solving skills. Saul noted, "the concepts studied in the texts generally had nothing to do with how to solve the related problems." Ora stopped studying from the texts altogether and relied on the tutorials. She said, "The instructor emphasizes the concepts which are most relevant and helps solve the assigned problems." Second, some units of the self-instruction texts were criticized for lack of clarity. Rachel described the problematic units as "extremely difficult to really understand."

Students' Initial Study Strategies

About six weeks before the start of the semester, students received the written self-instruction materials at home. About two weeks later, they were required to enroll in a tutorial group, either regular or extended. Their practices and strategies during the six-week period (whether they studied from self-instruction materials, the type of tutorial chosen, and whether they planned to attend the tutorials) are shown in Table 2.

After reviewing the self-instruction materials, all students developed a tentative study strategy. Six decided to attend the extended tutorial sessions. Some wanted the highest possible grades and were willing to invest the additional time, inconvenience, and effort to achieve them. Isaac, who

Table 2
Study Strategies Prior to the Start of the Course

| <i>Name*</i> | <i>used self- instruction materials</i> | <i>tutorial type chosen</i> | <i>planned to attend tutorials</i> |
|--------------|---|-------------------------------------|--|
| Isaac | yes | extended | yes |
| Rachel | yes | extended | yes |
| Ora | yes | extended | yes |
| Saul | yes | extended | yes |
| Abe | yes | extended | yes |
| Jacob | yes | extended | yes |
| Joseph | yes | regular | yes |
| Sarah | yes | regular | yes |
| Joshua | yes | regular | no |
| Ben | yes | regular | no |

*all names are pseudonyms.

was planning to study medicine, said, "Getting accepted at medical school is very competitive, very difficult, and I'll do all I can to get high grades, even if I have to take time off from work for the tutorials." Some were concerned that without additional help they would fail the course. This concern emerged from the self-instruction texts. Jacob found the texts "difficult to learn from." Saul pointed out that although texts were "readable and interesting, they weren't very helpful when it came to problem-solving." He believed that the "instructor was experienced and would know how to help students" when it came to problem-solving.

Four students opted for the regular tutorial sessions. Sarah and Joseph found the self-study materials somewhat difficult and Joseph purchased an additional text. Both felt that bi-weekly sessions would suffice for achieving a passing grade in this required course. Although Joshua and Ben enrolled in the regular tutorials as required, they planned not to attend the sessions. Both were confident they could pass the course on their own. Joshua said, "I do things on my own and I know I'll manage. I'm stubborn." Even though both found the texts "somewhat difficult," each was able to solve representative sample problems. Both defined success as getting a passing grade, not necessarily the highest possible grade, as neither intended to major in chemistry.

It appeared that students' initial learning strategies, reflected in the resources they chose to use or not, were derived from their aims and from their perceptions of course difficulty that were established from reviewing the self-instruction texts and the problems to be solved before the start of the course. For example, some students wanted only a passing grade whereas others wanted the highest possible one. Students planned to use the resource *face-to-face tutorial sessions* in a manner that would achieve this aim.

After the course began, initial study strategies were pursued. The students engaged in individual study (intrapersonal dialogue) by learning from the university texts, by attending the tutorials, and by learning from supplemental texts and materials from the Web site.

Overcoming Conceptual Difficulty

At some point *all* participants confronted conceptual difficulty, either the inability to understand a concept or the inability to solve a problem or both. The various courses of action taken to overcome conceptual difficulty and the communication modes by which they were mediated are shown in Table 3. The modes of communication, which appear in parentheses, are listed in order of preferred use.

Four patterns emerge from these findings.

1. On confronting conceptual difficulty, each student, except for Abe, responded by engaging in some form of interpersonal interaction,

learner-learner and/or instructor-learner. Joshua, who chose from the start not to attend tutorials, began working with a private tutor. Ben, who also initially chose not to attend tutorials, began attending them and asked questions. Students who had attended tutorials as listeners, in fact relating to the interactive sessions as lectures, began to ask questions (Isaac, Rachel, Ora, Joseph, and Ben). Saul and Sarah chose not to ask questions at the tutorials; instead they turned to peers for help in overcoming difficulty.

