

Chapter 2

Learning Science at a Distance: Instructional Dialogues and Resources

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Introduction

Today's distance education systems include resources for individual study (intrapersonal dialogue) such as self-instruction texts, Web-based instructional systems, video recordings, etc., and resources for interpersonal dialogue such as tutorials, telephone counselling, synchronous and asynchronous conferencing, and email. Given this diversity, we analyzed some aspects of Open University students' dialogic behaviour (what they did as they studied, how, and with whom) as they studied physics and chemistry courses. In addition, we compared these findings with those obtained from campus-based college and university students studying similar courses. To carry out such an analysis, a need exists for a broad conceptual framework of instruction that recognizes the centrality of instructional dialogue.

Such a framework was initially proposed as a general theory of distance education (Gorsky & Caspi, 2005) to replace the "Theory of Transactional Distance" (Moore, 1993). The framework subsequently evolved into the "Theory of Instructional Dialogue" (Gorsky, Caspi & Chajut, 2007); the theory provides a useful working model for

analyzing, designing, evaluating, and predicting outcomes in any instructional system, whether distance or campus-based.

This chapter includes three sections: (1) an overview of the “Theory of Instructional Dialogue” with emphasis placed *only* on its analytic capabilities. Prescriptive and predictive elements of the theory are *not* discussed (for an in-depth explication, see Gorsky, Caspi & Chajut, 2007); (2) a review of published empirical research findings that illustrate how Open University students and their campus-based counterparts learn science in terms of dialogues and supporting resources; and (3) current research projects and suggestions for further research.

THE THEORY OF INSTRUCTIONAL DIALOGUE: AN OVERVIEW

The theory is based on the axiom that instruction is dialogue. Given this axiom, we assume three postulates:

1. Every element in an instructional system is *either* a dialogue (intrapersonal or interpersonal) *or* a resource which supports dialogue.
2. Certain structural and human resources, common to all instructional systems, correlate with the type, amount, and duration of dialogue that occurs, or may occur.
3. Specific, situated dialogues correlate with learning outcomes.

For the purposes of this chapter, only the first postulate is discussed.

Intrapersonal dialogue

Intrapersonal dialogue *mediates* learning (Gorsky, Caspi & Chajut, 2007). It is defined as the interaction between a human resource (the learner) and a structural resource (any subject matter material, such

as texts or instructional web sites, provided within any given course). This approach enables us to quantify students' study/learning behaviours in terms of media choice (which resources were utilized, when, and where), utilization rates, "time on task," instructional outcomes and efficiencies. Students, of course, may utilize subject matter materials other than those offered by the course. Such materials are not "structural resources" since they are not specifically designated by the teacher.

The type, extent, and quality of intrapersonal dialogue that occurs in any given course or instructional system is related to variables that characterize learners (age, prior knowledge, motivation, learning styles, perceived course difficulty, and other possible variables that define the student's predisposition toward learning) and variables that characterize structural resources, especially their usability and quality.

We note that the mental processes assumed to occur during intrapersonal dialogue have been described in many ways: "assimilation" and "accommodation" (Piaget, 1970), "accretion," "structuring," and "tuning" (Rumelhart & Norman, 1978), "intra-psychological processes" (Vygotsky, 1978) or an "an internal didactic conversation" (Holmberg, 1989). We reiterate that the Theory of Instructional Dialogue deals only with quantifiable instructional events, not with learning processes that occur or not.

Interpersonal dialogue

Interpersonal dialogue *facilitates* learning. This is supported historically by leading philosophers and educationists of the previous century (Dewey, 1916; Buber, 1965; Bruner, 1966; Rogers, 1965, 1969; Vygotsky, 1978). More up-to-date findings also support this claim (Wells, 1999; Laurillard, 2002; Garrison & Anderson, 2003). To summarize, Rogers (1965) wrote: "We cannot teach another person directly; we can only facilitate his learning" (p. 389). Interpersonal dialogue is defined as the interaction between two or more

human resources (instructors and/or students). Interaction is an observable message loop: Instructor-Student-Instructor *or* Student-Instructor-Student *or* Student A-Student B-Student A. Such dialogues may be face-to-face or mediated; if mediated, synchronous or asynchronous. Students, of course, may engage in dialogues with significant others such as family, friends, or employers. These human resources, however, are not within the domain of instructional systems. Interpersonal dialogue has two distinct classes of outputs: subject-matter oriented and non-subject-matter oriented. One or both types may characterize a message.

