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Improving math scores through digitally hand written homework submission

Abstract

In this study we examined the impact of using an electronic pen in preparing homework on the Mathematics scores. We assumed that using an electronic pen would increase the amount of homework prepared by the experimental group (N=33) and their post-experimental scores, as opposed to the achievement of the control group (N=34), who prepared their homework with pen and paper, and submitted it in the usual way. Similarly, we assumed that the experimental group's average level of satisfaction from using the electronic pen would be significantly higher, and, accordingly, so would the group's care in performing the tasks assigned as homework.

Sixty-seven 11th and 12th grade high school students participated in the experiment. These students had failed in the basic Mathematics baccalaureate exam administered the previous year. They were candidates for a second examination the next time such an exam would be announced by the Ministry of Education.

We found that the amount of homework prepared and the average level of achievement in the post-experimental exam were significantly higher than those of the control group. We found that the degree of satisfaction on the part of those who used the electronic pen was on a good level. Similarly, it turned out that the use of the electronic pen was suitable to all students, and wasn't dependent on the individual's cognitive learning style.

Keywords: homework, electronic pen, Mathematics scores

Introduction

Various studies (Hitt, 2010) indicate that homework has a significant effect on the student's performance on Math examinations. Other studies point out that homework assigned in science and technology education needs to be focused and adapted to the individual student's level of knowledge, so that s/he will not avoid preparing it altogether (Trautwein, 2007). Studies also indicate that home is one of the factors influencing the efficacy of learning (Hodge, Richardson & York, 2009). However, despite the great importance attributed to the preparation of Math homework, and despite the great efforts made by schools in an attempt to convince the student of its importance, many teachers report that their students don't prepare their homework as they should.

In conversations with the high school students from the school in which this research was carried out, the students mentioned a number of reasons for their not preparing homework, as various studies report (Kohn, 2006). Among the reasons which were repeated often were: 1. There were many students in the class, and this frequently led to a lack of concentration, not to mention wild behavior, and the tumult at the end of the lesson, so that the students didn't have time to copy the assignment, not to mention writing down the material taught during that particular lesson. 2. The teachers' checking, correcting and commenting on the homework is often done in a shallow, perfunctory fashion, especially when it is done at the beginning of the lesson. For the most part, the examination of the homework consists of the teacher's writing down in his grade book the names of those who did their homework, and how much they did. The teacher's checking the homework in this way, without giving specific feedback regarding the material which was prepared, lowers the motivation to invest in the proper preparation of the homework assignments. 3. The long time that elapses between the submission of the homework and the student's receiving

it in return. The students believe that returning the homework, including the teacher's comments, in a short time after handing it in, would enable the student to make corrections as needed, and to learn from the process before going in to the next lesson. 4. The very large amount of homework they receive leads the students to give up on the idea of doing homework at all, when they see that doing homework will come at the expense of their leisure time. 5. There are times when a student needs help with his or her homework at a particular point in the week, but there isn't anyone around to give that help.

The points raised by the students encouraged us to examine whether the electronic pen could help improve the process of doing homework. In this study we sought to see if the amount of homework prepared and the level of achievement in the post-examination would be improved if the students had to prepare their homework directly on the computer with an electronic pen, and submit it as a digital file to their teacher, who would return it with comments via e-mail before the next lesson. We found that there is no significant difference between students who have different cognitive learning styles and the degree of satisfaction they derived from doing their homework with the aid of this technology, the amount of homework they prepared, and the amount of improvement in the post-experimental examination on which they were tested.

Literature Review

Research carried out in the last two decades sought an answer to the question of whether there is a positive correlation of some kind between preparing homework and achievement in learning. It seems that opinions are divided on that question to this very day (Doorn, Janssen & O'Brien, 2010). Hitt (2010) maintains, as did his predecessors (Turvey, 1986), that there is a positive correlation between preparing homework and educational achievement, but that the evidence could be found only in certain subject matters, and in specific circumstances. On the other hand, Trautwein (2007) found that the

great deal of time needed to prepare homework assignments detracts from the students' motivation to study and to improve their achievements. Cooper (1994), as well, found that homework generates pressure on the students which can produce conflicts with parents, and even have an averse effect on their health.

