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Teacher–student interactions and learning outcomes in a distance learning environment

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Abstract

This paper describes a distance learning project that enables talented high school students in geographically isolated and underdeveloped areas to participate in an introductory university course without leaving the supportive framework of their high schools. The rationale behind the project is described as well as a model in which university faculty work together with high schools in order to achieve broad educational goals. The online collection of student-related data is described, together with how this helped us to identify and solve problems experienced by high school students in a distance learning environment. The collection and implementation of teacher-related data used in order to increase the effectiveness of instruction during the course is described. Finally, some significant results of this research are presented, with a description of how they can be implemented not only to solve but also to prevent potential obstacles to effective distance learning in future projects.

Keywords: New economy; Content analysis; Interaction analysis; Performance-based assessment; Self-evaluation; Learning outcome; Learning by doing

1. Introduction

According to Giddens (1999), one of the school's most important functions is to empower the individual to play a meaningful role in today's "new economy." By preparing their students to participate in an advanced, technology-based economy, schools play an important

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role in closing the gap between the "haves" and the "have-nots." Unless considerable resources are invested in helping schools narrow this gap, the resulting stratification of society may have serious economic and social implications.

In our country, as in many other countries, talented students from weak socioeconomic backgrounds, especially in geographically isolated and underdeveloped areas, often remain underrepresented among university entrants. One of the factors contributing to this underrepresentation is that many of these students do not achieve matriculation grades and psychometric scores that reflect their high learning potential. Traditional university admission criteria such as minimum grade averages and psychometric scores therefore often prevent these students from entering university, despite their high learning potential.

University admission policies that inadvertently result in the underrepresentation of students from underdeveloped areas contribute to the perpetuation of the cycle of unemployment and weak socioeconomic conditions in these areas. As Giddens (1999) points out, this cycle has numerous negative implications for both the individual and society, and represents a potential threat to economic and social security. In order to break this cycle, schools in geographically isolated and underdeveloped areas need to equip their students with the knowledge, skills, and motivation they need for playing a meaningful role in a sophisticated, technology-based economy.

However, teachers in peripheral areas often spend much of their time and energy helping weaker pupils "catch up." The majority of the schools' resources are invested in helping students from culturally different backgrounds acquire the cognitive skills and noncognitive dispositions that represent necessary conditions for effective school learning. These conditions have been extensively documented by many researchers, including Feuerstein and Feuerstein (1991), Perkins (1992), and Tzuriel (1991). Schools in peripheral areas therefore often lack the resources to provide students with high levels of learning potential with the type of challenging learning environment necessary for maximizing their potential.

Today's advanced technological platforms and delivery systems have turned distance learning into an economically feasible means of "stretching" the walls of the classroom in order to "import" expertise and supplement school resources. In this paper, the authors describe how Bar-Ilan University's Distance Learning Laboratory works with high schools in the field in order to identify and enrich talented high school students in peripheral areas. Our field project represents an attempt to use distance learning as a cost-effective means of:

1. Identifying students with high learning potential from weak socioeconomic backgrounds in geographically isolated and underdeveloped areas.
2. Providing these students with a challenging learning environment enabling them to work at the upper edge of their ability and develop a sense of academic self-efficacy.
3. Providing students with a positive university experience in order to encourage academic career aspirations among students, especially girls, whose family and peers may not actively encourage them to continue their studies at university.
4. Offering an alternative channel of admission to university for students whose high learning potential does not translate into correspondingly high psychometric scores and school grades.

2. Description of the project

A "wide-funnel" admissions policy was adopted in order to identify students with high learning potential. The main criteria for participation in the project were student self-selection and/or teacher recommendations, instead of traditional cut-off admission criteria such as student psychometric scores and levels of prior subject knowledge. These criteria allowed many students, who would otherwise have been excluded, to participate in the project, including several dyslexic students. However, this "wide-funnel" admissions policy also resulted in widely varying levels of cognitive ability and prior content knowledge.

At the beginning of the academic year, 293 students from peripheral areas throughout the country registered as university students and enrolled in a one-semester introductory course in computer science. The student sample consisted of 293 students in Grades 8–10 from 10 high schools throughout the country. Lessons were transmitted once a week from Bar-Ilan University's Distance Learning Lab to participating schools.