Earlier studies have found that the extent of interpersonal dialogue is affected to a very large degree by three structural variables:

1. instructional design (Clark, 1983, 1994, 2004; Clark & Choi, 2005; Gorsky, Caspi & Trumper, 2004);
2. group size (Chen & Willits, 1998; Vrasidas & McIsaac, 1999; Caspi, Gorsky & Chajut, 2003); and
3. student and instructor availability (Chen, 2001a, b; Gorsky, Caspi & Tuvi-Arad, 2004; Gorsky, Caspi & Trumper, 2004)

and by two variables associated with human resources (i.e., individual learners):

1. prior acquaintance with fellow students (Caspi & Gorsky, 2006); and
2. autonomy (Moore, 1993; Caspi & Gorsky, 2006).

Instructors' personality traits and facilitation skills play a critical role in creating and maintaining dialogue with students, be it online or on-site. A teacher-centred, content-oriented approach decreases opportunities for interpersonal dialogue while a student-centred, learning-oriented approach may increase such opportunities.

The following two examples describe interpersonal dialogues in terms of human and structural resources:

1. Student A phones Student B to discuss the concept of angular momentum, which he doesn't understand. The availability of students' telephone numbers is a structural resource for interpersonal dialogue. Students are human resources for interpersonal dialogue. A subject-matter oriented dialogue between them occurs.
2. Student J wants the answer to an assigned exercise and posts a message in an asynchronous discussion group. Student K responds and provides an answer. The discussion group is a structural resource that enables interpersonal dialogue. A subject-matter oriented dialogue occurs between Students J and K; both students are human resources for interpersonal dialogue.

The final two examples, cited from Gorsky, Caspi & Chajut (2007), illustrate instructional processes in terms of dialogue types and their associated human and structural resources:

1. A face-to-face tutorial session is led by an instructor who encourages discussion. The tutorial is a structural resource for *both* intrapersonal and interpersonal dialogue. Instructor and students are human resources for dialogue.
 - Student X attended and listened attentively, but did not actively participate. This student utilized the resource for intrapersonal dialogue only; he did not utilize the human resources, instructor, and fellow students for direct interpersonal dialogue.
 - Student Y attended the same tutorial and, in addition to listening attentively, also asked the instructor several questions that were answered to her satisfaction. This student utilized the resource for *both* intrapersonal and interpersonal dialogue.
2. An instructor distributes exercises to her students. A student solves the assigned exercises and submits them

to the instructor, who then corrects, grades, and returns them to the student. The student reads the corrected exercises and understands the source of his mistakes.

The assigned exercise is a structural resource for *both* intrapersonal and interpersonal dialogue. The dialogue is intrapersonal as the student solves the exercises. It becomes interpersonal when the student submits the completed exercise to the instructor, thereby closing the loop — instructor to student, student to instructor. An additional interpersonal link occurs when the instructor returns the corrected exercise to the student. A further *intrapersonal* dialogue occurs when the student reads the corrected exercises with the intent to learn from them.

This brief overview should enable the reader to understand and to evaluate the following research findings and conclusions within the paradigm of the “Theory of Instructional Dialogue.”

LEARNING SCIENCE AT A DISTANCE: RESEARCH FINDINGS, CONCLUSIONS, AND IMPLICATIONS

Findings from empirical studies

To date, a total of five studies that map students’ dialogic behaviour as they learn science at a distance have been published. Findings and conclusions from these studies are reported below.

Two small-scale qualitative studies investigated the dialogic behaviour of distance education students as they studied introductory level courses in chemistry and physics at the Open University of Israel. In the first (Gorsky, Caspi & Tuvi-Arad, 2004), 10 out of a total of 128 students who completed the course “Pathways in Chemistry” participated in the study. In the second (Gorsky, Caspi & Trumper, 2004), 8 students out of 41 who had completed the course “Foundations of Physics II” participated. All participating students met the following two criteria: they had successfully completed at least two science courses in previous semesters and

they expressed a willingness to explore their own learning processes. The first criterion ensured that students were experienced in distance learning so that their study behaviour would be the result of conscious decision making and not the result of random trial and error.

