Moving between Mixed-Ability and Same-Ability Settings: Impact on Learners

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In this study we analyze why conditions for processes that generate cognitive gains are present in our TAP settings while absent in tracking and study how these processes may affect students' attitudes. During one school year students in four seventh-grades, who learned mathematics both in mixed-ability and tracked settings, were followed. Our observations indicate that there are fundamental differences between interactions in these settings that may affect students' achievements and attitudes.

We endorse many researchers' definition of "Ability-grouping as any school or classroom organization plan that is intended to reduce the heterogeneity of instructional groups; in between-class ability grouping the heterogeneity of each class for a given subject is reduced, and in within-class ability grouping the heterogeneity of groups within the class is reduced" (Slavin, 1996, p.168). Thus a mathematics classroom divided into small homogeneous groups (henceforth 'within-class' tracking') is categorized as tracking. In his comprehensive survey and analysis of tracking studies, Slavin (1996) did not find any significant benefits of tracking. On the contrary, there is a large body of evidence of the harm emanating from tracking. It has been shown that there a gap is created between learners, allocated to different ability-grouping levels, beyond what is to be expected on the basis of the initial differences between them (e.g. Kerckhoff, 1986; Cahan & Linchevski, 1996). On the other hand it has been demonstrated that it is possible to create a mixed-ability (henceforth MA) learning environment in which the growth in inequity, as manifested by the above-reported widened gap between learners, is avoided (The TAP Project, Linchevski & Kutscher, 1996). Moreover lower- achievers' achievements improve while higher-achievers' achievements are not impaired, when compared to their peers learning in the tracking-system (Linchevski & Kutscher, 1998). Thus learning in MA groups may benefit the lower-achievers without being at the expense of the higher-achievers.

Regarding students' attitudes to MA and tracked settings, high-achievers' attitudes seem to undergo change as a result of their learning experiences in the different settings. It has been found that while studying in MA settings all but the highest achievers prefer to study in MA settings; the highest-achievers prefer to change their setting to tracks (Kutscher, 1999). What research has also shown is that when students who have studied in MA settings, continue their studies in tracks: Most students, including 1/3 of the top-track, prefer to revert to learning in MA classes (Boaler, 1997).

In most tracking-studies there have been some attempts to explain the detected effects of the various settings on students' achievements and attitudes. However, there has not been close examination of the processes that lead to these effects. The purpose of the present study is: a) To analyze why the necessary conditions for processes that generate cognitive gains are present in our TAP MA settings while they are absent in the tracking system and to examine processes of interaction between students in the light of this analysis. b) To study how these processes may affect students' attitudes.

<u>Theoretical Background:</u> Interaction studies have shown that active interaction between incompetent and competent students yield cognitive gains both to the less competent students (Botvin & Murray, 1975) and to the more competent students (Doise & Mugny,

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1978) when conditions for productive argumentation are met: There is disagreement between the students, the students are strategic (ability to argue/reason the strategy), and the strategies they use are different. Schwarz et al (in press) showed that when these conditions are fulfilled and active hypothesis testing of the task-solution is available, even when the two interacting students are incompetent, at least one of them makes cognitive gains. In sum, all levels of interacting students may gain cognitively provided certain conditions are met.

The required conditions for productive argumentation between incompetent and competent students are intrinsic to the MA learning environment. During the interaction processes between them, competent students and incompetent students frequently disagree. In the resulting argumentation, the competent students are generally strategic; the incompetent students often appear non-strategic because of their difficulties in reflecting on their solution process. The competent students instinctively probe the incompetent students' thinking processes for the reasons of a given statement, thus transforming the incompetent students' explanations to strategic ones and the argumentation to productive. Since students are now able to verbalize their strategies, their argumentation results in their thoughts being organized clearly so that they can analyze their own strategies and pinpoint their differences. The strategy now becomes part of their analytical realm and thus each student gains cognitively.

On the other hand, in school reality it is almost impossible to design a lower-track environment that would meet the above-specified necessary conditions for productive argumentation between mathematically less-competent students. A design of this sort would necessitate first identification of students whose incorrect strategies for solving future tasks would be different. This implies pre-testing the students and analyzing the results before the topic is approached in order to construct small groups with the required profile of students. Moreover, in the case of lower tracks, the condition that both interacting students are strategic is rarely fulfilled. Although these students often do have strategies, they are usually non-strategic: They are unable to fully verbalize their own strategies, nor to dispute each other's arguments and thus their interaction is not argumentative.

Taking the above considerations into account, it seemed to us that in the MA environment conditions for all students to gain cognitively through argumentation exist naturally, while in the tracking system they do not.