Despite the differences of opinion on the issue of homework, researchers and educators continue to believe that the preparation of homework is of great importance in complementing the teaching, which begins in the classroom. Subjects such as Mathematics and the sciences demand skills in performing calculations which are best learned and honed through doing homework (Gage, Pizer & Roth, 2002).

With the appearance of computerized learning and teaching environments, researchers began to seek differences between the various platforms, and their influences on the preparation of homework. Even though not all of the researchers found differences between preparing homework via the internet, and the traditional pen and paper style (Demirci, 2006), many found that digital platforms enjoyed a wide range of advantages over the traditional pen and paper (Stansfield, McLlellan & Connolly, 2004; Lei & Zhao, 2007; Hodge, Richardson & York, 2009). Nonetheless, researchers in other studies (Anthony, Yang & Koedinger, 2007; Anthony, 2008) found that actions involved in preparing homework, which require the use of a keyboard and mouse, create cognitive overload when compared with actions performed by hand, which are more natural. Among other results of these experiments, they found that there is a statistically significant advantage to writing by means of the keyboard, in that it increases the speed of the student's learning curve, lowers the cognitive burden, and improves the two-dimensional space orientation which Mathematics demands in order, for example, to understand graphs better.

These findings encouraged the researchers to look into the combined use of the

electronic pen with the traditional methods of doing homework (Plimmer & Mason, 2006; Anthony, Yang & Koedinger, 2008). They proved that there are a number of advantages to combining the methods (Siozos, et al., 2000; Zou, 2009). To the best of our knowledge, the research performed to date has overlooked other important issues, offshoots from the use of the electronic pen in preparing homework. In our review of the literature we found no references to issues such as how the use of the electronic pen in preparing Math homework affected the amount of homework done by high school students, influenced their achievements in examinations, and affected their degree of satisfaction with the technology. The current study was designed to provide answers to some of those questions.

Method

Variables

The following were the independent variables of our research: 1. The methods for preparing homework. 2. Time and 3. Cognitive Learning styles. The variable of method for preparing homework included two variables: a) preparing homework by using the electronic pen; and b) the use of pen and paper. The variable of Time included two variables: a) pre-exam and b) post-exam. The variable of learning styles included two variables: a) motoric and b) Combined audio-visual.

In this study we looked into 1. The participants' level of knowledge in computer usage. In other words, the degree to which the participants' homes are involved with the internet; the sum of the hours during which the computer is used at home during an average day, relative to the primary use of the computer at home; knowledge and use of email and tested use of the MS Office applications; 2. The amount of time devoted to preparing homework, relative to the measurement times between two research groups, and also between two learning styles; 3. The average difference in achievement in the post-examination test, under supervision of the pre-test when results are received allowing

comparison of pre-test results achieved by students who represent two learning styles; 4. The level of satisfaction with the use of recorded lessons by the participants of both experimental groups, according to the methods of preparing homework, as well as between the two learning styles; 5. The difference between the average level of satisfaction with the use of the electronic pen by participants from the experimental group, as well as the styles of learning in that group.

Participants

Sixty-seven high school students from a particular Israeli vocational high-school participated in our study; 58 boys (86.6%) and 9 girls (13.4%). Thirty-five students (52.2%) were from the eleventh grade, and 32 students (47.8%) from the twelfth grade. The students were divided at random into two groups, the experimental group receiving 33 participants, 17 of whom were eleventh graders, while 16 students were from the twelfth grades. There were 34 participants in the control groups, 22 from the eleventh grade, and 12 from the twelfth grade classes. Even though the participants were from two different grades, the Mathematics teachers were of the opinion that the students who participated in the research were on the same level of knowledge, where Mathematics was concerned. The students who participated in the research had failed the baccalaureate exam on the one-point level (out of 5) the previous year, and were candidates to repeat the one-point level exam the following year. The Israeli final exams' system in high schools is based on 5 levels in each subject matter. Each student can choose, based on his or her abilities, the level s/he studies and is tested on. In order to graduate they need to reach a total of 21 points taken from lists of required and elective subjects.