Data were gathered from semi-structured interviews lasting about 40–60 minutes. Each student was interviewed once, toward the end of the course. Participants were asked neutral and open-ended questions which also probed for particular, idiosyncratic aspects of experience. The following examples are cited from Gorsky, Caspi, and Tuvi-Arad (2004):

- 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 website?
- 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?

Five major findings were reported:

1. *All* activities engaged in by students as they studied/learned introductory level undergraduate chemistry and physics courses could be categorized as dialogues enabled by a given resource.
2. A general approach to the use of dialogue was discerned. All students cited a clear preference for intrapersonal dialogue. This finding is supported by several other research studies (Rourke et al., 1999; Rourke & Anderson, 2002). At the start of the courses, intrapersonal dialogue, mediated through self-instruction texts and tutorials, was the primary dialogue

type utilized by students. This general course of action, individual study through self-instruction materials, is indeed the paradigm of distance education at the Open University of Israel.

3. Students opted for interpersonal dialogue only when they couldn't solve assigned problems.

4. The predominant first-partner choice for interpersonal dialogue was peers. Instructor-student dialogues were generally used as a last resort. Students reported that instructors offered concept explication as opposed to giving them the desired answer. Therefore, most students preferred collaborating with peers rather than with the instructor.

5. The preferred communication mode was synchronous, mediated first by telephone and second by face-to-face meetings. Asynchronous communication, offered by the website, was utilized to a limited extent. These preferences reflect student desire for immediate answers.

In a third small-scale study, Gorsky, Caspi, and Trumper (2006) investigated the dialogic behaviour of campus-based college and university students learning physics and chemistry in large and small classes. This study was carried out in order to compare the dialogic behaviours of campus-based students with distance education students. A total of 14 students participated in the study: 4 physics majors and 4 chemistry majors from a large university alongside 6 physics majors from a small college. As in the previous two qualitative studies, data were gathered from semi-structured interviews. Findings follow:

1. For most university students participating in large introductory level lecture-based courses (about 175 students), interpersonal dialogue was not a significant dialogue mode engaged in while learning physics and chemistry in the classroom. At any given lecture, more

than 90% of the students did not engage in interpersonal instructor-student dialogue. Even though tutorials were more interactive than lectures, they constituted only 20% of total instruction time.

2. For college students participating in small introductory level courses (about 12 students), interpersonal dialogue was a significant dialogue mode for learning in the classroom.

3. For both college and university students, interpersonal student-student dialogue was the primary dialogue mode engaged in for the purpose of solving problems. In other words, students predominantly turned to one another for help in problem solving, not to instructors.

Gorsky, Caspi, and Trumper (2006) noted that the first two findings illustrate clearly the impact of group size and instructional strategy on dialogue. The small group size at the college (a structural resource) afforded the *potential* for discussion-based class sessions while faculty (human resources) *chose* to implement this instructional strategy. Furthermore, the first finding highlights discrepancies between instructional theories on the one hand and actual practices engaged in by campus-based students participating in large lecture-oriented courses, on the other. Classical theories, such as those advanced by Bruner (1966) and Rogers (1969), as well as more recent ones (Garrison & Anderson, 2003), often assign an importance to interpersonal dialogue, especially instructor-student interactions, that may not be realized in practice. This finding was also reported by Beyth-Marom, Saporta, and Caspi (2005). Indeed, instructor-student dialogue in large lecture courses was very limited in scope. The third finding, highlighting the importance of peer dialogue for campus-based students, replicated findings from the first two studies.

Based on these preliminary findings, we developed a “Tactical Approaches to Study” questionnaire (see Appendix) appropriate

for large-scale studies. In our fourth study (Caspi & Gorsky, 2006), this questionnaire was distributed via e-mail to 3,512 students at the Open University of Israel, and 521 completed questionnaires were returned. Here, participating students represented all faculties and disciplines, not just physics and chemistry. Findings from the smaller-scale qualitative studies were replicated. In other words, the dialogic behaviour of distance education students from all disciplines, not just the exact sciences, was similar.