Regarding the attitudes of lower achievers, when the processes of interaction yielded constant gains favorable attitudes were expected toward the settings in which they were learning. Thus, among the lower achievers favorable attitudes towards MA settings and unfavorable attitudes towards tracking were predicted. As for the highest achievers, our conjecture was that where these students felt their cognitive gains to be greatest, their attitudes towards those settings would be more favorable.

<u>Study Design:</u> A junior-high school in Jerusalem, Israel, tracked its students in mathematics from the eighth grade and upward. Although the teachers in this school believed in tracks they still felt that it was unfair to track students for mathematics in the seventh grade because these students were new to the school. Thus the school implemented MA classes in the seventh-grade. The school requested a TAP[1] counselor

[1] TAP: Together and APart – a project for learning mathematics in mixed-ability classes.

to assist them implement the MA settings according to TAP principles. In this school, at the end of the school year all seventh-graders are tested on a common test and are consequently divided into three tracks according to predetermined cut-off points. As previously stated, this research's purpose was to study processes of interaction in MA and tracked settings and how they influence students' learning and attitudes. Two experiment designs were considered. The first possibility was to study the seventh-graders in their MA settings and to continue studying them when they learned in their eighth-grade tracked class. The second possibility was to study the seventh-graders in their MA settings and then, later on in the same school year, convert the setting from MA to within-class tracking and continue studying the seventh-graders in this tracked setting. Since we considered that the latter experiment-design held more factors constant than the former design, factors such as physical and social environment, teachers and teaching strategies, we thought the latter experiment design more appropriate. On approach, four TAP teachers showed interest in the results of such an experiment. Since the school anyway tracks its mathematics students in the eighth grade they agreed to participate in the experiment and organize their classes for within-class tracking during the last quarter of the year.

The research population was the students in four seventh-grade mathematics classes. The teachers organized their MA classes for small group-work. They prepared their teaching plan for the whole year at the beginning of the year - topics, textbooks, teaching strategies and so on – taking into consideration the heterogeneity of the student population. During the first phase of the experiment (henceforth 'the first phase') the children learned mathematics in small MA groups and during the last quarter of the school year (henceforth 'the second phase') the children learned mathematics in small homogeneous groups (within-class tracking). Cooperative learning through peer interaction was encouraged in all learning environments. The same quality of learning materials, learning strategies and class culture was fostered in both phases of the experiment. Before the second phase, the teachers assigned their students, without disclosing this to the students, to three mathematics tracks as they conceived the students would be assigned the following year. An 'H' student would most likely learn in the highest track in the eighth grade, an 'M' student in the middle track and an 'L' student in the lowest track. The researchers observed the classes for 60 hours. Seventeen of these hours focussed entirely on collecting data of within-group interactions – nine hours while the students learned in MA settings and eight hours while they learned in within-class tracking. A sample of students from each of the three tracks, 35 in all, were interviewed twice: once just before the class was reorganized into within-class tracking and once at the end of the school year. Each interview was semi–structured with 12 prompts. The interviews were recorded on audio tapes and transcribed in full.

Results and Discussion

Students' Learning in MA Settings: The cooperative-learning culture fostered in the research classrooms was one where students generally solved the tasks independently and thereafter were expected to present their solutions to their group-mates and resolve any disagreements through argumentation. However when a student experienced difficulties with a task s/he was engaged in, s/he was encouraged to discuss and try to resolve this difficulty with a group-mate. Thus a culture of mutual responsibility and support was fostered in these groups.

The following is a typical example of this sort of peer interaction in a MA group. The students were working on the concept of 'solution of an equation'. The current task called for the construction of equations according to given constraints. For example: "Construct an equation with *m* to represent its unknown, –2 is *m*'s coefficient, and 3 is the equation's solution." The teacher had taken great care to explain the notion of solution of an equation prior to this task. Six students made up this MA group: S_H (H-student), L_M (M-student) and Z_L (L-student) were three of the six students working in the group. (The student track-levels were added only during the write-up of this paper on the basis of the results of the end-of-the-year tracking-tests.) S_H was working with students on her right, while L_M, who was sitting on S_H 's left, was working with Z_L. They had just solved the first item (albeit incorrectly), and were attempting the second.

