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Nonprofessional mathematics tutoring for low-achieving students in secondary schools: A case study

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Abstract This article discusses the possibility of using nonprofessional tutoring as means for advancing low achievers in secondary school mathematics. In comparison with professional, paraprofessional, and peer tutoring, nonprofessional tutoring may seem less beneficial and, at first glance, inadequate. The described case study shows that nonprofessional tutors may contribute to students' understanding and achievements, and thus, they can serve as an important assisting resource for mathematics teachers, especially in disadvantaged communities. In the study, young adults volunteered to tutor low-achieving students in an urban secondary school. Results showed a considerable mean gain in students' grades. It is suggested that affective factors, as well as the instruction given to tutors by a specialized counselor, have played a major role in maintaining successful tutoring.

Keywords Nonprofessional tutoring · Secondary school mathematics · Low-achieving students · At-risk students

The singularity of mathematics as a school subject which, on the one hand, is compulsory in most educational systems world-wide, and, on the other hand, has probably the most infamous reputation for being difficult to learn, yields some unique phenomena. One of the most distressing among these is failure in mathematics as an impediment to higher education and lucrative employment. In Israel, data show that failing to pass the final school-leaving examination in mathematics is the single most common barrier that prevents students from acquiring a Matriculation Certificate, a prerequisite for higher studies and many occupations (Israeli Ministry of Education, 2006). This state of affairs persists in spite of various reforms that took place in the past

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three decades. As recent international research indicates, low achievement and failure in mathematics is strongly linked to social issues such as disadvantaged communities, civil rights, and inequalities associated with race, ethnicity, social class, and language (Boaler, 1997; Martin, 2000; Moses & Cobb, 2001; Oakes, 1990; Secada, 1992; Swanson, 2006; Tate, 1997). Accordingly, the magnitude of failure to acquire a Matriculation Certificate varies considerably among different Israeli cities. For example, in the city where the case study reported herein took place, only 37.65% of the relevant cohort (age 17–18 years) were entitled to this certificate in 2001, in comparison to 64.22% in a nearby city of a similar size. This gap further deepens in regard to higher education: within the cohort groups aged 20–29 years, the percentages of students enrolled in higher education programs in 2001 in these two cities were 6.48% and 27.58%, respectively (Israeli Central Bureau of Statistics, 2001). Several social organizations in Israel have initiated educational projects aimed at narrowing such gaps. Most of these projects centralize tutor-based programs for students who are at risk of failing to acquire the Matriculation Certificate.

This article focuses on nonprofessional tutoring as means to advance secondary school students who achieve poorly in mathematics. It presents a case study investigating a unique program in which nonprofessional young adults served as mathematics tutors. The first section contextualizes the study within the broad literature on tutoring. The section begins with examining the rationale of tutor-based programs, continues with comparing different types of tutoring in regard to their compatibility with various needs and levels of tutees, and concludes with inspecting the specific case of tutoring for secondary school mathematics. The concern raised in this section is that nonprofessional mathematics tutoring appears to be inadequate at the secondary level. The case study conducted, described in detail in the central part of the article, provides an opportunity to examine the benefits and limitations of this kind of tutoring. The main argument elicited is that, in spite of apparent and indisputable weaknesses, there is merit in mathematics tutoring conducted by pedagogically unskilled people, under certain defined conditions. Several elements of the tutoring process, perceived as key contributors to the success of the program, are discussed in the last part of the article.

1 Tutoring as means for raising achievements

1.1 The rationale of tutor-based programs for at-risk students

The advantages of tutoring in small groups or in one-to-one settings have long been acknowledged in the literature concerned with models of instruction (Bloom, 1984; Wasik & Slavin, 1993). As Gaustad (1992) notes, the power of tutoring derives from two of its main features: adapting to the individual learner's cognitive needs and the emotional benefits of the tutor–tutee relationship. Gaustad includes the following aspects within the first feature: (1) adapting instruction to the learner's pace, learning style, and level of understanding; (2) providing immediate feedback; (3) identifying and resolving basic misunderstandings; and (4) providing practice tailored to the student's readiness. Emotional benefits include the opportunity given to students to progress without being compared with faster learners, extra attention and support, a private learning environment in which students feel more comfortable to make mistakes, and lastly, immediate encouragement and recognition of progress, which build up students' confidence and belief in their capabilities to succeed.

These aspects of tutoring are particularly valuable when considering major characteristics of at-risk students. Although this population of students is not homogeneous (e.g., Brophy (1996) differentiates between low achievers with limited academic capabilities and underachievers who work below their abilities), some characteristics may be recognized in regard to their learning behaviors. Among these are inhibited classroom participation, low frustration threshold, low self-esteem, adult dependency, and constant need of attention (Brophy, 1996; Chazan, 1996). In case of insufficient instructional support, both low achievers and underachievers may develop symptoms of alienation and/or of failure syndrome. Thus, given the previously described features of tutoring, tutor-based instruction is commonly perceived as an efficient way to advance at-risk students at all grade levels (Balfanz, Ruby, & Mac Iver, 2002; Brophy, 1996; Slavin, 2002).