In addition, several correlations between students' self-reported characteristics and their corresponding dialogic behaviour were found.

1. Students having prior acquaintances with peers generally turned to peers for help while students without prior acquaintances generally turned to the website or asked questions at the tutorial sessions.
2. Students who reported a preference for working alone (high autonomy) generally posted questions on the website or asked questions at the face-to-face tutorials. Less autonomous students generally turned to peers.

In the fifth study (Gorsky, Caspi & Smidt, 2007), the dialogic behaviour of 121 Open University UK students was investigated as a function of perceived course difficulty. Here, all 355 students studying an advanced level quantum mechanics course were sent written questionnaires. Of the 123 students who returned the questionnaires, 121 perceived the course as difficult or very difficult. Again, previous findings were replicated, namely, students tend to study and learn alone until confronted with an insurmountable obstacle, either a concept not understood or, most commonly, a problem that can't be solved. One finding, however, was quite different. We found that a very large majority of students turned to instructors for help, not to their peers. This finding differed from previous ones wherein Israeli students turned overwhelmingly to peers for help, not to instructors.

Conclusions and implications

The findings from these five studies are straightforward and not surprising, *at least in retrospect*. What we believe important, however, is that these anecdotal and unrelated truisms are now grounded and linked in a unified framework or theory of instruction. We have suggested (Gorsky, Caspi & Chajut, 2007) that the widespread use of the theory will enable researchers to work from a common frame of reference with a common set of variables toward a common goal.

Implications for distance education and online science courses

First, we contend that the unified theory relates to online instructional design in precisely the same manner that it relates to any and all instructional systems. The structural resources for intra- and interpersonal dialogue (instructional materials, group size, instructional strategy, and instructor/peer accessibility) are the same. The only difference lies in the amount and type of resources, not in the instructional dialogues that occur or not. In addition, the human resources for interpersonal dialogue (instructors' facilitation skills, students' autonomy, and their need to overcome conceptual difficulty or to solve an insoluble problem) are also the same.

Furthermore, we contend that the mere existence of additional online resources has no significant effect on the learning process itself, although it may change students' satisfaction or attitudes toward learning. For example, in terms of achievement, an on-ground lecture and an online recorded copy of the lecture have essentially the same impact on learners (Beyth-Marom, Saporta & Caspi, 2005). Similar findings were noted when comparing students participating in remote videoconferencing with students attending on-ground lectures (Lou, Bernard & Abrami, 2006). The fact that all instructional resources are available for online and on-ground learners implies that there is nothing unique about online instruction *per se* and the subsequent learning that occurs or not.

Second, some initial and tentative practical implications vis-à-vis the relationship between perceived course difficulty and dialogic behaviour have emerged. To summarize the findings:

1. In courses perceived as difficult, (UK) students turned primarily to instructors for help when confronted with difficulty.
2. In courses perceived as moderately difficult or easy, (Israeli) students turned primarily to peers for help when confronted with difficulty.

These phenomena may be culturally biased. Further research will provide answers. In practical terms, however, these findings can help us optimize class size as a function of perceived course difficulty. On the one hand, if instructor-student dialogues are limited in “easy” or “moderately difficult” courses, then a large class size may be feasible and justifiable, both from economic and pedagogical points of view. On the other hand, if levels of instructor-student dialogue are high in “difficult” courses (as we have found), then a small class size may be feasible and justifiable, both from economic and pedagogical points of view (a higher rate of student success along with a reduction in dropout rates may be attained given a higher level of instructor presence).

Third, the correlation between “prior acquaintance with peers” and dialogic behaviour seems straightforward and meaningful: students who know other students speak with them. If so, and if such relationships help students learn as several educational theories contend and research findings have supported (Anderson, 2004; Ashwin, 2003; Garrison & Anderson, 2003), then organizational steps may be taken by both campus-based and distance education universities to help students become acquainted with each other prior to, or at the start of a course or program. Instructors might actively encourage students to participate in study groups, be they face-to-face or virtual. Furthermore, virtual forums, both synchronous and asynchronous, should be set up and their use encouraged.