2. For six participants, peer collaboration (learner-learner dialogues) was the most important and effective means of overcoming conceptual difficulty. Isaac participated in a study group of four that met face to face; members also communicated frequently by telephone. He described the study group as an “extremely important and highly efficient” means of learning.

Table 3
Courses of Action Taken to Overcome Conceptual Difficulty
and Modes of Communication

| <i>Name**</i> | <i>1st course of action</i> | <i>2nd course of action</i> | <i>3rd course of action</i> | <i>4th course of action</i> |
|---------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| Isaac | ask questions at tutorials | peers (f2f*; tel, Web) | Web site materials | instructor (tel) |
| Rachel | peers (f2f*; tel) | ask questions at tutorials | Web site materials | _____ |
| Ora | ask questions at tutorials | Web site materials | peers (f2f*; tel, Web) | instructor (f2f*; tel) |
| Saul | peers (tel; e-mail) | _____ | _____ | _____ |
| Abe | work harder | _____ | _____ | _____ |
| Jacob | ask questions at tutorials | _____ | _____ | _____ |
| Joseph | Web site materials | ask questions at tutorials | instructor (tel; f2f*) | _____ |
| Sarah | Web site materials | peers (f2f*; tel, Web) | _____ | _____ |
| Joshua | Web site materials | private tutor (f2f*) | _____ | _____ |
| Ben | go to tutorials | peers (tel; f2f*) | _____ | _____ |

*f2f = face to face.

**all names are pseudonyms.

3. A personal instructor-learner interaction (outside the realm of question asking at the group tutorials) was generally a last resort used only after other courses of action had been used, or not at all. Sarah explained why she did not use the instructor:

In order to ask the instructor an intelligent question, you have to understand quite a bit. Since I didn't even know what I didn't know, I didn't know what to ask. It's easier, better and certainly more comfortable to work with friends.

Other students pointed out that the two-hour-per-week availability of instructors was insufficient because the line was usually busy and their calls were not connected. Isaac, who spoke with the course coordinator by telephone about four times during the semester in order to get around the instructor's busy signal, pointed out that these conversations were of limited value because even though he received the necessary help for solving problems, he "really didn't understand the solution."

4. Asynchronous communication via the Web site was not a popular mode of communication. Several reasons were cited. First and foremost, Rachel said, "I didn't ask questions in the discussion group because I want the answer now, when I need it, and not in a few days time." Second, Saul, who was majoring in computer science, felt that the nature of chemistry problems was the primary barrier. He said, "When stuck with a computer program that doesn't work, I asked other students for help and got it. Unlike chemistry problems, solutions to computer problems are simple and easy to convey." Third, several students cited the difficulty of using the tools for writing chemistry formulae and simply chose not to use asynchronous media, either Web site or e-mail.

Comparing the Use of Resources and Dialogues in Chemistry With Other Courses

"Pathways in Chemistry" was perceived as a difficult course by all the students who participated in the study, even the very good ones. All had previous experience with at least one of three introductory courses generally recognized as easy. These were "Introduction to Life Sciences 1," "Foundations of Physics 1," and "Foundations of Physics for Biology Students 1." Students were questioned about how they studied in these courses.

In the previous semester Isaac, Joshua, Joseph, Sarah, and Saul completed the course "Introduction to Life Sciences 1." In this "easy" course, all studied alone, did not attend the face-to-face tutorials, and generally did not communicate with the instructor or with other students. Saul

attended the tutorials “just in case.” The students succeeded on their own without the need for interpersonal dialogue. They ascribed their success to the nature of the course, which Saul defined as “memorization and classification without the need for abstract problem-solving skills.” Because the self-study materials and the assignments were clear, there was generally no need for any further resources, interpersonal or otherwise. When some difficulty arose at infrequent intervals, these students turned to the instructor for help because they were able to define and phrase the appropriate question.