1.2 Comparing different types of tutors

The extensive research on tutor-based instruction relates to several types of tutoring, which markedly differ in regard to the nature of tutor–tutee connection, tutors' age and status, and tutors' professional qualifications. A basic distinction in that respect is the one between peer tutoring and adult-to-child tutoring (Slavin, 2002). Peer tutoring is the most widely known method included in the general field of peer-assisted learning (Topping & Ehly, 1998). Principally, it refers to a situation where tutor and tutee are the same age (however, often stretched to include instruction given by older students to younger students, see Gaustad, 1992, Topping & Ehly, 1998). A central element of peer tutoring is the dual focus, i.e., setting learning objectives for both tutee and tutor, whether explicitly or implicitly (Cohen, Kulik, & Kulik, 1982). In contrast, adult-to-child tutoring is focused only on the advancement of the tutee. The adult tutor is expected not only to have greater knowledge and experience than the tutee on the subject matter, but also to possess some pedagogical skills and a repertoire of useful teaching strategies. Comparing five tutoring programs for preventing early reading failure, Wasik and Slavin (1993) found that the most effective programs employed certified teachers as tutors. This is not surprising; as in any other field, best outcomes are assumed to be achieved by professionals. However, the high costs involved yields a growing interest in paraprofessional tutoring, i.e., tutoring performed by adults having some academic backgrounds and experience, yet who are not professional teachers, such as preservice teachers (Leblanc, Lietze, & Emenkar, 1995) or college students (Nesselrodt & Alger, 2005; Shulman & Armitage, 2005; Fitzgerald, 2001). In these cases, tutors were carefully selected to match the programs' goals, and in turn, were rewarded by academic credit, gain of teaching experience, or (relatively low) payment. Using minimally trained paraprofessional tutors is suggested as a low-cost solution for at-risk students' need of support (Fitzgerald, 2001). Nevertheless, in a number of reported cases, tutorial projects seek adult tutors who work on a completely voluntary basis. In these cases, tutors are usually nonprofessionals, i.e., having no educational backgrounds (except being former school students themselves). The reasons for this choice may be primarily cost-related, but also include considerations of social responsibility. For example, the HOSTS program for improving basic skills of elementary students recruits retirees, parents, and other community members. According to the program's agenda, “this problem is a community problem, and the solution belongs with the community” (Gaustad, 1992, p.40).

Despite the appreciation for the strong social commitment of volunteering adults, the limitations of nonprofessional tutoring cannot be ignored. Compared with professional tutors, nonprofessionals are short of acquired knowledge and teaching skills in the domain they are to teach. To use Shulman's term, they lack adequate pedagogical content knowledge (Shulman, 1986), and their deficiency is likely to be greater than that of paraprofessionals. Comparing nonprofessional adult tutoring with peer tutoring is more complicated. Peer tutors often have the advantage of sharing similar social backgrounds, experiences, and language use with their tutees, and this closeness enhances cooperation and mutual understandings (Gaustad, 1993; Topping, 1996). On the other hand, adults may have greater abilities to supply warmth and encouragement (Gaustad, 1993). Vogelwiesche, Grob, and Winkler (2006) found that peer tutors were at least as effective as adult tutors in teaching basic computer skills to socially disadvantaged adolescents. Considering, in addition, that peer tutoring may improve the learning outcomes of tutors as well as tutees, it hence appears that nonprofessional adult-to-child tutoring has lesser benefits than other kinds of tutoring. However, compared with regular classroom settings, it may well be advantageous, at least in the elementary school level for which basic skills of reading and arithmetic are likely to be mastered by volunteering adults. Reviewing three tutor-based programs for elementary schools, Gaustad (1992) argues that "nonprofessionals using professionally prepared tutoring materials can provide many of the components of successful instruction to a greater degree than group instruction" (p. 32). Yet, at the secondary school level, the adequacy and effectiveness of nonprofessional tutoring become more problematic and particularly so in mathematics. It could be claimed that, at the secondary level, mathematics is far too complicated a subject to be taught by people whose mathematical preparation is limited to their own high school experiences. This may explain why within the research literature on mathematics tutoring, there is almost no documentation of nonprofessional tutoring for secondary school mathematics.

1.3 Tutoring for secondary school mathematics

Tutorial support for low achievers in mathematics at the secondary level must take into account the domain-specific characteristics of the target population. In addition to the previously mentioned general learning behaviors, several cognitive characteristics were found among students who achieve poorly in mathematics (Arcavi, Hadas, & Dreyfus, 1994; Chazan, 1996, 2000; Karsenty, Arcavi, & Hadas, 2007). These include (1) short-lived memory for mathematical procedures; (2) difficulties with reading and writing in a mathematical language; and (3) impediments in using symbolic representations. Other observed characteristics are poor note-taking and homework habits and short concentrating periods. Some low achievers in mathematics develop a negative mathematical self-schema (Karsenty, 2004), i.e., feelings of fear, stress, and resentment towards mathematics. Lastly, low achievers in mathematics tend to view mathematics as an esoteric, unattractive subject, detached from their common sense (Karsenty & Arcavi, 2003).

Research on suitable teaching approaches for low achievers in secondary school mathematics is still relatively scarce. Several studies emphasize the need to tailor curriculum and classroom activities to students' characteristics (Arcavi et al., 1994; Chazan, 1996, 2000; Karsenty et al., 2007). These studies share the assertion that, in many cases, social and emotional comportments of low achievers mask their genuine ability to learn and succeed in mathematics. Students who arrive at secondary schools with a history of constant failures in mathematics usually withdraw from further efforts in this direction. However, suitable learning environments which emphasize students' points of strength, allow many of them to create sound mathematical products (Karsenty et al., 2007). Thus, researchers suggest designing mathematical tasks which build on students' common sense, intuitive reasoning, and everyday experiences, while minimizing formal treatments (Arcavi et al., 1994).

Teaching mathematics to low-achieving students is therefore a specific area of expertise, which is by no means an easy undertaking. As Chazan (1996) puts it, “even in the best of circumstances […] the job of teaching algebra to students who have not been successful in mathematics will remain a difficult challenge for those teachers willing to take it on” (p. 475). Hence, in light of the above, the main concern is the following: Can nonprofessional tutors help at-risk adolescents to improve their achievements in mathematics? This concern has motivated the study to be reported herein.