CURRENT AND FURTHER RESEARCH

1. The dialogic behaviour of diverse populations. We are currently exploring on a large scale ($N > 3,000$) the dialogic behaviour of K-12 students as they learn in the classroom and as they learn at home by dealing with homework assignments. We hope to map students' dialogic behaviour as a function of age, gender, academic discipline, socio-economic background, etc.
2. The cross-cultural aspects of dialogic behaviour. We have found that western students, both distance and campus-based, tend to study and learn alone. Students turned to interpersonal dialogue in order to resolve some specific difficulty. From informal meetings with colleagues, it seems that eastern cultures adhere to group learning. We suggest comparing the dialogic behaviour of students from diverse cultures and backgrounds in order to discover, what, if any, aspects of learning are universal.
3. To expand the theory's second postulate, namely, that certain structural and human resources, common to all instructional systems, correlate with the type, amount, and duration of dialogue that occurs, or may occur, both in-class and out. Some typical research questions might be:
 - Students' dialogic behaviour may be correlated with a changing rate of instructor accessibility.
 - What are the optimal limits for instructor accessibility, especially for courses perceived as difficult by students?
 - To what extent, if any, should expensive communications media (structural resources) be made available?
 - What kinds of intrapersonal structural resources (hyper-text, simulations, etc.) best support constructivist pedagogy and under what circumstances?

- To investigate the relationship, if any, between students' strategic approaches to study (deep/shallow) and the tactics they adopt to implement their strategies (dialogic behaviour). The importance of the research lies in the possibility that a relationship does indeed exist between students' strategic and tactical approaches to learning. For example, students' adoption of deep or surface-level approaches may be investigated as a function of the structural resources (e.g., course websites, videotaped lectures, or synchronous and asynchronous communication tools, etc.) available in an instructional system. Certain structural resources may enhance the use of deep-level approaches by students.

4. To investigate the theory's third postulate, namely, that specific, situated dialogues correlate with learning outcomes. Some typical research questions:

- What kinds of interpersonal dialogue types (inquiry, conversation, instruction, and debate) facilitate or retard students' abilities to make conceptual changes?
- Assuming a relation between "communities of inquiry" (Garrison & Anderson, 2003) and learning outcomes, what is an effective ratio between non-subject-matter (social presence) and subject-matter oriented dialogues (cognitive presence)?

These research questions are all interrelated in a single unified theory that assumes instruction is dialogue. To conclude, we're talking about building working models for *all* instructional systems in the cognitive domain based on dialogues and resources. We believe that such an endeavour, based on valid qualitative and quantitative research, will advance our field to new levels.

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APPENDIX

Tactical Approaches to Study Questionnaire (for distance education students)

1. Age: _____
 2. Gender: M / F
 3. How do you rate your motivation to achieve a high grade? very high, high, moderate, low or very low
 4. How difficult do you consider the course to be? very difficult, difficult, moderate, easy or very easy
 5. How do you prefer to learn? independently or with others
 6. Did you know at least one other student in the course before you started? Y / N
- How did you typically address conceptual difficulties that occurred while reading the course materials? Mark *all* actions undertaken:
- a. reread the text(s) Y / N
 - b. found alternative texts or instructional materials Y / N
 - c. without participating, browsed the (asynchronous) course forum Y / N
 - d. contacted another student from the course Y / N

- if yes, then typically how (circle the appropriate response):

1. face-to-face meeting
2. telephone
3. email
4. asynchronous course forum
5. other _____

e. contacted your tutor Y / N

- if yes, then typically how (circle the appropriate response):

1. face-to-face meeting
2. telephone
3. email
4. course forum
5. other _____

f. contacted someone from outside the course (parent, friend, employer, etc.) Y / N

g. asked a question at the next tutorial Y / N

h. gave up Y / N

i. enter any other additional actions taken: _____

7. List the order in which your first four actions were carried out (enter the appropriate letter) and estimate the relative contribution made by each (Total 100%).

1st action: ____ ; relative contribution: ____%

2nd action: ____ ; relative contribution: ____%

3rd action: ____ ; relative contribution: ____%

4th action: ____ ; relative contribution: ____%

{Questions 9 and 10 are identical to questions 7 and 8 except that they refer to solving difficult problems or exercises}