Instruments

We used five instruments in this study: 1. A questionnaire on computer literacy; 2. A questionnaire on learning styles; 3. Pre and post Mathematics exams; 4. A questionnaire on

the level of satisfaction after having used the electronic pen for preparing homework; and 5. A questionnaire for testing the level of satisfaction with using the system of recorded lessons for independent learning.

1. Questionnaire on computer literacy

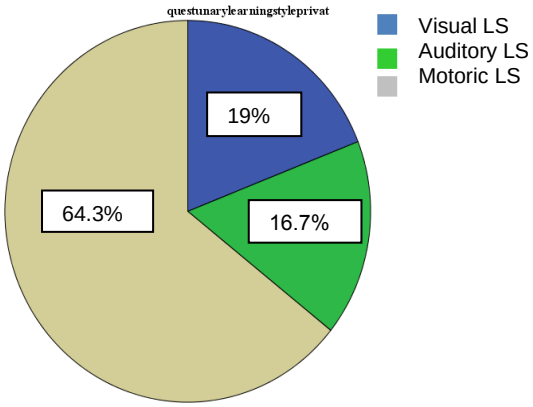
The goal of this questionnaire (Chin, Diehl & Norman, 1988) was to test the participants' level of elementary knowledge of their computer's applications. For example, knowledge of how to operate the MS Office in downloading files from their school's website and saving them on their computer; Use of the internet browser in order to access e-mail, as well as knowledge about how to manage emails. The questionnaire included 6 questions, and the answers were graded on a scale from 1-5, where 1 indicates the lowest level (not at all) and 5 indicates the highest level (to a very great extent). The reliability of the questionnaire was α=0.871. We did a free factor analysis (with an unlimited number of factors) of the Varimax type. The results of the factor analysis showed that the questionnaire about computer literacy has two factors. The first factor corresponds to knowledge in the use and operation of programs for carrying out computer applications. The second factor corresponds to knowledge in the use of features connected to the internet and email applications. The reliability of the first factor was α=0.915. It included a test of the participant's knowledge of MS Word, Power point, and Excel 2010. The reliability of the second factor was α=0.859. It included a test of the participant's knowledge of how to operate the Internet Explorer (IE), and knowledge of the uses of Gmail.

2. Questionnaire on learning styles (auditory, visual and motoric)

This questionnaire was designed to collect data on the learning styles of each of the participants in our study. Its purpose was to test our research assumption according to their learning styles (Conrath & Henderson, 2004). In addition, we hoped that this questionnaire would help us to see if the recorded lessons fit all the participants' learning styles.

The questionnaire was translated into the mother tongues of all the participants and was divided into three sections, appropriate to learning styles. While section A related to the visual learning style, B related to the auditory learning style, and C to the motoric learning style.

The reliability of the questionnaire, which included all of the learning styles together (visual, auditory and motoric) and was composed of 24 items (8 on each learning style) was α=0.829. The reliability of section A, which describes the factor of visual learning style, and which included eight statements, was α=0. 714. The reliability of section B, which describes the factor of audio learning style, and which included eight statements, was α=0.703. The reliability of section C, which describes the factor of motoric learning style, and which includes eight statements, was α=0.671. The distribution of learning styles among the participants who filled out the questionnaire (N=42) can be seen in Graph 1.



Graph 1. Distribution of learning styles in percentages of participants in the study (N = 42).

The number of participants who answered the learning styles questionnaire was relatively low, given the number of participants in the research (N=67). Most of them had a motoric learning style, while a minority had a visual or an auditory learning style. Despite that the N was just 67 participants, we didn't find a statistically significant difference in the relationship of one learning style from another (motoric, combined auditory and visual styles), regarding satisfaction with the recorded lessons.