2 The study: Background and research questions

The study is part of a wider project, named SHLAV.[1] The project's goal is to advance low achievers, from educationally disadvantaged environments in Israel, who are at risk of failing the Matriculation Examination in mathematics. It continues earlier research and design projects conducted at the Weizmann Institute of Science in the past 15 years. The project's team has designed a professional role, defined as a counselor focusing on difficulties and low achievement in mathematics. Main counseling activities, performed weekly in school during a full day, include identifying students in need of intensive support in mathematics, diagnosing students' difficulties, and instructing teachers.

As a pilot experimentation of this role, the author of this paper has been practicing it throughout the 2004–2006 school years in an urban secondary school located in a city in central Israel. According to the most recent socio-economic classification by the Israeli Central Bureau of Statistics (2001), this city is classified within the fourth socio-economic cluster, out of ten (1=lowest, 10=highest). Only 37.65% of the 17–18-year-olds in the city were entitled to a Matriculation Certificate in 2001, as mentioned earlier. The school's student population consists of a large portion of new immigrants from the former Soviet Union and from Ethiopia. Most students come from low-income backgrounds, where parents are blue-collar workers.

During the first 2 months of the implementation, the SHLAV counselor had identified students in grades 7–10 whose failure in mathematics could not be attributed to lack of cognitive capabilities, but rather to affective, social, or behavioral problems. It was assumed that many of these students could improve their achievements if placed in more intimate and supportive learning environments, such as tutoring in small groups. Since the school's mathematics teaching staff, however dedicated, could not provide more than few opportunities for such circumstances, and given the limited resources of the school, it was decided to accept an offer from a social organization to take nonprofessional volunteers for mathematics tutoring. Volunteers were high school graduates, aged 18–20 years, who participated in a year-long pre-army service welfare program operating in the neighborhood where the school was located. The SHLAV counselor assumed the responsibility for organizing and supervising the work of these volunteers, providing an opportunity to study the effectiveness of nonprofessional tutoring. The emerging research questions became:

(1) Will nonprofessional tutoring be effective, in terms of improving students' achievements in mathematics, and if so, to what extent?

[1] The name is the Hebrew acronym for Improving Mathematics Learning.

(2) Which factors will be identified by tutors as having the greatest impact on the success or failure of tutoring?

3 Method

3.1 Participants

In total, 53 students and nine tutors participated in the program between November 2004 and March 2006, within five separate tutorial periods. Five tutors participated in two of the three tutorial periods held during the 2004–2005 school year, four of them continued to the third period as well. Four new tutors participated in the two reported periods of the 2005–2006 school year.

3.1.1 Background data about tutors

All tutors were 18–20 years old, graduates of high schools spread over the country. A questionnaire administered to tutors collected data on their own mathematical high school experiences. Tutors were requested to choose from a list of eight statements[2] any combination that represents, as closely as possible, their feelings about mathematics by the end of high school. An additional option was to write about a personalized feeling. The data are presented in Table 1. It can be seen that tutors came from different types of high schools, and all except one had successfully completed the Mathematics Matriculation Examination at different levels (Hanna had taken only the first part of the low-level examination). Written statements show that most tutors were not enthusiastic about their mathematics experiences. Of the nine tutors, seven chose the statement "Glad I don't have to do this anymore" as one representative of their feelings towards mathematics. Using the categorization offered by Karsenty (2004), the statement choices suggest that only Gabriel can be characterized by the positive mathematical self-schema; Miriam and Sam may by characterized by the semi-positive mathematical self-schema, and the other six tutors seem to be characterized by the indifferent (or even somewhat negative, as in Hanna's case) mathematical self-schema. This characterization is confirmed by field notes from individual meetings with tutors.

3.1.2 Background data about students

Twenty-seven boys and 26 girls participated in the tutorial program (between eight and 13 students in each of the five tutoring periods). The selection criteria for students were:

(a) Low grades in mathematics in previous school assessments;
(b) Average cognitive abilities. Students with distinct learning disabilities were not included (except for one, referred to later on) since it seemed an excessive challenge for young unprofessional tutors.
(c) A "clean" record in terms of physical violence (however, students with discipline problems were included);
(d) Agreement from parents/guardians to participate in the tutoring program.

[2] The eight given statements were: Enthusiastic; Interested; Indifferent; Glad I don't have to do this anymore; Repulsed; Want to learn more; Sorry I didn't study more properly; Pleased with my success.

3.2 Settings

As mentioned, the study took place in an urban secondary school, in cooperation with a social organization that directs pre-army volunteering programs for Israeli high school graduates. The work of volunteers was monitored by the local representative (LR) of this organization. The LR introduced a set of nonnegotiable conditions, of which the two most significant were: (1) each volunteer would teach mathematics to a group of two to four students, for 8–10 hours per week. Sessions would be held during school time, using all the time slots intended for mathematics classes in the students' schedule, plus a few slots “borrowed” from other subjects; (2) volunteers would work with the same students for about 2 months, towards a specific predetermined goal. After this period, students would return to their regular mathematics classes, while volunteers take on a new group and a new goal. This model of work was not viewed by the school staff as optimal; they preferred tutoring spread over longer periods of time, with a smaller number of weekly hours (see Fitzgerald, 2001). Yet, staff members aligned with the LR's terms and were fully cooperative throughout the year. Within the given terms, the SHLAV counselor had a free hand in planning the tutors' work. The first decision was that all volunteers would work with students from the same grade level towards the same goal during each of the 2-month periods, in order to create a “tutoring team” within which tutors can share ideas, cooperate in preparing sessions, and support one another if problems arise.