L_M (reading the task with Z_L, sitting on her right): *Now "An equation with unknown 'a' and the operation of addition, so that it's solution will be 0'. So let's do –5+a=0. And: Check –5+5=0.*

And they proceeded to the third question completely unaware of their misconception. S_H, turned to see what L_M was doing and noted that for the first question that required "An equation with unknown *x* whose solution is –4", L_M had written *–4x=-4.*

S_H (says assertively): *No, it isn't right.*

L_M: *Why?*

S_H: *'x' is equal to –4, the 'x' is equal to –4.*

L_M: *But it doesn't matter, anyway I did it –4 times, like, 1.*

S_H: *But no, but the x is equal to –4.*

L_M: *Oh, I understand.*(L_M erased her old answer and wanted to write a new one.) *Now let's see, what will we do? First of all x* (and writes '*x*').

S_H: *The solution doesn't have to be at the equal, in the beginning. So what do you want to do? x plus or minus or multiplication?*

L_M: *Multiplication, but I'll write it after it.*

S_H: *So x times…*

L_M: *2* (L_M now has written '*x*•2')

S_H: *Okay, times 2 equals?*

L_M: *-4*

S_H: *Minus what?* (S_H holds L_M 's hand to stop her from writing). *'x' equals to –4! -4 times 2?*

L_M: *Just a minute. So I've done everything wrong. Oh, I thought that the final solution has to be –4.*

S_H: *No, "whose solution", that the unknown is –4.*

L_M: *So that's it, I thought that the solution at the end* (meaning that the number should comprise the right-hand side of the equation) *has to be –4.* (L_M verbalizes her strategy)

S_H*: -4 times 2 equals?*

L_M: *-8* (And L_M completes her equation to'*x*•2=-8')

S_H: *Check!*

L_M: *-4 times 2 is equal to –8* (Writes this down). *Now I have understood. Just a minute, then I'll erase everything. Oh no!! Oh no!!*

L_M proceeded to erase all her solutions that she now realized were incorrect, and to re-solve the tasks correctly on her own while S_H watched over her until convinced that L_M really understood. L_M now turned to Z_L and engaged in a similar argumentation with her, essentially repeating the same process that she had just undergone with S_H. Through L_M's discourse with S_H, L_M realized that she had misunderstood the notion of 'solution'. Even though the students had been exposed to the new definition of solution, for a while it seems that for L_M, the notion of solution as an 'answer' to a numerical string was dominant. Through S_H's continual argumentation, L_M became conscious of her strategy and was able to verbalize it - L_M had become strategic. L_M was able to analyze the source of her misconception, as is attested by her discovery: *"So that's it, I thought that the* *solution at the end has to be –4*", and thus gain cognitively. L_M was now able to set aside the 'old' notion of solution and to strengthen her 'new' notion of solution. Not only did L_M have the opportunity to clarify her misconception but, in the subsequent interaction with Z_L, L_M enabled Z_L to be strategic and in this process further refined her own understanding of the concept.

Students' Learning in Tracked Settings: All students sat in homogeneous small groups continuing the same cooperative learning-culture as had been nurtured in the MA settings. Although at no time did the teachers hint that the new groups were tracked it was evident to the students that it was indeed so. The teachers reported that the H-tracks functioned wonderfully, the M-students were trying hard but very often got stuck on a task and were unable to resolve their difficulties with the human resources in the group. As for the L-track, they barely managed anything on their own, and the teachers found themselves torn: Generally, if they didn't monitor the L-students, the latter accomplished very little; and yet M-students needed them too. The following is a typical example of M-students struggling within their group to solve a given task. This class was revisiting the notion of substitution[2] in algebraic expressions and all tracks were engaged in the following task:

3*a* is the given algebraic expression. Write next to each numerical expression, given that it was derived from this expression, what number/expression was substituted?
1) 3•8 ____________ 2) 3•(-5)____________ 3) 3*b* ____________ 4) 3(7+5) ____________

Five M-track students, T_M[3], A_M, Y_M, S_M and J_M are trying to work on the first item, but no one really understands. R – the researcher:

A_M: *Ah, I know. The fact that they say, let's say, these sentences* (maybe referring to the task instruction "what number/expression was substituted") *that: 8 is the sum. 3 times 8 something like this.*
T_M: *It's 3.*
A_M: *You're wrong T_M, it's not 3. You're wrong you have to write a sentence.*
Y_M: *You need letters here. That's what I know, that you need letters.*
J_M: *I think that you have to substitute instead of the "a" the number 3.*
A_M: *One can do 'a times d' and a=3 and d=8.*
J_M: *It could be right.*
Discussion ends. The researcher sees that the discourse has come to a dead-end and calls G_H from the H-track to see what would transpire:
R: *G_H, please come here.*
G_H joins the group. Productive argumentation is initiated, similar to the one described in the previous section. When the researcher sees that the group is able to answer the first two items correctly, she sends G_H back to her H-group, and observes the M-group continue working on the rest of this task:
R: *Right. S_M,* (who is the weakest in the group and did not even try previously to participate or make sense of the task) *what will be the answer in question number... S_M, what will be* (the answer to) *item 3?*
S_M: *a equals b.*
A_M: *What?*
J_M: *To b.*
S_M: *To b.*
A_M: *A letter is equal to a letter? What's these nonsenses?*
J_M *: A letter is like a number, but* (it's an) *unknown.*
R: A_M, *do you accept this?*
A_M: *No, I don't think so.*
R: (turning to T_M): *Can you explain to him?*