The course was taught synchronously, via a one-way video, two-way audio technological platform. A course website was established. This site served as both an electronic bulletin board and an informal meeting place between the students and the lecturer. Each week's lesson could be downloaded from the site after transmission in order to supply students with an asynchronous study option, which enabled them to review course materials when necessary. An electronic forum was also opened, enabling students to request additional help between lessons and communicate with students from other schools participating in this project.

At each participating school, an on-site facilitator was appointed to accompany the students throughout the course. At most of the schools, a computer science teacher served as the on-site facilitator. Since on-site facilitators were relieved of the responsibility for "covering the content," they were able to engage in "customized coaching." This included working with each student, diagnosing sources of difficulties and providing motivational and instructional support on an individual basis. On-site facilitators also worked closely with the Distance Learning Lab's research team, contributing valuable formative evaluation and practical solutions to problems that arose on-site. An electronic forum provided on-site facilitators with a "virtual teacher's room," which enabled the exchange of ideas and the sharing of problems and solutions during the course.

3. Online collection of student-related data

During each lesson, multiple criteria were used to collect data on each student's learning outcomes. The following features of the technological platform enabled us to track each student's progress online:

1. Records of students' questions and comments directed to the "help-desks," which operate online during each lesson. Content analysis of these records enabled us to track students in order to establish the type of assistance they required during the course.

2. Student’s self-evaluation of subject content comprehension. Each lesson was divided into separate units. As the lecturer completed each unit, students were requested to press a “yes” or “no” button to indicate whether they understand the content of the unit.
3. Electronic scoring of each student’s performance on multiple choice quizzes at the end of each lesson.

The above data were analysed after each lesson in order to establish the effectiveness of both the instructional and learning processes. Each set of data enabled the viewing of a different aspect of the difficulties experienced by high school students in an academic distance learning environment.

Content analysis of students’ questions and comments directed to the “help-desks,” which operate online during each lesson was performed. Tracking individual students’ questions and comments addressed to the help-desk showed that students who requested explanations of basic concepts experienced considerable difficulty in coping with the pace of the lesson. These students tended to become de-motivated even though they could download the lesson after transmission and review the content at their own pace. In contrast, students who had prior basic knowledge of the subject were able to detect gaps in their subject knowledge and request clarification accordingly. These students were able to persist in the face of difficulties and maintained considerably high levels of motivation throughout the course.

3.1. Student’s self-evaluation of subject content comprehension

After each unit during the lesson, the lecturer asked students to confirm whether they felt they understood the content of the unit. If less than three-quarters of the students confirmed comprehension of content, the lecturer would repeat the content of the unit instead of proceeding to the next unit. Each student’s self-report of content comprehension during each lesson was compared with the actual scores he/she obtained on the quiz at the end of the lesson (see Fig. 1). This comparison showed that actual scores obtained on weekly quizzes

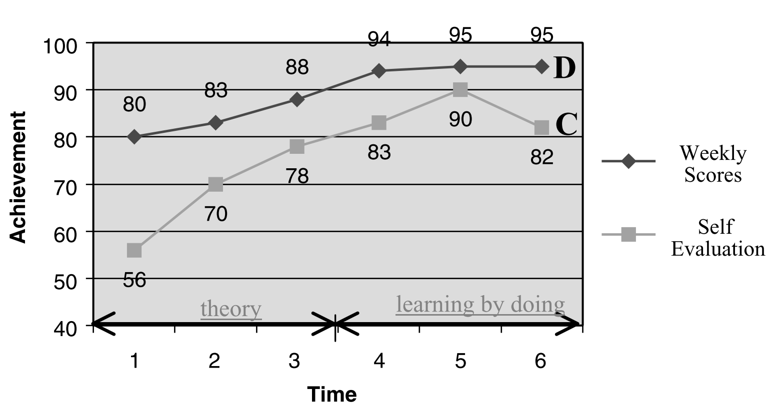

Fig. 1. Students’ weekly scores (D) and students’ self-evaluation of content comprehension (C) as a function of time (number of lessons).

(Curve D) were substantially higher than students' subjective evaluation of their comprehension of lesson content (Curve C). In other words, the students were consistently underestimating the extent to which they understood the content of the unit. Consequently, as Fig. 1 shows, no significant correlation was found between students' objective scores and their subjective self-evaluations of content comprehension.