3.2.1 Design of the tutoring process

For each tutoring period, the following steps were taken:

1) Deciding on the grade level and the mathematical goal of the tutoring period. Decisions took into account the number of unsuccessful students in a grade level and the centrality of certain mathematical contents in upcoming years. Thus, for instance, the first tutoring period was dedicated to linear functions, which is prerequisite for many other topics in the compulsory curriculum for all levels. It should be noted that the learning goals of all tutoring periods were not *remedial* but the same goals set for the rest of the students in the groups from which tutees were drawn; it was hoped that through tutoring, students would even up with their peers (as exemplified in section 4.1 below).
2) Selecting students for tutoring. See the criteria specified in section 3.1.2.
3) Matching students and tutors. In accordance with Tingley (2001), assigning students to a certain tutor concurred, as much as possible, with the tutor's expressed preferences. Some tutors preferred working with slow yet cooperative learners. Others specifically requested to work with students who were known to be “troublemakers”, but had less learning difficulties. Sometimes there were gender preferences as well.
4) Launching. Great emphasis has been put on creating a positive atmosphere about the tutoring process. Students were assembled for an opening session, where the principal congratulated them for being selected for the tutoring project, introducing it as a beneficial opportunity. Tutors then conducted acquaintance conversations with each of their assigned students. Finally, tutors visited students' homes and introduced the project to parents. The purpose of all these activities was to establish a personal commitment of students towards active participation.
5) Instructing tutors. Parallel to the preparations described above, tutors received a full-day instruction from the SHLAV counselor. The instruction model is described in section 3.2.2 below.

Table 1 Background information on tutors

School year	Tutors				
2004–2005 tutors	Miriam	Gabriel	Josh	Naomi	Hanna
Gender	F	M	M	F	F
Type of high school the tutor graduated from	Rural	Urban	Urban	Urban	Rural
Level of mathematics taken in high school	High	High	Intermediate	Intermediate	Low
Final grade in mathematics	79	97	99	95	100 (partial grade)
Statements chosen or written to describe feelings about mathematics at the end of high school	• Glad I don't have to do this anymore • Sorry I didn't study more properly • Pleased with my success • I didn't like math lessons, but it was the most gratifying subject when I was doing well	• Enthusiastic • Interested • Want to learn more • Sorry I didn't study more properly	• Indifferent • Glad I don't have to do this anymore • Pleased with my success • It wasn't so bad after all and even interesting at times	• Glad I don't have to do this anymore • Pleased with my success	• Glad I don't have to do this anymore • Pleased with my success • I thought maybe I should have done more, but I was glad I don't have to, because I didn't like math studies

2005–2006 tutors	Sam	David	Sharon	Ben
Gender	M	M	F	M
Type of high school	Urban	Rural	Urban	Urban
Level of mathematics	Intermediate	Intermediate	Low	Low
Final grade in mathematics	80	90	90	87
Statements chosen or written to describe feelings about mathematics at the end of high school	• Interested • Sorry I didn't study more properly • On the one hand, it's impossible not to hate this subject (as a school subject), on the other hand, there were many mathematical topics that interested me, regardless of school learning	• Indifferent • Glad I don't have to do this anymore • Sorry I didn't study more properly • Pleased with my success	• Glad I don't have to do this anymore • I was glad I took the low level and not the high level as I intended when I first entered high school	• Glad I don't have to do this anymore • Pleased with my success

All names are pseudonyms

Once completing these stages, the tutoring period began. Students were tutored for 8–10 hours a week, at the end of which they took a test, designed by tutors to assess their progress during the week. During the entire period, tutors met regularly with the counselor, to report on students' work, discuss problems, and receive further instruction. The LR was present at school during most sessions, to supervise the process and attend frequent problems, such as disruptive behavior or negative interactions between students. Two students were removed from the project (and are not included in the presented data). At the end of the period, students took a final test, composed by the counselor to assess the achievement of the pre-specified goal. The official end of each period was noted by a social evening gathering, to which students and parents were invited. The principal summarized the learning process and parents were informed about their children's progress.

3.2.2 The instruction model used for preparing tutors

For each tutoring period, instruction related to mathematical and pedagogical aspects of the specific teaching tasks. The instruction model consisted of a sequence of stages, described in Fig. 1. In the first two stages, mathematical concepts and representations were discussed. Since most tutors were familiar to a certain degree with the mathematical content, this part of instruction served to refresh their memory and assist them in making connections between different concepts and representations, which some tutors remembered as isolated facts or procedures. In the next stage of instruction, the counselor discussed with tutors possible difficulties that students might encounter with these concepts. Discussion was based on two resources: the professional knowledge of the counselor and the tutors' recollections of their own experience as students or that of their peers. Although most tutors were successful in high school mathematics, some of them could recall having difficulties in understanding certain content, and these were elicited and explored by the group. In the fourth stage of the instruction sequence, tutors were introduced to teaching approaches that

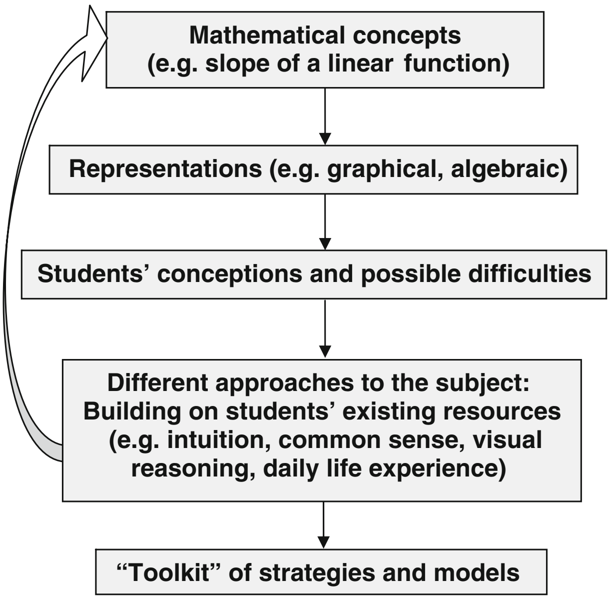

Fig. 1 The instruction model

might assist students in overcoming the difficulties discussed. As expected, this part was new to all tutors and formed the lion's share of the instruction time. The approaches presented were based on materials for low-track students, developed at the Weizmann Institute of Science to encourage students' informal reasoning, using their everyday experiences and sense making (see Karsenty et al., 2007). The four stages were repeated, if necessary, for more mathematical concepts or procedures included in the tutoring period's goal. Finally, tutors were presented with “toolkits” of strategies and models to confront gaps in prior knowledge. For example, many low achievers quit tasks which involve negative numbers, failing to recall the appropriate rules of operation. Figure 2 describes a toolkit of four models that assisted students in making sense of operations involving negative numbers, by grounding these operations in real-life situations and visual representations.