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[2] One of the principles of TAP is to revisit concepts spirally.

[3] Naturally the students referred to their group-mates by name and not by level. We attached the levels to their "names", according to the results of the end-of-year tracking test, to facilitate reading.

A_M: (Frustrated with not being able to understand and unwilling to address this issue further): *Alright, I understood.*
T_M: *Four* (meaning item four)*: a is equal to 12.*
R: A_M, did you understand the idea about 'a equals b'?
A_M: *No, it's alright.* (Item) *four is either 'a equals 12' or 'a equals 7+5'.*
R: *Right, nice.*

All students in this M-group were serious and motivated students who, when learning previously in their MA small groups and when they felt they needed had asked for help from their group-mates, and had consequently been able to tackle most tasks. Before student G_H joined the group the students were making no headway. There was disagreement but the students were not strategic: They could not offer reasons or arguments to defend their solutions nor to dispute other students' solutions, thus no learning evolved. With G_H's argumentation the picture changed. G_H was able to articulate her arguments very lucidly, was certainly strategic and enabled the M-students to analyze and clarify their thoughts. All members of this M-group seemed to gain a clear understanding of the concept involved in the task. Student A_M was a very diligent student and during the first phase had been able to resolve most cognitive conflicts within the framework of the heterogeneous group. Clearly this exchange shows that he was getting frustrated: He was unable to grasp that one could substitute a variable for a variable. In contrast with the cognitive gains that occurred through the interaction between G_H and the group, for A_M the interaction dealing with this concept proved unproductive, unfruitful, frustrating and apparently yielded for him no cognitive gain. This might have occurred since the present constellation of students were unable to help A_M become strategic and enter into a productive argumentation with him.

It seems that, even after a cooperative culture of argumentation has been established, it is very difficult for lower-track students to engage in spontaneous productive argumentation without the input of external sources. These sources might be specially designed learning materials, a teacher, a more competent student and the like. What has been demonstrated is that in a MA environment a cooperative culture of productive argumentation can be established quite naturally.

Attitudes to learning in MA and tracked settings: The students were interviewed at the end of the first and second phase of the experiment. The results will be divided into two categories: Those students who would eventually be assigned to lower tracks (L and M students: L&Ms) and those who would eventually be assigned to the highest tracks (Hs).
L&M's attitudes: In the first phase all the L&Ms consistently preferred learning in MA classes. They credited their progress to the group, emphasizing the mutual support. When prompted, the Ms all valued the opportunity of being able to help the students in their group as a medium for their own cognitive gains. All L&Ms objected to tracking, firstly because of the feelings of shame and failure related to being assigned to the lower tracks; secondly because of the lack of the stronger students, thus depriving them of progress. Some representative quotes:

G_L: (The groups helped him) *Because if I get stuck on something then they help me…and sometimes I helped children and sometimes they helped me…Sometimes* B^4_H *and sometimes* A_H *helped me. Both of*

[4] We remind the reader that the students referred to their group-mates by name and not by level. We attached the levels to their "names", according to the results of the end-of-year tracking test, to facilitate understanding.

them… And I helped N_L (and this helped him) *because I helped him and I began also – as if I'm explaining to myself.*

P_M: (The groups help since) *It helps more, that if you don't understand something, and the friend that is sitting next to you also doesn't understand, you also have many more friends that you can ask.* (I usually ask) *Tal*$_H$ *and Ad*$_H$*…I* (also) *help Mo*$_L$ – (and this helps P_M since) *I go over the material that I'm saying to her, that I'm explaining to her. I know it well every time I explain to her…*(She prefers learning in MA settings) *Because there, let's say there's the M-track, let's say I will be in the M-track, I think I'm an imbecile. But in the class when you learn together in the same group, and no one thinks that he is less good or better. 'Good' is the same measure* (for all). *And in tracks there is best, less good, and bad.* (And if she'll be in a lower track) *I'll say to myself, why did I try so hard and I didn't do well…And I won't feel good with myself".*

