ISSN: 1305-8223

E U R A S I A

Journal of Mathematics, Science and Technology Education

www.ejmste.com
December 2006
Volume: 2, Number:3

MOMENT

E U R A S I A
Journal of Mathematics, Science and Technology Education
Volume 2, Number 3, December 2006

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This journal is abstracted or indexed in
- EBSCO
- SCOPUS
- Cabell's Directory Index
- Higher Education Teaching and Learning Journals
- Index Copernicus
- Higher Education Research Data Collection (HERDC)
- MathDi and EdNA Online Database.

Published by:
MOMENT
Kazim Karabekir Cad.
Murat Carsisi 39/103
Altindag - Iskitler
Ankara - TURKEY

ISSN 1305 - 8223
www.ejmste.com

E U R A S I A
Journal of Mathematics, Science and Technology Education
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Eurasia Journal of Mathematics, Science and Technology Education

Volume 2, Number 3, December 2006

COMPUTER ATTITUDE, USE, EXPERIENCE, SOFTWARE FAMILIARITY AND PERCEIVED PEDAGOGICAL USEFULNESS: THE CASE OF MATHEMATICS PROFESSORS

Balarabe Yushau

ABSTRACT. As the pedagogical-effectiveness of information technology (IT) in mathematics education is carefully established the topic of discourse among mathematicians and mathematics educators is no longer a dispute about whether or not to use IT in the teaching and learning of mathematics but a shift to some debate about the when and how of its usage. Under this dispensation, both researchers and educators have emphasized the role that teachers' attitudes toward information technology play as a crucial factor in the successful use of computers in the teaching and learning of mathematics. In this paper, we seek to study and examine the attitude of mathematics professors toward computers. In addition, the paper also investigates the effects of age and computer experience on computer attitude, usage, software familiarity, and perceived pedagogical usefulness. The broader perspective of the paper has drawn its input from more than fifty five percent (55%) of the mathematical sciences faculty of King Fahd University of Petroleum & Minerals who participated in a survey conducted as feedback for the paper. Measurement tools deployed in this regard were a slightly modified Computer Attitude Scale (CAS) by Loyd and Gressard (1984), and the Pedagogical Use (PU) unit of the Computer Attitude Scale for Teachers (CAST) by Yuen and Ma (2001). The acquired data was analyzed using an analysis of variance (ANOVA). Although both ANOVA and Duncan multiple comparison revealed that Age and computer experience did not affect attitudes towards computers and their pedagogical usefulness, the raw data nonetheless does show some trend towards that. From the result, one can conclude that mathematics professors not only have positive attitude towards computers, but seems convinced of the positive role that computers can play in the teaching and learning of mathematics. The only aggravating factor is the technical know-how and concomitant experience that are essential in guiding pedagogical activities towards effective and proper utilization of these technologies.

KEYWORDS. Computer Attitudes, Computer Use, Computer Experience, Computer Usefulness, Mathematics, Software Familiarity, Mathematics Professors.

INTRODUCTION

In the industrial and consumer societies of the world, micro-chip technology is rapidly becoming all-pervasive; wherever one looks one finds more and more examples of its applications. In daily life microtechnology is something one uses, it is a tool for achieving ones objectives more quickly, more cheaply or more efficiently. It even facilitates things which, ten years ago, would have been considered impossible. Such developments must be reflected in our schools (Blease, 1986:3).

ISSN: 1305-8223

Computers have been used in education for more than four decades, and they have now been accepted "unconditionally" as an integral part of our entire educational system. The increase in computer use is rapid and has also generated new challenges. Perhaps more than other fields, mathematics as a subject is thought to have benefited and established a stronger intrinsic link with the development of computers in recent times. Nonetheless, Kadijevich (2002) has identified four issues as critical to proper and effective use of computer technologies in the mathematics classroom. Top among them is computer attitude, followed by software selection, a proper utilization direction, and Web-based professional development of mathematics teachers. Similarly, in his meta-analysis of the factors that are instrumental in promoting the use of computer aided learning, Griffin (1988) found that teacher attitude towards computers is an important factor related to the teacher's role towards the effective use of computers in education. Indeed, previous correlation studies have long forecasted that the use of computers in education would very much depend on how well teachers integrate them in everyday activities. And therefore, the question of teacher attitude toward computers is central to any successful use of computers in education (Loyd & Loyd, 1985; Kluever, Lam, Hoffman, Green, & Swearingen, 1994; Yuen & Ma, 2001). However, despite the attitudinal factor identified above, Yuen & Ma (2001) have noted that very little attention has been given to this factor in actual teaching practice. Not unlike any other innovation, teachers initially resisted the use of computers in education. As a matter of fact, the term "computerphobia" and "computer anxiety" were coined and entered in the literature vocabulary due to teacher (not student) resistance to computer use. The causes of this resistance according to Nickerson (1981) are not unconnected with feelings of stupidity, fear of obsolescence, fear of the unfamiliar, and the thought that computers have a dehumanizing effect.

Studies have shown that computer anxiety, lack of confidence, and lack of enjoyment influence both the acceptance of computers and their use as a teaching and learning tool (Gressard & Loyd, 1986; Smith & Kotrlik, 1990; Woodrow, 1991; Fletcher & Deeds, 1994). The need to therefore disabuse the minds of teachers from such fears and replace these misconceptions with confidence building measures is ever more paramount. In this regard, computer ownership and computer experience are two very important and interrelated factors that can help in mitigating fear and anxiety about computers from the minds of mathematics teachers and help to develop their confidence. With computer ownership, the teacher is guaranteed total access and freedom to experiment with the use of a computer as the machine tool that it is. With ownership, there then comes the reciprocal relationship of computer experience that provides the technical-know-how and the intellectual ability to manipulate and discover the pedagogical power of the machine. The importance of these two facts has been echoed and reiterated in many studies that encapsulate the argument about the effectiveness of computer use in teaching. Loyd and Gressard (1984b) have put it more succinctly:

> it is becoming increasingly evident that familiarity with computers and the ability to use them effectively will be of critical importance to success in many different fields. Computer experience is therefore gaining wide recognition as crucial component of the educational process (Loyd and Gressard,1984b, p.67).

It has been noted that, due to the lack of training and experience, "even when computers are available, mathematics teachers rarely use them in their educational practice" (Kadijevich, 2002). Limited computer experience has been found to be a factor that influences anxiety (Gressard & Loyd, 1986). Lack of training and experience is also believed to be, in part, the reason why many teachers have not been well-disposed to computers and consequently deprived of their usefulness in the classroom (c.f. Collins, 1996). Once computer-trained, teachers with computer experience will be less inclined to doubt the usefulness of the computer in their classroom. Thus the perceived usefulness of computers does clearly influence attitudes toward computers, and the amount of confidence a teacher possesses in using computers also influences the implementation of acquired skills in the classroom (Bandura, 1977; Gressard & Loyd, 1986; Yuen & Ma, 2001). The forgoing underlines the calls often made for personal education in computer technology, and promoting computer literacy for both learners and instructors within educational institutions (Jay, 1981). Some studies have investigated the relationships between computer attitude, age and experience but findings have been contradictory (Gressard & Loyd, 1984b; Loyd & Loyd, 1985; Pope-Davis & Twing, 1991). However, there has been little information related to mathematics professors, especially with regard to their computer experience, frequency of computer use, software familiarity, and perceived pedagogical usefulness of the computers in mathematics teaching and learning. This study aims at providing insight in that direction. The paper is divided into four parts. After the introduction in the first part, the second part discusses the research methodology, while the third part will carry an analysis of the results followed by some discussion and, finally, the concluding remarks together with the summary and recommendations.

METHODOLOGY

Sample

The data of this study was collected from 41 of 72 faculty members of the Mathematics Department at King Fahd University of Petroleum & Minerals. The age ranges of the participants are summarized in the following table:

Table 1. Age Ranges of the Participants

Age Ranges	Frequency
23 -30	5
31 – 40	7
41 – 50	11
51 -55	16
More than 55	2
Total	**41**

Instruments

The two instruments used in this study were Computer Attitude Scale (CAS) by Loyd and Gressard (1984a), and the modification of the pedagogical usefulness (PU) unit of the Computer Attitude Scale for Teachers (CAST) by Yuen and Ma (2001). The former aimed at assessing general attitude towards computers, and the later aimed at assessing teachers' perception of the usefulness of computers particularly in the teaching and learning processes (Yuen & Ma, 2001).

CAS consists of four subscales: Computer Anxiety, Computer Confidence, Computer Usefulness, and Computer Liking. The aim of the *computer anxiety* subscale is to asses the fear while dealing with computers, while that of *computer confidence* is to asses the confidence in the ability of dealing with computers. *Computer liking* subscale assesses the enjoyment of dealing with computers, and *computer usefulness* assesses the perception of the proliferation of computers on future jobs. All the questions present statements of attitude towards computers and their use. The reliability coefficient for these subscales was found to be .90, .89, .89, and .82 for Computer Anxiety, Computer Confidence, Computer Liking, and Computer Usefulness subscales, while the total score was estimated as .95 (Loyd & Loyd, 1985). Subsequent studies have yielded similarly high internal consistency scores (Nash & Moroz, 1997).

On the other hand, Computer Attitude Scale for Teachers (CAST) by Yuen & Ma (2001) was partially adopted from Selweyn (1997). The scale consists of four factors: Affective Attitude (AA), Behavioral Control (BC), General Usefulness (GU), and Pedagogical Use (PU). However, in this study only the Pedagogical Usefulness subscale was used, even that, most of the questions were modified and some localized to mathematics. According to Yuen and Ma (2001) the "standardized coefficient beta is 0.044 and was not alone statistically significant directly to the overall usage".

Apart from the above two scales, other questions included in this study are that of:

1. *Computer Experience*. The participants were asked about their experience with

learning about or working with computers with five ranges: 1 year or less, 2 – 3 years, 3 – 4 years, 4 – 5 years, and more than five years.

2. *The frequency of computer use*. Here the choices are: everyday, a few times a week, a few times a month, a few times a year, and not at all.

3. *The purpose of computer use*: Here the choices are: e-mail, Internet, word processing and spreadsheets, programming, and other research purposes.

4. *Frequency of computer use in teaching*. The question is how often they use computers in preparing for their lessons, and how often they give their students homework/assignments that will require the use of computers. The ranges are: every week, a few times in each semester, sometimes in some semesters, and never.

5. *Familiarity with frequently used software such as*: word processors (e.g. MS word, LaTEX, etc), spreadsheet and statistical packages (e.g. MS Excel), Presentation programs (e.g. PowerPoint), computer algebra systems (e.g. Mathematica, Matlab, Maple etc), programming languages (Fortran, C, C++, Java etc.), and Internet design software (e.g. FrontPage). The ranges here were: excellent, good, average, poor, and very poor. Also, the respondents were asked to indicate for which of these programs they would like to have more training for the enhancement of their research.

Procedures

Participants in the present study were given the questionnaire at the beginning of the semester, and were given two weeks to return. After collection, the data was analyzed using the statistical packages SAS and SPSS. The level of statistical significance (alpha level) was set at .05.

RESULTS AND DISCUSSION

The results of this study are summarized below followed by some discussion:

1. Summary of the Attitude Results

Both the Computer Attitude Scale (CAS) and Pedagogical Use (PU) subscale are Likert - type instruments. The former consists of forty items with each subscale consisting of ten questions, while the later consists of six items. The participants indicate the degree to which they agree with the statement on a four-point scale, with “agree strongly” on one end and “disagree strongly” on the other. Each response is given a value of 1 to 4, with 4 indicating a more positive attitude towards computers.

Table 2. Summary of the means and standard deviation of the subscales

Subscale	Mean	Standard Deviation
Computer Anxiety	35.39	4.15
Computer Confidence	34.93	4.89
Computer Liking	31.63	4.76
Computer Usefulness	33.41	4.05
Pedagogical Usefulness	19.17	3.85

It is worth noting that the participant that answered all the questions has a maximum score of 40 and a minimum of 10 score for each subscale and maximum of 24 and minimum of 6 for PU subscale. Participant with attitude score of 25 and above in each subscale of CAS and 15 and above in PU are considered to have positive attitude. Therefore, in general, the results of this study suggest that mathematics professors at King Fahd University of Petroleum & Minerals (KFUPM) have fairly positive attitudes toward computers (see Table 2). This is consistent with the results of other similar studies carried out with teachers and educators (see Loyd & Loyd, 1985; Gressard & Loyd, 1986; Park & Gamon, 1995; Robb, 1996; Nash & Moroz, 1997; Yuen & Ma, 2001).

In particular, the attitude of the teachers towards the pedagogical usefulness of computers is far above average with a mean more than 19 out of 24. This is an indication that the perception of the professor toward computer is more of a positive tool that can enhance teaching and learning process. However, as the results below indicate, the professors have difficulty in putting this positive perception into practice (See Table 6 and 8).

2. Computer Experience

In terms of years of use and working experience with computers, the results show that most of the mathematics faculty at KFUPM (over 80% of the respondents) has been using computers for more than five years. No participant indicated having computer experience of less than 3 years (see Table 3). Contrast this with Loyd and Gressard (1986) who derived experience values as: (a) none, (b) less than six months, (c) six months to one year, and (d) more than one year. With this range, Loyd and Gressard found a link between experience and computer anxiety. That is to say, teachers with more than one year of experience were significantly less anxious than those with less experience.

Table 3. Number of years of working with computers

Year of Experience	Number	Percentage
1 year or less	0	0%
2 – 3 years	0	0%
3 – 4 years	3	7%
4 – 5 years	4	10%
More than 5 years	34	83%
Total	41	100%

Therefore, the lack of computer anxiety shown by the mathematics faculty in this study may be associated with their years of experience in working with computers. More than 80% of the participants indicated having more than five years of experience in working with computers.

3. Frequency of Computer Use

The frequency of computer use, Table 4, shows that 99% of the faculty use computers every day in one way or another. This shows how pervasive the use of computer has become in our daily, personal, and professional life and, therefore, “such developments must be reflected in our schools" (Blease, 1986:3). This is more so if we take the cognizance that our students will soon graduate and join the workforce.

Table 4. Frequency of computer use

Frequency of computer use	Number	Percentage
Everyday	40	99%
A Few times a week	1	1%
A Few times a months	0	0%
A Few times a year	0	0%
Not at all	0	0%
Total	41	100%

4. The Purpose of Computer Use

Here respondents were allowed to make more than one choice.

Table 5 shows how intensively the faculty use computers for e-mail communication and Internet surfing. More than 95% of the faculty use computers for e-mail or Internet purposes. More than 60% use computers for word-processing and other research purposes. Programming takes the smallest factor with 46%, and this is understandable since only a few faculty members, who work in the area of numerical analysis and applied mathematics, use some programming in their work.

Table 5. The Purpose of Computer Use

Area of computer use	Number	Percentage
E-mails	41	100%
Internet	39	95%
Word processing & spreadsheet	32	78%
Other research purposes	25	61%
Programming	19	46%

5. Frequency of the Use of Computers in Teaching

In terms of computer use in teaching, the results in Tables 6 show that less than 40% of the faculty use computers in teaching on a weekly basis. It is important to note that this result includes the instructors of Math 001 and 002 and Stat 319, in which the weekly computer lab period is almost compulsory. This means that in the bulk of other courses that most of the engineering students are required to take, such as the calculus series, very few faculty use computers in teaching. This seems to be a common phenomenon (see, for example, Manoucherhri, 1999).

Table 6. Frequency of Computer Use in Teaching

Every week	16	39%
Few times each semester	8	20%
Sometimes in some semester	13	32%
Not at all	2	5%
Total	**39**	**96%**

As noted earlier, the result of this study coincides with the Kadijevich's (2002) observation that "even when computers are available, mathematics teachers rarely use them in their educational practice". The reason for this lukewarm attitude according to Kadijevich is "because they do not have (enough) knowledge and skills related to what and how can be achieved by using these tools (Manoucherhri, 1999)". Therefore, to change the present practice, we need to innovate, promptly yet thoughtfully, both pre-service and in-service professional development for mathematics teachers (Kadijevich, 2002). Some other factors identified as the major reasons for the reluctance of teachers to integrate computers into their teaching include: teacher perception of the computer as an efficacy of the change, lack of a curricular imperative for this (Heywood & Norman, 1988) i.e. teachers need to see the reason behind any changes in their teaching methods (Robb, 1996, Fullan, 1982). Other reasons include: lack of time, tight schedules, too much material to be covered, a rigid syllabus to be followed, lack of knowledge of how to use computers in teaching, and possibly faculty perception of computers as being a tool for communication, information, and research only, and not as a teaching and learning tool. The data in Table 6 shows how intensively the mathematics faculty use computers on a daily basis. In fact, the trend is indicating that our students today will live and work in an era dominated by computers, by worldwide communication, and by a global economy. Therefore, to have students adequately prepared for these challenges, computer-based technology should be routinely used at schools and universities (Steen, 1989; Pelton & Pelton, 1998), especially in mathematics classes.

6. Frequency of Use of Computers in Preparation for Teaching

Table 7. Frequency of Computer Use in Preparing for Teaching

Every week	22	54%
A few times each semester	10	24%
Sometimes in some semester	9	22%
Not at all	0	0%
Total	**41**	**100%**

This also shows how useful computers are in helping the preparation and organization of lectures in one way or another.

7. Frequency of Work Assigned to Students Requiring Computer Usage

Table 8. Frequency of Work Assigned to Students Requiring Computer Usage

Every week	3	7%
A Few times each semester	8	17%
Sometimes in some semesters	15	37%
Not at all	12	32%
Total	**39**	**93%**

Although only 50% of the faculty use computers a few times each semester in their teaching (Table 6), more than 60% of faculty members do not give students any assignment or homework that will require the use of computers in **most** of the semesters. Contrast this with the fact that 100% of the faculty use computers almost daily for their personal and professional work (see Table 6). Even for teaching preparation, whatever that means, almost 80% of the faculty use computers a few times each semester. One could not agree more with Blease (1986) in that “such developments must be reflected in our school" (p.3).

8. Software Familiarity

In the area of software familiarity, Table 9 indicates that more than 80% of the mathematics faculty is at least good in word-processing, which is the most commonly used software for writing memos, exams, and most journal publications. Similarly, more than 60% indicate that they are at least good at spreadsheet & statistical packages, 50% at computer algebra system, and 40% with programming languages such as Fortran, C, C++, Java, etc.

Table 9. Familiarity with frequently used Software

Software	Level of familiarity					Number of people that need further training in:
	Excellent	Good	Average	Poor	Very Poor	
Word processors (MS word, Tex, Scientific Work place, LaTEX, etc.)	14 (34%)	22 (54%)	4 (10%)	1 (2%)	0 (0%)	15 (37%)
Spreadsheet & Statistical packages (MS Excel, Statistica, SPSS, etc.)	11 (27%)	15 (37%)	9 (22%)	4 (10%)	2 (5%)	12 (29%)
Presentation programs (PowerPoint, etc.)	8 (20%)	13 (32%)	5 (12%)	7 (17%)	8 (20%)	21 (51%)
Internet design programs (FrontPage, etc.)	1 (2%)	10 (24%)	13 (32%)	5 (12%)	12 (29%)	25 (61%)
Computer Algebra System (Mathematica, Maple, Matlab, MathCAD, etc.)	5 (12%)	17 (41%)	9 (22%)	7 (17%)	2 (5%)	22 (54%)
Programing Language (Fortran, C, C++, Java, etc.)	5 (12%)	15 (37%)	8 (20%)	9 (22%)	4 (10%)	15 (37%)

However, only 20% indicated that they are good at Internet design programs (e.g. FrontPage, etc.), while 60% indicated that they are familiar, on average, with presentation programs like PowerPoint. The results also show that mathematics professors have shown interest in undergoing more training in almost all software areas in order to update their knowledge. Internet design software carried the highest number of volunteers with 60%, followed by computer algebra systems 54%, presentation programs (PowerPoint, etc.) 51%, programming and word processing with 37%, and spreadsheet & statistical packages with 29%.

9. The effect of Age and Experience on Computer Anxiety

Many studies have shown the significant effect of age and computer experience on attitudes towards computers (Loyd & Gressard, 1984; Pope-Davis & Twing, 1991). To replicate the findings in these studies, ANOVA analyses where done with age and experience as factors and subscales as criteria. However, age and computer experience did not show any significant influence of attitudes in any of the subscales (see Appendix I for the ANOVA Tables 10 - 14). Nevertheless, there is some trend in the raw data that indicates that the younger faculty seems to have higher means, indicating a more positive attitude. Similarly, the raw data also indicates some trend in all the subscales showing that the more the experience the higher the mean, except in computer usefulness subscale. The data in the pedagogical usefulness, though not statistically significant also, indicates a reverse role: the more the experience, the less the mean. This result is indeed surprising as we anticipated that the more the experience with computer the higher the perceived usefulness in classroom. A further study is required in this direction. However, as expected, the younger the years, the higher the mean, which seems to show that the younger ones are more optimistic on the pedagogical usefulness of computers.

CONCLUSION AND RECOMMENDATIONS

We have in this study investigated the computer attitude, use, experience, software familiarity, and perceived pedagogical usefulness among mathematics professors. In summary, the findings in this study are:

1. Mathematics professors at KFUPM have positive attitudes toward computers and towards the use of computers in their academic activities. This is encouraging as it has been realized that computer attitudes influence not only the acceptance of computers, but also their use as professional tools or as teaching/learning aids (Kadijevich, 2002). Therefore, to have computers widely used in mathematics classrooms, we should first help teachers develop positive attitudes toward the machine.

2. It was found that the number of years of working experience with computers by the mathematics professors at KFUPM was high. This might have influence their positive attitude towards the machine. It should be noted that the experience range used in this study is more than those considered in the previous studies in the literature.

3. Although mathematics professors at KFUPM were found to be intensive computer users in many of their academic activities, the rate at which they use computers in the classroom is low compared to the faculty computer usage in research and other purposes. This is the most appealing finding in this study. It shows that having positive attitude toward technology is not enough indicator that the tool will automatically be used in classroom. The result appears to show that teachers need to be shown the road to its utilization in the classroom. Therefore, it should be noted that computer ownership and free access to Internet facilities, though are good step, are not enough to trigger changes in our mathematics classroom practices. A concerted effort to enlighten and develop the confidence of the mathematics faculty on the use and

potential of computers in the mathematics classroom is necessary. This can be achieved by organizing periodic training or workshops for faculty on two fronts: (a) on recent development on various software items especially the ones relevant to their professional development, for instance, various CAS programs, word processing, spreadsheets, and possibly Internet authoring software, etc. and (b) on instructional technology, whereby the pedagogical usefulness of the various information technologies will be unveiled.

4. It was also found that Mathematics professors, despite their differences in age and experience did not differ significantly (in statistical sense) in their attitudes, knowledge, and use of computers. However, the younger ones appear to be more optimistic.

5. Mathematics professors at KFUPM were found to be familiar with most of the software needed in their professional development; however, they seem to be most knowledgeable in the area of word-processing software. The area in which they seem most deficient is in Internet design software where 61% registered their willingness to undergo more training in the area.

It is worth noting here that is one very important factor that has not been considered in this study, which is the issue of computer ownership. Computer ownership is one of the variables that many researchers have intensively investigated and found to be a statistically significant factor that influences attitude toward computers (see Nash & Moroz, 1997). However, at King Fahd University of Petroleum & Minerals there is a policy in which all faculty of the University are provided a personal computer in their offices that is upgradeable or changeable after every two years. Similarly, Internet access and e-mail facilities are free. Furthermore, the Information Technology Center (ITC) of the University provides most of the needed software and services free of charge. In view of this, computer ownership was isolated in this study since all mathematics professors have personal computers in their offices. This information should help in interpreting the level of computer use by the faculty. It is our belief that this policy is an excellent initiative that might have positively contributed in the professors' computer attitude, usage, computer experience, and software familiarity.

Limitations: This study is limited on the numbers of faculty members that participated, the way the faculty were categorized in terms of age, and the length of the questionnaire. Had these issues been examined differently, a different result may have been obtained.

Acknowledgement: The author acknowledges with thanks the excellent research facilities at KFUPM.

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APPENDIX I

Table 10. Age and Experience Differences in Computer Anxiety

	ANOVA STATISTICS		E DESCRIPTIVES			
Independent Variable	**F - Value**	**p**				
				N	**Mean**	**S.D.**
Age	F (4, 36) = 2.58	0.09	23 - 30 years	5	36.40	2.966
			31 - 40 years	7	36.00	2.582
			41 - 50 years	11	34.27	5.479
			51 - 55 years	16	36.13	3.384
			More than 55 years	2	31.00	8.485
			Total	**41**	**35.39**	**4.147**
Computer Experience			3 - 4	3	34.33	6.93
			4 - 5	4	35.5	3.70
			More than 5 years	34	35.5	4.06
			Total	**41**	**35.5**	**4.06**

Table 11. Age and Experience Differences in Computer Confidence

	ANOVA STATISTICS		DESCRIPTIVES			
Independent Variable	F - Value	**p**				
				N	**Mean**	**S.D.**
Age	F (4, 36) = 0.78	0.63	23 - 30 years	5	37.2	2.95
			31 - 40 years	7	36.71	3.30
			41 - 50 years	11	33.9	4.95
			51 - 55 years	16	34.63	5.88
			More than 55 years	2	31	1.41
			Total	**41**	**34.93**	**4.89**
Computer Experience			3 - 4	3	30	7.21
			4 - 5	4	33	5.94
			More than 5 years	34	35.6	4.42
			Total	**41**	**34.93**	**4.89**

Table 12. Age and Experience Differences in Computer Liking

Independent Variable	ANOVA STATISTICS F - Value	p	DESCRIPTIVES	N	Mean	S.D.
Age	F (4, 36) = 0.89	0.54	23 - 30 years	5	31	4.64
			31 - 40 years	7	33.86	3.18
			41 - 50 years	11	31.55	3.42
			51 - 55 years	16	31.63	6.00
			More than 55 years	2	26	1.41
			Total	**41**	**31.63**	**4.76**
Computer Experience			3 - 4	3	28	4.58
			4 - 5	4	31.5	5.45
			More than 5 years	34	31.97	4.71
			Total	**41**	**31.63**	**4.76**

Table 13. Age and Experience Differences in Computer Usefulness

Independent Variable	ANOVA STATISTICS F - Value	p	DESCRIPTIVES	N	Mean	S.D.
Age	F (4, 36) = 1.09	0.40	23 - 30 years	5	34.6	1.52
			31 - 40 years	7	32.71	3.86
			41 - 50 years	11	33.36	5.80
			51 - 55 years	16	33.75	3.53
			More than 55 years	2	30.50	2.12
			Total	**41**	**33.41**	**4.05**
Computer Experience			3 - 4	3	33.33	2.52
			4 - 5	4	34.25	3.862
			More than 5 years	34	33.32	4.25
			Total	**41**	**33.41**	**4.05**

Table 14. Age and Experience Differences in Pedagogical Usefulness of Computer

Independent Variable	ANOVA STATISTICS F - Value	p	DESCRIPTIVES	N	Mean	S.D.
Age	F (4, 36) = 0.95	0.50	23 - 30 years	5	21.2	2.95
			31 - 40 years	7	21.14	2.73
			41 - 50 years	11	19.18	3.31
			51 - 55 years	16	17.75	4.63
			More than 55 years	2	18.50	0.71
			Total	**41**	**19.17**	**3.85**
Computer Experience			3 - 4	3	21.67	1.53
			4 - 5	4	19.5	1.73
			More than 5 years	34	18.91	4.11
			Total	**41**	**19.17**	**3.85**

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Eurasia Journal of Mathematics, Science and Technology Education
Volume 2, Number 3, December 2006
www.ejmste.com

PRESERVICE SCIENCE TEACHERS BELIEFS ABOUT SCIENCE -TECHNOLOGY AND THEIR IMPLICATION IN SOCIETY

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Senol Bal

Hakan Akcay

ABSTRACT. The purpose of the study was to discern the beliefs of pre-service science teachers (PST) concerning science technology and their implications in society. A quasi-experimental design was used. The results indicate that students who experienced Science Technology and Society (STS) approach perform better than students enrolled in section where traditional approaches in terms of student understanding of scientific process, student ability to apply scientific concepts related to science and technology, more positive student attitudes, and demonstration of more and better creativity skills. The STS approach was found to have an impact on the beliefs of PST in science education.

KEYWORDS. Science Technology & Society (Sts), Preservice Science Teacher, Teacher Preparation, Real-World Context.

INTRODUCTION

As we move into the 21st century, science and technology will play an increasingly important role in all aspects of our society. It is imperative, therefore, that our future decision-makers develop positive attitudes about and confidence in their ability to solve problems using scientific concepts and principles. These attitudes foster curiosity to understand and appreciate the natural world as well as to comprehend the impact of science and technology on the individual, culture, and society. The quality of life in the future will rest on the contributions of the students in schools now.

Everyday development of science and technology change the society both negatively and positively. This rapid changing society should be evaluated by educators and social scientists. In the future, it is hard to guess how scientific and technological developments will affect human life.

The main purpose of science education should describe the role of science and technology as a way of solving current problems in light of the advantages and disadvantages of science and technology (Solbes & Vilches, 1997)

ISSN: 1305-8223

To promote students' meaningful learning that occurs when new experiences are related to what students already know, science educators should encourage student discussion, argumentation, social negotiation and cooperative learning (Tsai, 2001). Science education should also help students develop their problem solving skills and apply scientific knowledge to solving everyday problems.

Making responsible decisions for resolving problems related to science and technology address one of the most important goals for future citizens and leaders. Science educators should consider this goal. The STS approach serves an excellent way to achieve this aim.

Science-Technology-Society has been recognized as a major reform in science education (NSTA, 1990). The major goal for STS efforts is the production of scientifically and technologically literate persons who can evaluate the quality of scientific information on the basis of its source and the methods used to generate it (NRC, 1996) Seventeen features are identified by NSTA to describe a scientifically and technologically literate person. These features include:

- Uses concepts of science and of technology as well as an informed reflection of ethical values in solving everyday problems and making responsible decisions in everyday life, including work and leisure
- Engages in responsible personal and civic actions after weighing the possible consequences of alternative options
- Defends decisions and actions using rational arguments based on evidence
- Engages in science and technology for the excitement and the explanations they provide
- Displays curiosity about and appreciation of the natural and human-made world
- Applies skepticism, careful methods, logical reasoning, and creativity in investigating the observable universe
- Values scientific research and technological problem solving
- Locates, collects, analyzes, and evaluates sources of scientific and technological information and uses these sources in solving problems, making decisions, and taking actions
- Distinguishes between scientific and technological evidence and personal opinion and between reliable and unreliable information
- Remains open to new evidence and the tentativeness of scientific/technological knowledge
- Recognizes that science and technology are human endeavors
- Weighs the benefits and burdens of scientific and technological development
- Recognizes the strengths and limitations of science and technology for advancing human welfare
- Analyzes interactions among science, technology, and society

• Connects science and technology to other human endeavors, e.g., history, mathematics, the arts, and the humanities
• Considers the political, economic, moral, and ethical aspects of science and technology as they relate to personal and global issues
• Offers explanations of natural phenomena which may be tested for their validity (NSTA, 1990)

The purpose of the STS approach is to engage students in problem solving activities that they have identified. STS programs begin with real world issues and concerns. Students focus on problems and questions that related to their personal life.

Teacher education programs should provide a learning environment for prospective teachers to improve their understanding of the interaction among science, technology and society (Yager, Tamir and Kellerman, 1994)

METHOD

The study involved sixty-six pre-service science teachers in science education at Gazi University. It was completed during the spring semester (14 weeks period). Control and experimental group were used. Each group has thirty-three pre-service science teachers. Traditional instructional methods were used in control group. The STS teaching and learning methods were used in the experimental class. Students in STS class have been involved with following learning experience; role-playing; debates; library searches; brainstorming; problem-solving; class discussion and presentations; and decision making. A quasi-experimental design was the research design for this study. Several units form environmental and genetics issues were selected as the major topics for the experimental and control groups. These included such general topics as; nucleic acids, structure of DNA and RNA, gene therapy, chromosome, genetic code, genetic problems and disorders, genetic engineering and its implications to society, environmental pollutions and source of these pollutions such as radioactive, water, soil and air pollutions. The Views on Science Technology and Society (VOSTS) questionnaire was used to collect data. This questionnaire (VOSTS) was developed by Aikenhead, Fleming and Ryan in 1987. It is an inventory of student viewpoints about science, and how science is related to technology and society. The VOSTS consists of 114 multiple choice items that address a broad range of STS topics; however, this study consisted of six questions (Appendix 1) which were selected from the VOSTS to determine students' beliefs about science and technology and their implications on society. These six items were related to the environmental and genetics contents that thought during the spring semester. The same instruments were used for pre and post tests. The pre-tests were given at the beginning of spring semester. The teachers then thought the issues for using STS approaches or non-STS approaches. The post-tests were given at the end of spring semester.

RESULTS

Table 1 and Figures 1 through 6 indicate the data collected from the records for each of the six items.

First item provides information corcerning preservice science teachers beliefs about how science and technology can help people make some moral and ethic decisions. In the control group, students believed that technology and science cannot help people when they make moral and ethical decisions. Because moral and ethical decisions are made solely on the basis of an individual's values and beliefs for both pre and post-test (See Figure 1.a). In treatment group, at the beginning of the semester students believed similar to control group but at the end of the semester the post-test indicated that students beliefs have changed, most of them thought science and technology can help students make some moral decisions by providing background information and making them more informed about people and the world around them. This background information can help them cope with the moral aspects of life (See Figure 1.b).

The second item is related to ideas about how science and technology offer a great deal of help in resolving social problems such as poverty, crime, and unemployment. In control groups, both pre and post test indicate that most of the pre-service science teachers believe science and technology solve many social problems; however, it is noted that they also cause many of these problems. People should use science and technology wisely to solve social problems. They did not change their ideas during the semester (See Figure 2.a). For treatment groups, the pre-tests showed that students generally focus on the role of the people who are responsible for using science and technology rather than the importance and the role of science and technology for solving social problems. In post test, students not only mention about the importance and role of people but also mention that science and technology can solve the problems (See Figure 2.b).