Rachel had previously taken the course “Foundations of Physics for Biology Students 1.” She studied successfully from the texts and did not go to the tutorials. When some difficulty rose, she turned to a friend with whom she studied occasionally. Ora, Jacob, Abe, and Ben had all taken the course “Foundations of Physics 1.” They too reported learning from texts, not attending the tutorials, and succeeding.

These findings stand in contrast to the practices exhibited in the “difficult” course under investigation “Pathways in Chemistry.”

General Patterns

One general pattern, a typical study strategy used by all students, emerged from the data. It was found that experienced Open University students, whether in difficult science courses or in easy ones, used instructional dialogues and instructional resources in similar ways. Before the course began, all students received the self-instruction materials and began to browse, to read, and to learn. All defined goals, especially the desired grade, and all defined an initial study strategy based on one of two approaches.

1. If learning seemed easy and problems were solved correctly, students continued to learn from the self-study materials without attending tutorials and without communicating with peers or with the instructor.
2. If learning seemed difficult and problem-solving difficulty was experienced, students made plans to attend the tutorials.

After the start of a course, on confronting conceptual difficulty, several courses of action were chosen based on the initial study strategy:

1. Students not attending tutorials began attending them;
2. Students attending tutorials began communicating with peers or with the instructor or with anyone else who could help.
 - a. Collaboration with peers (learner-learner dialogues) was the preferred mode, and personal collaboration with instructor (instructor-learner dialogues) was generally used as a last resort.
 - b. The preferred communication mode was face to face followed by telephone.

These findings appear to indicate a general approach to the use of dialogue. For all students, individual study characterized by intrapersonal dialogue was the primary and preferred study strategy. At the start of a course, self-instruction materials and tutorials were the primary resources used by learners. Only when individual study failed did students opt for contact with others. This general course of action, individual study through self-instruction materials, is indeed the paradigm of distance education at the Open University of Israel. Students studied alone until they were unable to do so successfully.

All students participating in the study followed the same path. Differences among students expressed themselves on a time axis; that is, some learners experienced conceptual difficulty or the inability to solve a problem earlier in the course than did others. It appears that the use of interpersonal dialogue is motivated by the student's immediate need to understand a specific concept or to solve a specific problem rather than by a learning preference or cognitive style or some inherent degree of learner autonomy.

The simplicity of this general study strategy may be deceptive, because although several courses of action may have been pursued theoretically, in fact the actual degrees of freedom available to students were limited. First, during the period before the start of the course, the only resources available to students were the self-instruction materials. Thus individual study characterized by intrapersonal dialogue was the only realistic option available at the time. Second, after the course started, courses of action available to students who encountered conceptual difficulty (instructor-learner or learner-learner dialogues) were not equivalent; that is, availability of peers was essentially unlimited, whereas instructor availability was limited to either a once weekly two-hour open telephone that was often busy or a hurried conversation before or after instructor-led, face-to-face tutorial sessions. Furthermore, at least in this particular chemistry course, students were generally interested in getting the answer to a problem that had to be solved, whereas instructors were generally more prone to offer concept explication. It is not surprising, therefore, that many students preferred collaborating with peers rather than with the instructor.

Discussion

Two issues are discussed: (a) the compatibility of these findings with theoretical premises regarding the place of dialogue in distance education; and (b) the relation between research findings and the conceptual framework cited above.

The Place of Dialogue Types in Distance Education

Our findings indicate that for all students participating in the study, intrapersonal dialogue was the primary and preferred dialogue mode engaged in while learning science at the Open University of Israel. The primacy of intrapersonal dialogue (also referred to in the literature as learner-content interaction) is supported by several other research studies (Rourke, Anderson, Archer, & Garrison, 1999; Rourke & Anderson, 2002; Anderson, 2004).