V_M: *"I don't like this whole business with tracks. If one doesn't understand something, if you put somebody next to him that knows that after 9 comes 10, then he goes and asks him. So he answers him and the boy knows, he learned. But if all the students in the class didn't know what number comes after 9, then simply they'll have a long time to understand, till the teacher will teach them all..* (She prefers) *The class will be with children of a higher level,* (and) *children of a lower level, so that children of a higher level can explain to children of a lower level. When you sit* N_H (a borderline H-student who was in V_M's group in both phases) *next to* Al_H *then she will progress and become like him".*

In the second interview, the L&Ms continued to unequivocally prefer to learn mathematics in MA settings. They now also expressed frustration for two main reasons: Firstly, because they were often (the Ls – almost always) unable to resolve their problems in their groups. Secondly, concerning the tracking that would occur in the eighth grade they were concerned that they might indeed be assigned to the lower tracks in the following year, that in the M-track they would be slowed down, and that they would feel inferior. However, if indeed tracking was unavoidable, their fervent desire was to learn in the H-track and they felt they were certainly capable of it.

P_M*: In the former group* (MA) *there were children that were cleverer…they were able to help more…and* (now) *I understand the material less…In the M-track* (in the eighth grade) *there are many children, let's say, that don't understand the material, so one progresses slower... I want to be in the H-track…If I will be in the M-track I will think that I'm not clever and things like that.*

<u>H-students' attitudes:</u> Of the 35 students interviewed, after the end-of-year "tracking" test, 18 were eventually assigned to the H-track in the eighth grade. In the first interview eight wanted to try tracks, eight preferred to continue learning in MA settings and two were ambivalent. In the second interview ten preferred tracks (8+2), one (2-1) remained ambivalent, and seven (8-1) preferred MA settings. Generally, these findings support those reported in the literature.

How did the processes of interaction influence their attitudes? During the first phase, all the Hs who wished to continue learning in MA classes spoke of how good it was learning in their groups: the cooperation, explaining to one another, learning through arguing - for instance- "*why they were mistaken rather than what the mistake was"*. Those Hs who preferred to try tracking spoke of how they – "*want to progress faster*", even though all were very happy learning in the MA groups, enjoyed the group-work and especially appreciated their opportunity of being able to help others as a means of improving their knowledge. Although they wanted to try tracks some were also concerned about tracking because of the pressure involved, such as learning high-level material at a rapid pace. They felt more secure learning with their homeroom classmates, and felt bad about the stigma of the lower-tracks. During the second phase, most of the attitudes seemed to have been reinforced by their experience in their tracks. However, those for MA, now spoke about the unhealthy competition between the H-students, about the fear of dropping from a higher to a lower track, of too rapid a pace of learning. Those who favored tracks emphasized the fact that in tracks one can progress faster.

It is interesting to note that, unlike reported literature findings, the experience of changing the learning settings from MA to tracks had little influence on students' attitudes: It seems that the change only reinforced their former attitudes. Both in the first and second phase, all L&Ms' preferred learning in MA settings. However, the Hs' attitudes were not uniform: both in the first and second phase, two stable groups could be identified, about half favoring tracks and the other half favoring MA settings. It was only when we saw and analyzed the tracking-tests' results, that we discovered that there was a strong correlation between the results of the H-tracks and their attitudes: The highest-achieving Hs preferred tracks, the lower-achieving Hs preferred MA settings. And indeed cognitive gains seemed to feature strongly in their reasons.

Only two students changed their attitudes with the change in settings, both highest-achievers. In the first phase, Al_H was extremely satisfied with the way they learned: *Liat* (teacher*) gives us freedom* (to progress as they wished)*… It was fun, everybody discussing and working together…All* (his group) *are really on the same level. Only at certain points, some have difficulties…*(When working with them) *I revise the material and I see that I understand it.* In the second phase Al_H now favors tracks: *I think I progress faster in the new group…I learn more, I can ask more, I have more time for myself…* (Although, he saw the benefits of the groups in the first phase) *It helped me. When I explain to others I see that I really understand…In this* (the second phase) *I don't explain so well…they already all understand…It's a pity…If I have* (next year) *someone in my group that I'll be able to help, it will be very good. He doesn't have to be weaker or stronger than me. If I have the opportunity* (to explain) *then I want to do it.*

It would be interesting to see what effect each track would have on these students' attitudes when learning in between-class tracking. In particular, whether the lower and highest Hs would still maintain their previous attitudes.

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