3.2. Electronic scoring on multiple choice quizzes at the end of each lesson

Online scoring produces graphs and averages that present an objective picture of students' learning outcomes at the end of each lesson. As Fig. 1 shows, average scores obtained on weekly quizzes remained relatively constant throughout the course. Slight but statistically insignificant increases were observed in these scores when "learning by doing" benchmark tasks were included after the third lesson as permanent features of each lesson. These tasks will be described in the next section of this paper.

As stated previously, no correlation was found between students' objective scores and students' self-reports of content comprehension (Fig. 1, Curves C and D). As Fig. 1 shows, in the beginning of the course, students' objective scores were significantly higher than their subjective self-evaluation of content comprehension. However, as the course progressed, the gap between objective scores and subjective self-evaluation of comprehension narrowed as the students became more confident in their ability to cope with the content.

4. Discussion of findings

The absence of a correlation between the objective scores of the students and their subjective self-evaluation of comprehension emphasizes a central characteristic of talented students from weak socioeconomic backgrounds in geographically isolated and underdeveloped areas. When faced with a challenging learning environment, many of these students feel uncertain about their ability and tend to underestimate their acquired knowledge. This tendency emphasizes the importance of providing these students with a positive university experience in order to create a sense of academic self-efficacy and encourage academic career aspirations.

The absence of a significant correlation between the actual scores obtained on multiple choice quizzes and students' self-reports of content comprehension also indicates that not all students were able to accurately self-monitor and evaluate their comprehension of content. This finding reinforces the positions adopted by Bransford, Brown, and Cocking (2000), who maintain that the ability and disposition to accurately self-monitor and evaluate knowledge constitutes a meta-cognitive skill. Since not all students automatically possess this skill across content areas, the explicit teaching of this skill represents an important part of the "meta-curriculum," which, according to Perkins (1992), should be blended with and infused into the teaching of subject matter.

In a distance learning environment the student's ability and disposition to self-monitor and accurately evaluate content comprehension and request help accordingly may represent a crucial variable, which affects both learning and teaching processes. In a distance learning environment, instructors lack direct access to verbal and nonverbal feedback from their students. This feedback enables the teacher in a conventional learning environment to use verbal and nonverbal signals to adjust the instructional process in real-time, in order to meet their students' needs. For example, effective instructors will often re-organize and repeat content in response to students' confused expressions and off-task behaviour.

However, distance learning instructors, as opposed to instructors in a conventional learning environment, are unable to simultaneously monitor, decode, and use student feedback to modify instruction "online." In a synchronous distance learning environment the instructor frequently stops teaching in order to ask students whether they understood the presented content. In the absence of direct verbal and nonverbal feedback, the instructor relies on students' accurate self-reports of content comprehension in order to decide whether to repeat content or continue with the next unit.

4.1. Implementation of student-related findings

The above two findings helped us identify two conditions prerequisite for effective learning in a distance learning environment:

1. Prior knowledge of basic concepts related to the subject content.
2. Ability and disposition to accurately self-monitor and evaluate comprehension of content.

Since both prerequisites were identified at a relatively early stage of the project, we were able to feed these findings "back into the loop" in order to make data-based decisions on changes in instructional design. For example, with regard to the first prerequisite, all concepts that might be difficult for students without adequate prior content knowledge were identified in advance. These students could download a detailed explanation of the basic concepts from the course website before each lesson.

With regard to the second prerequisite, a number of instructional changes were instituted to help students self-monitor and evaluate their comprehension of content more accurately. Firstly, a benchmark "learning by doing" task was built into the design of each lesson. According to Perkins (1992), when students understand a subject they not only possess certain information about the subject, they can also do certain things with that knowledge. "Learning by doing" refers to tasks that require students to exercise and demonstrate understanding. Perkins refers to these tasks as "understanding performances" since these performances represent what he terms "the overt side of understanding." The execution of such tasks thus helped the students to process content and evaluate their comprehension of content more accurately. For example, Curve C in Fig. 1 shows that the number of students who felt they understood the content of the unit increased from 78% in the third lesson to 83% in the fourth lesson and 90% in the fifth lesson, and remained at approximately this level.

Secondly, the completion of the unit's benchmark "learning by doing" task replaced self-reports of content comprehension as a basis of the instructional decisions. The lecturer would proceed to the next unit of the lesson only after a sufficiently high percentage of students had successfully completed the benchmark task. Students who still required additional clarification of content were directed to one of the helpdesks or to the students' forum.