The third item used to get information about how knowledge of science and technology helps students to solve student problems in daily life. Students in control groups think that science and technology provide knowledge to understand everyday problems but most of them mention that the concepts and the problem solving techniques they learn from science classes are not directly useful in their everyday lives on both the pre-tests and post-tests (See Figure 3.a). At the beginning of the semester students in the experimental groups thought similarly to what was found with the control groups. But in this case the post-tests showed that they changed their ideas. Most of them indicated that everyday problems are more easily and logically solved if treated like "science" problems. Moreover, ideas and facts that they learn from science classes help them to solve problems or make decisions about their problems in their daily lives (See Figure 3. b).

The fourth item is concerned with environmental issues that are unsolvable today such as pollution problems. The pre-tests show that student beliefs are similar in both control groups and experiment groups. Students in both think that science and technology cannot fix the environmental problems because they are the reason that we have the problems. They believed that more science and technology will bring more pollution problems (See Figure 4.a and 4.b). In the pos- tests, the control groups did not change their beliefs. Students still thought that science and technology do not solve the problems. However, in the experimental group, most of the PSTs mentioned that science and technology are not able to resolve pollution problems. Instant they are everyone's responsibility. The public must insist that fixing these problems is a top priority. In this item, the results indicate that the PST in experimental groups develop more positive attitudes about science and technology than did others.

The fifth item was designed to probe the idea that high-technology industries will provide most of the new jobs in the next twenty years. PSTs in the control group responded that science and technology will provide many opportunities for people especially trained people who will be needed to operate and repair the new technology and to develop new kinds of hi-technology industries in both pre-tests and post-tests(See Figure 5.a). The PSTs in the experiment groups responded both positively and negatively in the pre-tests. In the post-tests, although some of the students responded similarly to those in the control groups, most of the students responded that only a few new jobs will be created. More jobs will be probably lost because of mechanical or computerized hitechnology (See Figure 5.b). This shows that when PSTs have more information about science and technology, they feel uncomfortable concerning their future.

The last item consists of the ideas about how technology will improve the standard of living. Both pre and post test showed that PSTs in the control groups responded that technology would make life easier, healthier, and more efficient. However, technology would also cause more pollution, unemployment, as well as other problems. They belived that people will be irresponsible with the technology. The standard of living may improve, but the quality of life may not (See Figure 6.a). Additionally, this result indicates that pre-service science teachers have a conflict regarding their beliefs about using examples including technology in daily life, rapid development of technology. This is because they do not feel comfortable in discussing negative effects of these aspects of technology in the classroom.

These results show the STS approach increases pre-service science teachers' beliefs about effectiveness of science and technology on society. Since pre-service teachers understand and visualize the interactions among science, technology and society as well as their effects on daily lives, they become more confident about the STS approach because they understand the importance of science and technology for the future of the society.

DISCUSSION AND CONCLUSION

The purpose of this study was find out how the impact of the Science-Technology-Society (STS) approach had on the beliefs of pre-service science teachers. The results indicate that the PSTs in experimental groups changed their ideas about scientific, technological, and social issues during the study. Even though the control group responded similarly, the experimental group responded differently for the pre-tests and post-tests. As a result of the study, pre-service science teachers beliefs about the importance of science and technology; being more responsible about solving problems and being aware of effectiveness of science and technology on our daily life have all been increased. In addition, pre-service teachers started to use more collaborative efforts with their colleagues instead of working alone on problems.

The effectiveness of STS instruction has been studied by many researchers. For example, Winter and Volk's (1994) study showed that STS instruction increased student achievement in chemistry. Another study conducted from Bradford, Rubba and Harkness (1995) showed that the views of college students concerning STS interactions increased after they were taught by the STS approach.

Science educator should focus on authentic instruction that give students opportunities to use their knowledge in real life situations instead of just "giving" them content knowledge in traditional classroom setting. This would increase students' positive attitudes toward science classes.

Using present information in the science classrooms increases students' positive attitudes toward science as well as their creativity (Yager, 1990). The STS approach encourages and enhances scientifically literate individuals. This is a major aspect of preparing for life in a democratic society (Wrage and Hlebowitsh, 1991)

Increasing pre-service science teachers' understanding of the theoretical and applications control to the STS approach will lead students to use more typical information from the science, technology, and society in context that students experience daily. This quality of program for preparing pre-service teachers will improve our society by preparing more scientifically literate citizens. It will succeed for making instruction more relevant and meaningful while modeling the nature of science and its importance in preparing students in future citizens.

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Comparisons between the Traditional (Control group) and the STS Students (Eperiment group) on each selected items

1.Item:

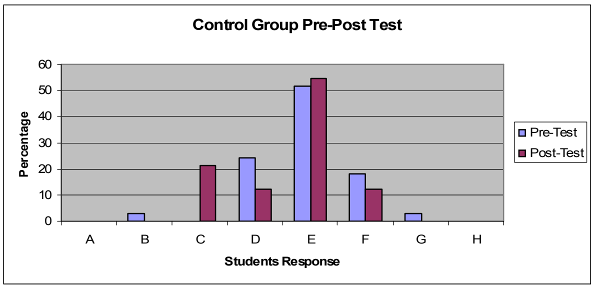

Figure 1.a Control Group (Traditional Approach)

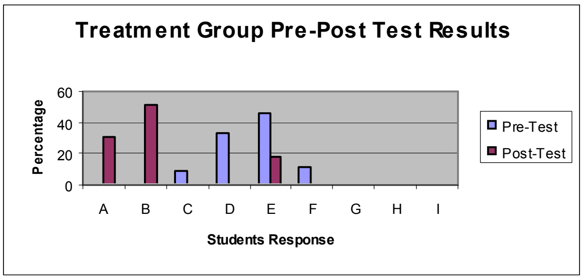

Figure 1.b. Treatment Group (STS Approach)

2.Item:

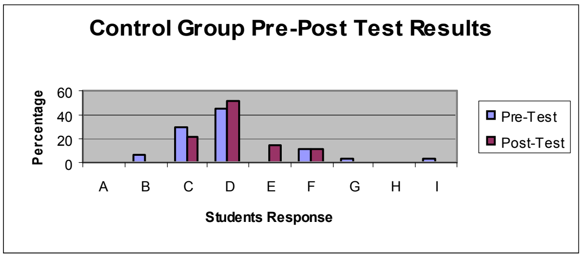

Figure 2.a. Control Group (Traditional Approach)

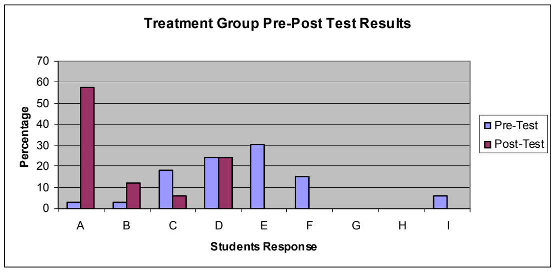

Figure 2.b. Treatment Group (STS Approach)

3. Item:

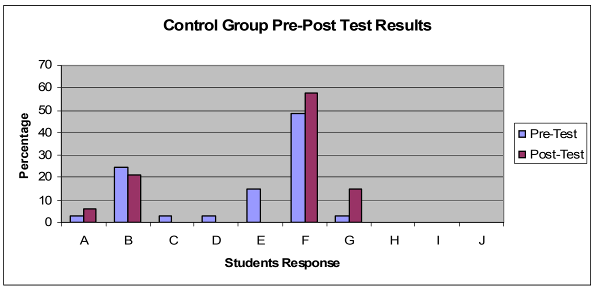

Figure 3.a. Control Group (Traditional Approach)

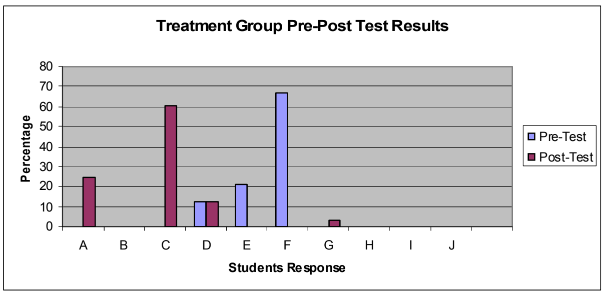

Figure 3.b. Treatment Group (STS Approach)

4.Item:

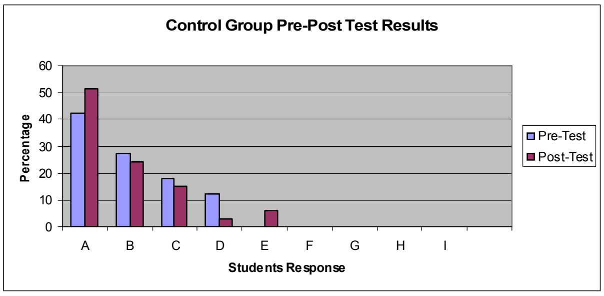

Figure 4.a. Control Group (Traditional Approach)

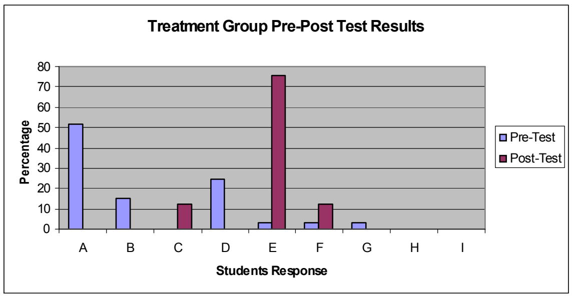

Figure 4.b. Treatment Group (STS Approach)

5. Item:

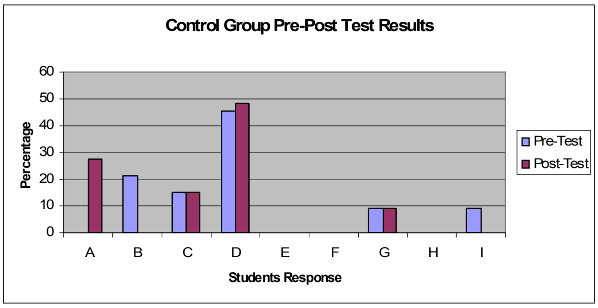

Figure 5.a. Control Group (Traditional Group)

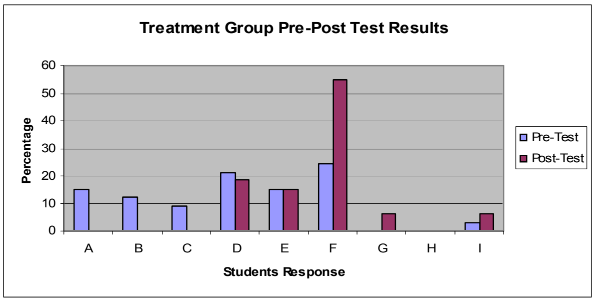

Figure 5.b. Treatment Group (STS Approach)

6. Item:

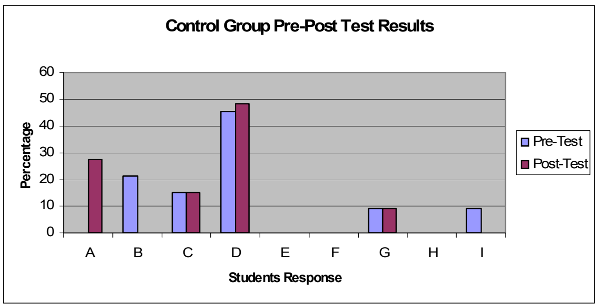

Figure 6.a Control Group(Traditional Approach)

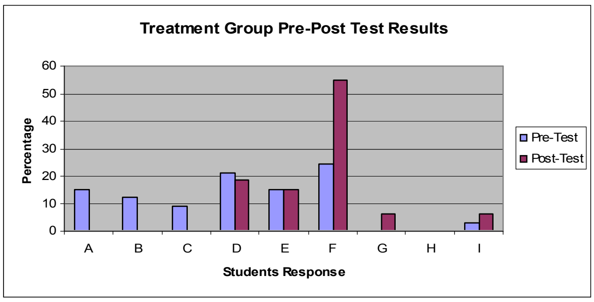

Figure 6.b. Treatment Group (STS Approach)

Table 1. A measure of Students Response about Science Technology and their Implications

		A		B		C		D		E		F		G		H		I		J	
		Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
1. Item	**Control**			3			21,2	24,3	12,1	51,5	54,6	18,2	12,1	3							
	Treatment		30,3		51,5	9		33,3		45,6	18,2	12,1									
2. Item	**Control**			6		30,3	21,2	45,6	51,5		15,2	12,1	12,1	3				3			
	Treatment	3	57,6	3	12,1	18,2	6	24,3	24,3	30,3		15,2									
3. Item	**Control**	3	6	24,3	21,2	3		3		15,2		48,5	57,6	3	15,2						
	Treatment		24,3				60,6	12,1	12,1	21,2		66,7		3							
4. Item	**Control**	42,4	51,5	27,3	24,3	18,2	15,2	12,1	3		6										
	Treatment	51,5		15,2			12,1	24,3		3	75,8	3	12,1	3							
5. Item	**Control**		27,3	21,2		15,2	15,2	45,6	48,5					9	9			9			
	Treatment	15,2		12,1		9		21,2	18,2	15,2	15,2	24,3	54,6		6			3	6		
6. Item	**Control**		3		3		24,3	45,6	48,5	33,3	15,2	12,1	3					3	9		
	Treatment		3	39,4		18,2		15,2			39,4	21,2	57,6					6			

Note:

1.The data indicate percentage of students population

2.Percentage of clasess with significant gains for each item

APPENDIX

Appendix 1: VOSTS items that used in the research as pre and post test

40221 Science and technology can help people make some moral decisions (that is, one group of people deciding how to act towards another group of people).

Your position, basically: (Please read from A to I, and then choose one.)

Science and technology can help you make some moral decisions:

A. by making you more informed about people and the world around you. This background information can help you cope with the moral aspects of life.

B. by providing background information; but moral decisions must be made by individuals.

C. because science includes areas like psychology which study the human mind and emotions.

Science and technology **cannot** help you make a moral decision:

D. because science and technology have nothing to do with moral decisions. Science and technology only discover, explain and invent things. What people do with the results is not the scientist's concern.

E. because moral decisions are made solely on the basis of an individual's values and beliefs.

F. because if moral decisions are based on scientific information, the decisions often lead to racism, by assuming that one group of people is better than another group.

G. I don't understand.

H. I don't know enough about this subject to make a choice.

I. None of these choices fits my basic viewpoint.

40412 Science and technology offer a great deal of help in resolving such social problems as poverty, crime and unemployment.

Your position, basically: (Please read from A to I, and then choose one.)

A. Science and technology can certainly help to resolve these problems. The problems could use new ideas from science and new inventions from technology.

B. Science and technology can help resolve some social problems but not others.

C. Science and technology solve many social problems, but science and technology also **cause** many of these problems.

D. It's not a question of science and technology helping, but rather it's a question of **people** using science and technology wisely.

E. It's hard to see how science and technology could help very much in resolving these social problems. Social problems concern human nature; these problems have little to do with science and technology.

F. Science and technology only make social problems worse; it's the price we pay for advances in science and technology.

G. I don't understand.

H. I don't know enough about this subject to make a choice.

I. None of these choices fits my basic viewpoint.

40421 In your everyday life, knowledge of science and technology helps you personally solve practical problems (for example, getting a car out of a snowdrift, cooking, or caring for a pet).

Your position, basically: (Please read from A to J, and then choose one.)

The systematic reasoning taught in science classes (for example, hypothesizing, gathering data, being logical):

A. helps me solve some problems in my daily life. Everyday problems are more easily and logically solved if treated like science problems.

B. gives me greater knowledge and understanding of everyday problems. However, the problem solving techniques we learn are not directly useful in my daily life.

C. Ideas and facts I learn from science classes sometimes help me solve problems or make decisions about such things as cooking, keeping healthy, or explaining a wide variety of physical events.

D. The systematic reasoning **and** the ideas and facts I learn from science classes help me a lot. They help me solve certain problems and understand a wide variety of physical events (for example, thunder or quasars).

E. What I learn from science class generally **does not help me** solve practical problems; but it **does help me** notice, relate to, and understand, the world around me. What I learn from science class does **not** relate to my everyday life:

F. biology, chemistry and physics are not practical for me. They emphasize theoretical and technical details that have little to do with my day-to-day world.

G. my problems are solved by past experience or by knowledge unrelated to science and technology.

H. I don't understand.

I. I don't know enough about this subject to make a choice.

J. None of these choices fits my basic viewpoint.

40451 We have to be concerned about pollution problems which are unsolvable today. Science and technology cannot necessarily fix these problems in the future.

Your position, basically: (Please read from A to I, and then choose one.)

Science and technology can NOT fix such problems:

A. because science and technology are **the reason** that we have pollution problems in the first place. More science and technology will bring more pollution problems.

B. because pollution problems are so **bad today** they are already beyond the ability for science and technology to fix them.

C. because pollution problems **are becoming** so bad that they may soon be beyond the ability of science and technology to fix them.

D. No one can predict what science and technology will be able to fix in the future.

E. Science and technology **alone cannot** fix pollution problems. It is everyone's responsibility. The public must insist that fixing these problems is a top priority.

F. Science and technology **can** fix such problems because the success at solving problems in the past means science and technology will be successful in the future at fixing pollution problems.

G. I don't understand.

H. I don't know enough about this subject to make a choice.

I. None of these choices fits my basic viewpoint.

40521 High-technology industries will provide most of the new jobs in the next twenty years.

Your position, basically: (Please read from A to I, and then choose one.)

A. Yes. New information and rapid change are the keys to society's future.

B. Yes, because Canada's industries will have to become more efficient by installing hi-tech systems in order to compete.

C. Yes, because new Canadian industries will produce hi-tech products. Public demand for these products will create new jobs.

D. Yes. There will be many new jobs. Specially trained people will be needed to run and repair the new technology and to develop new kinds of hi-tech industries.

E. Yes. Specially trained people will be needed to run and repair the new technology, BUT it will replace some of today's jobs. Overall, the total number of jobs will be about the same.

F. No. Only a few new jobs will be created. More jobs will be lost because of mechanical or computerized hitechnology.

G. I don't understand.

H. I don't know enough about this subject to make a choice.

I. None of these choices fits my basic viewpoint.

40531 More technology will improve the standard of living for Canadians.

Your position, basically: (Please read from A to I, and then choose one.)

A. Yes, because technology **has always** improved the standard of living, and there is no reason for it to stop now.

B. Yes, because the more we know, the better we can solve our problems and take care of ourselves.

C. Yes, because technology creates jobs and prosperity. Technology helps life become easier, more efficient and more fun.

D. Yes, but only for those who can afford to use it. More technology will cut jobs and cause more people to fall below the poverty line.

E. Yes and no. More technology would make life easier, healthier and more efficient. BUT more technology would cause more pollution, unemployment and other problems. The standard of living may improve, but the quality of life may not.

F. No. We are irresponsible with the technology we have now; for example, our production of weapons and using up our natural resources.

G. I don't understand.

H. I don't know enough about this subject to make a choice.

I. None of these choices fits my basic viewpoint.

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Eurasia Journal of Mathematics, Science and Technology Education
Volume 2, Number 3, December 2006
www.ejmste.com

USING DRAWINGS AND GENERATING INFORMATION IN MATHEMATICAL PROBLEM SOLVING PROCESSES

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ABSTRACT. The purpose of this paper is to investigate how drawings can contribute to generating new information when solvers use drawings in solving mathematical problems. For this purpose, two episodes, in which drawings enabled a solver to find ideas useful for his solutions, were qualitatively and closely analyzed, especially focusing on what roles drawings could play when the solver found new information about the problem situations. The analysis demonstrates the following aspects of use of drawings: (a) drawings can contribute to information generation by producing unexpected combinations or configurations of elements solvers identified in the problem situations previously, which led the solver to recognizing emergent patterns; (b) the use of drawings includes cyclic processes, through which the solver's understanding of the problem situations and his way of interacting with drawings varied each other. Implications for instruction will be also discussed on the basis of such aspects.

KEYWORDS. Mathematical Problem Solving, Mathematical Thinking, Heuristic Strategies, Use of Drawings, Problem Solving Processes.

INTRODUCTION

In discussing the use of drawings, one of the most well-known heuristic strategies for mathematical problem solving, the importance of self-generated drawings has attracted the attention (Gutstein & Romberg, 1995; Van Essen & Hamaker, 1990). Some of the recent researches have attended to the fact that drawings are usually modified or altered during problem solving processes (Bremigan, 2005; Nunokawa, 2000). For example, Gibson (1998) analyzed the problem solving processes of university students to investigate the effect of drawings in developing proofs. He observed that, in their search for proofs, "students added to, subtracted from, and redrew" their drawings and their alteration of drawings "allowed students to explore possible scenarios within the problem situation and, as a result, come up with ideas" (p. 296). In analyzing in detail the solution processes of high- and low-achieving secondary students, Lawson and Chinnappan (1994) considered the modification of drawings to be a kind of information generation and paid attention to the order in which each element of the drawings was drawn. Diezmann & English (2001) reported one student's solving process where the student's reflection on the adequacy of her diagram enabled the change in her understanding of the problem structure. Diezmann (2000) pointed out that diagrams were dynamic rather than static representation and it could be beneficial to produce more than one diagram.

ISSN: 1305-8223

Such focus has led to the research on how drawings are actually used in mathematical problem solving. These works have shown the interrelationships between use of drawings and analytical thinking (Hershkowitz et al, 2001; Nunokawa, 1994, 2004; Stylianou, 2002; Zazkis et al, 1996). They have showed the interwoven relationship between visualizing and analyzing modes in the use of drawings, and highlighted solvers' analytical operation on drawings. For example, Stylianou (2002) pointed out the importance of systematic and thorough explorations of drawings. There is, however, little research that explores how drawings per se can contribute to generating new information in such processes.

Larkin & Simon (1987) seemed to present a kind of contribution of drawings in problem solving. They mentioned as one of the merits of use of drawings the fact that drawings can group together all information that is used together and enable a solver to avoid large amount of search for the elements needed to make a problem-solving inference (p. 98). Their analysis, however, utilized the input data structured for their cognitive model and the completed diagrammatic representation of that data. In order to understand how drawings can help students solve problems, this feature of drawings should be reexamined through the analysis of authentic problem solving processes in the context of the recent research trend to emphasize the processes of using drawings, because students who face a difficulty in solving a problem cannot necessarily construct perfect drawings immediately.

The purpose of this paper is to investigate contributions of drawings by analyzing actual problem solving processes and to attempt to deepen our understanding of how drawings can help students solve mathematical problems. For this purpose, two episodes, in which a student tackled rather tough mathematical problems and drawings enabled him to find ideas useful for solutions, were analyzed in detail. In these analyses, the focus was laid especially upon what roles drawings could play when the solver found new information about the problem situations.

METHOD

The subject was the same graduate student as the subject of Nunokawa (2004), who studied mathematics education and worked as a part-time teacher of mathematics at a senior high school. Thus, as far as high-school-level mathematics is concerned, he could be considered an expert problem solver. The problems from Klamkin (1988) were used to provide genuine problem solving settings for this subject. He participated in 9 problem solving sessions.

All sessions were recorded by audio and video tape recorders. Those records were transformed into protocols of the solution processes. In transcribing, steps of making each drawing were incorporated into the protocols, as well as utterances of the solver and the written sentences and expressions. Based on such protocols and the video-taped records, the relationships between the steps of drawing and the solver's utterances or thought were analyzed to explore how the solver obtained new information and how drawings contributed to generating new information in the process of using drawings.

THE SOLVER'S USE OF DRAWINGS IN SOLVING MATHEMATICAL PROBLEMS

Episode 1

Episode 1 were excerpted from the seventh session. In that session, the solver made efforts to solve the following problem:

> If A and B are fixed points on a given circle and XY is a variable diameter of the same circle, determine the locus of the point of intersection of lines AX and BY. You may assume that AB is not a diameter. (Klamkin, 1988, p. 5)

The problem was presented to the solver without drawings. First, the solver attempted to find out a mathematical expression of the locus of the intersection point for about 30 minutes. After he failed that attempt, he decided to explore the problem situation to have a 'vision' about the solution. He drew the drawing shown in Figure 1, and then drew Figure 2 after getting an insight through the use of Figure 1. The solver drew those drawings in the following manner.

(a) The solver drew the circle and the coordinate axes in Figure 1. Set the points A and B. Drew the diameter XY. Then, he drew AX and BY to make an intersection point, Q1. (Fig. 3(i))

(b) The solver drew AY and BX to make another intersection point, Q2. (Fig. 3(ii))

(c) After tracing X'Y', he drew BY' and the tangent at A to make an intersection point, P. Moreover, he drew BX' and AY' to make another intersection point, which is the same as the point A. (Fig. 3(iii))

(d) He uttered, "It can vary rather extensively" and "this may be a circle." Then, he drew another circle so that it could pass through the four intersection points he had constructed. (Fig. 3(iv))

(e) Saying, "It would be enough to prove that this angle and this angle are equal," he added dots to the angles at P and Q1,, as shown in Fig. 3(iv).

(f) The solver began to construct another drawing (Figure 2). He drew a circle, the fixed points A and B, and diameter XY. Then, he drew AX and BY to make an intersection point, Q. (Fig. 4(i))

(g) He drew a diameter X'Y'. Then, he drew BY' and the tangent at A to make another intersection, P. He added the angle marks to $\angle$AQY and $\angle$APY' and the right-angle mark to $\angle$PAY'. (Fig. 4(ii))

(h) He drew AY and BX and marked ∠BYA, ∠BY’A, and ∠BXA with small circles. After a while, he traced ΔAYQ and ΔAY’P with his pen. (Fig. 4(iii))

(i) He marked ∠YAY’ and ∠QAP with small x’s. After tracing ΔAY’P, he added the right-angle mark to ∠XAY. (Fig. 4(iv))

(j) He drew AB and added the right-angle marks to ∠ABY’ and ∠ABP. Finally, he added the right-angle mark to ∠QAY. (Fig. 4(v))

(k) After seeing this drawing, the solver began to write a proof.

Figure 1

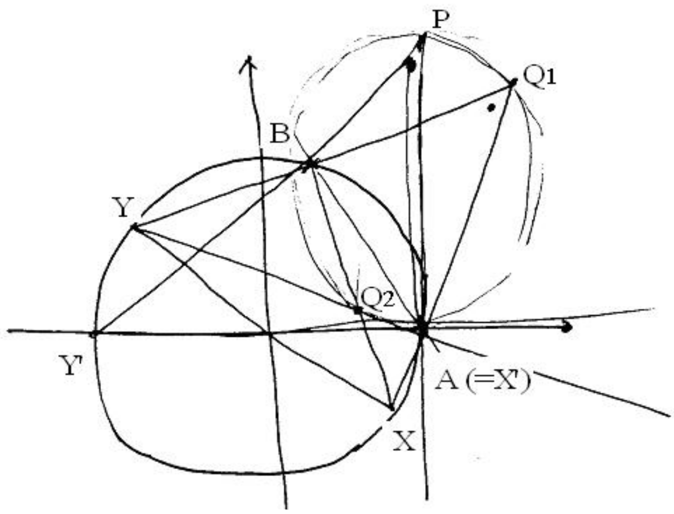


Figure 2

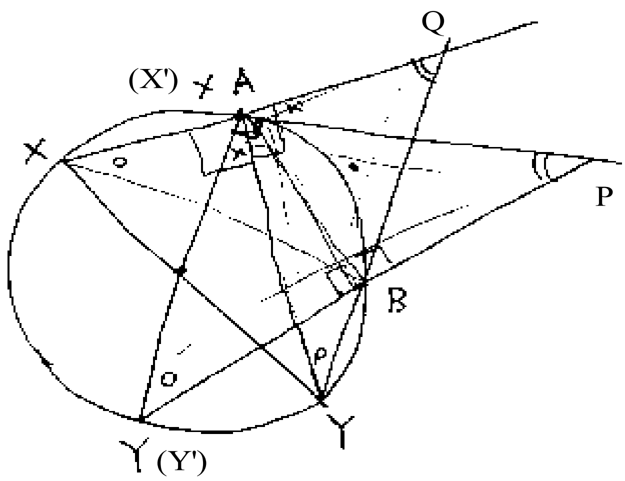


Figure 3

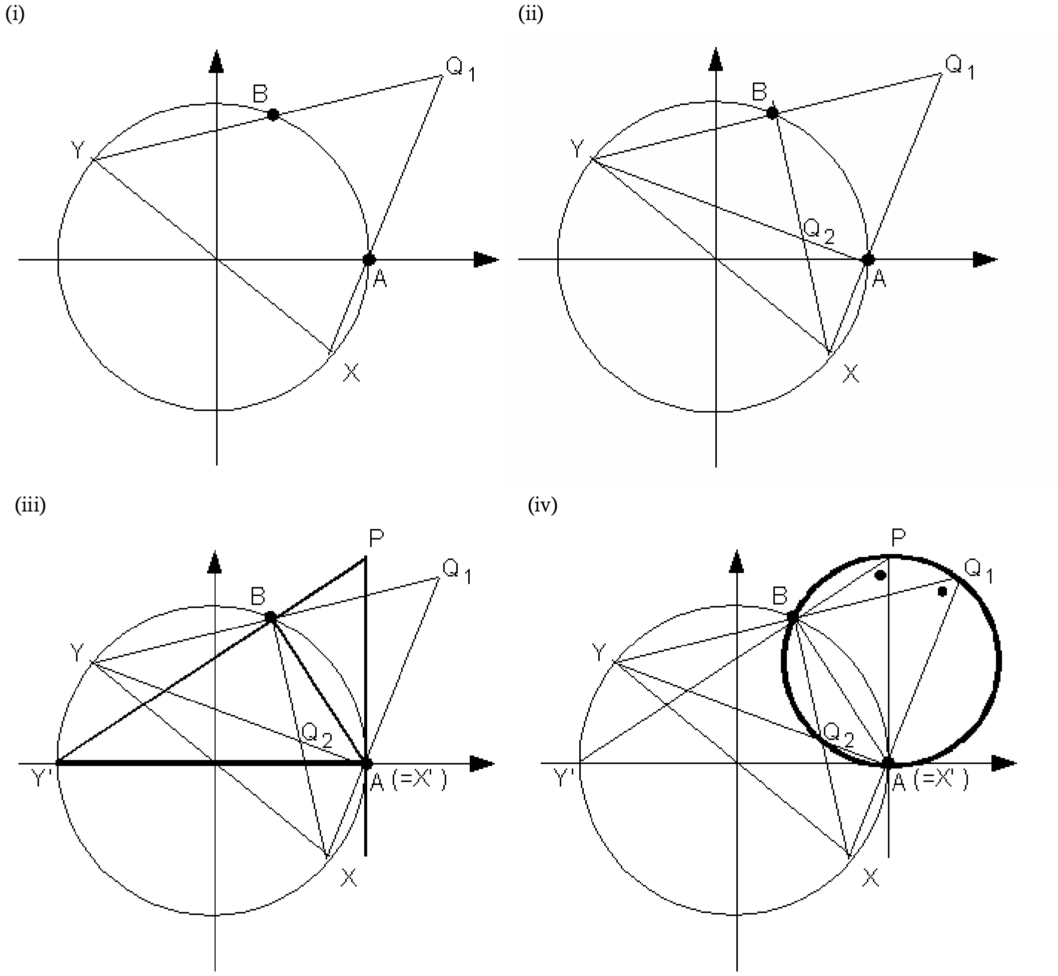
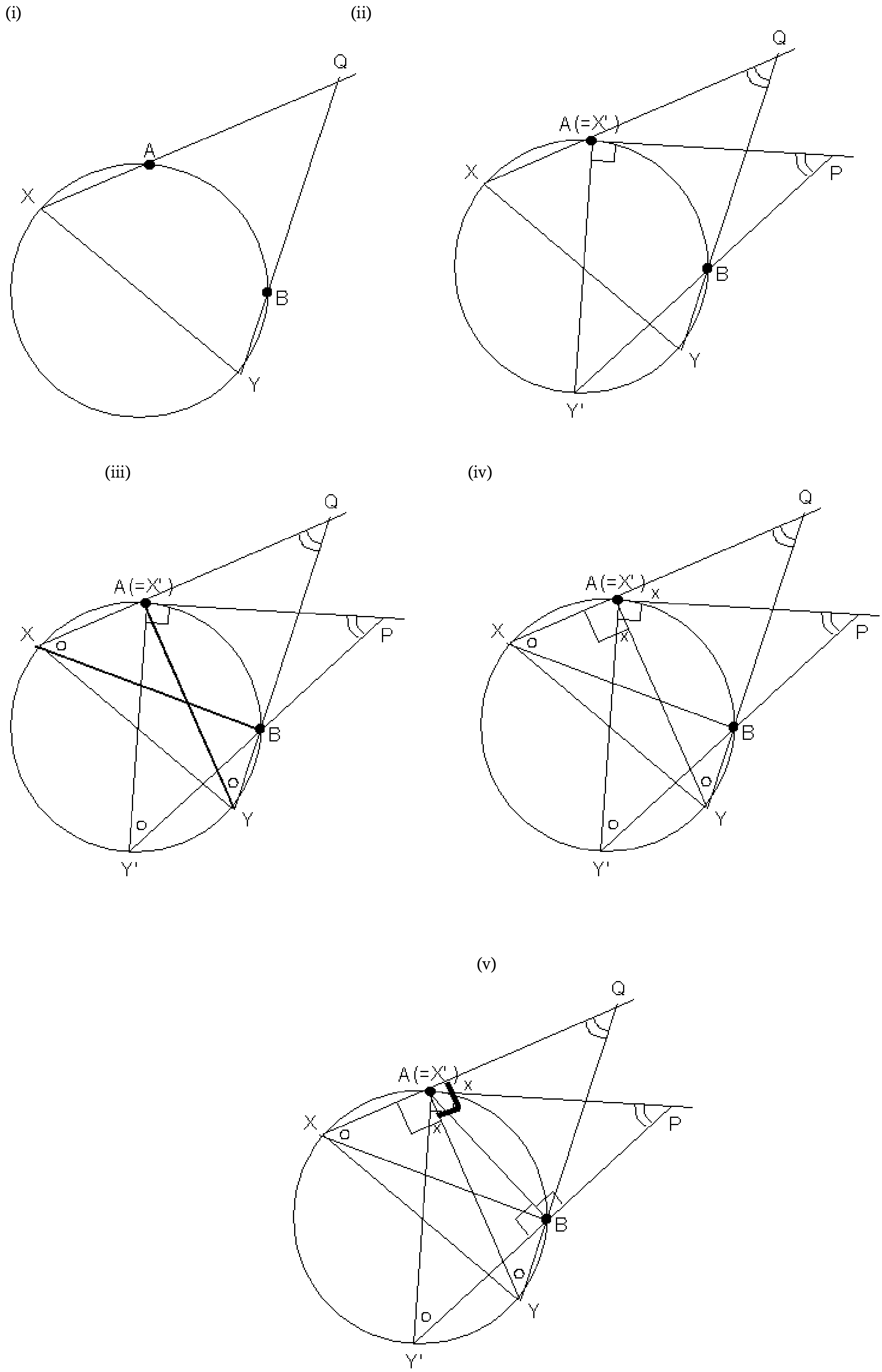


Figure 4


(i)
Q
A
X
B
Y
(ii)
Q
A(=X')
X
P
B
Y
Y'
(iii)
Q
A(=X')
X
P
B
Y
Y'
(iv)
Q
A(=X')
x
X
x
P
B
Y
Y'
(v)
Q
A(=X')
x
X
x
P
B
Y
Y'

As the Figure 3(i), 3(ii), and 3(iii) show, the solver constructed some interaction points following the problem statement. Although he seemed to draw only one diameter in this drawing, he succeeded in representing the varying of the diameter by using the diameter and x-axis cleverly and constructing four intersection points (P, Q1, Q2, and A) in one drawing (Nunokawa, 2004). His action of representing what is given in the problem statement led to a kind of combination of four intersection points. This combination made him utter “it can vary rather extensively” and “this may be a circle” at stage (d). Some researchers of creativity pointed out that properties which emerge through combinations of existing elements are important for discovery (Roskos-Ewoldson, 1993; Sawyer, 2003). In this case, a certain extensity emerged through the combination of four intersection points. The solver recognized such an emergent pattern in the drawing and made sense of it as a circle.