3. Mathematics exams (Pre and Post)

The pre-Mathematics exam included the following subjects: Finding the values for points, calculating length of lines and calculating geometric shapes in graphs. The questions in the exams were taken from a Mathematics textbook used in the school's Mathematics classes, with which the students were familiar. Its use is authorized by the Ministry of Education. Each participant was required to answer four questions out of six, which were answered in the traditional way, *i.e.* with pen on paper. The questions on the exam received expert validation by Mathematics teachers from the high school. This exam was designed to see if the participants' achievements in both groups involved in the experiment were similar prior to the intervention. The results showed that there was no significant difference between the results of the experimental group and those of the control group in the average level of achievements in the pre-test: $t_{(65)} = .221$, $P > .05$.

The post-examination, which was administered at the end of the intervention, included material which was learned in class. The student had to answer 4 questions out of 6. The questions were taken from a Math textbook and received expert validation by Mathematics teachers from the high school.

In a unidirectional ANCOVA analysis while controlling the pre-examination, we found that there was a significant difference among the research groups with regards to the average achievements in the post-exam. We found that the average achievement in the post-examination of the participants in the experimental group was significantly higher than the average achievements of the control group.

4. Questionnaire on the degree of satisfaction with the use of the electronic pen

After the post-exam, the participants in the experimental group responded to a questionnaire about the degree of satisfaction they felt in using the electronic pen while preparing their homework. The questionnaire was taken from a collection of standard

satisfaction-related questionnaires (Perlman, 2009). The original questionnaire, known as Quis 5 (Chin, Diehl & Norman, 1988) was designed to test the level of satisfaction obtained from the use of human computer interfaces, and was divided into 5 factors: 1) General satisfaction with the use of the interface; 2) Satisfaction with the screen [the order in which the information is presented on the screen and the ease of navigating one's way through the information which appears on the screen]; 3) Satisfaction with the terms and knowledge connected to the activity done with the interface, from the explanations and from the help available to the user; 4) Satisfaction with the ease with which a student can learn to operate the system; 5) Satisfaction with the abilities which one can acquire from the interface. The questionnaire included 27 questions, each one of which may be ranked from 0 to 9, where 0 indicates the lowest level of satisfaction, and 9 indicates the highest level of satisfaction.

The questionnaire was designed so that one could choose the aspects appropriate to the interface one is testing. We decided to use three of the five aspects in testing the satisfaction level regarding the use of the electronic pen. The first aspect was general satisfaction with the use of the electronic pen as a tool for preparing homework (Questions 37-43). The second aspect was satisfaction with the abilities stemming from the use of the electronic pen (Q: 51-53). The third aspect was satisfaction with the process of learning to use the electronic pen for doing homework (Q: 57-59). The reliability of the three aspects of the questionnaire was α=0.98.

In order to test the level of satisfaction with the use of email we chose two aspects from the Quis 5 questionnaire: 1) The general satisfaction with the use of e-mail as a medium for sending and receiving homework after having it checked (Q: 44-50), and 2) satisfaction with the abilities stemming from the use of e-mail (Q: 54-56). The reliability of the questionnaire's two parts was α=0.982.

5. Questionnaire on the degree of satisfaction with the use of recorded lessons

This questionnaire was taken from the satisfaction questionnaire designed to test satisfaction with the use of various media in teaching (Kleen, Shell & Zachry, 2002). The original questionnaire was divided into five sections: reliability, responsiveness, security, empathy, and concreteness. The reliability of the questionnaire is α=0.951.

Procedure

In order to study the participants' learning process while submitting homework with an electronic pen, we recorded the topics taught in class and uploaded the videos together with the corresponding PowerPoint slides to the school's website. Alongside the recorded lessons, we presented the assignments which the students were supposed to do at home following each lesson. We recorded the lessons taught in class to enable the students, who for any reasons could not follow the class, go over the materials again at home, or to refresh the memory before they sat down to prepare their homework.

For this purpose, we prepared 11 chapters on topics about which the participants would be tested in the post-experimental exam. Prior to the beginning of the study, the students received explanations on the research goals and on the process which would accompany it. Throughout the study, all the students who participated in the research, in both the experimental and control groups learned the 11 study chapters together, in the same lecture hall.