Tutors were advised on how to use the learning materials as a basis for composing individual work assignments. Then, on their own time, tutors practiced the material both individually and through group work and prepared worksheets. Instruction also included some reference to affective components to be considered when teaching at-risk students.

3.2.3 The tutoring sessions

Overall, sessions were held in as intimate an atmosphere as possible. Each tutor sat with his/her students in a separate area; no teacher was inspecting the process, and no cameras were used. In accordance with the instruction received, tutors attempted to communicate a message of a “fresh start”, where the key was not students' previous knowledge but rather their willingness to think and keep an open mind about the material discussed. Sessions were usually based on introductory informal activities, leading to more formal concepts and procedures. For example, the topic of equations began with exploring the meaning of unknowns and operations by which they may be found, through games such as “I wrote a number on this folded piece of paper, if you double my number and then add 10, you get 50. Can you guess my number? Can you write a number of your own and challenge me to find it?”. Gradually, students moved to more formal representations and solving methods. The general endeavor was to exploit, as fully as possible, the advantages of tutoring described in section 1.1 above, using pedagogical tools which were less likely to appear in the students' original classrooms (e.g., personalized tasks and immediate feedback). In addition, following the approach presented to them during instruction, tutors tried to

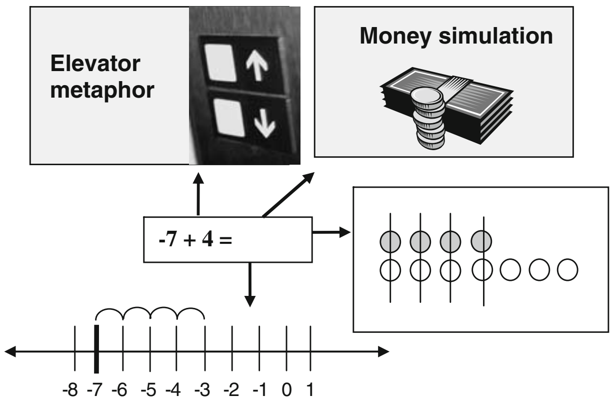

Fig. 2 An example of a “toolkit”: four models for adding positive and negative numbers

emphasize higher-order thinking skills such as estimating expected results, creating simple exercises, and using “reversed reasoning” (as reflected, for instance, in the following task: “Complete numbers in the empty squares so that the solution of the equation $3x + \square = 5x - \square$ will be $x=2$”). Attention was also given to the element of controlling for mistakes (e.g., presenting students with common errors, encouraging them to judge whether an obtained solution is reasonable).

3.3 Data collection

The data included:

1. Students' grades in mathematics before entering the tutoring program, as appeared in their most recent grading records
2. Students' grades in the final test of the tutoring period
3. Field notes of instructional sessions and meetings held with tutors
4. Questionnaires administered to tutors at the end of their last tutoring period. The questionnaire included both open and close items, relating to various aspects of the tutoring process.

4 Results

Findings are presented in relation to the two research questions introduced.

4.1 The effect of nonprofessional mathematics tutoring on students' achievements

The effect of tutoring on students' achievements was measured by comparing students' grades in the most current mathematical assessment available before tutoring began, to their grades in the final test at the end of the tutoring period. As this is not a regular pre–post test comparison, the origin and limitations of this measurement should be explained. Firstly, since the tutoring learning goals were not remedial but new goals, students participating in the program were unfamiliar with the material to be learned, therefore it was most probable that they would fail any pretest given on this material. The school staff and the project's team shared the view that students' motivation might drop if their first step in the program would be a frustrating one, and thus, it was decided to rely on existing assessments as an indication of students' achievements. Secondly, it should be stressed that the final tests, composed by the SHLAV counselor, were by no means easier than the expected classroom level. For example: The second tutoring period (8th grade, Feb–April 2005) was dedicated to linear equations. Prior to this period, all 8th graders learned about algebraic expressions and were expected to know how to (1) simplify expressions by collecting like terms; (2) match between equivalent expressions; and (3) substitute numbers for variables and calculate the result. All 13 tutees of this period achieved poorly in the test assessing this subject, which they took with the rest of their peers (their average grade was 46, whereas the average grade of all 8th grade students was around 70). This reflects a genuine difficulty in meeting the expected classroom level. During the tutoring period, all 8th graders learned how to solve linear equations and so did the tutees. The difference was that instead of attending the regular five weekly classroom sessions, tutees spent eight to ten sessions with their tutor. During that time, they had to bridge their learning gap concerning algebraic expressions, in order to learn the new material of equations. The final test assessed their knowledge in solving equations, checking to what degree tutees evened with their peers (for instance, items such as "solve the equation $\frac{4x}{3} - \frac{8x}{9} = \frac{5x+3}{12}$" appeared in the final test for the tutees, but also in a classroom examination taken by the rest of the 8th graders during that period). Therefore, comparing between students' achievements prior to tutoring and their achievements in the final test gives a realistic indication about change in terms of students' capability to cope with the mathematical level expected in classroom. However, since different means were used to measure students' level before and after tutoring, we suggest that the numbers to be presented should be considered as qualitative evidence, pointing to a certain trend, rather than taken as a quantified gain in achievements per se.