It should be noted here that the solver saw this combination of elements with the information he had obtained during the previous activity. In the interview concerning episode 1, the solver told that he had noticed that the locus in question could be expressed only by sine and cosine functions through his calculations implemented before drawing Figure 1. Thus, it can be said that the above-mentioned emergent pattern occurred at the contact point between the combination appearing in the drawing and the solver with the related information.

The solver drew another circle at stage (d), as shown in Figure 3 (iv), to represent the information he had just obtained. This action in turn led to another combination of elements, a combination of the circle and two pairs of lines constituting the intersection points. The solver recognized a new emergent pattern here, two inscribed angles in a circle. AP, BP, AQ1, and BQ1 were the lines given in the problem statement and originally were drawn to make intersection points. The combination of the circle and these lines was not intended in advance and it changed the pairs of lines into inscribed angles of this circle. This emergent pattern suggested to the solver new information that the measures of angles at intersection points would be constant.

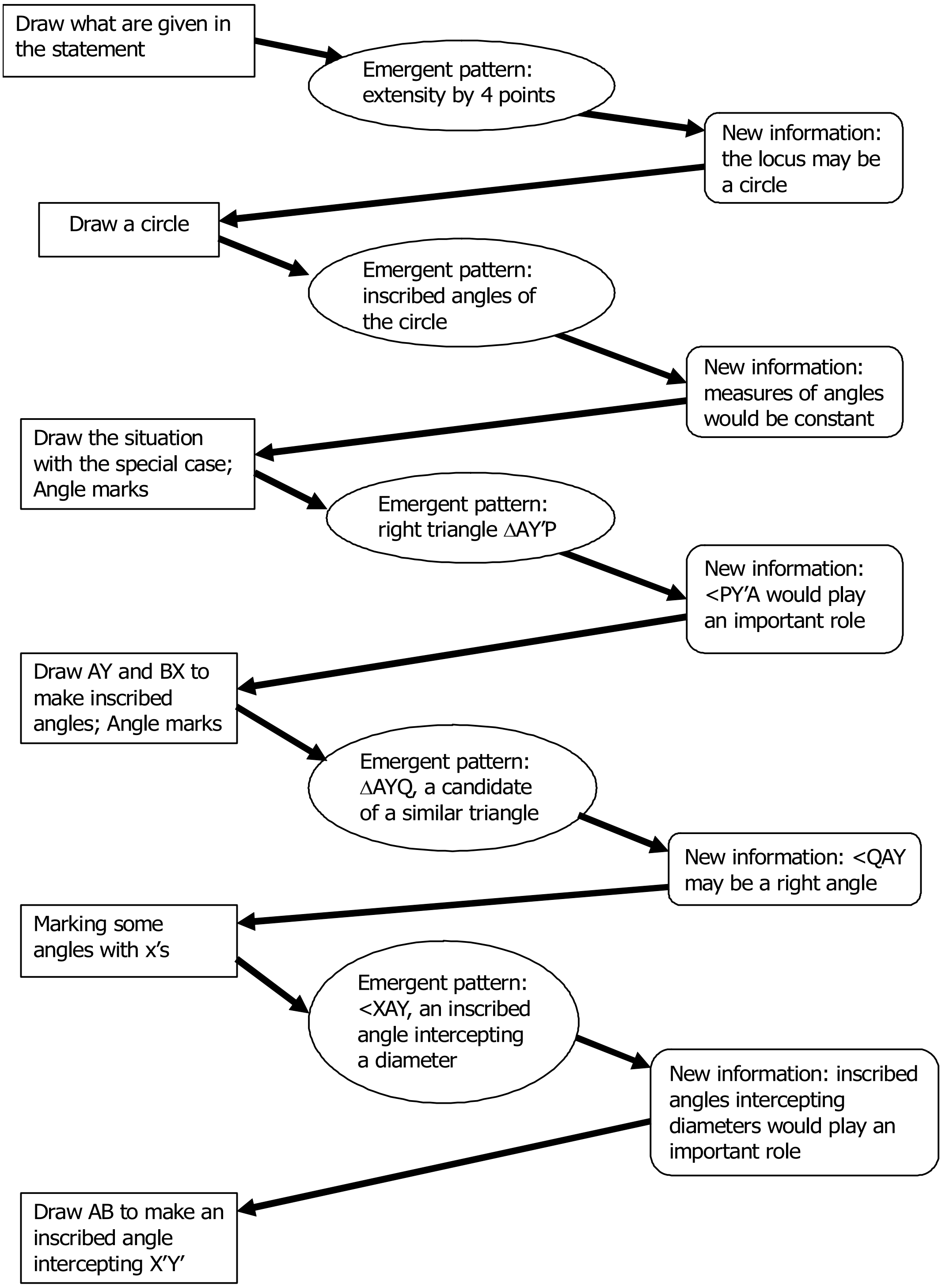
At stage (f), the solver constructed new drawing based on this information, saying “I will try a special case.” As Figure 4 (ii) shows, this drawing (Figure 2) included a special case where one of the end points of the diameter coincided with the fixed point A. Here, it should be noted that this special case had been used long before he drew Figure 2. The special case was originally adopted by the solver when he calculated an expression of the locus of the intersection point before he drew Figure 1. He introduced it as the case where the denominator of one expression was equal to zero. This case was ‘quoted’ in Figure 1 in exploring the movement of the intersection point. Thus, it can be said that the solver drew Figure 4 (ii) by associating what he knew at that stage. Since he came to attend to angles at stage (e), however, he added an angle mark to ∠PAY’ as well as ∠AQY and ∠APY’. This marking produced a combination of three lines, all of which were drawn to make ∠APY’, and the angle marks. This combination led to a new emergent pattern, ΔAY’P. Because one of the angles of this triangle was an angle at an intersection point and another was a right angle, the remaining angle of this triangle, ∠PY’A, came to attract the attention of the solver.

This made the solver draw AY and BX to make inscribed angles intercepting the same arc as ∠PY’A. In fact, he marked the newly constructed inscribed angles with the same marks as the ∠PY’A. This marking made a combination of the other three lines and the angle marks. Two of these lines were drawn to make ∠AQY and one of them was drawn to make an inscribed angle. However, this combination led the solver to another emergent pattern, ΔAYQ. The fact that the solver also drew an extra line BX suggests that the above combination was not expected in advance. He recognized this emergent pattern and traced it with his pen.

This recognition directed the attention of the solver to angles around the point A, because he could prove the conclusion if ∠QAY was a right angle. The fact that the solver marked ∠YAY’ and ∠QAP with small x’s seems a representation of such a subgoal. His attention to ∠QAY highlighted a combination of XQ and AY. Moreover, a combination of these lines and the x marks at ∠YAY’ and ∠QAP might highlight a kind of correspondence of the right- and left-side of AY, and this left-side composed an emergent pattern, an inscribed angle intercepting a diameter. Although XY, XA and AY were introduced independently, this combination led to an emergent pattern which could complete his proof. The solver tried to check inscribed angles intercepting another diameter, X’Y’, and drew AB.

The flow of the solver’s use of drawings can be summarized as Figure 5.

Figure 5


Draw what are given in the statement
Emergent pattern: extensity by 4 points
New information: the locus may be a circle
Draw a circle
Emergent pattern: inscribed angles of the circle
New information: measures of angles would be constant
Draw the situation with the special case; Angle marks
Emergent pattern: right triangle ∆AY'P
New information: <PY'A would play an important role
Draw AY and BX to make inscribed angles; Angle marks
Emergent pattern: ∆AYQ, a candidate of a similar triangle
New information: <QAY may be a right angle
Marking some angles with x's
Emergent pattern: <XAY, an inscribed angle intercepting a diameter
New information: inscribed angles intercepting diameters would play an important role
Draw AB to make an inscribed angle intercepting X'Y'

Episode 2

Episode 2 was excerpted from the ninth session, in which the solver tried to solve the following problem:

> The inscribed sphere of a given tetrahedron touches all four faces of the tetrahedron at their respective centroids [i.e. centers of gravity]. Prove that the tetrahedron is regular. (Klamkin, 1988, p.9)

First, the solver sketched the problem situation and explored the situation using that sketch. Through this exploration, he came to need to check the following: whether medians of two adjacent faces and radii orthogonal to those faces were on the same plane. After that, he said, "I will re-draw it clearly," and drew the drawing in Figure 6. The solver obtained new information about the problem situation using that drawing. Then he drew the other drawings like Figure 7 and Figure 8. The solver drew those drawings in the following manner.

(a) The solver drew two triangles in Figure 6 as adjacent faces of the given tetrahedron. Then, he drew the median lines AM and DM of these faces. He also added some dots on the median lines as trisecting points to indicate the centre of gravity of each face. (Fig. 9(i))

(b) The solver drew Oa and Od, each of which connected the centre of gravity of each face and the centre of the inscribed sphere. He added the right-angle marks to ∠DaO and ∠AdO. Writing "What I want to prove is that this angle is ∠R," he added the right-angle mark to ∠AMC. (Fig. 9(ii))

(c) The solver added the short double lines to Oa and Od for expressing Oa=Od. (Fig. 9(iii))

(d) After mentioning the equality of some right angles, the solver drew OM and traced Oa, OM, and ∠DaO with his pen. (Fig. 9(iv))

(e) After checking ΔOaM and ΔOdM, the solver marked dM and aM with small circles for expressing dM=aM. This relationship led him to concluding AM=DM. (Fig. 9(v))

(f) The solver attempted to extend this equality of medians to other pairs of medians and began to construct a new drawing. He drew the triangle ABC in Figure 7. He also drew its median, AM. (Fig. 10(i))

(g) He drew BD and CD to make another triangle. He drew the median of this triangle. (Fig. 10(ii))

(h) He drew A'B, A'D, A"C, and A"D to make two more triangles. (Fig. 10(iii))

(i) The solver drew the line A'C mentioning the equality of medians. He also drew A"B. (Fig. 10(iv))

(j) He marked AM, DM, BM, and CM with the pairs of double lines mentioning that AD and BC were bisected. (Fig. 10(v))

(k) The solver marked AC and BD with short lines saying that the opposite sides were equal. He also marked AB and CD. (Fig. 10(vi))

(l) The solver began to draw another drawing shown in Figure 8. He drew a larger triangle AA'A" first, then drew BC, CD, and DB by connecting points on the sides of this triangle. (Fig. 11(ii))

(m) The solver drew three long lines, AD, A'C, and A"B. (Fig. 11(iii))

(n) He marked A'B and DC with small circles. He also marked A'D and BC with small triangles and DB and A"C with small crosses, as shown in Figure 11(iv).

(o) The solver added another small cross to AC. He also added a small triangle to A"D and a small circle to AB. Saying that he could show that all four triangles were congruent, he drew a smaller triangle within each face. (Fig. 11(v))

(p) After he failed to show that each face was equilateral, the solver redrew a similar drawing as shown in Figure 11(vi). After he drew two lines A'C and AD, he marked the intersection of these lines with a dot and said that that point was a center of gravity and all the three lines intersected at one point. Then, he mentioned that showing that the lengths of the longer lines were equal (i.e. AD=A'C=A"B) would be enough for proving the conclusion.

Figure 6

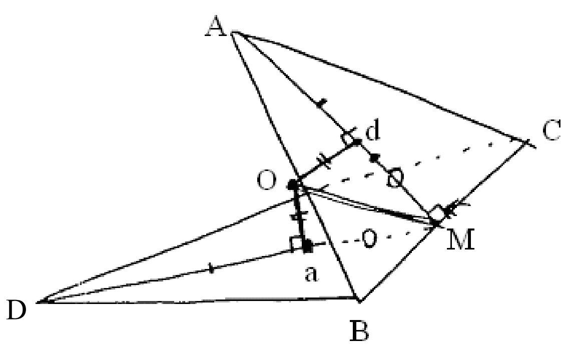


Figure 7

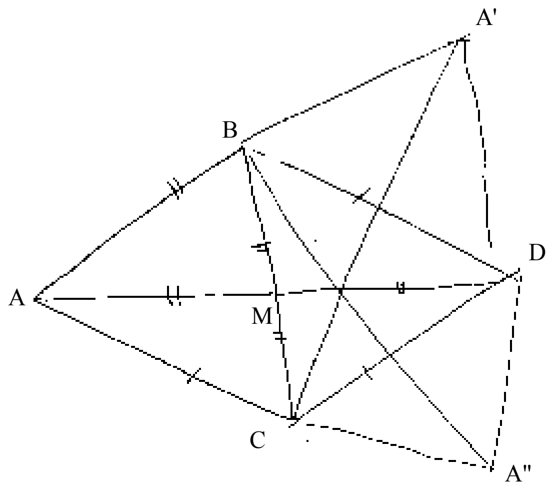


Figure 8

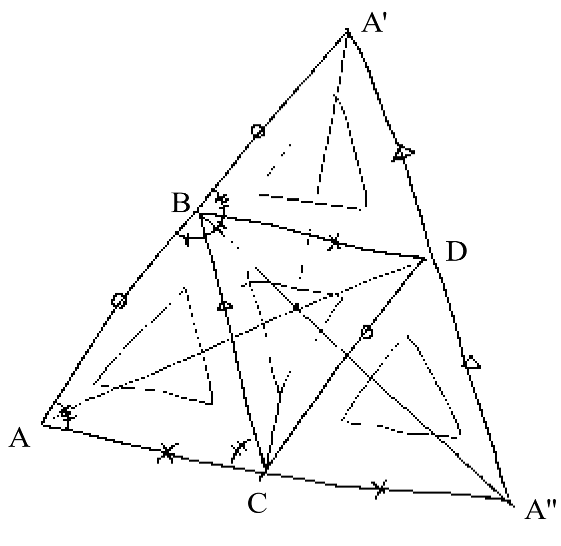


Figure 9

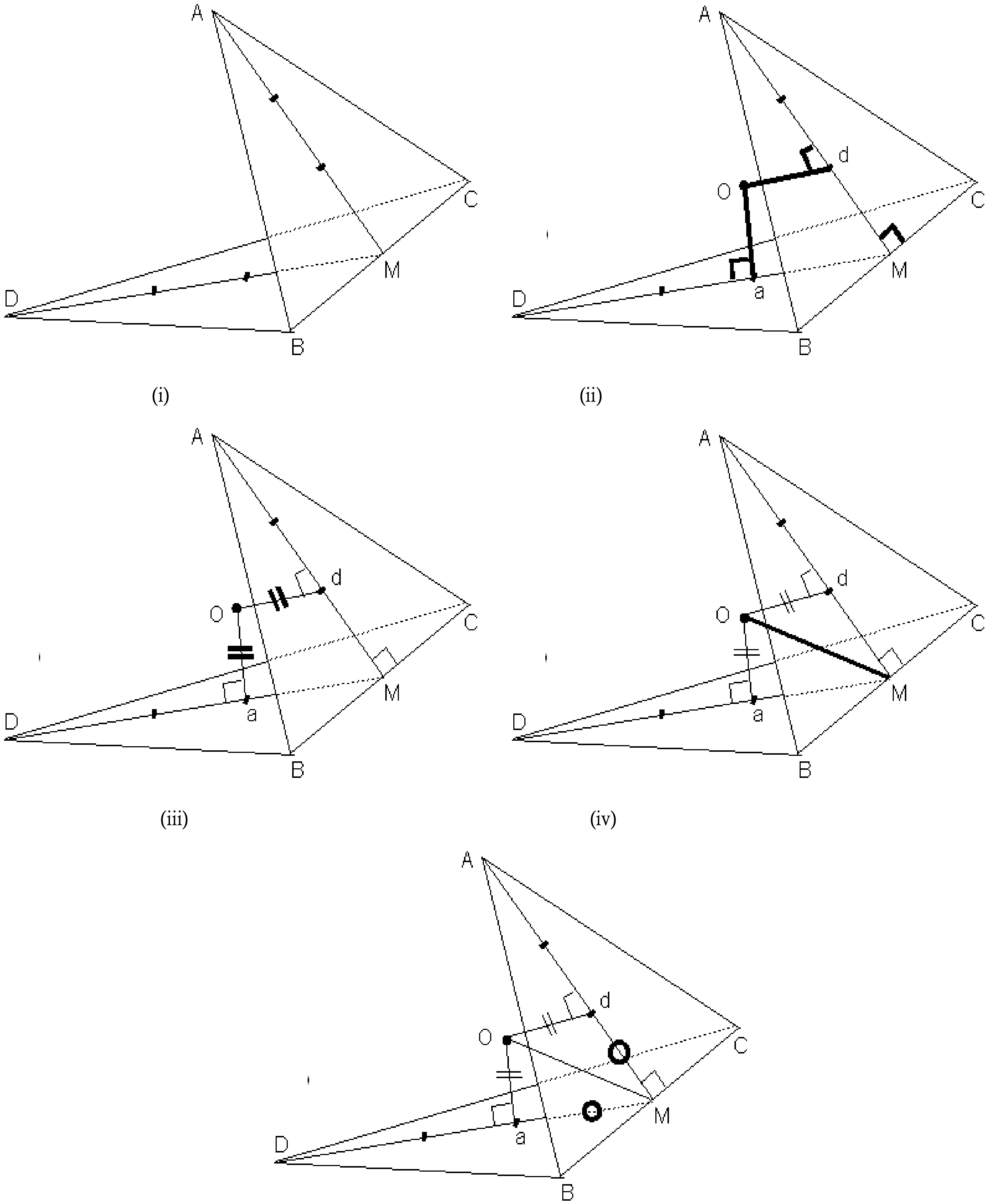
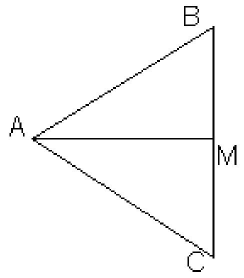
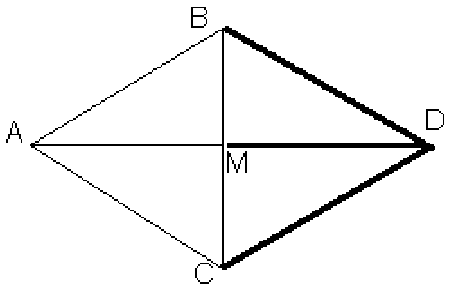


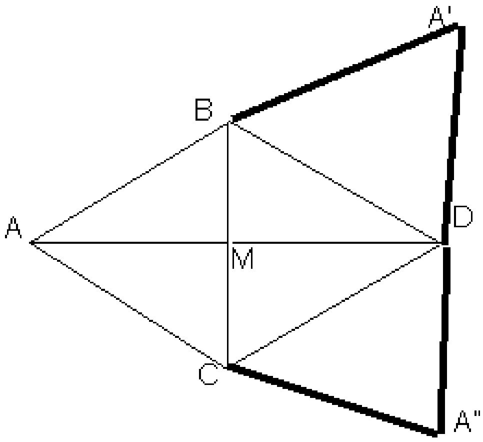
Figure 10



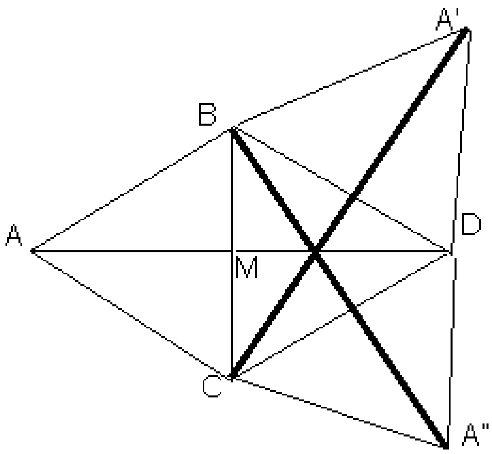
(i)



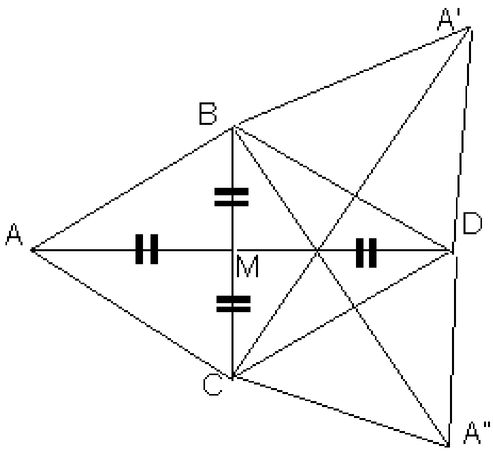
(ii)



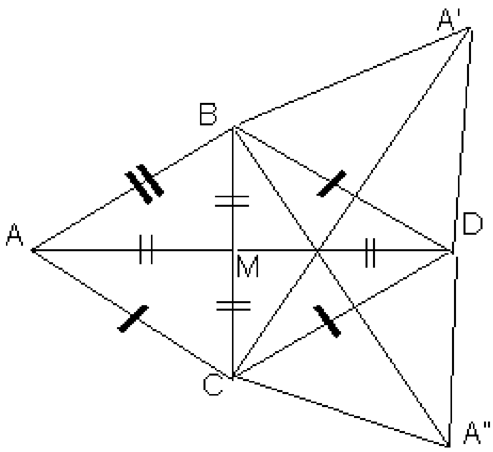
(iii)



(iv)

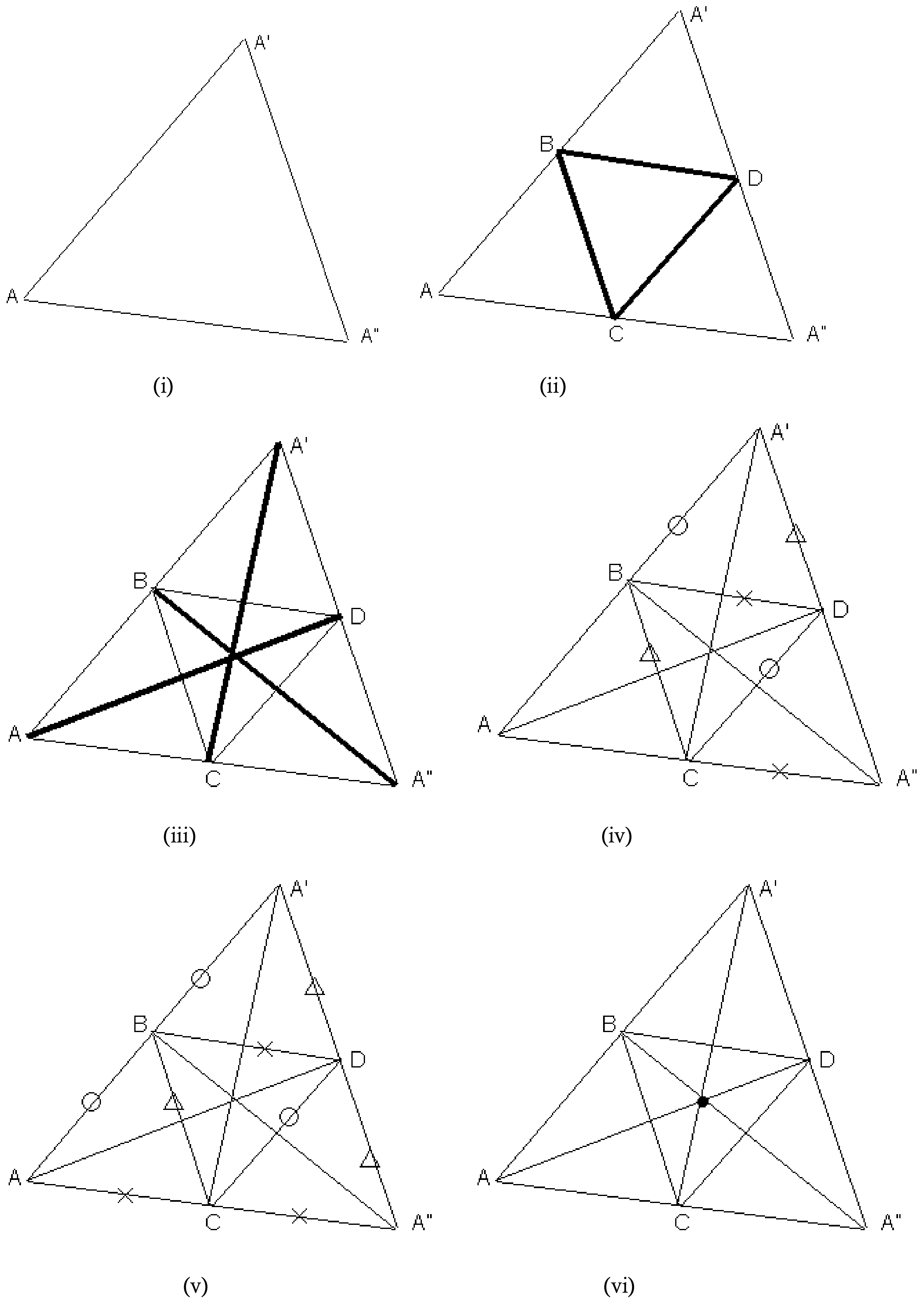


(v)



(vi)

Figure 11



Two of the trisecting points added at stage (a) represented the centers of gravity of the drawn faces. Two line segments marked with the short double lines at stage (c) represented the sphere. The right-angle marks added at stage (b) indicated that this sphere was tangent to the faces of the given tetrahedron. Eliciting only two adjacent faces was influenced by the information he had obtained during his previous activity (see Nunokawa, 2004). But, the solver seemed to represent the problem situation given in the problem statement at stage (a), (b), and (c).

In representing the problem situation, the drawing produced a combination of the elements, AM, DM, Oa, Od, and some marks. And this combination led to an emergent pattern, a quadrilateral like a kite, which could become a cue of one of the diagram configuration schemata, "Congruent-Triangle-Shared-Side schema" (Koedinger & Anderson, 1990). His recognition of this emergent pattern informed him that there might be two congruent triangles in this pattern. Following this information, he drew line OM at stage (d). The combination of the above-mentioned pattern and line OM led to another emergent pattern, two right triangles with the common hypotenuse. Checking that these triangles were congruent to each other, the solver obtained new information that the median lines of two adjacent faces had the same lengths and he marked those lines with circles. He might also obtain the information that median lines of other pairs of adjacent faces would have the same lengths, because he had noticed the symmetric nature of the problem situation at the earlier part of his solving process.

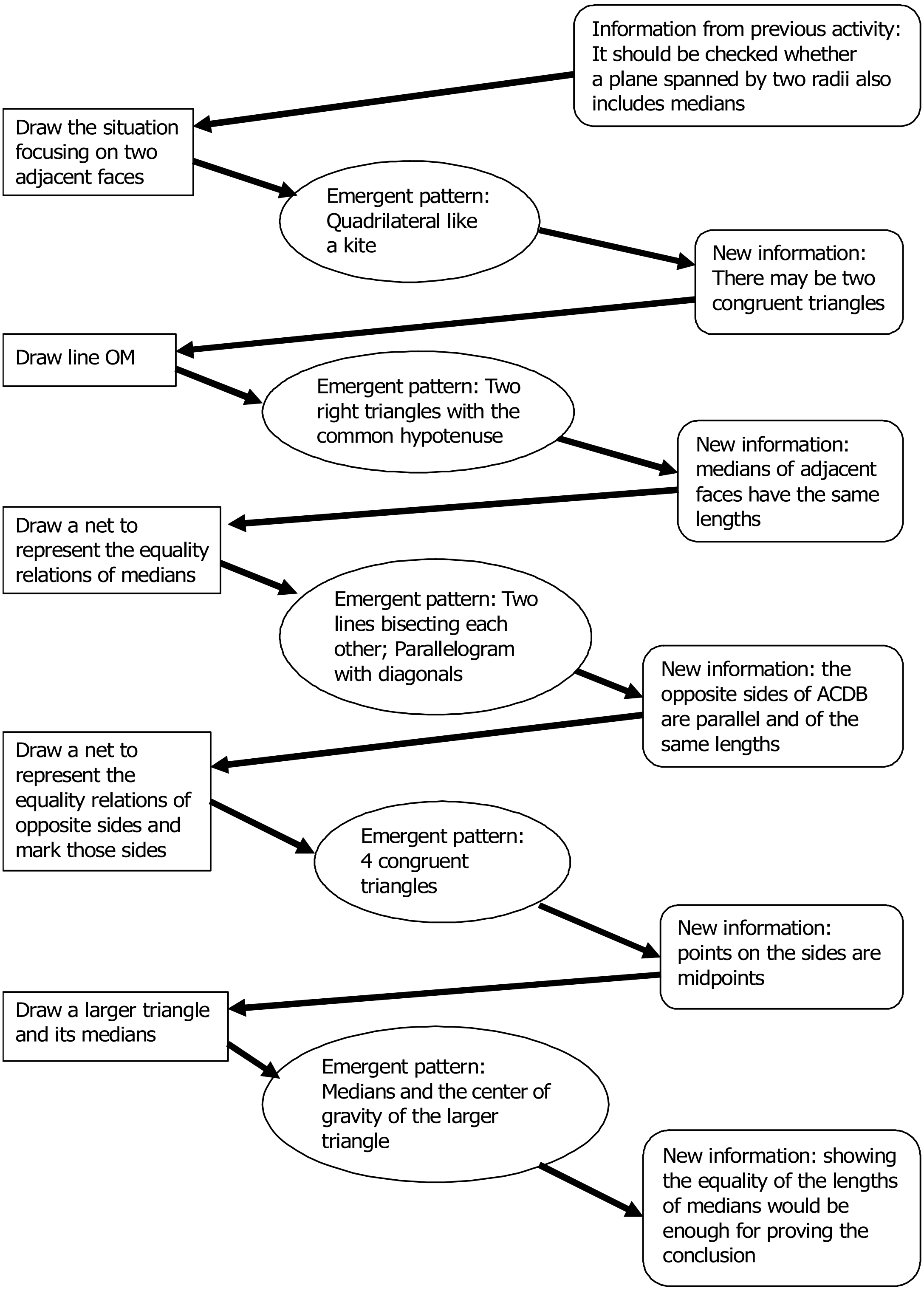
To represent such information, the solver drew a net including all the four faces of the given tetrahedron. After representing the equality of the medians he had found during the previous activity (Figure 10(i) and (ii)), he constructed two more triangles and drew median lines of those triangles (Figure 10(iii) and (iv)). When he marked some line segments to represent the equality relationships concerning those lines, a combination of two lines, AD and BC, and same-length marks occurred in the drawing. This combination led to an emergent pattern, two lines bisecting each other. Since the marks on BM and CM were added with the different intention from the marks on AM and DM, this combination might be unintended. This led to another emergent pattern, parallelogram ACDB and its diagonals. This pattern recognition was based on his implicit and incorrect assumption: Two medians of adjacent faces became one long line (see Figure 10(iv)). The recognized pattern informed him that the opposite sides of the quadrilateral were parallel to each other and of the same length.

To represent this information, the solver marked some sides at stage (k). Furthermore, he redrew the net at stage (l) to represent similar relationships among the sides of four faces of the tetrahedron. In drawing this net, the solver used the information that the opposite sides of each quadrilateral were parallel. This implied that, for example, AB was parallel to A'B and AB+BA' became one line. Thus, the use of the larger triangle AA'A" can be seen a representation of the information he had obtained before (Figure 11(i)). At this stage, the equality relations of the adjacent median lines were not expressed in the drawing. This means that Figure 8 was drawn to represent the information that the opposite sides of each pair of faces were of the same lengths. The solver marked all the sides of the four faces at stage (n) and (o). Through this marking, a combination of the sides and the three kinds of marks on them occurred in the drawing. This combination led to an emergent pattern, four congruent triangles in the net. It also led to another emergent pattern, the longer side bisected by a point on it (e.g. side AA' bisected by point B). Figure 11(iv) suggests that this bisection was not assumed in drawing Figure 8. The pattern implied that each point on the side of ∆AA'A" was a midpoint of that side.

To represent what he had found at the previous stage, he drew another net at stage (p). Although he did not mark any sides, the above information might let him consider that the lengths of the adjacent sides (e.g. AC and A"C) were equal. When he drew A'C and AD in Figure 11(vi), a combination of these lines and their intersection occurred in it and this combination led to an emergent pattern, the medians of the larger triangle and its center of gravity. When he found that four faces were congruent at stage (o), he mentioned that all the faces should be equilateral. It implied that a larger triangle, ∆AA'A", should be equilateral because it was similar to each face. This requirement and the above-mentioned emergent pattern, medians and a center of gravity of the larger triangle, might remind him of the mathematical fact that a triangle whose medians have the same lengths is equilateral. This is the mathematical knowledge that can be used for a solution of this proof problem (cf. Nunokawa, 2001). Although the solver could not solve this problem completely, he could arrive at some of the essential pieces of its solution through his use of drawings.