After both groups filled out the personal data questionnaire, the computer literacy and the learning style questionnaires, the experimental group received instruction in operating the electronic pen, and each participant received a pen for use in preparing his/her homework. The students, thereafter, received instruction on how to send their completed homework via email to their teacher. They were also trained to access the feedback by opening the PDF file which the teacher sent to their personal email addresses.

Before beginning the intervention, all the students took the pre-examination test.

At the end of the 11 weeks, during which the participants learned one topic per week of the topics chosen for this study, they took the post-experimental examination. After finishing the exam, the students in the experimental group responded to the question on satisfaction with the use of the electronic pen as a tool for doing homework, and its use with email as a way of submitting homework and receiving the homework, corrected by the teacher, in return.

Results

Amount of homework

In order to test if there was a difference between the points of measurement (pre and post intervention), in the amounts of homework preparation and submission among the experimental and control groups, we conducted a two–directional variance analysis. We found that there was a statistically significant difference in the amount of preparation of the homework assignments. We found that there was a significant difference in the results achieved by the participants in the experimental group from the results achieved by the participants in the control group: $F_{(1,65)}=15.589_{(1,65)}$, $P<.001$ $\eta^2=.193$ (Table 1).

Research group	N	M	SD
Experimental group	33	1.865	2.286
Control group	34	.72	1.9665

Table 1. Averages and standard deviations of the quantity of homework prepared by the experimental and control groups.

In addition, we found that there was a statistically significant interaction between the research groups, relative to the time at which the quantity of homework was measured: $F_{(1,65)}=5.080_{(1,65)}$, $P<.001$ $\eta^2=.072$.

In order to examine the source of the interaction, we performed a separate, one-

directional repeated measurement variance analysis for each research group. We found that even though among the participants in the experimental group, the average quantity of homework prepared before the intervention was not significantly different from the average quantity of homework prepared by the participants in the control group: $t_{(65)}$=1.612, P>.05, on the other hand, at the end of the intervention, the average quantity of homework prepared by the participants in the experimental group was significantly higher than the quantity of homework prepared by the participants in the control group: $t_{(65)}$=3.157, P>.01 (Table 2).

Measurement times	Research groups	N	M	SD
Beginning of research	Experimental	33	0.82	1.357
	Control	34	0.35	0.981
End of Research	Experimental	33	2.91	2.376
	Control	34	1.09	1.815

Table 2. Averages and standard deviation of the quantity of homework, by research groups and times of measurement.

Pre-examination

In order to test if there was a difference between the experimental and control groups in the pre-examination average, we performed a *t* test for independent samples. We found that there was no significant difference between the experimental and control groups on the average level of achievement on the pre-examination: $t_{(65)}$ =.221, P>.05.

Post-examination

In order to test if there were differences between the groups on the average score in the post-examination, while bearing in mind (supervising) the pre-examination variable, we conducted a one-directional ANCOVA variance analysis. The result indicated that there is a significant difference between the groups: $F_{(1,64)}$=19.226, P<.001 η^2=0.231. On pursuing the analysis with the Bonferrony-correction (Dunn, 1961), we found that the average achievements in the post-examination of the experimental group were significantly

higher than the average achievements of the control group (Table 3). We found that the supervised pre-examination variable was not significant in the analysis: $F_{(1,64)}=2.09$, $P<.05$ $\eta^2=0.032$. In Table 3 one can see the average post-examination scores of the participants in our study.

Research group	N	M	SD	M Estimated
Experimental	33	62.969	13.75	62.91
Control	34	49.735	10.79	49.794

Table 3. Averages, standard deviations, and estimated averages of the level of achievements of the post-examination

Satisfaction with the use of the electronic pen

In order to determine the level of satisfaction derived from using an electronic pen for preparing homework, we calculated the central tendency measurement analysis in the satisfaction questionnaire. The questionnaire included 13 questions on a scale of 0-9 that were divided into three factors: a) general satisfaction from using the electronic pen for doing one's homework, b) satisfaction with the abilities inherent in using the pen, and 3) satisfaction with learning how to use the pen. The comprehensive average of the three factors was M = 5.943 (SD=2.4139). This result supported the hypothesis that general satisfaction from using the electronic pen for preparing homework was on a reasonable level.