Table 2 presents the change in students' grades in each of the tutoring periods. Data show that, of the 53 students, 47 performed better after tutoring; one student did not show any change, and five students showed a decline in performance. Of the 47 positive gains, four gains ranged between 1–10 points; 26 gains ranged between 11–40 points, and 17 gains were higher than 40 points. The mean change in students' achievements (n=53) was 32.28 points (SD=23.58). Mean changes for periods 1–4, 5a and 5b were 52.7, 32.77, 13.1, 25.73, 31.5, and 24.12, respectively.

As revealed in Table 2, in several cases there was quite a notable change in achievements. Six students (see periods 1, 2, and 4) had received a "fail" grade (40 or under) in classroom assessments prior to tutoring and attained a grade of a 100 (or nearly so) at the end of the tutoring period. Of these six, five had discipline problems which their mathematics teachers found hard to cope with; thus, prior to tutoring, they frequently spent time outside the classroom. The other had emotional problems. All six students developed close relationships with their tutors and worked seriously during sessions. In weekly meetings with the counselor, tutors often expressed their amazement at these students' rapid progress. On the other hand, there were six students (see periods 2, 3, and 4) whose grades remained the same or declined after tutoring. Two of them suffered from test anxiety, which they could not overcome during the final test. In another case (see Table 2, S11 of period 2) the student was diagnosed as having a learning disability prior to tutoring, but the success of the first tutoring period had tempted the staff to include her in the program, hoping that the intensive attention would promote her understanding. This turned out to be a mistake. Her tutor was frustrated by the fact that she could not remember basic procedures from session to session, and the student herself became dispirited since she continued to fail the weekly tests and eventually failed the final test. In the other three cases, lack of students' progress cannot be attributed to a single factor; however, field notes report on tutees' frequent absences and low level of involvement.

Table 2 also shows that the third tutoring period was not as successful as the others. This may have happened due to the more advanced nature of the topic, perhaps combined with the fact that tutors had less time to prepare for this period, which was also shorter than the other four.

4.2 Tutors' perspectives on the tutoring process

4.2.1 Tutors' ranking of factors that contribute to effective tutoring

In a questionnaire item, tutors were requested to rank 14 given factors by their impact on successful nonprofessional mathematics tutoring. The five factors perceived by tutors as most important were (1) volunteer's ability to maintain warm and supportive relationship with students; (2) professional instruction regarding the mathematical content; (3) selecting students with no learning disabilities; (4) professional instruction

Table 2 Students' grades before and after tutoring, by tutoring periods

	Tutoring Period											
	1. Nov–Dec 2004		2. Feb–April 2005		3. May–June 2005		4. Sept–Nov 2005		5a. Jan–March 2006		5b. Jan–March 2006	
Grade level	9th grade		8th grade		9th grade		8th grade		7th grade		10th grade	
Mathematical content	Linear functions		Linear equations in one or two unknowns		Quadratic functions and quadratic equations		Quantitative thinking and simple linear equations		Pre-algebra basis		Trigonometry and analytic geometry	
Students' grades	GBT[a]	GFT[b]	GBT	GFT	GBT	GFT	GBT	GFT	GBT	GFT	GBT	GFT[c]
S1	11	74	55	88	55	79	20	93	40	84	60	94/94
S2	38	88	45	100	68	73	23	44	50	84	60	100/80
S3	26	70	58	98	55	80	48	70	55	90	60	100/50
S4	20	71	60	75	30	50	34	72	55	68	60	100/55
S5	39	98	60	100	50	70	0	30				
S6	50	93	40	100	49	56	42	66				
S7	50	67	40	100	73	73	25	81				
S8	51	78	50	84	65	59	68	78				
S9	0	100	50	46	52	79	48	44				
S10	12	85	55	94	15	24	64	84				
S11			40	10			77	99				
S12			18	60			68	65				
S13			28	70								
Mean grade	29.7	82.4	46.07	78.84	51.2	64.3	43.1	68.83	50	81.5	60	98.5/69.75
SD	17.56	11.46	12.24	25.96	16.56	16.7	22.51	19.86	6.12	8.17	0	2.56/18.03

[a] *GBT* Grades before tutoring (maximum score=100)

[b] *GFT* Grades in final test, after tutoring (maximum score=100)

[c] In this period, two final tests were conducted, the grades reported are in trigonometry/analytic geometry correspondingly. The mean value of the two grades was calculated for the purpose of finding students' gain in grade

regarding pedagogical issues; and (5) volunteer's willingness to learn mathematical material. The two factors perceived by tutors as least important were the former mathematical knowledge of the volunteer and selecting students with no acute behavioral problems.[3] The general picture that emerges from this piece of data is that volunteers viewed tutoring as a challenge they could meet by investing their affective–humane resources, provided that professional guidance was available. Tutors relied on their keenness to learn more than on their previous mathematical knowledge and were much more concerned by the possibility of teaching a student with a learning disability than they were by the need to teach students with undisciplined behavior. This interpretation is supported by field notes of discussions with tutors and partly also by comments written by tutors in open items of the questionnaire.

4.2.2 Tutors' descriptions of their relationships with students

In an open questionnaire item, tutors were requested to describe the nature of connections they had formed with their tutees. All nine tutors described the relationships with most of their tutees in terms such as positive, strong, meaningful, and friendly. The following citations demonstrate this predominant theme:

- “The connection differed from child to child, but all were positive and supportive connections that grew to be meaningful for certain children. Children who are used to failures on a regular basis and suddenly get a high grade tend to see the teacher (me!) as responsible; it's a situation that creates trust and appreciation towards me. The connection also depends on its out-of-school elements, knowing parents and friends, meeting in the afternoons, etc.” (Naomi)
- “It was a good connection, but different with each one; I went to their homes, and we had many laughs and fun together besides the lessons.” (Hanna)
- “At first, the connection was based on the mutual learning interest. As the acquaintance grew stronger the relationships changed [...]. For me, the satisfaction from the student's achievements was the initial incentive, but the personal connection in different levels was the main cause for continuing the investment in and out of school.” (Gabriel)

Although for the most part, descriptions were positive, three tutors also mentioned cases when students became remote, disrespectful, or angry. However, these cases appeared to be marginal in the summary of tutors' general impressions. Examining the citations above, it can be seen that a strong component of the described relationships is the personal bond, which goes beyond a teacher–student commitment and is manifested in activities that take place out of tutorial sessions.