Our findings also indicated that interpersonal dialogue was generally engaged in for the purpose of overcoming conceptual difficulty or, especially and most significantly, for solving problems. This finding illustrates clearly the tension between distance education theories on the one hand and practices engaged in by distance education students on the other. Students, especially those participating in a required course outside the realm of their particular major, are often motivated by practical concerns such as passing courses with the highest possible grade (Eison, Pollio, & Milton, 1986). Distance education theories such as Moore's (1993) theory of transactional distance often assign to interpersonal dialogue, especially between instructor and learner, an importance that may not be realized in practice.

This generalization must be limited, however, by a key constraint imposed by the particular study. Science courses, especially an intermediate-level chemistry course, are not generally discussion-oriented. Science is still too often seen by some science educators as an external, objective body of knowledge to be transferred to the learner, either through self-study texts or lectures. The role of dialogue is at best explicative, occurring when a learner does not understand some concept or is unable to solve some problem. Although constructivist approaches to science education (Gorsky & Finegold, 1992) show the need for and advocate discursive approaches to the acquisition of scientific concepts, this is still too infrequently implemented in university-level courses.

The Framework of Resources and Dialogues

The research questions of this study were formulated in terms of the elements of the framework of resources and dialogues. It was possible to categorize all the components of the instructional system of the Open University in terms of the model's categories (see Table 1). In addition, all activities engaged in by students could be classified in terms of dialogue type and resource type (human or structural). The significance of the framework, however, is not to be found merely in these acts of categorization. A framework is judged in terms of how adequately it represents the functioning of a system and the goodness of fit between deduced hypotheses (predictions) and empirical research findings. Because the

framework represented how students went about the tasks of studying and learning chemistry, the next step is to intervene in the instructional process by manipulating constructs and variables. The theoretical base of the framework, the centrality of instructional dialogue, points toward an extremely rich research agenda that encompasses many points of view: pedagogical, psychological, and economic. Several possible research agendas are briefly examined.

Implications for Future Research

This investigation dealing with students' strategies for the use of dialogue may also be viewed in terms of what is known in the literature as *approaches to studying*. Marton and Saljo (1976) found that campus-based students adopt either deep-level or surface-level approaches to study. A deep approach involves an active search for meaning in the subject matter under study and relating it to other experiences and ideas in a constructive and critical manner. A surface approach relies on rote learning and memorization isolated from other experiences and ideas. Given the diversity of resources available in modern distance education programs for intrapersonal and interpersonal dialogue, we suggest that students' approaches to studying might be investigated usefully in terms of the dialogues chosen and the resources used. That is, how do varying kinds of dialogue supported by varied kinds of resources (e.g., instructional materials and communications media) encourage or discourage deep or surface level approaches to study?

In the realm of economics, the concept *potential interaction* may be extremely useful. For example, given the importance of interpersonal dialogue as an instructional tool for overcoming conceptual difficulty and assuming the ability to calculate potential interaction on an ordinal scale, several capabilities emerge. For design purposes, the potential interaction of varying systems may be compared, and the effects of proposed structural changes on a system may be simulated for cost-benefit analyses.

In the realm of pedagogy, potential interaction may be useful for instructor evaluation purposes; that is, comparisons between potential and actual interaction in the same system may be made. For example, if a high potential was calculated for a given course or lesson and a low level of interaction was measured, then remedial steps may be taken.

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Paul Gorsky is a research associate in the Chais Instructional Technologies Research Center at the Open University of Israel. His interests include cognitive science; studying the nature and use of dialogue and interaction in distance education systems; and designing informal, hands-on science education programs. He can be reached at paulgo@openu.ac.il.

Avner Caspi is a research associate in the Chais Instructional Technologies Research Center at the Open University of Israel. His expertise is in cognitive psychology, and his research efforts are directed toward studying the effects of educational technologies on cognition.

Inbal Tuvi-Arad is a lecturer in the Department of Natural Sciences at the Open University of Israel where she is responsible for teaching and developing various courses in physical chemistry. In the realm of chemistry education her main research interests are applications of computers and Web-based learning to the undergraduate chemistry curriculum.