5. Online collection of teacher-related data

After each lesson, we used the Model for Analyzing Content of Interactions in a Distance Learning Environment (MACINDEL) to analyse the content of teacher–student interactions (Offir & Lev, 2000). This instrument has an interrater reliability of r=.82* and is based on analytical frameworks developed by Henri (1992) and Oliver and McLoughlin (1996). As we have described elsewhere (Offir, Lev, Lev, & Barth, 2001), the instrument's coding scheme contains the following five categories:

1. Social: teacher statements that create a positive atmosphere and support motivational-affective aspects of learning.
2. Procedural: teacher statements containing information regarding administrative and technical issues related to the lesson or course.
3. Expository: statements presenting knowledge content.
4. Explanatory: the teacher uses a question or comment initiated by the learner in order to explain content.
5. Cognitive task engagement: the teacher presents a question or learning task that requires learners to actively engage in processing the given information.

A sixth category, learning assistance interactions, was added to the categorization system for identifying teacher statements that help students cope with a high cognitive load. Examples of interactions classified in this category include the instructor's attempts to gain and maintain students' attention, as well as repetition and organization of content to facilitate retention.

One of the main purposes of interaction content analysis research is to systematically observe and categorize types of teacher–student interactions in order to illuminate interaction patterns that might otherwise be overlooked (Stubbs & Delamont, 1986). Interaction content analysis thus helps researchers "tease apart" the essential elements of the interaction, and to investigate which interactions correlate with positive learning and attitudinal outcomes. Empiric examination of interaction patterns, which correlate significantly with positive outcomes, facilitates data-based decisions on the "quality" of the interaction and enables researchers to supply teachers with effective formative evaluation.

For example, Fig. 2 shows that as the course progressed, the correlation between social interactions (Curve B) and learning assistance interactions (Curve A) increased. At the beginning of the course, no correlation was found. Later, the correlation became

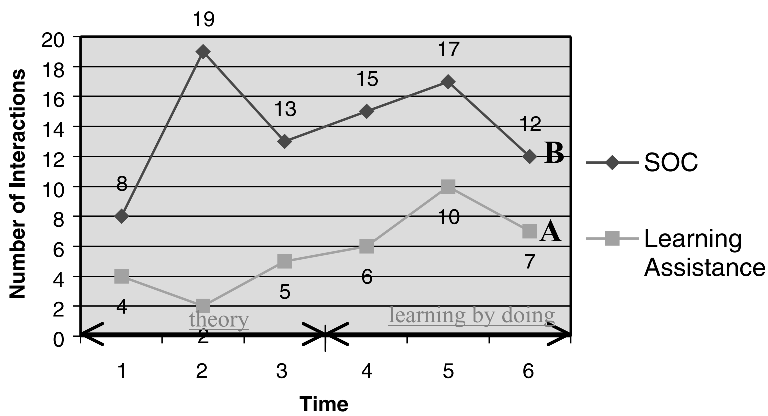

Fig. 2. Teacher's social interactions (B) and teacher's learning assistance interactions (A) as a function of time (number of lessons).

significant (r=.487*) and during the last part of the learning process the correlation increased to r=.678*. No correlations were found between the other categories of interactions used by the teacher. As we describe in the next section, this increased correlation between social interactions and learning assistance interactions was accompanied by a concomitant increase in the percentage of students who confirmed that they understood the content of the unit.

5.1. Discussion of teacher-related findings

The category of social interactions included all noncontent-related teacher statements that support motivational-affective aspects of the learning process. This category includes instructors' attempts to increase student confidence and mediate a feeling of competence. For example, statements such as "Come on guys, this just looks complicated—when you actually start to use this, you will soon see that you have already mastered much more complicated stuff" are classified in this category. When teacher-related findings were collated with student-related findings, a correlation of r=.9582* was found between the percentage of students who indicated that they thought they had understood the content of the unit (Curve C, Fig. 1) and teacher's "social" interactions (Curve B, Fig. 2).

Similarly, a correlation of r=.8357* was found between the percentage of students who indicated that they thought they had understood the content of the unit (Curve C, Fig. 1) and teacher's "learning assistance" interactions (Curve A, Fig. 2).