We also administered a questionnaire on satisfaction with the use of e-mail. We carried out a central tendency measurement analysis. It contained 10 questions on a scale of 0-9 and included two satisfaction factors. One general satisfaction factor was with regard to the use of e-mail, and the second one was with regard to the existing features in e-mail, including being able to send completed homework to the teacher, and to receive it quickly in return, with the teacher's comments. The central tendency measurement analysis of both factors indicated that the satisfaction was M = 6.0395 (SD = 2.441), which was

high.

Satisfaction with the use of recorded lessons

The results indicate that there were no significant statistical differences between the two research groups on the average level of satisfaction with the use of recorded lessons. Moreover, the results show a high degree of satisfaction with recorded lessons. These results support studies that claim that it is worthwhile to develop recorded lessons in Mathematics (Glover, et. al., 2007).

Satisfaction and learning styles

As stated above, we were also interested in testing whether there is a correlation between learning styles and satisfaction with the use of the electronic pen and from recorded lessons in teaching Mathematics. The results demonstrate that even though there wasn't a significant difference in the general level of satisfaction from the recorded lessons by students who have the different learning styles we tested – motoric, and auditory mixed with visual – our findings show that students with a motoric learning style were satisfied with the recorded lessons to the same extent as those who had auditory-visual learning styles.

Quantity of homework and examinations

Our results indicate that before the intervention there were no statistically significant positive connections between the amounts of homework prepared before the pre-examination in either of the two groups. However, after the intervention, it turned out that a moderate, statistically significant correlation was formed among the participants in the control group, while among the participants in the experimental group, who used the electronic pen, a strong, positive, and statistically significant correlation was formed between the amount of homework done and the achievements in the post-examination, just as other studies had found (Anthony, Yang & Koedinger, 2007; Van Schaack, 2009).

Quantity of homework and learning styles

Another point of interest which stood out from the analysis of the results was that there was no significant difference between participants who had a motoric learning style and those who had a combined audio-visual learning style, as to the amount of preparation which went into doing their homework assignments. This was true on a one-to-one basis and also between them and every other research group separately. At the same time, it is important to note that the amount of homework prepared by the participants of the experimental group with the two learning styles was significantly higher after the intervention than was the case with the participants of the control group with two learning styles.

Learning styles and post-examination achievements

The results also show that the average achievements among the participants in the experimental group with two learning styles in the post-examination, while supervised with the pre-examination, were not significantly higher than those of the control group who also had two learning styles.

Learning styles and satisfaction

We wanted to know, as well, if among the participants in the experimental group there would be a difference in the average level of satisfaction with using an electronic pen for preparing their homework and with using email for returning it based on their learning styles.

As regards the electronic pen, from the results of the analyses of the three factors of satisfaction, taken separately (in general, from the features, and from learning how to operate the pen) and from the results including the three factors of the questionnaire altogether, it turns out that there was no statistically significant difference between the participants who had a motoric learning style and the participants who had a combined

learning style. The averaged results indicate that satisfaction with the use of the electronic pen for preparing homework was on a good level for the two learning styles.

As regards e-mail, from the results of the separate analyses of the two factors of satisfaction (general, abilities) and from the results including the two factors of the questionnaire altogether, it turns out that there was no significant difference in satisfaction between the participants who had the motoric learning style and the participants who had the audio-visual learning style. The averaged results point to the conclusion that satisfaction was on a good level for the two learning styles.

Discussion

The possibilities inherent in the electronic pen as a flexible, convenient, ergonometric and relatively inexpensive interface, motivated researchers to test its efficacy and its use in various settings. They examined the differences (Marshall & Scharff, 2009; Zou, 2009) in the performance of diverse kinds of writing (Nagai & Kitazawa, 2010), some of which were even in parallel with traditional writing implements such as pen and paper (Hofacker & Ernie, 2009). However, the research to date, to the best of our knowledge, did not address the influence of the electronic pen on the amount of homework or on the level of academic achievements in various subjects. For that reason, the goal of the present study was to test the use of the electronic pen and its effects on the quantity of homework in Mathematics that the students would prepare, and on the level of achievement which they would reach in doing so.