The flow of the solver's use of drawings can be summarized as Figure 12.

Figure 12


Information from previous activity: It should be checked whether a plane spanned by two radii also includes medians
Draw the situation focusing on two adjacent faces
Emergent pattern: Quadrilateral like a kite
New information: There may be two congruent triangles
Draw line OM
Emergent pattern: Two right triangles with the common hypotenuse
New information: medians of adjacent faces have the same lengths
Draw a net to represent the equality relations of medians
Emergent pattern: Two lines bisecting each other; Parallelogram with diagonals
New information: the opposite sides of ACDB are parallel and of the same lengths
Draw a net to represent the equality relations of opposite sides and mark those sides
Emergent pattern: 4 congruent triangles
New information: points on the sides are midpoints
Draw a larger triangle and its medians
Emergent pattern: Medians and the center of gravity of the larger triangle
New information: showing the equality of the lengths of medians would be enough for proving the conclusion

USE OF DRAWINGS AND INFORMATION GENERATION

The analyses of the above two episodes show some insights into how drawings can contribute to generating new information and promote problem solving processes.

When the solver represented what he understood (e.g. the given conditions or the information obtained in the previous activities) in a drawing, a kind of combination or configuration of elements occurred in this drawing. While there was a case (i.e. drawing OM at stage (c) of Episode 2) in which the solver added an element in the anticipation that a certain emergent pattern could be recognized, in the other cases, the solver did not seem to know what kind of emergent pattern would be recognized in advance. The combination of elements occurred beyond his intention.

For example, in episode 1, the solver drew the line AY to make an inscribed angle congruent to a certain angle. However, representing it in the drawing brought about the combination of this line and other lines given in the problem statement, which would be recognized as an emergent pattern, ΔAYQ. The short time lag between marking angles and tracing ΔAYQ implies that this triangle was not intended in advance. In episode 3, the solver drew the situation focusing on two adjacent faces. He drew the medians of these faces and the radii orthogonal to these faces in order to represent the centers of gravity and the given sphere respectively, both of which were given in the problem statement. However, representing them in the drawing brought about the combination of these lines, which would be recognized as an emergent pattern corresponding to a diagram configuration scheme. When he recognized this emergent pattern, the solver said, “I’ve come to an unexpected place.” His utterance implies that this emergent pattern was unexpected in advance.

Although such combinations or configurations of elements were supervenient, they seemed to trigger the solver’s recognition of certain emergent patterns. Larkin & Simon (1987) pointed out that drawings can group together all information and enable a solver to avoid large amount of search. However, at least according to the analyses of the above two episodes, drawings could not only group together the elements, but also produce certain combinations or configurations of them, and drawings enabled the solver not only to avoid large amount of search for necessary elements, but also to notice unexpected emergent patterns. This role of producing supervenient combinations or configurations can be seen an important contribution of drawings, because it could support the creative aspects of the solver’s thinking through bridging what he knew and what did not know. Since the combinations or configurations can be beyond solvers’ intentions, they can make them reach novel information about problem situations.

While drawings could contribute to the solver’s thinking through producing supervenient combinations or configurations, the above episodes also showed the limitation of this contribution of drawings. As discussed in the analysis of episode 1, when the solver saw the combination of the four intersection points which occurred in Figure 3 (iii), he had the information that the locus in question could be expressed only by sine and cosine functions, which he had obtained through his calculations implemented before drawing it. It might be said that this information about the problem situation helped the solver to recognize the emergent pattern. In Episode 3, it might be critical for attending to the combination of elements like a kite that the solver had the Congruent-Triangle-Shared-Side schema. What the solver knew at that time seemed to play significant roles in recognizing emergent patterns in drawings, in a similar way in which arithmetic facts play an essential role in identifying patterns in numerical data (Haverty et al., 2000). Whether an emergent pattern can be recognized depends upon whether a solver has knowledge or information which can support his recognition of that pattern, as well as upon how easily a produced combination or configuration of elements makes the solver recognize that pattern (e.g. typical configuration for a certain pattern or configuration with much noise).

This limitation of the contribution of drawings also implies that, as a solver obtains more information about a problem situation in his problem solving process, how the solver interacts with drawings about that situation can change and he may get able to recognize emergent patterns he could not identify before. Yerushalmy (2000) reported that, as their learning on functions proceeded, the students could elicit appropriate information from rough sketches of graphs because they connected the sketches to the structure of the symbolic rules, mathematical knowledge they had learned (p. 137). Although it may be rare that the mathematical knowledge base of a solver is changing in one problem solving process, especially in a problem solving at elementary and secondary level, it must be plausible that the solver's knowledge base about the problem situation grows in that problem solving process and that the solver can recognize emergent patterns he might not be able to notice before.

For example, although the triangle ΔAY'P existed in drawings when the solver drew Figure 1 in episode 1, it was recognized as an emergent pattern after he had noticed that the measure of $\angle$APY' would be constant at stage (e). The inscribed angle $\angle$XAY in Figure 2 appeared when the solver drew the line AY. However, it was recognized as an emergent pattern after he had noticed that $\angle$QAY would be a right angle. In episode 2, it was the information that the point C, for example, bisected the side of the larger triangle that enabled him to recognize the emergent pattern of the medians and the center of gravity of the larger triangle, while the longer lines (e.g. A'C) and their intersection already existed even in Figure 7 and Figure 8.

Diagrammatic summaries of two episodes (Figure 5 and 12) clearly show a cyclic nature of use of drawings in mathematical problem solving. This cyclic nature was partially supported by the fact that while drawings produced combinations or configurations of elements, new information obtained from emergent patterns suggested the ways of modifying drawings. However, it was also supported by the fact that what kinds of emergent pattern the solver could recognize might change as his knowledge base about the problem situations grew in his solving processes. Some researchers have highlighted the relationship between two modes of thinking, visualizing and analyzing, in the use of drawings. The analyses of the above episodes suggest that we should also attend to the relationship between changes in solvers' use of drawings and changes in solvers' knowledge base about problem situations.

CONCLUDING REMARKS

The analyses of this paper highlighted one contribution of drawings in generating new information: to make an unintended combination or configuration of known elements which leads to an emergent pattern. Even when the solver can find an appropriate emergent pattern, the information the solver will obtain is not necessarily an idea that will directly imply solutions, but additional information that can deepen the solver's understanding only a little further. Therefore, the use of drawings should be considered in the cycle discussed above, where a series of information generation deepens the solver's understanding of the problem situation gradually and may make it more likely for him to reach solutions (cf. Nunokawa, 2005).

Taking account of the influence of what solvers know, developing students' repertoire of diagram configuration schemata may be one way to develop students' competence to effectively use drawings in mathematical problem solving (see also Stylianou (2002)). The same discussion, however, highlighted the importance of the information solvers have about problem situations. Also in this sense, use of drawings should be treated in relation to its cyclic nature or gradual deepening of solvers' understanding through those cycles.

Following the above analyses, use of drawings cannot be automatically helpful. Therefore, when encouraging their students to use drawings in solving mathematical problems, it may be necessary for teachers to pay attention to the following issues: (a) what kinds of emergent pattern can be expected to appear when students represent what they know in drawings; (b) what kinds of information about problem situations or what kinds of mathematical knowledge will be necessary for identifying those emergent patterns. Above all, it seems necessary for teachers not to expect that the initial drawing will show students the ideas critical to solutions, but to support them so that they can go through the cycle of their use of drawings.

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Eurasia Journal of Mathematics, Science and Technology Education
Volume 2, Number 3, December 2006
www.ejmste.com

EFFECTIVENESS OF REPTILE SPECIES IDENTIFICATION – A COMPARISON OF A DICHOTOMOUS KEY WITH AN IDENTIFICATION BOOK

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ABSTRACT. Species identification tasks are a prerequisite for an understanding of biodiversity. Here, we focused on different educational materials to foster the identification of six European reptile species. Our educational training unit was based on natural plastic models of six species and pupils either used an illustrated identification book or a dichotomous key. 71 secondary school pupils (6th graders) from four classes participated in our study and received a hands-on lesson about the identification of these species. 37 of them were aided by an identification book, and 34 received a dichotomous key. We found a significant increase in identification skills immediately after and with a delay of four weeks in both treatment groups. Further, we found no differences in achievement between both groups nor did we detect differences in the emotional variables (well-being, interest, boredom) or in the difficulty of the task. We propose that species identification should be taught in everyday school life using models and identification materials that allow a learner-centred environment.

KEYWORDS. Identification Skill Training, Classification Task, Self-Regulated Learning, Identification Keys, Model Specimen, Taxonomy.

INTRODUCTION

One major prerequisite for an understanding of ecology and ecological interactions is some basic knowledge about species and their natural and life history (Lindemann-Mathies 1999, Randler & Bogner 2002, Randler 2006). This is especially true when it is taught at the school level. Training in identification skills or making use of identification books, therefore, is an important task in biology teaching. Previous studies found that some basics must be considered when pupils were taught species identification: The number of species taught during such an educational unit should not be exceedingly high (Randler & Bogner 2002), and approximately five to six different species should be considered as sufficient (Randler & Bogner 2006). Further studies revealed that student- or learner centred environments often cope better with the need of pupils to autonomously explore new fields of knowledge, to perceive competence and to be socially related (self-determination theory; Deci & Ryan 1990).

ISSN: 1305-8223

Usually, outdoor educational settings are given preference over classroom instruction (Killermann 1998), however, most of these empirical studies are related to plant species or invertebrate identification or to measuring abiotic factors (Killermann 1998). Identification tasks in a herpetological context have been seldom empirically tested (Randler et al. 2005). In amphibian identification, for example, pupils were instructed in the classroom (pre-visit instruction), then encountered living amphibians during a conservation action, and the field trip received a post-visit instruction (Randler et al. 2005). In contrast to amphibians during their spring night-time migration, reptiles are highly mobile species in their natural environments and difficult to observe and identify at least on the level of pupils. Therefore, we developed an identification task that used model specimens instead.

Different identification materials can be used during such a learner-centred environment. Identification books represent the most common media used for animal identification, and, by using them, pupils learn how to cope with such reference material which emphasises the value of identification in their everyday life and encourages a lifelong learning. From a scientific viewpoint however, pupils should be enabled to make us of dichotomous identification keys (Randler 2006). Such a dichotomous key is always based on two alternatives (decisions) which were subsequently followed by another pair of alternatives unless the final species name (or other taxonomic level) is reached. Such keys were developed, e.g. in human biology (Bavis et al. 2000), plant identification (Ohkawa 2000), fruits, nuts and cones of trees (Collins 1991), timber (Thomas 1991) or in amphibians (Randler 2006), but most of these have not been evaluated. The benefits of an identification book is its value as a real or original medium, while its disadvantages may be that they are costly and often depict many more animals than were explored during the lesson. However, this, in turn, fosters competence and skills in pupils to use such books as references. Another disadvantage of pictures in books is that pupils focus on the pictures alone and discard reading the specific text which usually supports identification features and is helpful for memorising. Therefore, an identification key based on dichotomous decisions between two alternatives and on language may provide a closer and more detailed look at the objects and these keys are usually scientifically precise and afford the understanding of specific scientific terms. In a pilot study, using tracks and signs of animals as original objects (Randler & Knape 2007), pupils using an illustrated identification key (a selection of pictures for identification) achieved significantly higher scores compared to pupils using a dichotomous, language-based identification key. Therefore, to cope with these results, we used a dichotomous key that was supported by a few black-and-white pictures which aid the final identification of the respective species. The benefit of this key is that it can be copied and pupils can take them home for their personal use.

The aim of this present study was to enhance learning and retention effects when pupils in small groups were working together in an identification skill training using model specimens of reptiles and either using a dichotomous key or an identification book. Therefore, the educational material was the variable in question, and the educational treatment, namely group-based learning (Lou et al. 1996), hands-on science (e.g. Stohr-Hunt 1996) and the use of models remained equal in both approaches.

METHODS

Species selection

As outlined previously, we focused on six autochthonous species of reptiles that could be encountered in Baden-Wuerttemberg, the federal state where the educational unit was carried out. We selected models of six species: Western green lizard *Lacerta bilineata*, sand lizard *Lacerta agilis*, smooth snake *Coronella austriaca,* grass snake *Natrix natrix*, adder *Vipera berus*, and slow worm *Anguis fragilis*. These models closely resembled original reptiles and were obtained from a scientific producer (SOMSO; Schlüter Biologie, Winnenden, Germany).

Materials for identification

Two different identification materials were compared with each other. The identification key was obtained from Schroedel-Verlag (Schrodel, Braunschweig, Germany) and was explicitly made for the use in a school setting (biology lessons, 5th and 6th graders). It contains a DIN A 3 page in black-and-white that can be easily copied and given to the pupils. The key has a dichotomous structure where there is always a decision between two alternatives, e.g. whether the pupil of the eye is vertical or horizontal. When you have gone through all alternatives the final species' name is reached and there is a black-and-white illustration to further support the identification.

The identification book (Amphibien und Reptilien erkennen und schützen, amphibians and reptiles; total pages: 159; Blab & Vogel 1996) was also obtained from a commercial producer. This book depicts a total of 19 reptiles species on 37 pages. The book provides various photographs and sketches in colour and verbal information about identification, behaviour, natural history and ecology.

Educational program

Pupils worked together in groups of 2-4 pupils and each group received either an identification book or the dichotomous key. The plastic models were presented in a kind of workstations (Schaal & Bogner 2005). Pupils then moved from one desk to another, looked at the models and identified them. After pupils had finished their work, results were discussed and corrected in the classroom.

Test instrument

Tests were based on a slide presentation. Pupils received a sheet of paper where they had to label the species as precise as possible. The species were numbered and the pupils wrote down their identification at the respective number. This procedure was repeated three times (pretest, posttest and retention test). The posttest was applied immediately after the lessons and the retention test with a delay of four weeks. However, the order of presentation of the species was changed between all three test sessions to avoid effects produced by order. Each correct identification on the species level was scored with 1.0, each correct identification on the genus level was scored 0.5. Others received the value 0. This was added to a total score for each participant. The logic behind this scoring is that a gain in knowledge must not result in the correct species identification – for example, a species may be totally unknown to someone but after an educational treatment it is identified on the genus level (e.g. as a lizard). Further, we consider it as an improvement or refinement of a concept when there appears a shift from the genus identification, e.g. previously identified as a lizard and later on identified correctly with the species' name (sand lizard; see discussion in Randler & Bogner 2006).

Additionally, we measured emotional variables derived from the inventory proposed by Laukenmann et al. (2003) and Gläser-Zikuda et al. (2005). We measured these constructs based on four different dimensions: interest, well-being, boredom and difficulty of the questions based on a five-point Likert-scale. Each dimension was tested with one question immediately after the lesson.

Pupil sample, randomisation

71 (14 boys, 57 girls) pupils from four different classes of two schools participated in our study. The design was balanced because the treatments were randomly assigned to the two classes of each school (quasi-experimental approach). One class out of each school received the identification book and the other one received the dichotomous key. One school was mono-educative (girls only), therefore, the sample is biased towards girls. 37 pupils (7 boys, 30 girls) received an identification book to support their learning and 34 pupils (7 boys, 27 girls) received the black-and-white illustrated dichotomous key.

Statistics

For comparison of the means of both approaches we used T-tests and to further investigate differences in a more complex manner and controlling for covariance and interactions a general linear model was applied (GLM). All tests were carried out two-tailed. We used SPSS version 13.0. Means ± standard errors (s.e.) are given.

RESULTS

Species identification

Pupils did not differ in their prior knowledge (book: 1.18 ± 0.11 versus key: 1.48 ± 0.10; T-test: T=-1.90; df=69; P>0.05; Figure 1). Immediately after the educational treatment there were no significant differences between both treatment groups (book: 4.52 ± 0.19 versus key: 4.66 ± 0.19; T-test: T=-0.48; df=69; P>0.05). After a delay of four weeks, there were also no differences in retention (book: 3.85 ± 0.20 versus key: 3.51 ± 0.14; T-test: T=1.29; df=69; P>0.05). This suggests that both educational materials are equivalent in their effectiveness and that both may be used to achieve a sustained learning and retention (Figure 1). Examining the species in detail found interesting results. Prior to teaching, only the slow worm was identified correctly on the species level by most pupils, while both lizard species were known as lizards (genus name) to the pupils (Figure 2). In the posttest, most pupils were able to recognise both lizard species, the slow worm and the adder on the species level while smooth snake and grass snake were more difficult to identify (Figure 3). Retention test revealed similar results although the scores were generally lower. Scores of adder and slow worm remained high suggesting that these species were recognised on the species level by most pupils even after a delay of four, while smooth snake score was extremely low.

The multivariate general linear model (GLM) used pretest as covariate and both gender and treatment as factors. There was no significant effect of gender, treatment and pretest in the multivariate model. Univariate models revealed a significant influence of pretest on posttest (F=3.82; df=1; P=0.05) but not on retention test (P>0.05).

Emotional variables

We found no significant differences between the treatments in emotional variables (P always >0.05). Generally, interest was rather high (≈ 4 on the five point Likert scale), as was well-being (≈ 4). Boredom was perceived as low (≈ 1.6) and the task was not considered difficult (≈ 1.8). This suggests that the educational treatment was well-accepted in the assessment of the pupils. Further, as the pupils perceived their task as equally difficult, we suppose that both identification materials are suitable for species identification.

DISCUSSION

Model specimens, identification tools (either books or keys), hands-on instruction and group-based learning approaches provide successful learning environments for secondary school pupils. This was proved in some earlier studies (Randler & Bogner 2006, Randler & Knape 2007). Here, we used these previous results and focused on the identification material itself. We found that both treatment groups significantly improved their species identification knowledge about reptiles and we further suggest that such methodological teaching sequences should be embedded into everyday school practice. Further, we emphasize that the number of species that should be taught during such lessons should not be exceedingly high – approximately six different species seem sufficient for 5th and 6th graders.

The general linear model did not detect differences between boys and girls, however, this might be hampered by the low sample size of boys in the groups. Nevertheless, we feel that boys and girls equally benefit from this kind of instruction since other recent studies also did not reveal gender differences although they provided larger samples of boys (discussion in Randler & Bogner 2002, 2006). This might also result from the content of the lessons as reptiles may be equally interesting for boys and girls. In plant identification, for example, girls usually score higher (Killermann 1998, Scherf 1985).

With regard to our identification materials, we found no significant difference between both approaches, suggesting that either the identification book as well as the black-and-white key were equally suitable for this identification task. The advantages of the key are clearly its low costs, i.e. it can be copied and each pupil may retain the key and may use it further in out-of-school settings. Further, this key trains pupils to look critically at verbally explicated differences and to scrutinise the models in detail. However, the identification book also has its advantages. The book consists of many pages and, therefore, pupils must thoroughly go through it to find the correct identification. Further, such books also provide a wealth of information about the respective species' ecology and behaviour.

Why are some species more easily to memorise? There were only two species of lizards and most pupils were able to identify them prior to the educational unit on the genus level, thus they had a concept of lizard and refined it during the identification task. The slow worm was correctly identified prior to the lesson by more than 60% of the pupils and afterwards by nearly all. This species closely resembles a kind of worm rather than a reptile which may also make it easy to recognise. Three species of serpents were used, all rather unknown prior to teaching. In retention, the adder was most often labelled correctly, followed by the grass snake and the smooth snake. The adder is one of two venomous snake species in Germany which made it perhaps impressive for the pupils. Grass snake has two yellow patches behind the head – a very conspicuous trait while the smooth snake does not show any pronounced coloration. Both snake species presented difficulties during the identification lessons (IZ; pers. observ.) which might explain the low retention scores.

ACKNOWLEDGEMENTS

We appreciate the co-operation of the principals, teachers and pupils involved in this study. IZ carried out the educational treatment and the tests in the school and input the data into the computer. CR made the statistical analyses an wrote up the paper. This study was partially funded by the University of Education PH Ludwigsburg by a grant # 1430 5771 'Teaching and learning in biodiversity'.

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Table 1. Results of a multivariate general linear model (GLM) using pretest as covariate and gender and identification material as factors.

	Wilks-Lambda	F value	P
Constant	.225	112.039	.000
Pretest	.942	1.990	.145
Identification material	.994	.212	.809
Gender	.960	1.338	.270
Interaction gender * material	.965	1.171	.316

FIGURES.

Figure 1. Comparison of two different identification materials (coloured identification book versus language-based dichotomous key). Mean scores of tests were depicted (maximum: 6 points). Posttest was applied immediately after the lessons and retention test was applied after a delay of four weeks.

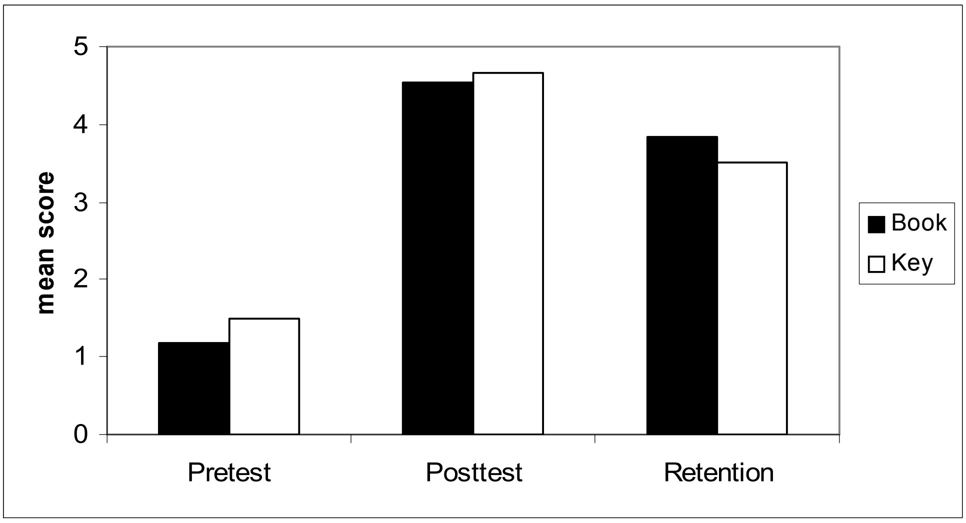


Figure 2. Percentages of correct identification of six different reptile species prior to the educational unit. Data from both treatment groups pooled.

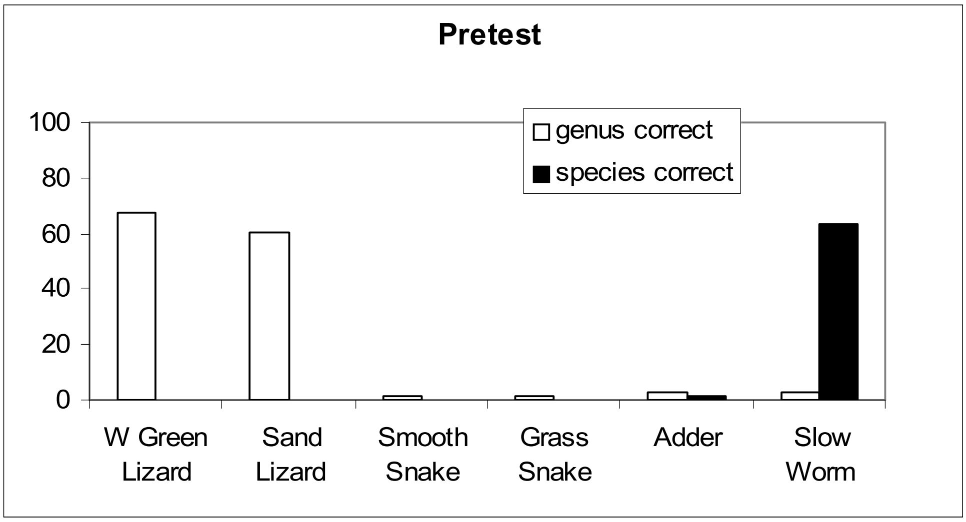


Figure 3. Percentages of correct identification of six different reptile species immediately after the educational unit. Data from both treatment groups pooled.

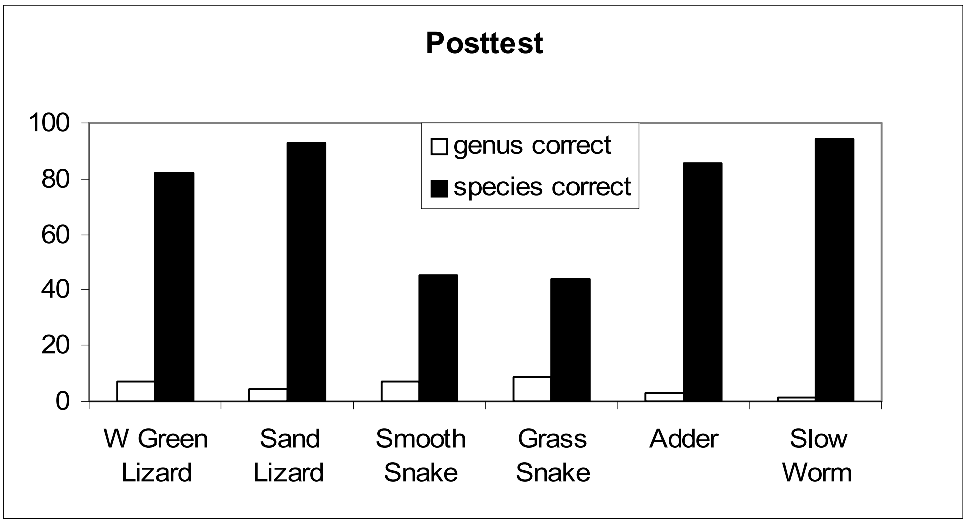


Figure 4. Percentages of correct identification of six different reptile species four weeks after the educational unit. Data from both treatment groups pooled.

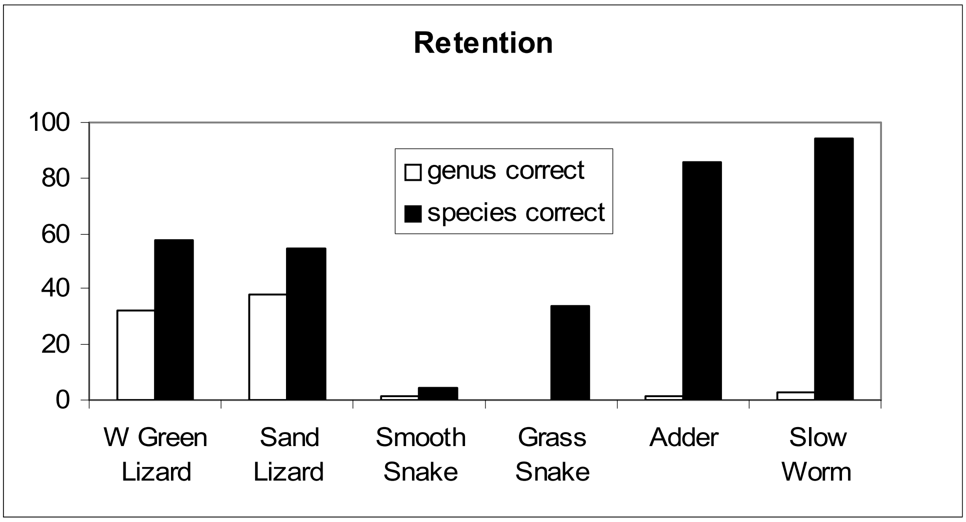
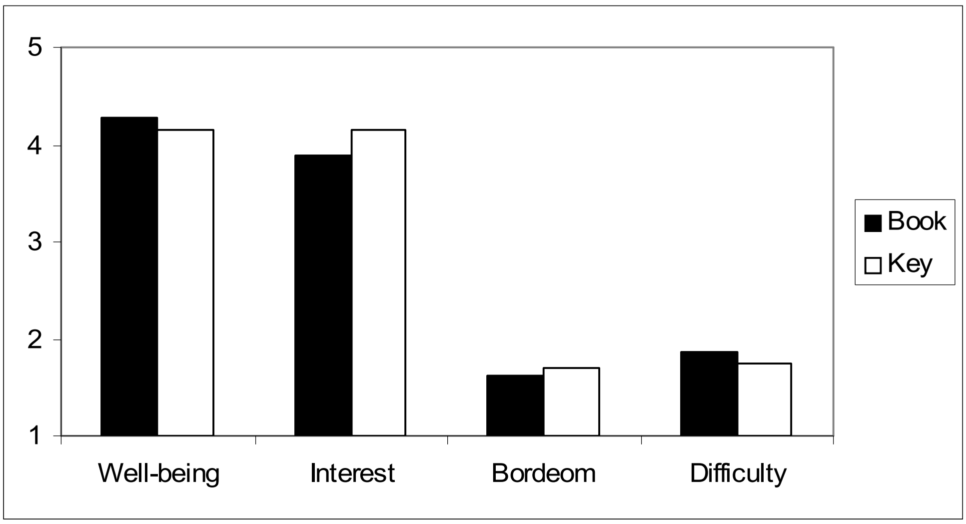


Figure 5. Comparison of two different identification materials (coloured identification book versus language-based dichotomous key). Mean scores of emotional variables were depicted (Likert-scale 1=lowest, 5=highest value).



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Eurasia Journal of Mathematics, Science and Technology Education

Volume 2, Number 3, December 2006

EXPLORING THE EFFECTS OF TI-84 PLUS ON ACHIEVEMENT AND ANXIETY IN MATHEMATICS

Noraini Idris

ABSTRACT. Most of us want our students to feel that mathematics is an enjoyable and rewarding study for them … but do we succeed? Some of our students are successful whereas others are anxious and fearful. The performance of Malaysian students in mathematics has been generally been not good. It has been realized that poor mathematics performance of students at the secondary level would result in a decrease in the number of students getting to the university. It was with this realization that the present project was mooted. This study is designed to investigate the effect of TI-84 Plus graphing calculator on the achievement of mathematics and the students' anxiety. The sample of the study consists of four classes of form four students from two of the public schools in Selangor, Malaysia. In each school, one class was assigned to be the experimental group (N=54) and the other the control group (N=55). For the experimental group, all students used the graphing calculator. The treatment took about ten weeks. Regular teachers taught and used the graphing calculator. A paper and pencil test on the achievement and anxiety test developed by the researcher was given to both groups before and after the treatment. The result showed that there was a significant difference on the achievement and anxiety of the treatment groups ($p < 0.01$).

KEYWORDS. Achievement, Anxiety, Mathematics Anxiety, Graphing Calculator, Technology.

INTRODUCTION

In the era of fast technological advancement, keeping up with the latest innovations and inventions that technology can offer is essential in order to be relevant now and in the future (Abd. Rafie, 2002, Bitter & Hafield, 1994; Pomerantz, 1997; Noraini Idris, 2006). Educators have to be prepared to deal with enormous challenges in mathematics education and to forge ahead because holding on to the old and familiar ways would mean putting students at a disadvantage in a world that is fast embracing technology (Ames, 1992; Dunham & Dick, 1994).

In mathematics, this would mean that the order and treatment of most topics would need to be aligned to new technologies and innovations so that the students can function with optimal advantage with their surroundings. In particular, the place of algebra needs to here-examined such that routine manipulation becomes less important, and topics such as linear algebra and modelling becoming more important. Algebraic proof may be of greater importance since there is more opportunity for more rigorous mathematical argument once a good intuitive understanding is acquired through investigation with the help of technology such as TI-84 graphing calculator.

ISSN: 1305-8223

Mathematics achievement is an object of much interest and of utmost importance in any secondary school (Noraini Idris, 2002; Dunham & Dick, 1994). It is defined as a measure of the ability of students to understand, analyze and answer specially designed test items based on the standard syllabus. The level of achievement exhibited by the students will categorize them as high or low mathematics achievers. In the present ever-demanding success-oriented society, mathematics achievement is often seen as a key factor in ensuring the success of a student in the school system (Ministry of Education, 2000). In addition, coupled with our country's present emphasis on mathematics subjects as the tickets to becoming a developed nation by the year 2020.

Mathematics teachers also face increasing demands to improve student performances in Mathematics, and this is by no means a simple task in many parts of the country. Many students have the misconception that mathematics, or anything related to mathematics, is confusing and therefore difficult to learn, let alone master (Pomerantz, 1997; Romberg, 1991).

An area of concern in many mathematics classes is the attitude of the students towards mathematics. Specifically, many students find the topic on Straight Lines difficult and boring. Many also find that drawing and interpreting statistical plots and interpreting coordinate geometry is tedious and even confusing (Bitter & Hafield, 1994; Herrera, 2002). This poor attitude towards learning mathematics often leads to the poor appreciation of these two topics, which will consequently result in poor mathematics achievement. This poor attitude could be attributed to a number of reasons, namely the students a) were not able visualize what they were learning, b) found that plotting and drawing graphs was tedious and time consuming, c) realized that plotting graphs was a routine procedure and thus became boring, or realize that problem solving situations, activities and the answers that were generated were too unit These factors will tend to make learning mathematics unpopular and uninteresting.

The National Philosophy of Education and Malaysia's Vision 2020 aims to produce a new generation of Malaysians who are able to think critically and systematically and who are able to use their knowledge of mathematics to meet the new challenges in this fast changing world (Ministry of Education, 2000). In the age of Information and Communication Technology (ICT), the use of current technology is essential to enhance the teaching and learning process in order to stimulate the critical and logical thinking capabilities of the students. The use of graphing calculators will cause changes in the way teachers teach and in the way students learn mathematics. It will also reduce the drudgery of applying arithmetic and algebraic procedures when those procedures are not the focus of the lesson. They provide better ways to compute and manipulate symbols. Graphing calculators can help students to generate hypothetical examples that emulate everyday situations so that the students can experience real-life problems and situations (Dunham & Dick, 1994; Noraini Idris, 2006). By generating theoretical data, students can be led to apply higher order thinking skills in various problem-solving situations. Logical thinking can be taught. practiced and nurtured by projecting "what if' questions. Students can then be made to rationalize the decisions that they have made.