4.2.3 Tutors' comments on the tutoring experience

The concluding item in the questionnaire administered to tutors allowed them to add any comments in regard to the tutoring process they have experienced. Except for one tutor who left this space blank, all the others added interesting comments, categorized below.

[3] The other seven given factors were: Selecting students motivated to learn; Tutor's level of investment in preparing tutoring sessions; Appropriate physical conditions; Tutor's ability to solve problems turning up during sessions; The LR's ability to coordinate tutoring activities in collaboration with the school's staff; Cooperation of the mathematics teachers and school staff; The LR's ability to supervise tutors and handle problems.

Personal gains Seven comments related to self-improvement as a result of tutoring: Three tutors noted that they have improved their instructional skills or their abilities to work with people in general. Four tutors mentioned that they have extended their mathematical knowledge and understanding. For instance, Hanna wrote:

> [The work] opened for me a mathematical approach and understanding, it helped me to learn math, which I didn't do so much in high school, and to accept this subject more positively.

New understandings about education Two comments brought forward ideas about school, teaching, and learning. Tutors described these ideas as new understandings, evolving as a result of working in a tutoring program located within a school system. Gabriel wrote:

> The most important thing I understood is that every student is capable of much more than the abilities he demonstrates in class, and this is the leading principle of the program. This fact also projected on me as a teacher: I'm capable of much more than I have first expected, meaning—chapters I didn't believe I would be able to teach successfully in a limited time period, were grasped by students in contrast to the logic entrenched in me as a student in school.

Concerns about the long-term impact of the tutoring program Three tutors expressed their concern that not enough attention was given to the program's impact on students after the tutoring period was over and they were placed back in their mathematics class.

Two main themes are revealed in the tutors' comments, in all three categories, and these are involvement and personal change. Clearly, tutors became very much involved in the educational task they took upon themselves. They cared about students and their success, and invested many efforts in trying to achieve the learning goals set for the tutoring periods. This theme is further confirmed by examining the tutors' responses to the questionnaire item requesting them to describe their preparations before tutoring periods. Responses show that tutors dedicated a considerable amount of time and were engaged in various instructional techniques, in their attempt to master the material. The following citation, by Naomi, is a representative response that illustrates this point:

> We divided the material into sections, by time and by lessons, and each tutor prepared a lesson and a test for his chapter. Then we taught the lessons to each other and this way we practiced teaching and also took the tests on this material so we became technically skillful in it.

It is reasonable to assume that the strong involvement of tutors played a role in the development of new understandings and personal changes which are exemplified in the comments above. Although the tutoring program was categorized as an adult-to-child tutoring, which is focused on the tutee's needs, it became clear that its impact on tutors was valuable as well.

5 Discussion

When studying tutorial programs focusing on secondary school mathematics, one should bear in mind the wider context of such an investigation. Developing appropriate and attainable instructional means that can be utilized in order to narrow educational gaps of socially disadvantaged students is a matter of equity. In particular, the fact that mathematics is frequently used as a critical filter for post-secondary education creates a pressing need to investigate practical issues, concerning mathematics teaching and instruction for at-risk students. In spite of the substantial increase in the literature on low achievers in mathematics in recent years, this need is addressed mostly at the elementary education level (e.g., Baker, Russell, & Dae-Sik, 2002; Lumpkins, Parker, & Hall, 1991; Miller, Harris, Strawser, Jones, & Mercer, 1998; Morris, 1995). Much less research can be found in regard to mathematics teaching of low achievers at the secondary level. Moreover, studies that do relate to this age level often concentrate on basic arithmetic skills (e.g., Ben-Yehuda, Lavy, Lynchevski, & Sfard, 2005; Bottge & Hasselbring, 1993; Woodward, Baxter, & Robinson, 1999). The case study reported in this article focused on teaching of more advanced mathematical content, such as linear functions and equations, to low-achieving students and therefore addresses the general need stated above from the specific angle of mathematics tutoring. The article examines the role of mathematics tutors as it emerges from situations where choices and possibilities of educational systems are limited; schools that lack adequate resources to address the needs of low-achieving students may turn to the low-cost option of nonprofessional tutoring. It should be stressed here that this does not imply we can now replace professional teachers with inexperienced enthusiastic young people. Moreover, the study does not aim to compare the outcomes of professional and nonprofessional tutoring. It is well known from the literature that professional and paraprofessional tutoring both have very positive effects on students' achievements (as presented explicitly in section 1.2 above). The novelty of the argument raised here is that using nonprofessional tutoring can still provide a certain positive effect on students' achievements in secondary school mathematics, which seems quite a surprising finding. Although the quantitative data collected in the study cannot be used as a measure of actual gain in grades, it shows that, after tutoring periods, during which tutees have learned mathematics solely with tutors, students' capability to handle the mathematical material presented in class has, on average, increased considerably. This finding is consistent with results reported by Gaustad (1992) in regard to the positive effect of nonprofessional tutoring. Furthermore, it provides some evidence that nonprofessional tutoring may be beneficial even when the material to be taught is not elementary.