As we pointed out, the variance analyses we performed indicated that prior to the intervention, there was no statistically significant difference in the average quantity of homework prepared by participants in the experimental, vis-a-vis the control groups (who used traditional means to prepare their homework). However, after the intervention, the results point out that there is a statistically significant difference between the amounts of

homework prepared by the participants in the two research groups. We found that the average quantity of time used for the preparation and submission of the homework assignment for the experimental group was significantly higher (M = 2.91) than the average (M = 1.09) in the control group.

This result corroborates other research results which were published recently. For example, some (Hodge, Richardson & York, 2009) found that the use of the internet as an online tool for preparing homework can play an important role in motivating the student to finish his homework assignments. In our research, as well, we found that the degree of satisfaction on the part of the experimental group was significantly high. It seems that the experience of the participants in the experimental group in learning how to prepare homework in a digital format, sending and receiving their corrected work faster than in the past, increased their motivation to do more homework in comparison with the control group. This result reflects others' observation (Plimmer & Mason, 2006) that when no one checks the students' homework assignments, they tend to be disappointed and their motivation is diminished. It would seem that the teacher's checking of the homework is a crucial phase in the educational process, one which signals to the students that the teacher takes seriously their work at home.

It is possible that the factor that brought about the improvement in the post-examination achievement on the part of participants in the experimental group in this study is in motivation itself, even though opinions are divided in the literature as to the role which homework plays on the level of achievements in exams. In the nineteen-eighties (Turvey, 1986), the common opinion was that there are positive and statistically significant correlations between the preparation of homework and achievement in studies. There are some (Cooper, 1989, 1994) who also found that homework had a significantly positive influence on achievements of high school students. In the last few years, however, the pendulum seems to have changed direction. In an analysis published by TIMSS

(Trends in International Mathematics and Science Study), it was found (Kohn, 2006) that there is no correlation between the quantity of homework which the students prepared and their achievements on the TIMSS scores. Moreover, the TIMSS scores indicate that there exists a negative connection among the two variables.

In our opinion, the improvement in the achievements we observed in the post-exam in this study came as the result of the use of the electronic pen, probably because this is what raised the students' level of motivation to prepare their homework, as was also observed. It could be that Kohn's (2006) opposite findings derive from the fact that their motivation dropped to the point that it did not affect their achievements, and worse, it affected their achievement in a negative way. We may add that it is possible that lower TIMSS scores was the result of overburdening in the assigning of homework. This may have led the students to develop a lack of patience with, and negative motivation toward succeeding in those exams. A similar claim was raised by Trautwein (2007), who asserted that the very large amount of time needed by students in order to prepare their homework lessens their motivation to engage in preparing them and is what put cognitive pressure on them, and inflames tension with their family and friends.

In the current study, nonetheless, the electronic pen contributed to increased motivation, and that contributed to achievements, even though the amount of homework which the participants were required to do was not larger than the amount which participants from the control group were required to prepare.

One may also connect a number of other factors with motivation: learning styles, the use of the electronic pen, the improvement in the quantity of homework, and an increase in the grades on exams. In the present study, we did not find differences between the two kinds of learning styles and the level of motivation in using the electronic pen. This result is supported by a comprehensive study conducted recently (Speak Up Survey, 2012), in

which learning patterns with digital instruments of more than 416,000 students were analyzed. It was found that the digital instruments in education stimulate the development of personal learning styles. The authors of the study also looked into the question of how communication via email, the social networks, chats, and the use of digital files make personal education more effective. They found that the intensive use of digital means of communication motivates the students to set higher personal study goals, which leads to their wanting to advance their performance in examinations. In our humble opinion, our study too indicates that the electronic pen used in preparing and submitting homework better motivated the majority of the students to succeed, and in that way, has contributed to higher scores in their examinations.

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