Often in schools where students adopt ability goals, students come to believe that success is defined in terms of how they do in comparison to others. Mistakes and failures, because they indicate lack of ability, are threats to a students' self-confidence. Students who adopt ability goals are more likely to avoid challenging tasks and to give up in the face of difficulty. In contrast, learning goals define success in terms of developing skills, self-confidence, expanding knowledge, and gain understanding (Maehr & Mify, 1997). Success means being able to do something you could not do before. When students adopt learning goals, they take on more challenging tasks, persist longer, are less debilitated by mistakes and failure, and use higher-level thinking skills than when they focus on ability goals (Ames, 1992; Elliot & Dweck, 1988).

In technology-supported learning environments as envisaged in the Malaysian Smart School conceptualization, students are encouraged to be reflective (Malaysian Ministry of Education, 1997). Fast technological advancement poses great challenges to mathematics educators in Malaysia. Changes for improvement and development have to be undertaken to be prepared in dealing with such enormous challenges. There is a need to be familiar with these technological trends so as to be relevant in the present and future. In secondary school mathematics, this means that the order and treatment of most topics would need to change

STATEMENT OF THE PROBLEM

The teaching and learning of mathematics in many Malaysian schools has been reported to be too teacher centered and that students are not given enough opportunities to develop their own thinking skills (Malaysian Ministry of Education, 2000). This situation invariably results in students becoming passive receivers of information, which in many cases do not result in conceptual understanding. Many students are not able to comprehend what their mathematics teachers teach because mathematics content is taught with the intention of finishing the syllabus and preparing for examinations. Little regard is given to how well the students understand mathematical concepts. Research has also shown that students in many of today's mathematics classrooms have little opportunity to explore mathematical patterns and processes (Ross & Kurtz, 1993) which can help them understand mathematical concepts better.

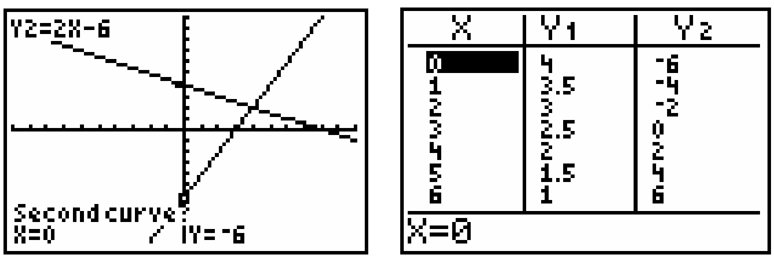
In addition, teacher-centered classes are usually carried out without the help of teaching aids or tools. Moreover, most existing teaching aids are inanimate objects that cannot respond and complement the varying levels of student understanding found in a classroom. These teaching or learning aids hardly allow opportunities for students to be creative and imaginative in their thinking and reasoning. Such tools do not allow students to consider "what if' situations, which are very useful and effective for building conceptual understanding. It is by considering alternative mathematical situations that better mathematical understanding can be developed.

Poor reasoning skills are also another area of concern among secondary school students. Many are unable to extract necessary information from given data, and many more are unable to interpret answers and make conclusions. However it is unfair to blame the students for their lack of thinking and reasoning skills. Much of the problem may lie with the pedagogical approach. Teacher-centered classrooms seldom encourage or involve students in mathematical communication and in making logical reasoning. Traditional teaching approaches emphasizes more on how much the students can remember and less on how well the students can think and reason. Thus learning becomes forced and seldom brings satisfaction to the students.

Thus learning mathematics for many weaker students becomes uninteresting and boring. This poor attitude towards learning mathematics is not helpful for the students, as it will lead to poor mathematics performances (Dunham & Dick, 1994). The reasons for the students' poor attitude towards mathematics may also lie with traditional teaching approaches, like the "chalk-and-talk" method where the teacher talks and the students only listen. Instead teaching and learning mathematics should portray an active and dynamic classroom with the students thinking, learning and applying what they have learnt. Mathematics should be enjoyable and time to learn. In fact, in his paper "Directions and Policy: Mathematics Education and National Development", the Malaysian Director-General of Education also encouraged mathematics teachers to steer the perceptions and interests of students towards the concept of "Mathematics is Fun" (Abd. Rafie Mahat, 2002). Thus by building good attitudes towards learning mathematics, it is hoped that mathematics performance can also improve.

In addition, Mathematics is traditionally thought of as the memorization of formulae, the long and monotonous computation and the manipulation of numbers. It is also tradition that rules that the tools to computing and manipulating mathematics are the pencil and paper. Finally it is also thought that the conventional way of delivering lessons is the chalk and talk method. However, mathematics has always been concerned with logic and reasoning, number sense, problem solving, and a search for relationships, and abstract thinking (Pomerantz. 1997). Therefore, educationists are earnestly looking beyond the traditional approaches to enhance the teaching and learning process. The use of TI-84 Plus graphing calculators is one of the avenues that can inject new excitement and enthusiasm into the mathematics teaching and leaming process. One of the important criteria is that mathematics encourages logical thinking among students. Graphing calculator has the ability to draw and analyze graphs, carry out complex computations, numerically solve equations, perform matrix arithmetic, statistical analysis and plotting a graph as in Figure 1.

Figure 1. Plotting a Graph



Conceptual Framework

The performance of Malaysian students in mathematics has been generally been not good. It has been realized that poor mathematics performance of students at the secondary level would result in a decrease in the number of students getting to the university. It was with this realization that the present project was mooted. Three constructs are thus compared leading to the purpose of the study: achievement, anxiety of mathematics, and use of graphing calculators.

Achievement assists the learning and teaching of mathematics: The confidence that children bring to mathematics reflects the confidence of those around them: peers, home, school, community the media. To help students develop self confidence to mathematics and towards themselves as learners and users of mathematics, they should experience enjoyment through confidence in their ability to succeed, a sense of purpose through relevant experience and meaningful activities, pride in achievement and pleasure in the use of suitable materials and graphic calculator. Confidence is an important factor 111 success in any area and this is especially so in mathematics. Students need to experience success frequently in order to feel confident that they are making progress and to enhance their enjoyment of mathematics.

Further, the amount of effort students are willing to invest in a mathematical task is dependent not only on the value they recognize in the task but also on their perception of the likelihood that they will successfully complete the task (Maehr & Midgley, 1991, Noraini Idris, 2006). Problem solving, discovering relationships, proving theorems, analyzing situations, and interpreting mathematical communications are all cognitive tasks requiring students to work through perplexing moments. Those who are not confident in their mathematical abilities tend to stop working on a task as soon as they become perplexed; more-confident students tolerate perplexity longer and are more likely to continue with the task.

Many experienced teachers recognize that anxiety is another domain that affects students' achievement in mathematics. Most students feel anxious and tense when manipulating numbers and solving mathematical problems. Mathematics anxiety is a psychological state engendered when a student experiences or expects to lose self-esteem in confronting a mathematical situation. Such anxiety prevents a student from learning even the simplest mathematical task.

Graphing calculators can be used to enable students to investigate and apply mathematical ideas in a way not easily achieved by other means. The TI-84 Plus graphics calculator is relatively new technology in Malaysia that was developed as aid in teaching and learning mathematics. In Malaysia, as the graphing calculator is still being introduced, there were not many schools which have explored the use of the technology. The motivation to learn and perform better in mathematics is affected by the learning procedure, the instructional materials and technology used, and non-cognitive factor such as anxiety.

PURPOSE OF THE STUDY

The purpose of this research was to explore and investigate the use of TI-84 Plus graphing calculator as a tool in enhancing teaching and how its help in achievement and reduce anxiety in mathematics.

Specifically, the research project seeks to:

(1) determine the effects of graphics calculator use on students achievement in mathematics;

(2) determine if there is any significant change in the respondents' anxiety in mathematics; and

(3) gather students' insights about the graphing calculator as an instructional technology.

Specifically, it will seek to find answers to the following questions:

(1) Does the graphing calculator contribute in increasing student achievement in mathematics?

(2) Does the graphing calculator contribute in reducing students' anxiety in mathematics?

(3) What are the perceptions of students towards the use of the graphic calculator?

METHODOLOGY

Location and Sample: The research study employed the quasi-experimental, non-equivalent control pretest and posttest design. The sample of the study consisted of two experimental secondary schools in Selangor, Malaysia. Each school was assigned one intact Form Four class to be the experimental group and another one intact class to be the control group. The experimental group learned mathematics using the TI-84 Plus graphing calculators for ten weeks, while the control group teamed mathematics using the traditional whole-class instruction. The mathematics teachers who taught in the experimental group were trained in the workshops. During the workshops, the teachers were trained using TI-84 Plus graphing calculator to teach and also designed the instructional activities to be used in the treatment group.

Instruments: The instruments in this research consisted of (1) Mathematics achievement test, (2) Mathematics Anxiety test, and (3) Questionnaire for students' perception. The three instruments were designed by the researcher. The instruments were pilot-tested in another school of similar characteristics to the selected study school. The degree of internal consistency as estimated by Cronbach alpha for mathematics achievement was .81 and mathematics anxiety was .78

Procedure: Quantitative data was collected using a pretest and posttest, mathematics anxiety, and questionnaire for students' perception.

Data Analysis: Data from students' achievement in pretest and posttest, mathematics anxiety and questionnaire for students' perception were analyzed using quantitative analysis. The SPSS program was used to analyze the data.

RESULTS OF THE STUDY

Student Achievement in Mathematics: To answer the question whether students in the experimental group using TI-84 Plus graphing calculator achieved significantly greater improvement on mathematics achievement compared to students in the control group who did not use the graphing calculator, the adjusted mean scores on the posttest of the two groups were determined. Table 1 provides a summary of the adjusted means of the experimental and control groups of subjects.

Table 1. Means and Standard Deviations for Experimental and Control Groups on Pre- and Posttest Mathematics

Test		**Experimental**	**Control**
Covariate (Pretest)	N	54	55
	Mean	12. 203	12.211
	Standard Deviation	3.679	3.216
Dependent (Posttest)	N	54	55
	Mean	34.714	29.271
	Standard Deviation	3.213	3.145
	Adjusted Means	34.823	29.315

The pretest mean for the experimental group was 12.203 (SD=3.679) compared to the control group means of 12.211 (SD=3 .216). The posttest means for both groups increased from the pretest, with experimental group showing the greater increase. Table I shows that the adjusted mean of the experimental group was significantly higher than the adjusted mean of the control group. The results showed that students in the experimental group showed significantly greater improvement on mathematics achievement than students in the control group.

Mathematics Anxiety Scores: To answer the question whether students in the experimental group using TI-84 Plus graphing calculator reduced significantly on mathematics anxiety compared to students in the control group who did not use the graphing calculator, the adjusted mean scores on the posttest of the two groups were determined. Table 2 provides a summary of the adjusted means of the experimental and control groups of subjects.

Table 2. Means and Standard Deviations for Experimental and Control Groups on Pre- and Posttest Mathematics

Test		**Experimental**	**Control**
Covariate (Pretest)	N	54	55
	Mean	3.11	3.03
	Standard Deviation	1.67	1.21
Dependent (Posttest)	N	54	55
	Mean	1.34	2.92
	Standard Deviation	1.21	1.23
	Adjusted Means	1.15	2.31

The pretest mean for the experimental group was 3.11 (SD=1.67) compared to the control group means of 3.03 (SD=1 .21). The posttest means for both groups reduced from the pretest, with experimental group showing the greater reduction. Table 2 shows that the adjusted mean of the experimental group was significantly reduced than the adjusted mean of the control group. The results showed that students in the experimental group showed significantly greater reduction on mathematics anxiety than students in the control group.

Perceptions of Students Towards the Use of Graphing Calculator: Fifty three Form Four students completed a form with the questions as shown in Table 3. The scaled score is calculated based on five point scale from 5 (strongly agree) to 1 (strongly disagree).

As shown in Table 3, most of the students showed positive reactions towards the use of TI – 84 Plus graphing calculator.

Table 3. Students' Survey Result on the Usage of Graphing Calculator

Item	5	4	3	2	1
1. It was easy to learn math using TI-83.	5	48	1	0	0
2. I enjoy math better now than before.	10	42	1	1	0
3. I like math better now.	12	39	2	1	0
4. I learn math better with TI-83 instead of only with book.	11	42	1	1	0
5. I spent more time on math now than before.	9	43	1	1	0
6. I feel confident about trying a new problem on the TI-83	12	41	1	0	0
7. Graphic calculator TI-ES help me in understanding the topics better.	11	42	1	0	0
8. I am able to interact with my teacher and friends.	8	44	0	2	0
9. It helps me to learn mathematics by discovering.	10	42	1	1	0

As shown in Table 3, most of the students showed positive reactions towards the ue of graphing calculators. Students felt that graphing calculator made them comfortable learning mathematics.

DISCUSSION AND CONCLUSION

In this study, the TI-84 Plus graphing calculator was used as a tool in the teaching and learning of two topics, namely straight-line geometry and Statistics, in the mathematics classroom. The results of the study as discussed shows promising implications for the potential of the graphing calculator in teaching mathematics at the secondary school level.

From the results obtained, a number of implications can be put forward in the interest of improving mathematics teaching in the classroom. Firstly, the generally significant differences of mathematics achievement of the experimental groups as compared to the control groups indicate that the graphing calculator can possibly contribute towards improved learning in mathematics. The results of this study is consistent with the TIMSS' findings that students with the highest scores used calculators more frequently in mathematics instruction than students with the lowest scores (Mullis et al., 2000). This observation can therefore encourage classroom teachers and even curriculum developers on the potential of the graphing calculator as an effective tool in learning mathematics.

Secondly, the significantly reduced scores in the Test of Mathematics Anxiety achieved by the students in the experimental groups implied that learning Statistics and Straight Line Geometry with the graphing calculator had been beneficial for the students. The students seem to have indirectly acquired the skills of logical thinking whilst manipulating and processing data on the graphing calculator. Thus these results imply that the graphing calculator not only helps students to process data and perform calculations, it may also help them to develop and cultivate better thinking skills. NCTM (1989, 1991, 2000) claim that students will not loose their ability to think if they were to use the graphing calculator. Instead, the students need to know more than what keys to push and in what order. They need to understand the mathematics of the problem they are going to solve. They need to be able to decide what information to enter and what operations to use, and then they need to interpret the results that the calculator gives them in return. Therefore the calculator makes them think even more.

Such logical thinking skills would therefore become a valuable asset for the students in not only learning mathematics but also in managing their other studies and their own lives, Indeed, this would be exactly what the mathematics educators strives to inculcate in the young minds of the nation. Therefore, the result of this study has strong implications for the graphing calculator to become an integral and important learning tool in the school curriculum. In fact thousands of teachers in the US can attest to the power of this using graphing technology in the mathematics classroom (Herrera, 2002). According to Bert Waits, the co-founder of an organization called Teachers Teaching with Technology, the graphing calculator is an excellent pedagogical tool as it provides multi- representational approaches to the teaching and learning of mathematics. This is because it allows a problem to be viewed and manipulated analytically using the MATH functions, viewed and interpreted graphically using the graphing functions, and viewed numerically using the table functions (Herrera, 2002).

Similarly, the students in the experimental group showed a reduced in mathematics anxiety test indicate that the usage of the graphing calculator seemed to have helped the experimental group students to be better able to extract information and patterns from given data or diagrams. This ability can be useful for students attempting problem solving questions and activities. In problem-solving situations, the students need to correctly extract information or patterns from given diagrams, graphs or tables to be able to correctly answer or solve the problems. Thus this study suggests that the graphing calculator can play an important role in helping the students acquire the ability to disembed information and pattern from given data or diagrams.

From the results of the Attitudes Inventory, it was clearly seen that most students enjoyed their Mathematics lessons when they could make use of the graphing calculator. Many of the students indicated that they had enjoyed being able to explore mathematical concepts using the Tl-84 Plus graphing calculators and were amazed of its capabilities and of its wide range of functionalities. Many of the students even claimed that they would like to learn mathematics using the graphing calculator. These results support the findings of a calculator project to evaluate the impact of calculators in mathematics instruction carried out in the US, which claims that calculators can motivate and support students who have negative attitudes towards mathematics (Bitter and Hatfield, 1994). These results also support Noraini's (2002) study among Malaysian Form Four students, which reported that using the graphing calculator had helped the study sample to reduce their mathematics anxiety. This study therefore suggests that the graphing calculator may represent an effective tool to encourage students to enjoy learning mathematics.

In conclusion, this study suggests that the use of graphing calculators in the mathematics classroom is especially effective in helping students to perform better in mathematics, think more logically and critically. There is also evidence that students who use graphing calculators during their mathematics lessons are better able to disembed information from given data or patterns. Consequently, these calculators may also encourage students to learn mathematics in a more enjoyable, yet effective way.

Learning does not occur in a vacuum. The brain constantly searches for patterns and attempts to categorize information into relevant chunks of information. It matches, compares, and patterns incoming information after information already stored in memory. This is done at both the conscious and subconscious levels. The more meaningful, relevant, and complex the sensory inputs is, the more actively the brain will attempt to integrate and develop patterns. Usage of graphing calculator in the learning of mathematics provides the complex and relevant stimuli necessary to allow learning to occur more easily. By using graphing calculator, exploring possibilities, and seeing the outcomes of their investigations, students can form the connections between previous learning and new information.

Students generally have very positive attitudes towards graphic calculator and their use. Graphics calculators give students a powerful means of solving problems. Students enjoy using graphics calculators. Many graphic calculators provide students with an environment in which mistakes can be quickly and easily amended, trial solutions are encouraged, mistakes often lead to unexpected results that encourage further exploration.

Mathematical ideas, situations and problems can be explored and investigated in many possible ways. Some investigations can be carried out by using graphics calculator. One aspect of an investigation is the formulation of problems and another is the solving of those problems. Part of the value of using the investigational approach to problem solving is that the students construct their own questions. This means they will be more motivated to solve the problems raised because they are of more immediate concern and interest.

If students have confidence in their ability to understand, develop, use and discuss mathematics, they are more likely to apply the mathematics they have been learning to problems they encounter in everyday life. This will lead to even greater confidence in their ability to solve mathematical problems and thereby enhance self-esteem. The processes which are successful used in solving problems will lead to further learning because they contribute to the ability to reason and think mathematically.

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Eurasia Journal of Mathematics, Science and Technology Education
Volume 2, Number 3, December 2006

EFFECTIVENESS OF A LANGUAGE BASED PROGRAM IN SCHOOL MATHEMATICS ON STUDENTS UNDERSTANDING OF STATISTICS

Duncan Wekesa Wasike

ABSTRACT. Mathematical knowledge and understanding is important not only for scientific progress and development but also for its day-to-day application in social sciences and arts, government, business and management studies and household chores. But the general performance in school mathematics in Kenya has been poor over the years. There is evidence that students have problems in understanding and interrelating the symbols and special language structure as used in mathematics. Nevertheless in a recent study, a program called Socialized Mathematical Language (SML) module was designed to enhance student's learning outcomes in school mathematics. The study was carried out in a real classroom setting that involved comparisons between the treatment and control groups. A Solomon Four Group quasi-experimental design was employed to involve four high schools in Bungoma District. A total of 156 form two students enrolled in four intact classes from the selected schools were exposed to the same content in statistics for a period of two weeks. Three dependent measures namely the Mathematics Achievement Test (MAT), the Mathematics Skill Test (MST) and the Mathematics Classroom Environment Questionnaire (MCEQ) were used to assess the effectiveness of the program on students' academic achievement in understanding of statistics, their skill performance and perceptions of the classroom environment during statistics lessons. The results affirm statistically significant learning gains in favour of the treatment groups. The study concludes that the use of SML program has a major implication for school mathematics instruction in the area of statistics.

KEYWORDS. Students Understanding, Statistic Education, Mathematical knowledge.

INTRODUCTION

Mathematics plays a central role in scientific progress and development. Its fundamental role lies in its everyday application in most social sciences, government and business transactions, physical sciences and engineering, biological sciences and medicine, military and aerodynamic advancements and household chores. This has made the subject compulsory in the school curriculum in Kenya (Mutunga and Breakel, 1992; Republic of Kenya, 1999). This is because students are expected to apply the knowledge of mathematics in both familiar and unfamiliar situations. However, the literature indicates that a considerable number of students have inadequate understanding of mathematics and mathematical concepts and skills

ISSN: 1305-8223

(Kenya National Examinations Council (KNEC), 2000; Ministry of Education, Science and Technology (MOEST), 2001). In effect the topic on statistics has constantly been difficult to learn by students or teach by teachers. However, this should not be the case considering the central role of statistics in the mathematics curriculum at all levels (Kenya Institute of Education (KIE), 2002; Wasike, 2003). According to the Kenyan education system, the teaching and learning of statistics involves concepts and skills dealing with data collection, organization, analysis, representation and interpretation. This is not only useful but applicable in planning, decision making and research by companies, government departments and scientists (KIE, 2002).

The language policy in Kenya stipulates that English language is the medium of instruction at the secondary school level (Bogonko, 1992; MOEST, 2001). But, mathematics as is conceived everywhere in the world has a subject language with internationally accepted terminologies and symbol system that has condensed meaning (Costello, 1991; Durkin and Shire, 1995). These symbols and terminologies are not familiar and sometimes contradict meanings in ordinary English especially in the area of statistics. The literature is replete with studies indicating that language interferes with mathematics learning especially when English is used as a medium of instruction to second language users (Thijs and Van Den Berg, 1995; Durkin and Shire, 1995; Gramley and Patzold, 1996; Wasike, 2003). This provides evidence to suggest language problems where students have to understand and interrelate the symbols and special language structure as used in mathematics and especially statistics. There is need therefore to incorporate language models in mathematics instruction.

The language-based program is one such model that has recently been lauded for its capability to simply and explain the symbols and special language structures in mathematics (Wasike, 2003). This program describes the meaning of technical terms in mathematics in comparison to their meaning in English. Such a program may be used in a mathematics instructional setting to provide an environment for student understanding of mathematical symbolism and language structure. In other words, it enables the student to understand concepts and skills not only in mathematics but also make comparison with the ordinary meaning from the English language (Costello, 1991; Durkin and Shire, 1995; KNEC, 2000; Wasike, 2003). Therefore the study reported in this paper was set up to develop a language based program in school mathematics and investigate its effectiveness on students understanding of mathematics and their perception of the learning environment.

THE PROBLEM

The general performance in mathematics among secondary school students in Kenya has been poor for many years (KNEC, 2000). There is evidence that many of the serious problems facing secondary school mathematics instruction today should not be attributed to deficiencies in the curriculum, teaching or assessment but spring from language considerations rather than the inherent difficulties of the subject (MOEST, 2001; KNEC, 2000; Wasike, 2003). There is need however to improve student understanding of mathematics as this is core to Kenyan quest for industrialization. As such a language based program was developed and its effect on student understanding of mathematical concepts and skills in statistics and their perception of their learning environment studied. This paper is an attempt to contribute in regard.

THE PURPOSE OF THE STUDY

The purpose of the study was to investigate the effect of a language based program on form two students understanding of the topic statistics in mathematics and also assess their perception of the mathematics classroom environment.

METHODS

The Sample

A total of 156 secondary school students from four secondary schools in Bungoma District of Western Province in Kenya served as the subjects of the study. These students were randomly selected from intact classrooms because school authorities do not normally allow classes to be split for research purposes once they are constituted. The subjects were randomly selected from four intact classrooms in four schools. All the groups were comparative enough in terms of number and resources. Moreover, the pretest analysis showed no significant difference on all the dependent measures (Wasike, 2003).

Research Design

The Solomon- Four group quasi – experimental design was employed for this study. The design is rigorous and robust enough in eliminating variations that might arise because of experiences and contaminate the validity of the study (Koul, 1992; Kothari, 2003). The design involves a random assignment of subjects to four groups with two groups being the treatment group and the others being the control group. One treatment and one control were administered the pretest. The experimental groups were exposed to the program – the experimental treatment while the control groups denied. The four groups were all post tested after the exposure to the content of statistics.

Instruments

Three dependent measures namely the Mathematics Achievement Test (MAT), the Mathematics Skill Test (MST) and the Mathematics Classroom Environment Questionnaire (MCEQ) were used to assess students' academic achievement in understanding statistics, their skill performance and perception of the learning environment during the topic statistics. The dependent measures were developed for purposed of this study and reviewed by a group of seven experts knowledgeable in mathematics and mathematics education. MAT, consisting of 25 items was developed based on the table of specification designed for the topic statistics. These items were analysed for difficulty level and discrimination indeces. It was established that the items difficulty level (between 0.42 and 0.65) and discrimination index (between 0.21 and 0.35) were within acceptable range of 0.3 - 0.7 and 0.2 – 0.5 respectively (Kothari, 2003; Koul, 1992).

Similarly, MST consisting of 10 items on science process skills relevant to statistics was developed. On analysis of the items, the difficulty and discrimination indices of between 0.40 – 0.59 and 0.25 – 0.45 respectively were obtained. The student affective domain i.e. perception of the mathematics learning environment was measured by MCEQ. This consisted of a checklist of 25 items on a five –point Likert-type scale. This was also vetted by six experts knowledgeable in science and mathematics education.

On the whole MAT, MST and MCEQ were piloted on a group of 20 students in one school that didn't take part in the actual study. The piloting of these instruments yielded reliability coefficients of 0.78, 0.79 and 0.77 for MAT, MST and MCEQ respectively using K-R 21 formula. This indicate that all the dependent measures were valid and reliable because the reliability coefficients obtained were higher than the recommended level of 0.70 (Koul, 1992).

RESULTS AND DISCUSSION

The effectiveness of language-based programe presented from this study was ascertained by the one-way Analysis of Variance (ANOVA) and confirmed by post hoc multiple comparison tests. All the analysis was done using the Statistical Package for Social Sciences (SPSS) computer program whose results are presented in tables and discussed in the sections that follow.

RESULTS ON MAT

Table l compares the results of pretest and post test scores obtained by the subjects on MAT. An examination of this result shows that the subjects in E1 and C1 groups attained similar mean scores on pre-test. This indicates that the subjects had similar characteristics before exposure to the topic statistics.

A close examination of the results in Table 1 shows that the subjects in E1 group attained a mean gain score of 38.87, which is higher than the mean gain score of group C1 (26.84). Thus the latter is less than the overall mean gain (33.40) for the whole after correcting for lack of the pretest in groups E2 and C2. The result also indicates higher mean scores for the treatment groups than for the control groups. The mean scores of the two treatment groups are quite similar. This is probably due to the program to which they were exposed.

Table II indicates significant difference for treatment groups from the control groups. The mean scores of the treatment groups yielded t- values of t (1,73=2.74), t (1,86=3.54), t (1,68=2.32) and t (1,83=3.93) at $p<0.05$. A further analysis of the difference using Turkey's Honest Significant Difference (THSD) test also revealed the following trend:E1=E2 $\geq$ C1=C2. This suggests that students exposed to the treatment outperformed those denied the treatment and hence significant learning gains may be attribute to the treatment administered to the groups.

Results on MST

The purpose of the MST instrument was to measure the psychomotor aspects of the learning outcomes before and after the commencement of the topic statistics.

A perusal of the results in Table III shows that the pre-test mean scores obtained by the students in group E1 (52.38) and C1 (51.22) were similar before teaching the topic statistics. After exposure to the topic, students in treatment group E1 (78.68) and E2 (77.28) scored higher mean scores than those in control groups C1 (69.22) and C2 (68.75). The mean gains of process skills for E1 (26.27) and for the whole group (21.75) were both higher than C1 (18.00). This suggests differences in the mean scores obtained by treatment groups (E1 & E2) and control groups (C1 & C2).

An inspection of Table IV indicates significant difference in the mean scores obtained by the subjects on MST. However, this does not show the direction of the difference. An analysis of the difference using the independent sample t-test reveals that the mean scores obtained by the treatment groups were significantly different from and higher than those in the control group. A comparison of post test t-values of t(1,73 = 3.58), t(1,86 = 3.06), t(1,67 =3.54) and t(1,83=3.80) at $P< 0.05$ level were obtained. Moreover, the THSD test also confirms the trend E1 = E2 > C1 = C2 at 0.05 level. This suggests that students exposed to the treatment had better learning outcomes in mathematics process skills in statistics.

Results on MCEQ

The purpose of the MCEQ was to assess the affective aspect of the learning outcome before and after exposure of the subjects to the topic statistics. The results of the students' checklists on MCEQ were quantified and presented in Table V.

An examination of results in Table V reveals that pretest mean scores of E1 and C1 and post test mean scores of groups E1 and E2, and C1 and C2 are quite similar. However the mean gain for E1(21.71) was higher (by 7.34) than that of C1 (14.37). The mean gain for E1 is higher and close to overall mean gain than that of C1. This suggests difference in the perception of the learning environments. This was perhaps possible because the program exposed to the treatment groups was designed to offer the students opportunities to interact more frequently during the lessons and exercise language skills than passively go through the lessons as in regular programs (Wasike, 2003). Contrary to the regular learning program, the program under study was meant to simplify and harmonize the language during mathematics instruction.

Thus this program has proved that students' academic achievement and affective learning gains are improved when learners participate actively in the learning process. From the results, there is evidence suggesting that the language-based program significantly affected the mean scores of the treatment groups on the cognitive and affective variables. It may therefore be concluded that the significantly higher mean scores obtained by the treatment groups as opposed to those of control groups and the similarity in the mean scores of the treatment groups is not coincidental but probably influenced by the program administered.

CONCLUSION

An attempt has been made to use the results of a study on the effects of a socialized mathematical language module on students understanding of mathematics and their perception of the learning environment.

The findings have demonstrated that the use of a well designed language based program can be effective in improving students knowledge and performance in statistics as well as their perception of the learning environment. The differences between the mean gains of students exposed to the program and those denied the program on all the dependent measure are in the affirmative. The inferential statistics used revealed that differences in the mean scores obtained by student in the treatment groups and those in the control groups were statistically significant. This seems to have demonstrated the effectiveness of a language-based program in engendering cognitive and affective gains in mathematics. This is consistent with earlier findings that show that learning outcomes may be enhanced by restructing the classroom environment (Kiboss, 1997; Wasike, 2003; Wekesa, 2003). Given the huge class sizes and inadequate resources as the key characteristics of most Kenyan classrooms, this program may be handy in improving student understanding of mathematics. However, this being the first program of the kind in Kenya, future studies should make attempts to ascertain whether or not the present findings are incidental or genuine.

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Table I. Comparison of Means, Standard Deviation (SD) and Mean Gain Obtained on MAT

Scale	Overall	E1	C1	E2	C2
Pretest Mean	38.71	38.93	38.49	-	-
S.D	8.99	9.45	8.53	-	-
Post test Mean	71.35	77.80*	65.30	77.10	66.70
S.D	11.35	10.84	11.40	11.32	11.84
Mean Gain	33.40	38.87	26.84	-	-

* Denotes similar means

Table 2. independent sample t-test for Posttest mean scores on MAT

Groups	t-value
E1 Vs E2	0.12
E1 Vs C1	2.74*
E1 Vs C2	3.54*
C1 Vs C2	0.45
C1 Vs C2	2.32*
E2 Vs C2	3.93*

* denotes significant at $P<0.05$.

Table 3. Comparison of Means, Standard Deviations (SD) and Mean Gain obtained on MST.

		Groups			
Scale	Overall	E1	C1	E2	C2
Pretest Mean	51.83	52.38	51.22	-	-
S.D	2.78	2.77	2.45	-	-
Post test Mean	73.48	78.65	69.22	77.28	68.75
S.D	6.15	3.95	4.32	3.25	4.17
Mean Gain	21.65	26.27	18.00	-	-

Table 4. ANOVA test of Post test Mean Scores on MST

Source	Df	SS	MS	F-value
Between Groups	3	1065.36	355.12	9.11*
	153	5966.07	38.99	-
Within Groups	156	7031.43	-	-
Total				

* denotes significant difference at P<0.05

Table 5. Comparison of Means, Standard Deviations (SD) and Mean Gain by subjects on MCEQ.

		Groups			
Scale	**Overall**	**E1**	**C1**	**E2**	**C2**
Pretest mean	56.36	56.78	55.94	-	-
S.D	9.61	8.74	10.48	-	-
Post test mean	74.68	78.49	70.31	76.41	71.52
S.D	8.43	8.09	8.38	8.12	9.13
Mean Gain	18.32	21.71	14.37	-	-

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Eurasia Journal of Mathematics, Science and Technology Education

Volume 2, Number 3, December 2006

DEVELOPMENT OF A MATHEMATICS, SCIENCE, AND TECHNOLOGY EDUCATION INTEGRATED PROGRAM FOR A MAGLEV

Hyoung Seo Park

ABSTRACT. The purpose of the study was to develop an MST Integrated Program for making a Maglev hands-on activity for higher elementary school students in Korea. In this MST Integrated Program, students will apply Mathematics, Science, and Technology principles and concepts to the design, construction, and evaluation of a magnetically levitated vehicle. The focus of this program was to help students to understand and solve integrative problems in relation to Mathematics, Science, and Technology Education in the real world.

KEYWORDS. MST Integrated Program, Hands-on Activity, Technology Education.

INTRODUCTION

This study developed and tested a series of instructional units that were designed to enhance the study of mathematics, science, and technology at the elementary level in Korea. This program sought to tap motivation and interest in mathematics, science, and technology. In PISA 2003 (Program for International Student Assessment), organized by the OECD, Korea was ranked third, fourth, and first, in mathematics, science, and problem solving areas. Korea was located much higher than OECD average of PISA 2000, but Korean students' interest, self-concept, and efficacy in mathematics were lower than other OECD countries and their anxiety in mathematics was very high. It is not desirable for Korean students to feel so negatively about mathematics (KICE, 2004). In addition, pupils say that Science and Science lessons are boring and difficult.

The mathematics, science, and technology education communities are undergoing major reform in curriculum design, instructional strategies. It is therefore necessary to develop instructional methods to improve students' interest and self-related beliefs. It is necessary to develop systematic MST integrated programs to meet students' abilities and attitudes. For this reason, this study’s purpose was to create an MST integrated program for elementary school students in Korea.

ISSN: 1305-8223

MATHEMATICS, SCIENCE, AND TECHNOLOGY EDUCATION

MST Integrated Program Need

The traditional separation of mathematics, science, and technology instruction showing only concretely defined subjects provides an unrealistic view of the world. Today, inter-relatedness is needed to solve problems. Students best realize this when they engage in learning activities that cause them to apply their knowledge of mathematics, science, and technology concepts while seeking solutions to realistic problems.