The additional question raised in the study concerns factors of the described tutoring program, which can serve to explain the improvement in students' achievements. Vogelwiesche et al. (2006), who reported on a tutoring program for training adolescents in basic computer skills, suggest that offering an attractive learning domain is a key concept in the success of tutoring. This factor does not appear to have an explanatory power in the case reported here, since informal observations indicate that tutees did not perceive mathematics as an attractive subject. Examining the background data of the nine tutors, it appears that they were not particularly enthusiastic about the domain of mathematics either. On the contrary, most of them, although generally being successful as former mathematics students, stated they were pleased to be finished with mathematics upon graduation from high school. Only one tutor was characterized by the positive mathematical self-schema (Karsenty, 2004) while six tutors were characterized by the indifferent mathematical self-schema. Thus, it is most unlikely that students were motivated by tutors through conveying positive feelings towards mathematics per se. However, the same data suggest that tutors were able to identify with students on the grounds of the shared obligation to pass mathematical tests as part of schooling. Indeed, in conversations with tutors, most of them reported that they often encouraged students using arguments such as "mathematics was not my favorite subject either, but I nevertheless succeeded and so can you". This point is demonstrated in Hanna's concluding comment, written in her questionnaire:

> It was an amazing experience, especially for me, because the system and ways of my own high school did not suit me, and I succeeded for myself and for the kids because I understood them.

It should be noted, however, that the instruction given to tutors was aimed, among other targets, at changing the common viewpoint among most of them that mathematics is difficult and uninteresting (see further discussion below). Field notes from instructional sessions document comments such as: "I must tell you, I hated this in high school but now it seems rather nice (Sharon, during session on equations)" or "I wish that they had explained it this way when I was a student, it makes much more sense to see it visually first" (Naomi, during session on the slope concept). Yet, as can be expected, shifts in attitudes (if occurred at all) were not deep enough to alter the tutors' mathematical self-schemas, since this construct is assumed to be persistent (Karsenty, 2004).

Tutors' perspectives on the process of tutoring point to the capability to develop warm relationships with tutees as a major factor contributing to students' success. Descriptions of connections with tutees were typically characterized by tutors in positive terms. In addition, this factor was ranked, on average, as having the greatest impact on successful nonprofessional tutoring.

This perspective centralizes social relationships in adult-to-child tutoring processes, a theme supported by Vygotskian theories as well as by emotional analyses of at-risk students' learning characteristics. Vygotskian theories (Vigotsky, 1978; Hogan & Tudge, 1999; Wertsch, 1985) emphasize the crucial role of social interactions in the advancement of learners through their zone of proximal development. Knowledge is considered to be socially constructed and internalized by joint processes into which learners bring their personal experiences. It follows that close and supportive relationships play an important role in the enhancement of tutees' knowledge growth.

Analyses of emotional characteristics of at-risk students also confirm the tutors' perspective. Such analyses (e.g., Chazan, 2000; Mor & Mendelson, 2006) bring forward the importance of addressing students' need of personal attention and sincere interest in their lives, as a necessary condition for a fruitful learning dialog. Since tutors were young people with no family or work obligations, they were available to students not only during scheduled tutoring sessions, but also occasionally after school hours, as reported earlier. This availability seemed to have contributed to the tutoring process, in terms of attention and the formation of informal relationships. One may argue that the remarkable commitment displayed by the young volunteers is unique, and perhaps originates from cultural conventions typical to the Israeli society. However, we suggest that similar experiences may occur in other circumstances, especially in communities with a strong sense of shared social responsibilities (e.g., as reported in Gaustad (1992)).

In addition to the social factors discussed above, the other main element suggested as a key factor in the success of the program is the instruction given to tutors by a professional counselor. The instruction was research-based and derived from a combination of theoretical and empirical findings (see Arcavi et al., 1994), and therefore, its strength was in the ability to expose tutors to documented difficulties and misconceptions, as well as materials and strategies designed to tackle these obstacles. The guiding theme of instruction was that students, who are classified by their school system as low achievers in mathematics, are nevertheless capable of reaching mathematical goals if taught in ways that take into account their characteristics (as demonstrated by Karsenty et al., 2007). The materials introduced during instruction emphasize learning mathematics through understanding, thinking, reflecting, and controlling for mistakes. As shown in the study's results, tutors found this type of instruction meaningful and useful. There are grounds to assume that the young age of tutors was beneficial in that respect, too. Experienced teachers are often inclined to dismiss higher-order-thinking tasks as unsuitable for low-achieving students (Zohar, Degani, & Vaaknin, 2001). Nonprofessional tutors are less likely to have firm opinions on this matter, and thus, they are more inclined to accept new methods, especially if they realize that these methods sharpen their own understanding, as was repeatedly the impression during instructional sessions.

Findings therefore suggest that the lack of professional experience, which is the major disadvantage of nonprofessional tutoring performed by young adults, is compensated by some social features that may constitute the strengths of this kind of tutoring: better ability to bond with students and understand them, increased availability, enthusiasm about instruction, and keenness to learn.

The single experience reported herein, of tutoring a student with learning disabilities by a nonprofessional tutor, was not a successful one. The failure to advance this student and the frustration of both her and the tutor appeared to have a considerable impact on all tutors, who ranked the factor "selecting students with no learning disabilities" to be the third, on average, in the list of influential factors regarding the success of the program. This specific case calls for further research. It may well be that nonprofessional tutoring is not recommended, and may even be damaging, for students with learning disabilities. However, the possibility that a specific kind of instruction, by special education professionals, may promote nonprofessional tutors' skills in assisting such students, should also be explored.

In sum, the tutoring program presented in this paper shows a potential for advancing students, whose low attainments in mathematics could be attributed to social or behavioral circumstances. Subsequent research is needed in order to affirm and broaden the results of this study. Questions about the long-term effect of such programs, the impact of group work as opposed to individual preparations of tutors, and the role of social organizations in monitoring tutoring models, are few of the issues that need to be further investigated.

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