The significant increase in the number of students who confirmed that they understood content when the teacher's learning assistance interactions correlated with teacher's social interactions underlines three basic assumptions on which this study was based:

1. Nonintellective factors play a key role in determining the extent to which talented students fulfill their learning potential. The significance of a cluster of nonintellective

traits has been identified by Terman and Oden (1959) in their 30-year follow-up study on high-IQ persons. Their study clearly indicates that traits such as persistence in the accomplishment of ends, integration toward goals, self-confidence, and freedom from inferiority complexes differentiated between achieving and nonachieving persons. Feuerstein and Tannenbaum (1993) have also recently examined the relationship between nonintellective dispositions and underachievement among highly talented students.

2. Students in peripheral areas with high learning potential must be taught nonintellective dispositions, together with subject content. Acquisition of content alone, without these enabling dispositions, will not necessarily empower these students to maximize their full potential. High school students' participation in a university course within the framework of their own school creates a challenging yet supportive learning environment that also focuses on the acquisition of enabling dispositions. In our project, for example, one of the main functions of the on-site facilitator is to identify and prevent potential obstacles to effective learning. These obstacles have been reviewed by Tzuriel (1991) and include rapid loss of persistence in the face of failure, interpretation of errors as indicative of insufficient ability and expectation of future failure.
3. In a conventional learning environment, effective instructors constantly use verbal and nonverbal messages to encourage and reassure their students that they are capable of learning the material. In a distance learning environment, students lack access to teacher's nonverbal expressions and gestures. According to Cookson and Chang (1995), distance learning instructors must compensate students for the loss of this visual dimension. Our findings regarding concomitant improvements in students' self-evaluations of content comprehension when the teacher's social interactions (Category 1) correlate with learning assistance interactions (Category 6) reinforce this position.

5.2. Implementation of teacher-related findings

Collation of data on teacher interactions with student-related data enabled us to identify specific types of interactions that correlated with positive student outcomes. This information was then "fed back into the loop" in order to help the teacher increase usage of "social" and "learning assistance" interactions. The lecturer received a "map" reflecting his use of interactions after each lesson, together with recommendations on the types of interactions that should be increased or decreased.

For example, a relatively low frequency of Category 4 statements (teacher's response to student-initiated communication) indicated that students were hesitant to direct questions and comments to the lecturer and that the interactive capacity of the platform was not being fully utilized. Consequently, the lecturer was advised to stop the lesson from time to time in order to create "space" for students to ask questions and contribute comments. This recommendation resulted in an increase in frequency of explanatory interactions (Category 4) and improved the utilization of the system's interactive capacity.

6. Limitations of the study

6.1. Generalizability of student-related findings

Since the field project was designed to identify and enrich students whose psychometric scores and school grades did not reflect their high levels of learning potential, the student sample did not contain a full range of ability levels. Although the findings in this study regarding the correlation between types of teacher interactions and students' evaluation of content comprehension reinforce our previous findings (Offir & Lev, 2000), our conclusions, at this stage, remain limited to samples consisting of students with relatively high ability levels.

In addition, our findings regarding the impact of teacher interactions remain limited to students' subjective feelings and attitudes towards content comprehension. In our future research we intend to focus on clarifying when, and under what conditions, teacher interactions significantly affect students' objective scores (Curve D, Fig. 1).

6.2. Generalizability of teacher-related findings

This study focused on the interactions of one university lecturer who transmitted an introductory course in computer science to high school students within the framework of their own high schools. Our findings regarding the use of objective feedback to modify teaching behaviours reflects previous research on feedback and behaviour modifiability as reviewed by Mory (1996). Consequently, our future research will focus on teacher-related variables, which affect the modifiability of teacher interactions.

In this study, the content and pace of the course was relatively suited to the students' level of ability. However, future research is required to establish to what extent teacher interactions influence student outcomes when the level of content difficulty is increased. In future studies, we hope to include additional courses representing varying degrees of difficulty in order to investigate how teacher interactions affect student outcomes in a dl environment (1) across subject content areas and (2) across varying levels of student ability.

7. Conclusions

This paper describes how online data collection within the framework of a distance learning field project helped achieve a broad range of educational goals. Collation of student-related data with teacher-related data represented an integrative approach that helped clarify the complex interrelationships between person, process, and product variables in a distance learning environment. Information yielded by the data was then fed "back into the loop" and enabled data based instructional decisions to improve learning outcomes. Online collection of data thus helped solve students' cognitive and affective difficulties that arose during the course, and formulate operational guidelines for preventing these difficulties in future distance learning projects.

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