MST Integrated Program Rationale

Mathematics, Science, and Technology Education Integrated hands-on program is intended to promote the Mathematical, Scientific, and Technological literacy and innovative capacity of elementary and secondary school students.

There is strong support for an integrated curriculum within the areas of mathematics, science, and technology (Wescott & Leduc, 1994). The mathematics community is calling for an increase in an applications-oriented approach. Science educators are encouraging emphasis on an experientially based curriculum and learning. Technology education also recognizes the value of strengthening the curriculum and its programs by including integrated applications of mathematics and science principles; all then becoming more meaningful and relevant to students.

Integrating Mathematics, Science, and Technology Education

A. Mathematics

The National Council of Teachers of Mathematics suggests a framework for the types of technology based activities and content that should be taught (NCTM, 2000). Technology is essential in teaching mathematics. It influences the mathematics that is taught and enhances student learning. With available technological tools students can focus on decision making, reflections, reasoning and problem solving. But technology alone is not a panacea for teaching computational strategies. To enhance student' learning opportunities, teachers must select or create proper mathematical tasks that take advantage of what technology can do efficiently and well. Taught will be graphing, visualizing, and computing.

Problem solving with mathematics and other areas of text is crucial to students better understanding their world. More specific, school mathematics experiences at all levels should include opportunities to learn by working on also the problems arising outside of mathematics.

B. Science

Scientifically literate people should understand the interdependence of science, mathematics, and technology (AAAS, 1993). Observing, thinking, experimenting, and validating, a kind of merger of mathematics and technology into scientific inquiry holds promise for a scientifically literate society. Defining the human experience, technology allows us to interact, shape, or more fully understand our environment. Distinction between technology and science blurs as technology becomes more sophisticated. Seen then can be that technologies shape science as they develop, thereby providing more motivation and direction for theory building.

As with mathematics, it is our belief that technology-rich instruction is integral in nurturing the development of students as active science inquirers. The National Research Council's National Science Education Standards include suggestions for science education reform in technology-based content and its professional development.

C. Technology

About 2.4 million years ago, the first humans created primitive tools by chipping away the edges of the stones. Tool making was the first technology. It was a means to solve problems. Over the millennia, humans have refined their capability to create technological ways to solve problems. Technology is created, managed, and used by societies and individuals, according to their goals and values (ITEA, 2000). Possible to improve the human situation or damage it, in technology is the potential to save or destroy lives. The promise of the future lies not in technology alone, but in people's ability to use it, manage it, assess and understand it. The major goal of technology education is to develop a technologically literate citizenry, one that has the ability to use, manage, assess, and understand technology. One should further accept it that technology has consequences or impacts affecting individuals, society, and the environment. A full inspection and integration of mathematics, science, and technology based activities and education goals will develop a technological literate society. Technology has shifted from tools, machines, and products to systems, problem solving, and interfacing with science and mathematics.

Technological, scientific, and mathematical literacy go hand in hand. Technologists use math and science, scientists use math and technology, and mathematicians use science and technology. Mathematicians employ reasoning and analysis to explore relationships among abstractions. Scientists use methods of inquiry when observing the natural world and building explanatory structures. Technologists design products and systems to create the human-made world.

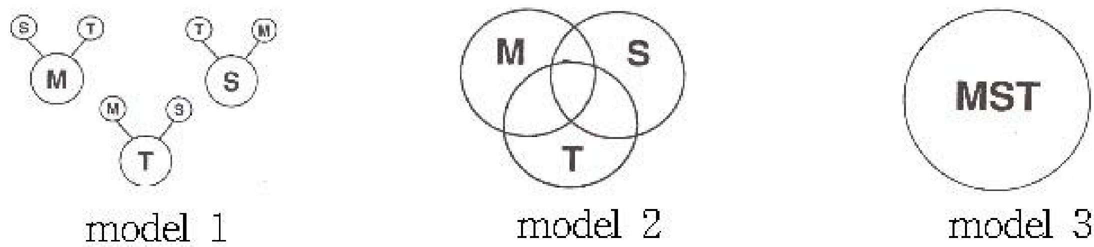
Just as mathematics and science consider problem solving a foundational skill, technology educators include the idea of inductive and deductive problem-solving as essential.

These three disciplines are moving society toward new horizons, and a technologically literate society will help the scientists and technologists of the future to make wise decisions for the benefit of all.

MST Integrated Program Models

There are three types of integrated programs. In model 1, individual teachers help students to make explicit connections between what they learn in a particular M, S, or T class and what they are learning in other classes. The disciplines are connected through a theme or issue that is studied during the same time frame, but in separate classrooms. In model 2, teachers work together to develop interdisciplinary units. The subjects are interconnected in some way beyond the common theme or issue. These connections are made explicit to the students. Model 3 illustrates a fully integrated approach, Students are either block-scheduled into three periods of mathematics, science, and technology or an integrated mathematics, science, and technology course where teachers team teach (New York Education Department, 1997). This approach transcends the disciplines. The disciplines are embedded in the learning, but the focus does not start there. It does not begin with the disciplines in the planning process; rather, the planning begins from a real life context.

Figure 1. MST Integrated Program Model



HANDS-ON, MINDS-ON ACTIVITY

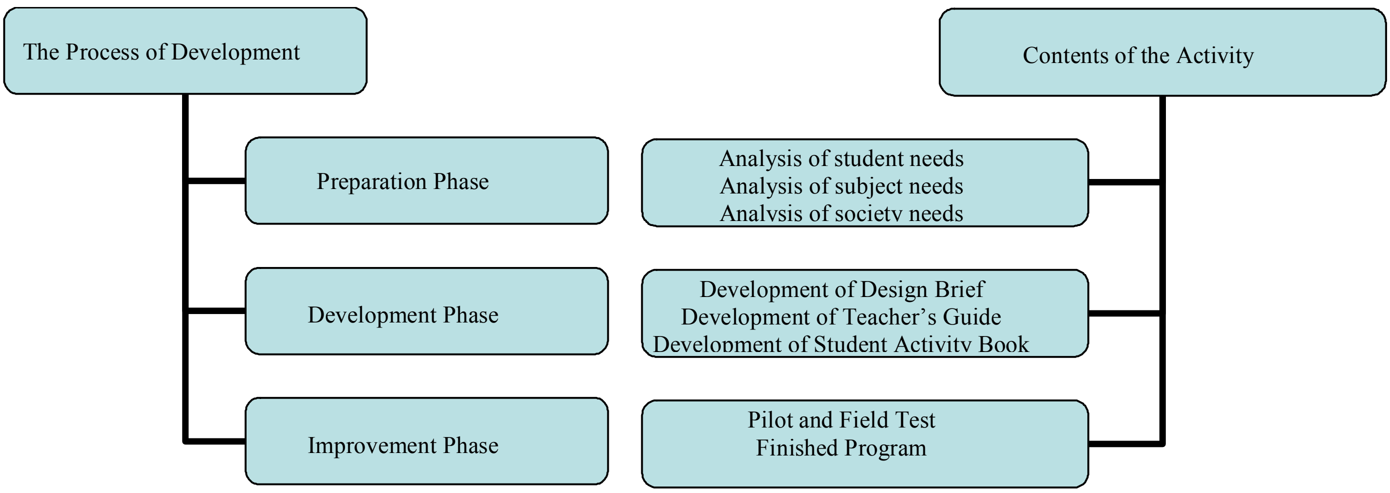
Homo sapiens have been called the animals that make things, and at no time has that been as apparent as the present (ITEA, 2000). The term 'learning–by-doing' suggests that students will be more interested, learn more easily, and retain learning longer if they are actively engaged in constructing, manipulating, and experimenting (Foster & Kirkwood, 1997). A hands-on, minds-on activity is the interaction of mind and hand, inside and outside of the head (Todd, 1997). The concentration is not only on the thinking and decision making processes that result in an end product, but also on why and how pupils choose to do things rather than on only what it is they choose to do. Students often believe that they have worked out a complete solution in their minds, and they will set out to translate that idea into a final form. This belief seldom if ever is satisfactory, for they cannot mentally sort out all the issues and difficulties in the task, let alone reconcile them in a successful solution. To enable an idea to develop fully, it is necessary to take it out of the mind and express it in concrete form. To accomplish a significant hands-on activity there must be a minds-on activity.

This hands-on activity requires students to work in groups to discuss ideas, to identify a problem, to draw preliminary plans, to collect materials, to construct a Maglev model from their initial plans, and to evaluate their final Maglev model for creativity and problem solving abilities in the technology lab. The Maglev hands-on activity defines the principle of magnetic levitation and the application of mathematics and science to the construction of a Maglev. Maglev utilizes a near frictionless method of transportation using magnetic fields.

DEVELOPMENT OF THE MST INTEGRATED PROGRAM

To achieve its objective, this study was designed in three phases. The developmental model of this MST integrated program shown as figure 2 includes the preparation phase, the development phase, and the improvement phase. Each phase includes several steps, and a general description of these steps follows (Park, 2005; Park, 2006a; Park, 2006b).

Figure 2. Development Model of the MST Integrated Program



Preparation Phase

The preparation Phase includes a developmentally appropriate analysis of subject needs, society needs, and student needs (Tyler, 1949). In the analysis of needs of students, the developmental level of the student is a factor in determining the sequence of the MST integrated program. Needs, interests, abilities, and the experiences of students are important in deciding the nature of the MST integrated program. In the analysis of needs of the subject, the subject's needs are organized into broad areas of study rather than into the traditional areas. Mathematics, science, and technology are organized as parts of a single cluster (Black & Atkin, 1996). In the analysis of the needs of society, we are seeing dramatic changes. Mathematics, science, and technology are essential to the education of today's children for tomorrow's world and all will be at the center of radically causing, shaping, and responding to it (Black & Atkin, 1996).

Development Phase

The development phase consisted of three sections: the development of a design brief, the development of a teacher's guide, and the development of a student activity book.

Design Brief

A design brief is a written plan that identifies a problem to be solved, its criteria, and its constraints (ITEA, 2000). It is a short description of a design problem and a proposed solution. It provides a planning tool for the project. A design brief includes a sketch or sketches of the solution. This may include a written report, the construction of a model, data collection and its report, or a multimedia presentation to the class. The students are expected also to keep with this design portfolio, and any additionally generated drawings or other relevant papers.

1. Situation. The situation sets the context and rationale for the activity. A narrative description places the challenge in a context that gives it real meaning for the student. A 'real world' scenario frames the problem to be solved. Here is an example.

> Fossil fuels are dwindling. They are also a source of pollution that is threatening our atmosphere. Maglevs do not need engines. They do not burn fuel. Maglev is the transportation technology of the future. Unfortunately, Korea is not the world leader in Maglev technology, so now is a good time for her young and budding Maglev designers to make a name for themselves.

2. Problem. The problem explains generally what needs to be accomplished through the problem-solving process. A very concise statement of the task facing the student is made.

> Use math, science, and technology to optimize the design of a Maglev vehicle. Research, design, and construct a vehicle that will levitate on a magnetic track and travel a 100cm track in the shortest amount of time.

3. Design constraints. The design constraints are resources, materials, tools, machines, software, and limitations of time or other conditions imposed upon the students. They will identify the maximum size and the allowable materials to be used in the solution of the problem.

> The materials needed to build the maglev device include: two pieces of formboard (6x50x0.5cm, 6x10x0.5cm), ten pieces of ferrite magnet (1.3x10x0.3cm), both-sided sticky tape, two pieces each of acrylic (2x50x0.3cm, 1x10x0.3cm), a 1.5 volt battery, Styrofoam (2x2x3cm), a motor, and a propeller. The students must achieve levitation along a track 100 cm in length of a maglev device powered by the motor and the propeller. The maglev must operate without being touched, or otherwise being interfered with once it is in place at its starting position on the track.

4. The Challenge. The challenge is clarified in a statement that describes the design problem that the student needs to solve, describes the competitive event that is used to assist with the evaluation of the student solutions; and, whenever feasible, it is important to run the Challenge two or more times so that the students may revise their designs and retest them. This notion of ‘iterative testing’ is very important. In the ‘real world’ there are problems solved only after many tests have been completed.

> Your challenge is to develop an innovative Maglev that is significantly different from any conventional train. This maglev hands-on activity demands that you design new methods of moving people on trains using magnetism. You will examine the magnetic levitation principle and be introduced to relevant applications of math and science. You will research, design, construct, and contest run a magnetic levitation vehicle. A winner will be decided through racing a 100cm in the shortest amount of time. Recycling, design, problem solving, teamwork and safety will be covered.

5. Documentation. The students will be evaluated using a list of expectations that defines what the student needs to complete the challenge successfully. Documentation included provides some suggestions for the type of work that should be included in the portfolio that students are to use to record their work as they proceed through the activity.

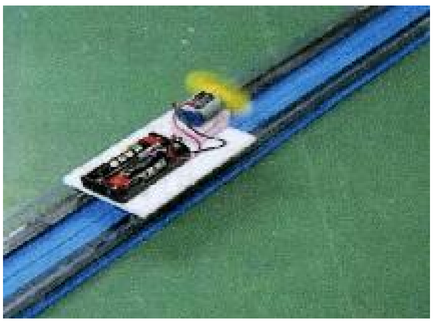
> Document the problem-solving and critical thinking processes used to solve, design, and produce your Maglev in a design portfolio. Document the math and science processes and skills used to solve, design, and produce your Maglev. Present, and demonstrate your completed Maglev design to the class, identifying its unique features and user considerations.

Development of the Teacher' Guide

1. Sample solution. Provide an illustration of what a typical solution to the problem described in the design brief might look like. This is intended for the teachers' eyes only, as students who are shown one or more sample solutions often tend to copy those designs. Strongly encourage them to design their own creative solutions to the problem that is posed in the design brief. Given the opportunity, students generally are very creative in formulating solutions in this MST integrated program.

During their program, the students are to apply learned mathematics, science, and technology principles, as well as their own concepts to the design, construction, and evaluation of a magnetically levitated vehicle. A possible solution is shown in Figure 3.

Figure 3. Sample a Solution of Maglev



2. Objective. The overall objective of this MST integrated program is for students to apply the concepts, principles, and skills learned in mathematics, science, and technology to design, construct, and evaluate their Maglev.

The students are expected to design and engineer a maglev vehicle that travels 100cm track in the shortest possible amount of time; develop a design and solve problems through the construction of a Maglev vehicle driven by a motorized propeller; and develop critical thinking skills and creative design ideas.

3. Applications list. Here are some of the concepts and principles to be actively applied from each of the three areas of mathematics, science, and technology.

The mathematics applications are distance/rate/time, graphic and mathematical relationships, and cost analysis. Science applications are electrical circuits, motors, and magnetic fields and forces. Technology applications are transportation, magnetic levitation, vehicle design and fabrication, engineering, and testing.

4. Suggested instructional sequence. A chart depicts the relative order for the topics suggested in this MST integrated program. Very useful during the planning stages, it provides each teacher with a general idea of what will be studied and approximately when a topic will be addressed within the scope of the activity.

Table 1: Suggested Instructional Sequence

	Mathematics	Science	Technology
Designing		Ferrite magnets and magnetic Fields (attraction and repulsion flux lines, field strength Series and Parallel circuits, (motor and propeller)	Designing a Maglev Levitation Real-world Maglevs Design considerations
Constructing			Constructing a Maglev
Evaluating	Speed, distance, time Calculate speeds Average speed Cost Analysis	Concept of speed	Evaluating a Maglev Testing the Maglev Weighing the maglev

5. Phases of the activity. The suggested instructional sequence of the MST integrated program shows its design, construction, and evaluation phases described in general terms. Thinking of the MST integrated program is a good way to better understand how all phases work in practice.

In the design phase, the students need to apply their knowledge of magnetism, magnetic fields, and magnetic forces to help them to create a Maglev. Show the students how to brainstorm and capture their ideas on paper before trying to rush into a design. In the construction phase - primarily done in the technology education laboratory – the Maglev vehicle prototypes that the students will be building should serve as instructional props for the teachers. Directly related to the Maglev problems, the Maglev track may be set up also in either or both the science and mathematics classes to further relate all contributed from and in these two areas. As students try different body types, as well as power and propulsion systems, they found that the Maglev systems required the least amount of force needed to move the vehicle. In the evaluation phase, the students will test their vehicle's performance during the Challenge. Real data on vehicle weight, distance traveled, and elapsed times are collected during the Challenge. Students also determine the cost of their vehicles. Students tested their Maglev, evaluated the results, made modifications to their design and tested the Maglev again.

6. Sequence of student activities. This is similar to the 'Suggested Instructional Sequence' but this sequence specifically addresses the essential student activities that take place. It lists these activities in sequential order. It identifies the class (technology, science, or mathematics) in which each student activity will take place. Laid out is the sequence of student activities that allows each teacher to see how the focus of the activity shifts from one class to another.

Table 2: Sequence of Student Activities

Class	Student Activity
All three classes	General design considerations
Technology	Begin sketches and drawings of designs
Science	Ferrite magnets (attraction and repulsion) Flux Lines Field strength Series and parallel circuits
Technology	Construction of a Maglev
Science	Concept of speed
Mathematics	Speed, distance, time Calculation of speeds Average speed Cost analysis
Technology	Evaluating the Maglev

7. Introduction. Some teachers may need more general background material in order to implement this activity successfully.

Maglev has the promise of becoming the largest development in transportation technology since the wheel. Maglev does away with the wheel and all the problems inherent with it. Maglev uses magnetism to levitate a vehicle above a track and to move it from one place to another. Maglev is an abbreviated form of Magnetic levitation, which uses basic principles of magnets to replace the old steel wheels and track. Magnets use the fact that opposite poles attract and like poles repel each other, the principle behind electromagnetic propulsion. Electromagnets are similar to other magnets in that they attract metal objects, but the magnetic field is temporary. Maglevs are high-speed trains that use electromagnets to float only inches above a track. Maglev is the ideal mass transport system of the future. A magnetic levitation vehicle is safe, fast, quiet, and non-polluting. The greatest advantage to this is the absence of friction. Maglev vehicles float above tracks instead of riding on wheels. While the Maglev was first proposed more than a century ago, the first commercial maglev train - developed and tested by the German company, Transrapid International - made its debut run in Shanghai, China, in 2002. Germany and Japan are both developing maglev technology and are currently testing prototypes of their trains. Although based on similar concepts, the German and Japanese trains have distinct differences.

8. Glossary of terms. Here is a brief description of terms that teachers may need to better understand this particular MST integrated program.

Superconductivity is a phenomenon occurring in certain materials at low temperatures, characterized by the complete absence of electrical resistance and the damping of the interior magnetic field (the Meissner effect).

Ferrite magnet is most widely used because of its low cost, high-energy, good electric insulation, and excellent resistance to demagnetization.

Levitation is the act of an object being suspended in air, seemingly in defiance of the forces of gravity.

9. Resources. This activity is supplied with a list of helpful reference sources. It includes literature, suggested software, and so forth. The following may be used when studying terms in the MST integrated program.

International Technology Education Association. (2003). Models for Introducing Technology: A Standards-Based Guide.
http://www.transrapid.de
http://kowon.dongseo.ac.kr/~seewhy/Science/Maglev.htm
http://www.rtri.or.jp/
http://www.most.go.kr/most/Young_most/rnd_6.html
http://www.kimm.re.kr

Development of a Student Activity Book

A student activity book covers specific topics and suggested instructional activities. Its technology component describes the design and construction of solutions that would typically take place in the technology education laboratory; as well, it provides guidance for designing, constructing, and evaluating a Maglev that will solve the problem stated in the design brief. Science and mathematics components describe experiments and activities for related science and mathematics concepts. Mathematics principles are related to the product, to product performance, and to real world problems. The science component relationships deal with principles related to designing, constructing, and/or evaluating the product and to real world situations.

Improvement phase

The improvement phase included a pilot and field test. The researcher performed a pilot test for increasing reliability and a field test for establishing content validity. Interviews resulted in more elementary school student level pictures, examples, word size considerations, and margin and blank areas between lines; and all helped to increase the effectiveness of the program. Overall, the MST integrated program was made easier and more interesting. Unnecessary or overly difficult sections were eliminated. The program was made to fit the teachers and provide particular focus on the goals. The MST integrated program became additionally clear, interesting, and a better fit for the level of the participating students.

According to the testimony of the field-test teachers, the MST integrated program was conceptually rich, pedagogically sound, time and cost effective, and for the most part, developmentally appropriate. The field-test teachers felt that their students were able to learn more by using the MST integrated program than with all three subjects taught in isolation of one another.

CONCLUSIONS AND RECOMMENDATIONS

Students enjoyed the opportunity to become design engineers and create Maglev. Students designed, constructed, tested, and modified the Maglev. Students continued the process of testing, modification, and testing again to fine tune the performance of their Maglev. This MST integrated hands-on program required that student research, design, experiment, and problem solve. As a development study, this program has involved both questionnaire and pilot/field tests. A hands-on activity was chosen because higher elementary school students were perceived to be interested. The study was performed in three major phases: preparation, development, and improvement. In the preparation phase, the research conceived the development of an MST integrated program for making a Maglev hands-on activity through the literature review for the needs of students, society, and subject matter. In the development phase, the design brief consisted of situation, problem, design constraints, challenge, and documentation. The Teacher's Guide consisted of a sample solution, overall objective, listing of applications, suggested instructional sequence, phases of the activity, sequence of student activities, introduction, glossary of terms, and resources. The student activity book consisted of mathematics applications, science applications, and technology applications. In the improvement phase, the research performed a pilot test for increasing reliability and a field test for establishing content validity.

More objective evaluation will determine the usefulness and impact of the MST integrated program on elementary students and teachers.

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Eurasia Journal of Mathematics, Science and Technology Education

Volume 2, Number 3, December 2006

THE EFFECT OF USING SIMPLE EQUIPMENT ON THE ACQUISITION OF PLAN MAP CONCEPTS IN THE VOCATIONAL SCHOOLS

Eskandar Fathi-Azar

ABSTRACT. The purpose of this study was to investigate the effectiveness of using simple equipment on teaching plan map concepts as a main topic in a surveying course of vocational education. Six groups of students, enrolled in the surveying course, were randomly selected and pre-tested to examine their experience on plan map concepts. Three groups received traditional methods of teaching and used theodolite in plan map-making, while the other three used simple equipment as an extra fieldwork activity. At the end of the semester, all participants were post-tested. A significant difference was found between experimental and control groups on post-test scores. Also, there was a significant difference between the two groups with respect to students' high-level understanding of plan map concepts. The use of the simple equipment was strongly recommended in science and vocational schools to overcome some main problems.

KEYWORDS. Teaching Plan Map Concepts, Vocational Education.

The most notable characteristics of vocational schools in Iran are to prepare skillful technicians to involve in the industrial development of the country. In this connection, the surveying course was offered to eleventh grade students in the vocational schools. The course introduces planimetry, altimetry, topographies, and other kinds of surveying, four hours a week during a semester. However, the planimetry is the main part of the course, which is called "plan map" with the following main objectives:

1. The student knows common terms used in the plan map construction and interpretation.
2. The student demonstrates skills in finding azimuth, scales, and other necessary variables in making plan map.
3. The student uses the theodolite device correctly.
4. The student properly measures leveling.
5. The students construct and make a proper plan map in a given area.

ISSN: 1305-8223

BACKGROUND

In the past few decades many science program, has been available to represent science as a direct or laboratory – based experience rather than to present science as only a body of knowledge (Hudes & Moriber, 1969). "When students have direct experiences with materials & events, each comes from that experience with his / her own interpretations." (Marker & Methven, 1991). In the other words students construct their own concepts from their experience, that is why, it is a well established fact that theory is more understood and appreciated by the students when subjected to experimental techniques (simpler the better), and visual presentation is preferred to abstract lectures and mere statement of facts.

The main part of course namely plan map was commonly offered in two components, with lecture typically once per week and practical work two times a week. The practical or fieldwork needs a complex device called theodolite. The theodolite is expensive and the schools can have just a few of them. As a result, learning experiences in practical work may have minimal impact on helping students construct understanding of plan maps' concepts, content, or relationships.

As a result, practical work is now emphasized in school science. Hodson (1996), identified three justifications of practical work for learning of science:

1. To help students learn science
2. To help students learn about science and to
3. Enable students to do science.

Also, Woohnough and Allsop (1985) have argued that practical work can be viewed as providing experiences, exercises, and investigations.

Laboratory-based experiments are not necessarily needed for practical work. Out school activities can provide opportunities to learn and to do science as well. In this regard, Griffin (1998) pointed out the importance of informal settings of learning processes, and showed how carefully planned museum-based experience could provide a vehicle to achieve some goals of practical work in school science. Lock (1998), realized that "the limited available empirical research findings suggest that field work may be more effective than equivalent teaching carried out in laboratory." He further concluded "field work can make significant contributions to all three [objectives of practical work in science]." It is inevitable that science, vocational education, and practical work should be changed over time and be geared toward fieldwork. The work can be done in the schoolyard or in the wider environment.

It is known that textbooks are used as an alternative to practical work (Lock, 1997). Even though practical work can include the design of experiments, and when the work goes according to the textbook, it may add little to conceptual mastery.

Laboratory and fieldwork need not reasons for emphasizing the use of complex and expensive equipment. One area of Japanese superiority on test achievement and comprehension in school science can be seen on their teachers' emphases in "the experiment done with everyday simple equipments and materials" (Walberg, 1991).

Kirschner and Huisman (1998), in designing non-traditional practices to replace traditional practices suggest that, "the use of simulations is advocated when: (1) the 'real' laboratories are unavailable, too intricate; (2) the experiment to be carried out is dangerous for the experimenter or to the object of experimentation; (3) the techniques which need to be used are too complex for the typical student; and (4) there are severe time constraints."

Based on local reports and experiences in vocational schools, most of the students who take the surveying course, fail at the end of semester, and their achievement in the course is not adequate, particularly in plan map concepts.

Generally, the framework and the theoretical orientation of this study were based on the following assumptions:

1. Students acquire plan map concepts through out- school activities
2. Use of simple equipment can reduce the complexity of the concepts.
3. Use of simple equipment can overcome the unavailability of real laboratory and reduce the students' fears of using expensive and limited tools.
4. Use of simple equipment causes teachers to do activities beyond the textbooks as a complementary plan without time consuming.

PURPOSE OF THE STUDY

The primary purpose of this study was to determine the effectiveness of two different types of instruction on plan map concepts: that involved simple equipment, and implemented traditional methods. More specifically the research sought data to answer the following hypotheses:

1. There is a significant difference in the students' achievement on plan map concepts between the experimental and control groups.
2. There is a significant difference in the students' level of understanding plan map concepts between the experimental and control groups.

METHOD

Procedure

This study was conducted using students enrolled in a the surveying course during the Fall 1998 in vocational schools of the East Azerbaijan Province in Iran. The course content included the main topic of making plan map concepts.

A quasi-experimental design was employed. The subjects in both control and experimental groups received a traditional lecture method and practical work, using theodolite for an entire semester. Additionally during the semester the experimental groups used the simple equipment of plan map-making as an extra activity.

The plan map as the main part of surveying course was, two-credit, 18-week course offered through the vocational high schools. The class met once a week in 50-minute periods and 100-minute practical work. Worthwhile to mentioned that the same teachers taught both control and experimental groups. However, 50-minute of 100-minute practical work of the experimental group was devoted to use the simple equipment.

Participants

The sample consisted of public vocational school students in grade 11, ranged in age from 17 to 18, of the East Azerbaijan Province in Iran. Five school districts were randomly selected to represent a variety of students in terms of demographic characteristics. Within the districts, six groups of students were randomly selected, three as experimental and three as control group as multistage cluster sampling (Borg and Gall, 1989). Therefore, the study was based upon 155 students, of which 65 students were in the experimental and 90 in the control groups. This sample was part of a total 534 male students who took the surveying course in vocational schools.

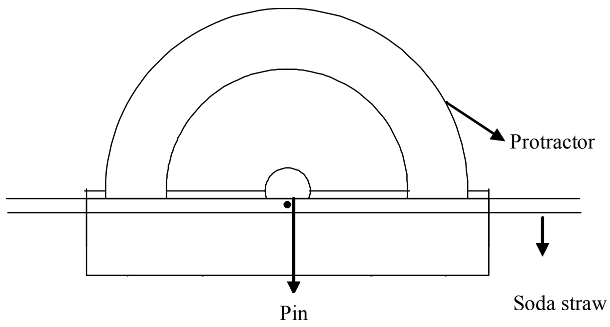
Measures

Forty multiple test items were used as pre-and post-test to measure plan map concepts. Four instructors and two specialists in surveying confirmed the test validity. The reliability of the test was measured by a split-half method, using Spearman Brown formula (r = 0.69). Since the current effort to reform science education emphasizes the importance of understanding for students (National Research Council, 1996), in response to such notion the author examined the subjects' understanding level in the plan map concept. For that reason the forty items were given to the instructors to select as being in a high level of instructional objective. As an aid for classifying the items, a table that is describing the major categories of each domain of taxonomy (Gronlund, 1976) was given to the instructors. The twenty items were selected as being in a high order level such as comprehension, application, analysis, synthesis, and evaluation of cognitive domains. These items were used to compare the understanding level of plan map concepts among subjects.

Materials

The material consisted of the use of equipment such as a protractor, soda straw, measuring tapes and ropes, paper, and pin. With these materials a piece of equipment was made as shown in Figure 1.

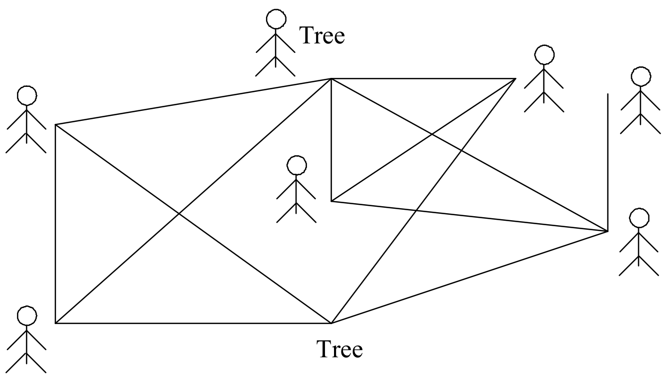
Figure 1. The simple equipment of plan map making



Before going into the field, the students of the experimental groups were asked to be divided into teams, keeping in mind that they could sight correctly and use the equipment. Then, the students were asked to use equipment according to instructions given by the teacher.

Each team was asked to indicate the north on their paper and then sight on a distant object of their choice, such as trees or sticks. The following figure is used to illustrate this technique.

Figure 2. The illustration of sighting



RESULTS

Since the students in the control and experimental groups did not match according to their pre-test scores, any differences in these scores was done by assessing the D score (D=posttest-pretest) to obtain a more reliable difference between the two groups.

A t-test model was used on the students' achievement scores. There was a significant difference between the D scores of experimental and control groups $t(154)=-12.95$, $p<0.01$. Thus, students who used the simple equipment achieved higher that the control group students. One-way analysis of variance (ANOVA) was also conducted to test the difference among groups of the study (Table 1, groups 1,2, and 3=experimental, and groups 3,4, and 5=control ones in range of mean scores).

Table 1. Analysis of variance among the D scores of the subjects

Source of Variance	Sum of Square	df	Mean Square	F	p
Between	146.4437	5	29.2887		
Within	542.8563	149	3.433	8.0390	0.0001
Total	699.3000	154			

There was a significant difference between the achievement of the students in the control and experimental groups $f(5, 149)=8.0390$, $p<0.01$. Thus, the first hypothesis of this study, which was "there is a significant difference in the students' achievement plan map concepts between the experimental and control groups" was confirmed. A post hoc analysis was done by Tukey method to see the differences of the groups with each other. The results are contained in Table 2.

Table 2. Tukey test between groups achievement

Mean Score	Group	5	4	6	3	1	2
1.0333	5						
1.4667	4						
2.0000	6						
2.3571	3						
3.2308	1	*	*				
4.0278	2	*	*	*			

$P<0.01$

Thus, it can be concluded that at $p<0.01$ there was a significant difference of the two experimental groups with the control ones, in regard to the subjects' level of understanding, but there was no significance difference of one experimental group (1) with the others.

An ANOVA was done in regard to the students' higher level of plan map concepts in the groups of the study. The results are shown in table 3.

Table 3. Analysis of variance results for high achievement plan map concepts among the subjects

Source of Variance	Sum of Square	df	Mean Square	F	p
Between	86.1660	5	17.2332	23.8785	
Within	107.5337	149	0.7517		0.0001
Total	193.6997	154			

Thus, the second hypothesis of the research “there is a significant difference in the students’ understanding plan map concepts among the experimental and control groups” was confirmed.

In order to find out the difference between the groups a Tukey post-hoc analysis was conducted and the results were shown in table 4.

Table 4. Tukey post-hoc analysis on the students’ high achievement

Mean Scores	Groups	6	4	5	1	2	3
1.0467	6						
1.3033	4						
1.4767	5						
2.7500	1	*	*	*			
2.7610	2	*	*	*			
2.7857	3	*	*	*			

$p<0.01$

It should be mentioned that the plan maps made by the subjects, are comparable by the ones that are made by the theodolite. The students used the formula of $S = \frac{1}{2} ab \sin \alpha$ for calculating the given area. More figures of the plan maps are presented in appendix A and B.

CONCLUSION

This study provides evidence that students’ achievement were enhanced through using the simple equipment as an extra activity of plan map making. During the treatment period, the experimental groups, except one, were able to improve plan map concept and skills. While in comparing to the experimental groups, none of the control group could make an improvement of plan map concepts and skills. The most surprising result of this study is that the statistical analysis indicates a highly significant improvement in the students’ achievements for all experimental groups, when those high levels of cognitive skills were measured.

The theoretical framework proposed in this study appears to be consistent with the experimental data. The enhancement of the students’ performance reveals that the simple equipment reduces the complexity of plan map concepts. This reasoning is in the line of Japanese superiority on test achievement on school science, which emphasized on using simple and everyday materials (Walbeg, 1991). This kind of activity provides opportunities for pupils to learn and acquire the concepts in informal setting (Griffin, 1998) of learning processes. As Lock (1998) identified, fieldwork such as this may be more effective than equivalent laboratory approaches. Finally, using the simple equipment overcomes the costs and time constraints associated with real laboratory experience (Kirschner and Willbord, 1998).

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Appendix A
An example of plan map made by the experimental group

Station	Length	Angle
OA	27.90(m)	∠ AOB = 80°
OB	39.80(m)	∠ BOC = 30°
OC	36.00(m)	∠ COD = 62°
OD	49.00(m)	∠ DOE = 91°
OE	41.40(m)	∠ EOF = 48°
OF	30.90(m)	∠ AOF = 49°

$$S_1 = \frac{1}{2} OA \times OB \sin C = 27.90 \times 39.8 \times 0.988 = 548.$$

$$S_2 = \frac{1}{2} OB \times OC \sin C = 39.80 \times 36.00 \times 0.500 = 358.$$

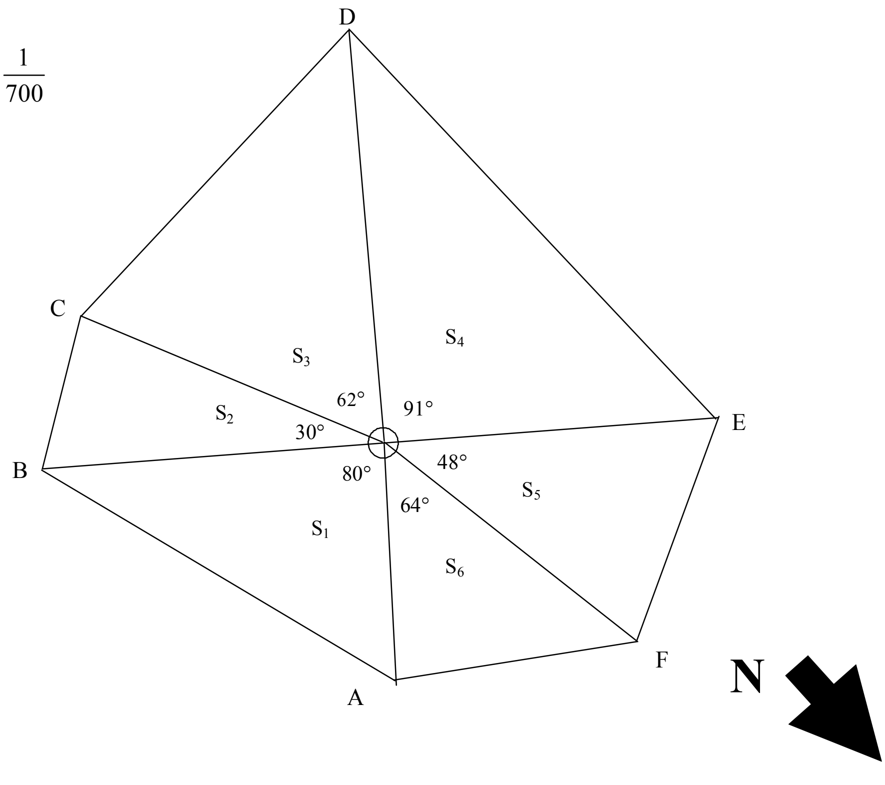
$$S_3 = \frac{1}{2} OC \times OD \sin C = 36.00 \times 49.00 \times 0.909 = 801.$$

$$S_4 = \frac{1}{2} OD \times OE \sin C = 49.00 \times 41.4 \times 0.999 = 1013.$$

$$S_5 = \frac{1}{2} OE \times OF \sin C = 41.40 \times 30.9 \times 0.689 = 440.$$

$$S_6 = \frac{1}{2} OF \times OA \sin C = 30.90 \times 27.9 \times 0.739 = 318.$$

$$Scale = \frac{1}{700}$$

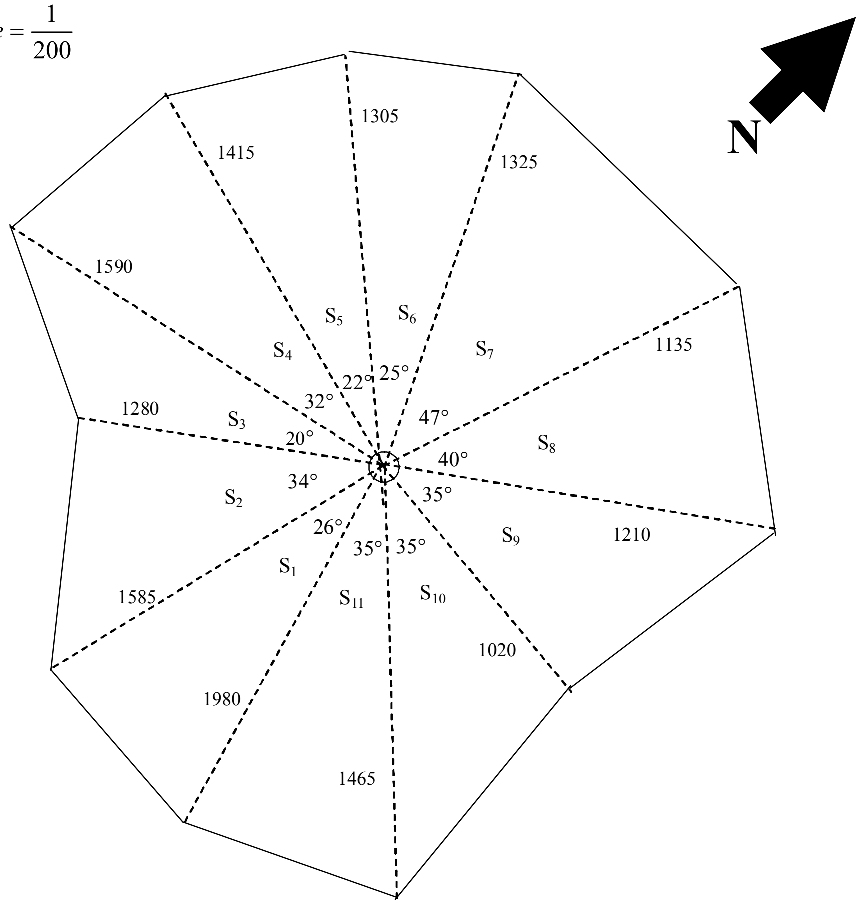


Appendix B

An example of plan map made by the other experimental group

Section	Length	Angle	Area
S_1	13.80(m)	26°	47.94
S_2	15.85(m)	34°	56.72
S_3	12.80(m)	20°	34.80
S_4	15.90(m)	32°	59.61
S_5	14.15(m)	22°	47.55
S_6	13.05(m)	25°	36.53
S_7	13.25(m)	47°	54.99
S_8	11.35(m)	40°	44.13
S_9	12.10(m)	35°	35.39
S_{10}	10.20(m)	35°	43.43
S_{11}	14.85(m)	35°	58.77

$Scale = \frac{1}{200}$



Eurasia Journal of Mathematics, Science and Technology Education

Volume 2, Number 3, December 2006

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A COMPARISON OF A COMPUTER-BASED AND A LECTURE-BASED COMPUTER LITERACY COURSE: A TURKISH CASE

İlhan Varank

ABSTRACT. Computer-based instructional applications are considered an effective alternative to traditional teaching methods and today in numerous educational and training settings, interactive computer programs are used to teach young students and adults computer literacy skills. The purpose of this study is to compare the attitudes and motivations of students who attended a computer-based in-class computer literacy course with the attitudes and motivations of those who participated in a classical lecture-based computer literacy course. The results show that there is no significant difference between computer-based instruction group students' and lecture-based instruction group students' total attitudes scores. However, a significant instructional mode effect on students' motivation was detected.

KEYWORDS. Lecture-Based Instruction, Computer-Based Instruction, Computer Literacy, Motivation, Computer Attitude.

INTRODUCTION

Advances in computer technology have caught the attention of many educators and researchers. Computer-based instructional applications are considered an effective alternative to traditional teaching methods (Pucel & Stertz, 2005; Larkin, 2003; Leigh, 1996). Today in numerous educational and training settings, interactive computer programs are used to teach young students and adults computer literacy skills. However, as indicated in the study by Merchant, Kreie and Cronan (2001), much research is needed to investigate the effectiveness of computer-based interactive computer literacy teaching programs.

Bertz and Johnson (2000) conducted a research study to determine the effectiveness of an innovative approach for teaching basic computer literacy. The innovative approach was web-based which was administered over the internet, self-paced that required students to study on their own without attending a regular classroom instruction and competency-based that compared students' technical skills against certain norms. Based on data gathered from 314 college students, it was found that the new innovative approach for teaching computer literacy was preferred more and had advantages over traditional teaching methods.

ISSN: 1305-8223

In another study by Desai, Richards and Eddy (2000) the importance of training methods in computer literacy training programs was investigated. Novice computer users, who were employees of a company, attended two different training programs, instructor-based training (IBT) and computer-based training (CBT), to learn word processing skills. The IBT used a combined traditional training which consisted of stand-up lecture and hands-on exploratory method. The CBT was similar to the IBT approach except for that there was not an instructor, and that subjects directly interacted with the computer. It was found that "the CBT group's overall end-of-training and one-month-after-training performances were significantly better than IBT subject's performances." (p.242)

Merchant, Kreie and Cronan (2001) measured and compared three groups of a total of 54 undergraduate students' performance ratings of computer skills and their evaluations of the training methods after they participated in three different training programs, which were lecture, handout, and multimedia CBT, to learn spreadsheet software. In the lecture method, information on spreadsheet software was given in verbal format in a classroom. In the handout method, a booklet of information was given to trainees to study by themselves. Graphic examples and text-based explanations were included in the handout. The multimedia CBT included text and graphic-based information and animated examples with an option of sound. Similar to the handout method, subjects used the CBT program individually. Based on an analysis of variance, subjects' performance scores in multimedia CBT group were significantly less than those in lecture and handout groups and the multimedia CBT group was less satisfied with their instructional method.

Gurbuz, Yildirim and Ozden (2001) studied Turkish college students' attitudes towards two computer literacy courses (one is offered on-line and the other by traditional methods). Sixty nine students attended the on-line computer literacy course, and 140 students attended the traditional computer literacy course. It was found that neither the on-line nor the traditional computer literacy course significantly changed student teachers' attitudes towards computers.

An intensive literature review did not yield much research that investigated and compared subjects' both attitudes towards computers and motivations about computer lessons who participated in computer-based and lecture-based computer literacy course. Moreover, very few studies have been found investigating the same issue in Turkey. Thus, the purpose of this study is to compare the attitudes and motivations of students who attended a computer-based in-class computer literacy course with the attitudes and motivations of those who participated in a classical lecture-based computer literacy course.

There were two central research questions for this study:

1. To what extent are the computer attitudes of subjects, who participated in a computer-based in-class literacy course, improved, as compared to the attitudes of those who attended a classical lecture-based computer literacy course?

2. To what extent are the learning motivations of subjects, who participated in a computer-based in-class computer literacy course, improved, as compared to the motivations of those who attended a classical lecture-based computer literacy course?

METHOD

Participants

The participants of this study were 323 (172 females and 151 males) freshmen and sophomore students, majoring in elementary education, social science education, and preschool education, enrolled in seven sections of the computer literacy course at a university in mid-west Turkey.

Independent Variable

The independent variable of this study is the instructional mode of the computer literacy course. There were two categories of the instructional mode: Classical lecture-based instruction and in-class computer-based instruction.

The computer literacy course, regardless of the instructional mode, covered ECDL standards (European Computer Drivers' License). The ECDL standards are a list of internationally accepted computer skills and reflecting minimum competencies to be licensed as a computer user (ECDL, 2001). The ECDL standards include computer skills in seven areas, which are the basic concepts of information technology, file management, word processing, spreadsheet, database, presentation, and the Internet. Each area has several specific subskills. For instance, the basic concepts of information technology have subskills related to general computer concepts, hardware, software, health and safety, computer security etc. Word processing has subskills related to main operations, page formatting, using objects etc.

The classical lecture-based instruction was given by two instructors in a computer lab four hours a week for 12 weeks. The ECDL standards list was given to the instructors and they were asked to strictly follow it. Similarly, the in-class computer-based instruction was given in a computer lab. Students attended the class four hours a week for 12 weeks. However, instead of listening to an instructor, they logged in to a training web site which was commercially prepared. The training web site provided students with a self-paced and interactive computers literacy instruction based on the ECDL standards.

Dependent Measures

There are two dependent measures of the study:

1. Students' attitudes towards computers as measured by the Computer Attitude Scale.
2. Students' motivation towards the computer literacy course as measured by the Course Interest Survey.

Dusick (1998) defined attitude as "an evaluative disposition based upon cognition, effective reactions, behavior intentions, and past behaviors which can influence future cognitions, effective responses, intentions, and behaviors" (p. 127). In this study, the Turkish version of Computer Attitude Scale (CAS) was used to measure changes in attitudes towards computers manifest after the intervention (Loyd & Loyd, 1985).

The CAS has 40 Likert-type items involving statements of attitudes towards computers and the use of computers. The items are divided into four categories, each of which represents one subscale of the CAS: (a) anxiety or fear of computers, represented by the Computer Anxiety subscale, (b) confidence in or ability to use or learn about computers, represented by the Computer Confidence subscale, (c) liking computers or enjoying working with computers, represented by the Computer Liking subscale, and (d) perceived usefulness of computers for present or future work, represented by the Computer Usefulness subscale. Each subscale has ten items and respondents rate items by indicating to what extent they agree or disagree with the expressions in each item (from strongly disagree to strongly agree with four choices).

The estimated total alpha reliability coefficient of the English version of the CAS is .95 with the following coefficients for the subscales: .90 for Computer Anxiety, .89 for Computer Confidence, .89 for Computer Liking, and .82 for Computer Usefulness (Loyd & Loyd, 1985). In a previous study by Varank (2003), the CAS was translated into Turkish and the Turkish version was administered to middle school teachers. The observed alpha reliability coefficients of the Turkish version for Computer Anxiety, Computer Confidence, Computer Liking, Computer Usefulness, and the total scale were .77, .84, .86, .81, and .94, respectively.

Motivation is defined as "deciding to engage in a learning task and persisting in that task" (Driscoll, 1993, p. 295). For our purposes, the Turkish version of Keller's (1995) Course Interest Survey (CIS) was used to measure students' motivation towards in-class computer-based literacy course and lecture-based literacy course. The CIS measures students' motivation to learn in a particular course. The CIS has 34 items divided into four categories: Attention, Relevance, Confidence, and Satisfaction. Survey items in the Attention category measure the extent to which the interest of learners is captured and their curiosity to learn is stimulated by the lesson. Items in the Relevance category serve to measure the extent to which the personal needs and goals of the learner are met in such a way as to affect a positive attitude. Items related to Confidence evaluate the perception of learners about whether they will be able to succeed and control their success. Finally, the items in the category of Satisfaction measure the extent to which student accomplishments are reinforced. Cronbach's alpha coefficient for the English version of the CIS is .95. Alpha coefficient values for the subscales are: .84 for Attention, .84 for Relevance, .81 for Confidence, and .88 for Satisfaction. Similar to the CAS, the Turkish version of the CIS was administered to 6th, 7th and 8th grade students in Turkey and Crombach's alpha coefficients were calculated for Attention, Relevance, Confidence, Satisfaction, and the total scale as .55, .59, .67, .59, and .83, respectively (Varank, 2003).

Some of the items in the CIS, such as "you have to be lucky to get good grades in this course", "it is difficult to predict what grade the instructor will give my assignments", and "I am pleased with the instructor's evaluations of my work compared to how well I think I have done", were specifically designed to collect information about students' motivation in courses in which an instructor performs the teaching and student evaluation. Those items were not appropriate for the students in the computer-based instruction group of this study. Therefore, those items were removed from the CIS and the total number of items was reduced to 29.

The literature indicates that there is a strong relationship between computer skills and computer attitudes (Gayle & Thompson, 1995; Kay, 1993; Dori & Barnea, 1994; Geissler & Horridge, 1993; Garland & Noyes, 2003). A significant initial difference in students' computer skills may affect the post-survey computer attitudes results. Therefore, although it was not intended to measure the effects of the instructional modes on students' learning performance in this study, a perceived computer skills survey was administered before the study to ensure that characteristics of the students in both lecture-based instruction group and in-class computer-based instruction group were not different.

Perceived computer skills can be described as students' believes or perceptions about to what extent they can use the computer. Information on the students' perceived computer skills was collected by a self-evaluation questionnaire called Perceived Computer Skills Scale (PCSS) developed by the researcher. The questionnaire included 55 items randomly selected from ECDL (European Computer Drivers' License) standards list and intended to measure computer skills in five areas, file management, word processing, spreadsheet, presentation, and the Internet. Some sample items in the Perceived Computer Skills Scale were as follow: creating a shortcut icon on the desktop, copying and pasting files in folders, changing text colors, creating standard tables, sorting values in cells in alphabetical order, previewing a worksheet, copying and pasting slayts, accessing a website, and creating an e-mail message. Using a four-point Likert scale (4 = definitely I can do it, 3 = I can do it, 2 = I am not sure and 1 = I can't do it) the students indicated to what extent they believed they could perform each computer skill. Because it was not used in any research study before, no data was available concerning the reliability of the Perceived Computer Skills Scale prior to this study. However, the alpha reliability coefficient of the survey was calculated after the survey was administered.

Procedure

Using a random sampling method, each of seven sections of the computer literacy course was randomly assigned to either classical lecture-based computer literacy instruction group or in-class computer-based computer literacy instruction group. The assignment resulted in two sections of social science education students and one section of elementary education students with a total of 141 students (57 females and 84 males) in classical lecture-based computer literacy instruction group and three classes of elementary education students and one class of pre-school education students with a total of 182 students (115 females and 67 males) in computer-based computer literacy instruction group.

The students, at the beginning of the study, completed the Computer Attitude Scale (CAS) and Perceived Computer Skills Scale (PCSS). Both the lecture-based instruction group and computer-based instruction group attended the computer literacy course four hours a week for 12 weeks in a computer lab on campus. At the end of the study, students completed the CAS and the CIS.

The CIS, as indicated above, measures students' motivation to learn in a particular course, e.g. lecture-based computer literacy course and computer-based computer literacy course in this study. However, the students did not attend these particular courses before and it should not be expected that the students had a motivation to learn in those particular courses. Therefore, the CIS was not administered as a pre-survey at the beginning of the study.

Research Design and Data Analysis

A pre-survey/post-survey control group design was used for the first research question. For the second research question, post-survey only control group design was used. To determine whether there were significant attitudinal and motivational difference between the computer-based and the lecture-based groups, t-test was used.

RESULTS

The total alpha calculated reliability coefficient of the CAS in this study was .94; the reliability coefficients for Computer Anxiety, Computer Confidence, Computer Liking, and Computer Usefulness were .84, .82, .84, and .70, respectively. The alpha reliability coefficient for the PCSS was .98 with the following coefficients of the subscales: .93 for file management, .96 for word processing, .96 for spreadsheet, .95 for presentation, and .94 for the Internet. The Cronbach alpha coefficients of the CIS were .27, .55, .71, .30, and .78 for Attention, Relevance, Confidence, Satisfaction subscales, and the total scale, respectively.

As can be seen above, reliabilities of Attention and Satisfaction subscales are low. The alpha reliability coefficient is a function of test length. Therefore, the reliability of a given subscale should be expected to be lower than the total reliability of the scale because subscales have fewer items than the total scale (Gay, 1996). However, students' Attention and Satisfaction subscales were excluded from the analysis, due to their low reliability coefficients, and intervention groups were compared based on their Relevance and Confidence scores and total motivation scores.

The probability of Type 1 error increases when there is more than one hypothesis being tested. In general, if there are K multiple comparison tests at á/K level, the probability of a Type 1 error for the total of multiple tests will not exceed á (Myers & Well, 1995). The Computer Attitude Scale, Perceives Computer Skills Scale, and Course Interest Survey used in this study had subscales and those subscales were compared individually. Therefore, the subscales of the CAS and the CIS were tested with an alpha set at the level of 0.0125 (0.05 divided by 4) and the subscales of PCSS were tested with an alpha set at the level of 0.01 (0.05 divided by 5)

Some students were absent from the class when the surveys were administered either at the beginning or at the end of the study. Some students also were not able to properly complete the surveys. Thus, the data from all of these students was disqualified. Survey data from 270 students were used to analyze students' attitudes and perceived computer skills and 259 students' CIS results were used to analyze students' motivation.

The descriptive data for students' pre-survey attitudes scores show that computer-based instruction group's (M = 125.5, SD = 15.4) and lecture-based instruction group's (M = 124.0, SD = 17.5) total attitudes scores are similar and the difference between those scores is not significant ($p > .05$). Furthermore, as can be seen in Table 1, none of the difference between computer-based instruction group's and lecture-based instruction group's subscale scores of attitudes (Computer Anxiety, Computer Confidence, Computer Liking, and Computer Usefulness) are significant ($p > .0125$).

Table 1. t-test Summary Table for Students' Pretest Attitudes Scores

Attitudes	Groups	N	Mean	SD	df	t	p
Computer Anxiety	Comp.-based	174	33.2	4.6	268	1.73	.08
	Lect.-based	96	32.2	5.2			
Computer Confidence	Comp.-based	174	29.9	4.5	268	1.22	.22
	Lect.-based	96	29.0	5.5			
Computer Liking	Comp.-based	174	29.7	4.6	268	.35	.73
	Lect.-based	96	29.4	5.3			
Computer Usefulness	Comp.-based	174	32.8	3.8	268	-1.16	.24
	Lect.-based	96	33.4	3.9			
Total Attitudes Score	Comp.-based	174	125.5	15.4	268	.71	.48
	Lect.-based	96	124.0	17.5			

Table 2 shows t-test results for students' perceived computer skills. The computer-based instruction group's total perceived computer skills score is not significantly different from the lecture-based instruction group's score ($p > .05$) and this is true of all of the perceived computer skills subscales ($p > .01$).

Table 2. t-test Summary Table for Students' Computer Skills Scores

Skills	Groups	N	Mean	SD	df	t	p
File Management	Comp.-based	174	21.8	6.6	268	-.54	.59
	Lect.-based	96	22.3	6.5			
Word Processing	Comp.-based	174	32.4	12.3	268	-1.06	.29
	Lect.-based	96	34.1	12.7			
Spreadsheet	Comp.-based	174	26.4	11.2	268	-.45	.66
	Lect.-based	96	27.0	11.2			
Presentation	Comp.-based	174	19.3	8.3	268	-.82	.42
	Lect.-based	96	20.1	8.9			
Internet Applications	Comp.-based	174	25.4	9.0	268	-2.30	.02
	Lect.-based	96	27.9	8.7			
Total Compt. Skills	Comp.-based	174	125.3	43.0	268	-1.13	.26
	Lect.-based	96	131.5	44.1			

To assess the overall effects of instructional modes of the computer literacy course on attitudes, t-test was performed. No significant instructional mode effect on students' post-survey attitudes scores was detected. The computer-based instruction group students did not have significantly higher score in neither the total attitude scale ($p > .05$) nor the subscales ($p > .0125$) than the students in the lecture-based instruction group (see Table 3).

Table 3. t-test Summary Table for Students' Posttest Attitudes Scores

Attitudes	Groups	N	Mean	SD	df	t	p
Computer Anxiety	Comp.-based	174	31.4	5.4	268	-.58	.57
	Lect.-based	96	31.8	6.0			
Computer Confidence	Comp.-based	174	28.0	5.6	268	-.15	.88
	Lect.-based	96	29.1	6.1			
Computer Liking	Comp.-based	174	29.2	5.5	268	-.07	.95
	Lect.-based	96	29.3	6.2			
Computer Usefulness	Comp.-based	174	32.0	4.1	268	-.91	.36
	Lect.-based	96	32.5	5.1			
Total Attitudes Score	Comp.-based	174	121.5	18.6	268	.44	.66
	Lect.-based	96	122.6	21.4			

Conversely, there was a significant instructional mode effect on students' motivation. Students' Relevance ($M = 30.0$, $SD = 5.4$) and Confidence ($M = 21.8$, $SD = 5.2$) subscores and total motivation score (*M* = 92.3, *SD* = 14.4) in the lecture-based instruction group did significantly change when compared to Relevance (*M* = 28.6, *SD* = 3.7) and Confidence (*M* = 16.0, *SD* = 2.3) subscores and total motivation score (*M* = 88.1, *SD* = 9.1) of those in the computer-based instruction group.

Table 4. t-test Summary Table for Students' Motivation Scores

Scales	Group	N	Mean	SD	df	t	p
Relevance	Comp.-based	154	28.6	3.7	257	-2.48	.01 [b]
	Lect.-based	105	30.0	5.4			
Confidence	Comp.-based	154	16.0	2.3	257	-12.40	.00 [b]
	Lect.-based	105	21.8	5.2			
Total	Comp.-based	154	88.1	9.1	257	-2.90	.00 [a]
	Lect.-based	105	92.3	14.4			

[a] $p < .05$, [b] $p < .0125$

DISCUSSION

The results of this study show that neither computer-based instruction nor lecture-based instruction significantly changed students' attitudes towards computers. Thus, it could be concluded that computer-based instruction and lecture-based instruction are similar in terms of improving computer attitudes.

As indicated above, attitude is an evaluative disposition related to past behaviors or behavior intentions (Dusick, 1998). Therefore, the non-significant difference in the computer attitudes could be attributed to the subjects' computer-related past behaviors or experiences. As education level increases, people tend to utilize computers more, even with limited skills, for a variety of purposes. The subjects of this study, in both computer-based and lecture-based instruction groups, were university students and they could have used computers in school, at home or even at work for different purposes such as writing assignments, searching databases, filling out forms, playing games or communicating with others, which could make them experienced about and familiar with computers. The experience and familiarity might improve people's perceptions about their computer skills and consequently improve their computer attitudes (Rozell & Gardner, 1999). Accordingly, because they might have already had as high computer attitudes as it could be, the instructional modes might not have changed students' attitudes towards computers significantly.

The computer software used in this study for teaching the students computer literacy skills was a self-paced interactive instructional module designed to change the typical computer literacy instruction where teachers directly teach students computer skills and than the students practice those skills on the computer. The software had a variety of motivational factors which could potentially kindle students' interests in the subject. However, the students in the lecture-based instruction group more believed that the computer literacy course is relevant to their personal needs and goals and they felt more confident about their success in the course. In general, the lecture-based instruction students felt more motivated towards the computer literacy course than the computer-based instruction students.

The Relevance aspect of motivation is related to the extent to which personal needs and goals of learners are met in such a way as to affect a positive attitude. The main instructional tactics supporting the Relevance aspect of motivation is to tie instruction to learners' experiences, to link instruction to personal interests of learners, and to meet learners' needs (Keller, 1995). Those tactics could be achieved through using different materials and analogies related to individual learners' backgrounds, modifying goals of instruction to individual students' expectations and providing students with various opportunities for personal achievements (p 4-10). However, the computer software used in this study employed a single instructional strategy. First, step by step, it taught students computer skills and than provided an interactive environment in which the students practiced the skills they learned. The software did not use any alternative instructional strategy for those who were not able to successfully attain the computer skills. On the other hand, in the classical lecture-based instruction given in this study, the instructors might have used different teaching strategies or given satisfying responses when students encountered learning problems or asked questions. Thus, as compared to the students in the classical lecture-based instruction group, it is possible that the students in the computer-based instruction group might have not believed or felt that their personal learning needs and goals were met.

One explanation of the significant difference in Confidence between student groups might be that lecture-based instruction students more felt they received adequate feedback during the instruction. To build Confidence about lessons, students should be provided with confirmational and corrective feedback about their learning performances (Keller, 1995). Due to the fact that the students had better chances to interact with teachers during the lecture-based instruction, they might have felt they received better responses and feedbacks about how they did in the course. However, in the computer-based instruction, no explicit feedback system was embedded in the software. Thus, the students might not feel they got adequate feedback from the computer about their course performance. In light of this view, the lecture-based instruction students' significantly higher Confidence score should not be considered surprising.

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Eurasia Journal of Mathematics, Science and Technology Education

Volume 2, Number 3, December 2006

A PROFILE OF PRE-COLLEGE CHEMISTRY TEACHING IN BEIRUT[1]

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ABSTRACT. The purpose of this study was to answer the following questions: 1) How well prepared are chemistry teachers in terms of content and pedagogy, 2) What are chemistry teachers trying to accomplish in their teaching and what activities do they use to meet their objectives and 3) What are the barriers to effective chemistry teaching identified by teachers? Eighty six teachers from 39 public and private schools participated in the study. Data for the study came from teachers' responses to questionnaires and records of two classroom observations per teacher. Results showed that the majority of teachers had university degrees, two-thirds majored in chemistry, only 50% had teaching credentials, and most teachers did not have enough training to use computers in their classrooms. Finally, results related to classroom practices indicated that Lebanese chemistry teachers emphasized academic objectives and perceived the purpose of school chemistry as preparation for higher studies.

KEYWORDS. Chemistry Teaching, Teacher Preparation, Barriers to Effective Teaching, Teaching Practices, Teaching Activities.

INTRODUCTION

Lebanon is presently in the midst of an educational reform that started shortly after the end of a fifteen-year civil war (1975-1989). The most important outcomes of this reform included an operational reform plan (1994), a new educational ladder (1995), and new curricula and textbooks for all school subjects, including science. In addition, the reform entailed a series of comprehensive teacher training activities that covered the privates and public sectors nationwide.

According to the national Center for Educational Research and Development (CERD) (1995), the old curriculum has neither met societal needs nor prepared students properly for the future. This is primarily due to the fact that the curriculum was outdated, lacked general and specific objectives, and was mainly focused on the theoretical rather than the practical aspects of knowledge (CERD, 1995).

The outcomes of the educational reform initiatives are currently being evaluated and revised in light of feedback from all stakeholders in the reform. Eventually, the evaluation will

ISSN: 1305-8223

[1] This article is based on research supported by the Research Center of the Lebanese University, Beirut, Lebanon.

result in recommendations for change that will be studied and institutionalized after being scrutinized by the appropriate committees and institutions within the Ministry of Education. Concurrently, the Education Development Plan, which is a five- year plan, 2002-2007, funded by a grant from the World Bank, is now well underway. This plan has three components pertaining to the development and administration of the educational system, leadership development, assessment and evaluation, and education infrastructure. The leadership development, assessment, and evaluation component includes three sub-components: a) development of school principals, b) teacher training, and c) assessment.

Science attracted increasing attention in the 1995 Lebanese Educational Reform Plan. For example, the number of hours apportioned to science has increased in the new educational ladder. Biology, chemistry and physics are taught as separate subjects starting in Grade 7, and an issues-oriented science curriculum, labeled "scientific literacy", is being implemented for those students who do not choose science at the secondary level. Moreover, the Science Curriculum Committee that was commissioned by CERD to design and write the new curriculum has decided to give emphasis to hands-on and minds-on science learning (Author, 2002). The current Lebanese curriculum stipulates that chemistry be taught as a separate subject starting at the Grade 7 level. The number of periods of chemistry per week is presented in Table 1.

Table 1. Number of Periods per Year of Chemistry at Each Grade Level of the Lebanese Educational System

Grade	7	8	9	10	11		12			
					S	H	GS	LS	SE	LH
Number of periods per week	1.5	2	2	2	3	1	4	5	1.33	1
Number of periods per years	45	60	60	60	90	30	120	150	40	30

S = Science, H = Humanities, GS = General Sciences, LS = Life Sciences, SE = Sociology and Economics, LH = Literature and Humanities.

Alongside the efforts to reform the Lebanese educational system, there has been some activity in educational research, in general, and science education research more specifically. A comprehensive review of the science education literature in Lebanon between 1992 and 2002 (Author & Abd-El-Khalick, 2004) reveals several limitations in this body of literature. First, even though at least ten universities in Lebanon offer undergraduate and/or graduate degrees in education, the number of empirical studies conducted in these universities is rather small. Actually, the vast majority of the empirical studies in the review came from two universities, the American University in Beirut and the Lebanese University. Additionally, this body of research is poorly disseminated. Only about one third of all reviewed studies were published in accessible resources including refereed journals, international databases, book chapters, and conference proceedings. The rest of the studies were theses or projects available in university libraries with limited access. Moreover, research conducted in Lebanon is limited in terms of its exclusive focus on intermediate and secondary school students. Only a handful of the reviewed studies focused on elementary students. Another limitation is that several of the reviewed studies did not have substantial mass. For instance, several of the studies that examined science textbooks were limited to the analysis of a few chapters from a single textbook. Finally, there was a clear lack of studies focusing on documenting and investigating classroom practices related to science teaching and of large-scale national studies that aim, for example, to implement and assess curricular innovations or generate comprehensive reports on the status of science education in Lebanon. This is despite the fact that investigating teachers' classroom practices and the possible links of these practices to student academic performance might provide insights into improving the quality of science teaching and learning at all educational levels as suggested by Anderson and Helms (2001), She (1999), Princeton (2000), and Wenglinsky (2000).

On the international scene a number of educational research projects have investigated science teachers' classroom practices. One of the established projects is the large scale National Survey of Science and Mathematics Education, conducted in the USA over a number of years to gauge the status of science and mathematics education in the USA. Reports from these studies written by Weiss (1987, 1988, 1994), Weiss, Banilower, McMahon, Kelly & Smith (2001), and Weiss, Pasley, Smith, Banilower & Heck (2003) have attempted to answer the following questions using data from questionnaires distributed to stratified random samples of teachers from all states in the USA: 1) How well prepared are science and mathematics teachers in terms of both content and pedagogy? 2) What are teachers trying to accomplish in their science and mathematics instruction, and what activities do they use to meet these objectives? 3) To what extent do teachers support reform notions embodied in the National Research Council's *National Science Education Standards* and the National Council of Teachers of Mathematics' *Principles and Standards for School Mathematics*? And 4) What are the barriers to effective and equitable science and mathematics education? It is worth noting that no classroom observations were conducted in these studies and all data sources were based on teachers' self reports.

Analysis of the trends between 1993 and 2000 in the above studies showed that science teachers' classroom practices have seen some changes. These changes include the reduction in the amount of time spent on reading about science during class and doing textbook/worksheet problems. Approximately 50% of teachers at all grade levels reported in 2000 that their students completed textbook/worksheet problems in the most recent lesson, representing a small decrease from 1993. Moreover, while there was some increase in the use of hands-on activities at the Grade 1-4 level (from 41% to 50% of classes), the percentage of classes in which hands-on and laboratory activities took place have remained stable and amounted to approximately two thirds of the classes. There does not seem to be a change in the percentage of classes in which computers were used: teachers reported that 10 percent or fewer science lessons included students using computers in 1993 and 2000. However, many more teachers reported using other instructional technologies such as CD-ROMs in 2000 than in 1993.

Another international project that has investigated science and mathematics teachers classroom practices in science and mathematics is the TIMSS 1999 video study, the science results of which were released in 2006 (Roth, Druker, Garnier, Lemmens, Chen, Kawanaka, Okamoto, Rasmussen, Trubacova, Warvi, Gonzales, Stigler, & Gallimore, 2006). This study examined patterns of science and mathematics teaching practices in 439 videotapes of eighth grade science lessons in five countries: Australia, the Czech Republic, Japan, the Netherlands, and the United States. Results of the study showed that there were variations across the five countries in the organization of science lessons, development of science content for students, and student involvement in doing science. For example, the study results showed that students in the Czech Republic were required to master challenging and theoretical science content and that classes were mostly focused on talking about science in whole class settings. In Japan the focus was on presenting science in conceptually coherent ways while stressing the identification of patterns, making connections among ideas, and the interplay between evidence and ideas in an inquiry-oriented approach to teaching. Australian students were mostly involved in making connections between ideas, evidence, and real-life situations using inquiry approaches to teaching similar to those used in Japan. Students in the Netherlands were held accountable for independent learning of science content with emphasis on homework and independent seatwork. Finally, in the United States students experienced variety in instructional approaches, organizational structures, content, and activities with less emphasis on developing coherent science ideas and content. The focus of the activities was on engaging and motivating students rather than on developing challenging content knowledge.

As evident from the above, there is important research on classroom practices being conducted worldwide; research that has the potential to provide useful recommendations for improving science teaching and learning. Even though the Lebanese Association for Educational Studies has conducted a number of research projects that aimed to evaluate the Lebanese curriculum[2] , there is a conspicuous absence of research in Lebanon on teachers' backgrounds, classroom practices, and barriers they face during their teaching; research that has the potential to provide information that is necessary, among other things, for planning teacher training programs and for evaluating the results of implementing new curricula. Consequently, there is a need for research to answer the following questions: 1) How well prepared are chemistry teachers in terms of content and pedagogy, 2) What are chemistry teachers trying to accomplish in their teaching and what activities do they use to meet their objectives and 3) What are the barriers to effective chemistry teaching identified by teachers?

A basic premise behind the present study is that educational systems are extremely complex, and a full understanding of all their components is beyond the scope of this investigation. However, we have adopted a simplified conceptual model of educational systems used by the National Research Council Committee on Indicators of Pre-college Science and Mathematics Education (Weiss, 1988) that considers teachers' quality and quantity and

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[2] See the LAES (Lebanese Association for Educational Studies) (2000-2003). Evaluation of the Lebanese Curriculum (unpublished report). Beirut, Lebanon: UNESCO, Regional Office for Education in the Arab States.

curriculum content as inputs, instructional factors as processes, and student achievement as the primary outcome of any system. This study focused on studying two components of the model, namely science teachers' quality and instructional processes.

METHOD

Sample

The sample for this study was drawn from the greater Beirut area and used a two-stage probability sampling design with schools as the first stage of sampling and teachers as the second stage sample. Schools were classified into private and public, and each was classified into five types: 1) Schools including elementary and intermediate classes (Elementary/Intermediate); schools including intermediate and secondary classes (Intermediate/Secondary); schools including intermediate (Intermediate); schools including secondary (Secondary); and schools including elementary, intermediate and secondary classes (All Levels). A 25% probability sample from each school type was selected for inclusion in the study. The list of schools in the greater Beirut area available from CERD was used in this process (CERD, 2003).

The second stage sampling involved selecting chemistry teachers from the selected schools at the intermediate and secondary levels because these are the levels at which chemistry is taught as a separate subject (Table 1). For this purpose, a list of teachers at each level from each school included in the sample was acquired and up to two teachers from each level was randomly selected for participation in the study. These teachers were asked to fill out a questionnaire designed for the purposes of the study. Then, one or two teachers from each school at each level were randomly selected for in-depth observation for two teaching periods. A special observation log designed for the purposes of this study was used for observation.

Eighty six teachers (73% females and 27% males) from 39 schools (50% public and 50% private) participated in the study. Teachers' ages ranged from 22 to 62 years with an average age of 41 years. The number of years of teaching experience ranged from 1 to 38 years, with an average of 16 years. Finally, the number of periods taught per week ranged from 6 to 38, with an average of 20 periods.

All 86 teachers who participated in the study filled out the questionnaires. Sixty-one teachers from 29 schools agreed to be observed resulting in 114 classroom observations. Fifty-three of the teachers were observed twice while eight were observed once. Approximately, 54% of the observations were in classes that used English as the language of instruction while the rest of the classes used French. It is worth noting that the observations showed that approximately 57% of the teachers used Arabic, the mother tongue of most students, for more than 50% of the time. Table 2 presents details regarding the schools and teachers who participated in the study.

Table 2. Number of Schools and Teachers participated in the Study.

	School education level					
School type	**Elem/ Inter.**	**Inter. /Sec.**	**Inter.**	**Sec.**	**All levels**	**Total**
Public	7	7	3	3	0	20
Private	0	9	1	0	9	19
Total schools	7	16	4	3	9	39
Number of teachers responding to questionnaire (Public)	12	16	6	9	0	43
Number of teachers responding to questionnaire (Private)	0	20	2	0	21	43
Total number of teachers responding to questionnaire	12	36	8	9	21	86
Number of teachers observed (Public)	8	10	6	7	0	31
Number of teachers observed (Private)	0	10	2	0	18	30
Total number of teachers observed	8	20	8	7	18	61
Number of observations (Public)	15	19	12	14	0	60
Number of observations (Private)	0	15	4	0	35	54
Total number of observations	15	34	16	14	35	114

Elem: Elementary Inter: Intermediate Sec: Secondary

Instruments

A questionnaire and an observation log were used to collect data in this study.

Questionnaire: A questionnaire entitled "Intermediate and secondary teachers' questionnaire" was designed for use in this study. The questionnaire was modeled after those used by Weiss (1987, 1988, 1994) to investigate the status of science education in the United States. In addition, elements of a questionnaire used by Author (1987) in studying the needs of teachers regarding the teaching of science in Cincinnati, Ohio were incorporated in the questionnaire.

The questionnaire included six sections. The first section asked teachers for background information regarding their sex, age, and years of teaching. The second section asked teachers to comment on chemistry teaching and identify the barriers to effective science teaching in their schools. In the third section, teachers were asked specific questions about a particular chemistry class of their choice. In the fourth section, teachers were asked questions about a recent chemistry lesson. In the fifth section, teachers were asked about their preparation in science content and pedagogy and about in-service opportunities available to them. Finally, in section six teachers were asked about their involvement in professional development activities.

The questionnaire was written in English and then was translated into Arabic. The English and Arabic questionnaires were then piloted with a number of teachers who were asked to evaluate the content and ease of understanding of the questions. In addition, a number of general education and science education faculty members at two universities in Lebanon were asked to judge the adequacy and appropriateness of the questions. The pilot study showed that all the questions were understandable by the teachers involved in the pilot study. Moreover, the general and science education faculty who judged the questionnaire indicated the questions were appropriate for teachers.

Observation Log: A special observation log was developed to be used as a guide during the observation stage of the study. The log focused on instructional activities performed by the teacher such as lecture, discussion, teacher demonstration, students' use of hands-on or laboratory materials, students' working in small groups, students working on worksheets, and students doing assigned work from textbook, among other activities.

Data Analysis

Frequency counts and percentages were computed for each of the variables used in the questionnaire to answer the research questions and construct a profile of chemistry teachers in terms of their instructional practices and the perceived barriers to effective science teaching. Analysis of the data from the observation log involved searching and categorizing teachers' activities during the lesson. The first round of categorization resulted in a large number of categories which were reduced in a second round of analysis into four main categories: Teacher-dominated activities, student-dominated activities, interactive activities, and managerial activities. Data regarding teacher- and student-dominated activities were subdivided to 4 and 8 subcategories respectively. Table 3 presents the categories and subcategories used in data analysis.

Table 3. Categories and Subcategories Used in Data Analysis

1. Teacher-dominated Activities
Teacher talking, writing, reading, etc.
Teacher solving problems
Teacher using lab equipment/demonstrating
Teachers using computers
2. Student-dominated Activities
Students doing seat work, worksheets and solving problems, etc.
Students using lab equipment
Students using computers
Students working in groups
Students taking notes
Students writing on the board
Students watching TV
Students taking tests
3. Interactive Activities
Discussion, asking and answering questions, recitation, revision, students explaining or presenting work, students summarizing, students expressing understanding, etc.
4. Managerial Activities
Teacher enforcing discipline, praising a student, checking students' work, distributing and collecting papers, wasted time, etc.

RESULTS

The following sections provide answers to the three questions of this study. These questions investigated teacher preparation in content and pedagogy, Teachers' accomplishments when teaching, and Barriers to effective teaching.

Teacher preparation in content and pedagogy

To answer Question 1 (How well prepared are chemistry teachers in terms of content and pedagogy?), data from the sections of the questionnaire concerning pre-service and in-service education in terms of chemistry content and pedagogy is considered. Data concerning teacher preparation indicate that approximately 93% of the teachers who participated in the study held a bachelor's or license degree, and 7% held a graduate degree. Sixty seven percent majored in chemistry and biochemistry, 23% in biology and 10% in physics, math, health sciences, or other science related areas. Fifty one percent of the teachers had teaching credentials, 55% of whom held teaching diplomas in secondary education, 16% held graduate degrees, while 29% held intermediate or elementary teaching credentials.

With regard to the types of chemistry courses teachers have taken, responses show that almost 93% of the teachers said that they took general chemistry and organic chemistry courses, 81% took inorganic chemistry, 70% took biochemistry and analytical chemistry, and 60% took physical chemistry. In addition to the chemistry courses, 65% of the teachers said that they took physics courses, 55% took math courses, and 45% took biology courses. Concerning the types of education courses that students took, 62% said that they took general methods courses, 43% took teaching science at the intermediate level and 36% took teaching science at the secondary level, 55% took educational psychology courses, 26% took computer related courses, and 42% said that they participated in student teaching. Teachers also reported that they all took chemistry courses and that 76% of them took six courses or more, 91% took physics courses, 86% took math courses, 42% took computer science courses and 36% took earth science courses (Table 4).

Table 4. Percentage of Courses Completed in Different Subject Areas

	None (%)	1-5 courses (%)	6-8 courses (%)
Chemistry	0	24	76
Biology	36	26	38
Physics	9	71	20
Earth Science	64	30	6
Math	14	71	15
Computer Science	58	42	0

Data concerning in-service professional development revealed that 37% of the teachers have not had any in-service training in science or teaching of science activities in the past 12 months, 40% said that they have spent between 6 and 15 hours on in-service activities, 14% spent between 16 and 35 hours, and 9% spent more than 35 hours. One significant fact reported by all the teachers was that they took no formal chemistry courses since graduating from the university. When asked specifically about their readiness to use computers in their classrooms, 55% said that they felt unprepared and 19% felt that they are well prepared. Additionally, 45% said that they had not been involved in any computer training and 47% said that they had received some training on the use of computers during the last 12 months either by taking college courses (13%) or by participating in in-service workshops (34%) while thirty six percent reported that they taught themselves to use the computer. Moreover 92% of the teachers reported that they had no training in teaching handicapped children. Specifically, 87% felt they are totally unprepared to teach mentally retarded children, 64% to teach physically handicapped children and 59% to teach children with learning disabilities.

When asked about specific topic in chemistry they find difficult to teach, 62% said they did not have any difficulty while the other 38% reported that different topics were difficult such as atomic structure and chemical bonding to chemical equilibrium, kinetics, electrochemistry, polymers, enantiomers and new materials with no more than 5% of the teachers reporting difficulty in any of these topics. Forty nine percent of the teachers indicated that learning more about the basic concepts would be most useful in helping them teach a difficult topic while 57%

said that leaning more about the applications of these concepts in daily life, careers and technology would be helpful. Similarly 65% said that learning more about teaching materials and techniques would be more helpful.

Ninety one percent of the teachers reported that they would use research if they needed more information about a special topic in education, 87% said they would attend in-service programs and 73% would attend college courses, 82% would consult other teachers, 48% would consult principals, 68% would use magazines or journals and 48% radio and television. Finally 8% said that they would consult books and 19% would use computers and the internet.

In general chemistry teachers said that they enjoy teaching chemistry (96%), think that laboratory-based classes are more effective than non-laboratory classes (91%), hands-on experiences are worth the time and expenses (89%) and that chemistry is not a difficult subject for children to learn (80%). Moreover, when asked about the use of instructional resources other than the required textbooks, 47% said that they used other textbooks, 10% that they used the internet or electronic recourses, and 6% said that they collected extra sets of problems from a variety of sources. The rest said that they did not use any extra resources. When asked about usefulness of science journals, 46% indicated that journals were helpful but only 13% said that they had referred to science or science education related journals during the past 12 months.

Teachers' accomplishments when teaching

To answer Question 2, (What are chemistry teachers trying to accomplish in their teaching and what activities do they use to meet their objectives?) data is presented about the objectives that teachers are trying to accomplish, the nature and time spent on different types of activities, the time spent on using textbooks and teachers' perceptions of the utility and necessity of these textbooks, and the types of activities that involve using computers.

Objectives that chemistry teachers are trying to accomplish

Table 5 shows that approximately 97% of chemistry teachers in this study place moderate to high emphasis on teaching students basic chemistry concepts, this is followed by 95% who say that they attempt to promote interest in chemistry, 94% percent who emphasize on developing a systematic approach to solving problems, and 92% who stress preparation for further studies in chemistry. Moreover, between 83% and 88% of the teachers think that laboratory safety, developing inquiry skills, learning to communicate, and awareness of the role of chemistry in daily life are important objectives. Between 72% and 76% of teachers consider developing laboratory skills, understanding application of chemistry in technology, and career relevance of chemistry as important aims of chemistry teaching. Finally, only 38% of teachers think that learning about the history of chemistry is an objective worthy of being emphasized in the curriculum.

Table 5. Degree of Emphasis Teachers Place on Different Types of Chemistry Teaching Objectives

	Minimal Emphasis (%)	Moderate Emphasis (%)	Heavy Emphasis (%)
Learn basic chemistry concepts	3	18	79
Develop awareness of safety in laboratory	17	18	65
Develop a systematic approach to solving problems	6	31	63
Develop inquiry skills	13	26	61
Become interested in chemistry	5	36	59
Learn to effectively communicate ideas in chemistry	13	29	58
Become aware of the importance of chemistry in daily life	12	31	57
Prepare for further study in chemistry	8	44	48
Develop skill in laboratory Techniques	24	29	47
Learn about applications of chemistry in technology	28	29	43
Learn about the career relevance of chemistry	28	33	39
Learn about the history of chemistry	62	30	8

Activities teachers use to accomplish their objective

Data from the questionnaires (Table 6) indicate that teachers spend on the average 8% of the time in each period on routine tasks such as enforcing discipline, checking homework, and distributing and collecting assignments. In addition, approximately 28% of the time is spent on teacher-centered activities, mainly lecturing and disseminating information, while approximately 50% of the time is spent on student-centered activities such as performing hands-on tasks (25%), reading from the book (11%), and taking tests (14%). Finally, on the average 14% of the time is spent on interactive activities such as discussion, recitation, and asking and answering questions.

Data from the observations (Table 6) indicate that approximately 35% of the time is spent on teacher-centered activities, 31% on student-centered activities, 24% on interactive activities, and 10% on routine tasks. Further in-depth analyses reveal that teacher-centered activities mainly include lectures during which teachers disseminate information rarely using demonstrations or computers. The in-depth analyses also show that student-centered activities are almost equally divided among taking notes, doing seatwork, and solving problems on the board, with rare instances of group work, laboratory activities, and using computers.

Table 6. Percentage of Time Spent on Different Categories of Activities as Revealed by Classroom Observations (N=114) Compared to Teachers' Responses on Questionnaires (N=70)

Activities	Questionnaires	Observations
Teacher centered	28	35
Student centered	50*	31
Interactive	14	24
Managerial	8	10

*Hands-on: 25%, reading: 11%, testing: 14%.

Teachers' use of textbooks

Approximately 81% of the teachers responding to the questionnaire said that they usually finish 75% or more of the textbook while only 6% finish less than 50% of the book. Table 7 also reveals that more than 70% of the respondents consider the language of the book easy and at an appropriate reading level for the students. Although 66% of the respondents agree that the textbook explains concepts clearly, 75% said that it needs more examples to reinforce concepts. More than 50% of the respondents said that the book contains examples not relevant to students' experiences, lacks examples of the use of chemistry in everyday life, provides good suggestions for activities and assignments, helps develop problem-solving, and is clear and organized. Almost one third of the teachers indicated that the textbook they use has high quality supplementary materials and provides applications of chemistry in careers and 45% considered the book as not very interesting to students.

Table 7. Teachers' Opinions of the Chemistry Textbook

	Agree	No opinion	Disagree
Is at an appropriate reading level for most students	74	5	21
Uses easy language for students	71	6	23
Explains concepts clearly	66	10	24
Needs more examples to reinforce concepts	75	2	23
Contains examples not relevant to students' experiences	32	11	57
Lacks examples of the use of chemistry in daily life	35	10	55
Provides good suggestions for activities and assignments	51	12	37
Helps develop problem-solving	52	11	37
Is unclear and disorganized	32	14	54
Has high quality supplementary materials	35	14	51
Shows applications of chemistry in careers	38	19	43
Is not very interesting to students	45	20	35

Teachers' use of computers

Approximately, 70 % of the respondents said that computers are not available for use in the chemistry classrooms and this percentage increased to 91% when those who said that computers are available but difficult to access were included. Only 12% of the respondents (10 teachers) reported that they use computers in the chemistry classroom. Seven out of these teachers said that they use computers for teaching science content, 4 as a laboratory tools, 3 for simulating scientific processes, and 1 to perform problem-solving activities. It is worth noting that none of the teachers said that they use computers for drill and practice and games. In addition, 2 respondents mentioned that students use computers to conduct research and prepare power point presentations. As for the time students spent working with computers during one week, two teachers reported less than 15 minutes and one 15-29 minutes.

Barriers to effective teaching

To answer Question 3, (What are the barriers to effective chemistry teaching identified by teachers?) data mainly comes from a number of questions that asked teachers to identify the barriers that hinder effective chemistry teaching.

As can be seen in Table 8, more than 90% of the respondents think that inadequate language proficiency among students, lack of sufficient time to teach chemistry, and lack of materials for individualizing teaching are somewhat of a problem or serious barriers for effective chemistry teaching. Other barriers identified by between 80% and 86% of the teachers included the language used for teaching, lack of student interest in chemistry, inadequate curriculum coordination across grade levels, inadequate facilities, and lack of funds to purchase equipment and supplies. Finally, between 74% and 79% of teachers said that student absenteeism, large class sizes, perception that chemistry was not an important subject, disciplinary problems, and poor quality textbooks were barriers to effective chemistry teaching. It is noteworthy; however, that only 55% of the teachers thought that inadequate access to computers did not constitute barriers to effective teaching.

Table 8. Teachers' Perceptions of the Barriers to Effective Chemistry Teaching

	Serious Problem	Somewhat a Problem	Not a Significant Problem
Inadequate student language proficiency	57%	36%	7%
Not enough time to teach chemistry	57%	34%	9%
Lack of materials for individualizing teaching	38%	52%	10%
Language of chemistry teaching	43%	43%	14%
Lack of student interest in chemistry	47%	38%	15%
Lack of teacher planning time	61%	21%	18%
Inadequate coordination of teaching across grade levels	34%	49%	17%
Inadequate facilities	42%	39%	18%
Insufficient money to purchase equipment and supplies	36%	45%	19%
Student absences	44%	35%	21%
Class sizes too large	54%	24%	22%
Belief that chemistry is less important than other subjects	30%	47%	23%
Difficulty in maintaining discipline	35%	41%	24%
Poor quality of textbooks	37%	38%	25%

DISCUSSION

Five trends emerged from the data regarding preparation for teaching. First, the overwhelming majority of teachers had university degrees. Second, approximately two-thirds of the teachers majored in chemistry, while the other majored in other science areas. Third, almost half the teachers did not have teaching credentials and out of those who had those credentials, only fifty percent did not have a secondary teaching certification. That is, only 25% of the chemistry teachers in the sample were certified to teach at the secondary level. Fourth, all teachers reported that they did not take any content matter course since their graduation. Finally, most teachers reported that they did not have enough training to use computers in their classrooms.

These results have many implications. The fact that the majority of teachers held university degrees, while necessary, is not sufficient. Many of these teachers tend to teach the same way they were taught (Scott et al., 2003) neglecting the current findings of research on teaching and learning which suggest that students achieve higher when their teachers have the required pedagogical preparation (Scott et al. 2003; Darling-Hammond, 2005) and have had extensive practical experience in their pre-service programs (Cannon, 1997). Another possible implication from these results emanates from the fact that almost one third of the teachers were not chemistry majors, with possible effects on the quality of chemistry learning of their students.

The fact that teachers did not take any courses in chemistry since their graduation may have serious implications. The new Lebanese curriculum introduced many new chemistry topics and advocated the use of student centered approaches to teaching. To intensify the problem, not all teachers participated in the workshops organized by the Center of Educational Research and Development (CERD) to update teachers' knowledge in chemistry and in pedagogy. Consequently, students may not acquire the depth of understanding of chemistry required for pursuing higher learning opportunities or using chemistry in their everyday lives.

The use of Information and Communication Technology (ICT) in the classroom has become a necessity to prepare students for a world that is increasingly dependent on technology in all realms of life. Educational systems that do not encourage the use technology are disadvantaging their students and depriving them from important opportunities to function properly in higher education and the world of work. Lebanese teachers may not be blamed for not using ICT because the educational system does not provide them with infrastructure to do so.

Results related to classroom practices indicate that Lebanese chemistry teachers place a great deal of emphasis on academic objectives and seem to perceive the purpose of school chemistry as basically preparation for higher studies. While these teachers say that they attempt to develop a systematic approach to solving problems, this should be understood within the context of a Lebanese system that is examination driven and in which teachers stress on teaching algorithmic problems in chemistry (Author & Barakat, 2000). Thus the systematic approach to problem solving may be interpreted as one focused on solving algorithmic chemistry problems. Nevertheless, even though teachers say that they value academic objectives, they seem to appreciate science-technology-society (STS) objectives such as relating chemistry to real life, understanding the role of technology in chemistry, and career awareness. Scrutiny of the results, however, shows that teachers are almost equally divided between those who place minimal, moderate, and heavy emphasis on STS objectives. Finally, it is evident that the majority of Lebanese teachers do not find any relevance of history of chemistry to their teaching. In summary, there emerges from the results a view of chemistry teaching that is heavily focused on academic objectives, with some apparent attention to STS objectives, and almost total negligence of history of chemistry. While the emphasis on academic objectives is understandable in a curriculum that focuses on such objectives, the lack of emphasis on history of chemistry is in contradiction with the general objectives of the Lebanese science curriculum that highlight the importance of understanding the development of science across history (Author, 2002).

Data related to teachers' classroom practices were collected from two sources: A teachers' questionnaire and classroom observations. As evident in the results, Lebanese chemistry teachers perform a variety of student-centered, teacher-centered, and interactive activities when teaching chemistry, a finding that is consistent with what takes place in science classrooms in the USA (O'Sullivan & Weiss, 1999; Weiss, Banilower, McMahon, Kelly & Smith (2001); and Weiss, Pasley, Smith, Banilower & Heck (2003). A close examination of the results, however, shows that many of the student-centered activities, such as taking exams, taking notes, and reading from the textbook may be passive rather than active in nature.

An interesting issue that emerges when the results from the questionnaires are compared with the results from the classroom observations is the fact that the percentage of time teachers seem to think they are spending on student-centered activities is less than the time that these activities are actually performed in the classroom (50% vs. 31% respectively). This is similar to results reported by Simmons et al. (1999) in their research with pre-service teachers. Moreover, teachers seem to spend more time on interactive activities, such as question-answering sessions, then they think they do; a situation that may be due to the fact that teachers may think the question-answering sessions are student-centered rather than interactive because questions are typically initiated by students. Yet, even if all the time spent on interactive activities is added to student-centered activities, there is a still a difference between teachers' perceptions of what they do and what actually happens in the classroom. This finding highlights the importance of finding methods to help teachers obtain valid and reliable information about the practices they actually use in the classroom, information that is necessary if they are to benefit from reflection on their teaching. Peer observations followed by feedback sessions, or peer observation along with videotaping followed by feedback sessions can be beneficial in this regard.

Textbooks are major sources of information in an educational system that is examination driven, such as the Lebanese educational system. Consequently, how teachers perceive textbooks is an important issue to consider when discussing classroom practices. The view regarding textbooks that emerges from the results is that textbooks are heavily used, with a large majority of teachers (81%) covering most of the textbook content, and that textbooks are appropriate in terms of alignment with students' reading and language abilities and in terms of explaining concepts, findings that are consistent with the teachers' emphasis on academic objectives. However, textbooks seem to be lacking in terms of the number and quality of examples and resource materials. In addition, teachers seem to be divided on the quality of suggestions that the book provided for activities and assignments.

The minimal use of computers in science classrooms seems to be an international phenomenon. Findings from this study show that a very small minority of chemistry teachers report using computers in their classes, a finding that is consistent with findings about the USA reported by Weiss, Banilower, McMahon, Kelly & Smith (2001), and Weiss, Pasley, Smith, Banilower & Heck (2003). One major difference between Lebanon and the USA, however, is access to computers, because a large majority of teachers report that they do not have access to computers, which is not the case for teachers in the USA. What is intriguing is that science teachers in most cases do not use computers even if they are present in their classrooms despite the fact that we are living in a world in which the use of Information and Communication Technology (ICT) is indispensable if students are to function successfully in the world of work. Therefore, there is a need to think carefully about meaningful ways to integrate the use of ICT in teaching science and other subjects, provide teachers with appropriate professional development (Author, 2005, 2006), and find ways to incorporate ICT activities in assessment approaches to encourage teachers to use them in classrooms.

The problem of inadequate language proficiency of students seems to be a serious barrier for effective chemistry teaching and raises an important issue that has not been addressed adequately in education circles in Lebanon. While the language of science instruction in Lebanese schools is either English or French, even though the mother tongue is Arabic, there is a conspicuous absence of studies that investigated the benefits and burdens of using a foreign language in teaching science; studies that are needed to shed light on the intricacies of this situation, provide practitioners with recommendations to help students acquire coherent knowledge in chemistry while at the same time mastering one or more foreign languages (Author & Sayah, 2000), and prepare students to benefit from science resources in foreign languages available electronically and in print. Such studies are indispensable if the aim is to improve student achievement in and understanding of chemistry.

The lack of enough time to teach chemistry is an authentic problem for many chemistry teachers, especially at the secondary level (Association of Secondary Public School Teachers in Lebanon, 2001). The number of periods apportioned to chemistry at the intermediate and secondary levels is small compared to the size of the curriculum. This situation has put tremendous pressure on chemistry teachers who end up completing the curriculum without being able to involve students in meaningful and useful hands-on activities.

The general view of chemistry teaching that emerges from this study is that of teachers who joined the teaching profession with university degrees but with minimal teaching credentials, rarely get involved in professional development activities, are very interested in academic objectives and preparation of students to pursue further studies in chemistry, are heavily dependent on textbooks, and do not make an effort to integrate computers in their teaching for a variety of reasons, the most important of which is the apparent difficulty of having access to computers. These teachers are concerned about the foreign language skills of their students particularly that chemistry is taught in a foreign language. The view is of students who are involved in a variety of activities that are mostly teacher-centered and who spend a significant amount of time in reading from the book, taking notes, and asking and responding to questions but who do not spend a significant amount of time on doing hand-on activities.

The emphasis in the new Lebanese science curriculum is on the knowledge of science, the investigative nature of science, and the interactions of science technology and society, but neglects science as a way of knowing (Author, 2002). This emphasis, however, is not reflected in the teaching practices prevalent at the present time in Lebanese classrooms. The reasons for this mismatch are numerous including the current examination system, the scarcity of supportive instructional materials, and most importantly the amount and quality of professional development activities available to teachers. Providing opportunities for teachers to participate in meaningful professional development activities (see for example Anderson & Helms, 2001; Fletcher, 2004; Judson & Sawada, 2001; Moussiaux & Norman, 1997; Monk, Swain, & Johnson, 1999; O'Sullivan & Weiss, 1999; Richie & Rigano, 2002; Schneider & Blumenfeld, 2003; Schneider, Krajcik, & Blumenfeld, 2005; Shaka, 1997; She, 1999; Sheau-Wen, 2001) can be the key to the implementation of the objectives of the curriculum and improving the quality of chemistry teaching in Lebanon.

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Eurasia Journal of Mathematics, Science and Technology Education
Volume 2, Number 3, December 2006
www.ejmste.com

MAKING CONNECTIONS: SCIENCE EXPERIMENTS FOR ALGEBRA USING TI TECHNOLOGY

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ABSTRACT. Using science experiments in life science, chemistry, and physics, helps ground students' understanding of abstract algebra concepts in real-world applications. Hands-on activities connect mathematics with science in a way that is accessible to teachers and students alike. Each activity explores a scientific phenomenon, connecting it to algebra concepts such as quadratic functions and trigonometry. Students understand abstract algebra concepts by experiencing how scientists solve problems and use mathematical models to design experiments. They apply a variety of techniques to verify their experimental results and develop conjectures. These activities: use the Calculator Based Laboratory, CBL2™, with different probes, common science equipment, and basic tools, in addition to calculators. The experiments can be used as hands-on activities or demonstrations.

KEYWORDS. Algebra, Science, Technology, Quadratic, Trigonometry.

INTRODUCTION

'Why do we need to know this?" Sounds familiar? I had to answer this question to my students over and over again. I was facing a challenge - how can I make mathematics meaningful and real for most if not all my students?

We know that real-life applications, especially, visual and hands-on demonstrations enhance students' learning of the material, meet needs of kids with different learning styles, and create additional motivation for learning a discipline. The use of experiments allows students to create visual image and practical understanding of abstract mathematics concepts and relationships. Experimental demonstrations and lab activities in the course of mathematics make mathematics more interesting and appealing to students. Real experimentation with mathematical concept adds students' emotional component to the learning process. Coincidence of the experimental and theoretical results is equivalent to the Archimedes' "Eureka!".

In this article I would like to share with you two of several science experiments that I designed for algebra class. In the first experiment students develop understanding of the graph of cosine function by using fan cart, in the second one students learned properties of parabolas by using projectile launcher. Suggested experiments are designed for students taking different

ISSN: 1305-8223

courses of algebra. Use of hands-on activities within rigorous mathematics content provides additional opportunities for students to make connections, and to master algebra concepts and skills. Another important part of this approach is use of technology and different measuring equipment in mathematics classes. Real-life problems do not provide us with "nice" numbers. Students educated on sets of standard problems get accustomed to the fact that only "nice" numbers, usually integers, can be correct answers to the problem. Real practical problems give students an understanding that any number that are not very "nice" can be a correct answer to the problem.

I also felt that from this experience students realized that mathematics plays an important role in every aspect of our lives, and especially in science applications. Mathematics is needed at each step of scientific investigation. In high school science curriculum students are usually exposed to only one role of mathematics – use of mathematical technique for computations of parameters from the experimental results or verification of experimental and theoretical data. In students' minds this approach reduces the role of mathematics to a basic computational tool. By using science experiments in algebra class students are exposed to different roles of mathematics in science:

* use different mathematical technique to verify results of experiments with theoretical predictions

* use set of mathematical models and methods that allow them to describe some real-life situation, and to design an experiment for this situation.

* develop conjectures based on the results of the experiment that go beyond the scope of the experiment and only mathematics allows verification of these conjectures for general case.

Cosine Graph. Thrust Force of Fan Cart.

In a *Die Another Day* James Bond is in a fast-paced hovercraft chase. Hovercraft is a ground or water-effect vehicle. There is very little friction between the craft and the surface. Like the hovercraft, the fan cart that students will be using in this experiment is powered by the airflow created by the fan mounted on top of the cart (Fig. 1). The airflow produced by the fan creates a force F acting on the cart in the direction opposite to the airflow that causes the cart to move. Since the fan cart is designed to move in one direction only, the thrust force of the fan cart is the component of the force F parallel to the wheels of the cart. This component can be defined as $F_x = F \cos \theta$, where θ is the angle between the cart's direction of motion and the direction of the force F (Fig. 2) By turning the plane of the fan students can change the direction of airflow and observe the effect of the angle θ on the thrust force F_x. In this experiment students investigate the graph of the cosine function by measuring the thrust force as a function of the angle. In a sense this experiment is a hands-on technology based version of unit circle analysis.

Figure 1

Before we start the experiment, I ask students to predict when the thrust force will be maximal and minimal. Most of kids can easily predict that if thrust force is parallel to the wheel axes of the fan cart, it should go fastest, and of course they can easily check that by turning the switch on and let the cart go. It is not as obvious for them what happens if we turn the fan perpendicular to the wheel axes. Immediate check demonstrates that cart does not go anywhere, since the thrust force pushes perpendicular to the direction it can go. Now, with the use of Vernier Dual Force Sensor (Vernier Software and Technology), data interface (CBL2 or EasyLink also available from Vernier Software and Technology), and graphing calculator we can collect data for all different positions of the fan dial. The force sensor allows us to measure an average force for each dial position and present data graphically. Sample data for this experiment are shown on Fig. 3. Students can now analyze the graph and answer set of questions about graph properties, for example:

1. At what angle(s) the magnitude of the thrust force is zero? Why?

2. At what angles does the thrust force reach its maximum possible magnitude (equal to the air flow force F)? Why?

3. What is the function that describes the ratio F_x/F? Does it depend on actual values of F_x and F?

4. What is the domain and range of this function? What are x and y – intercepts?

5. What will happen to this function if we keep turning the fan dial through several revolutions?

Figure 2

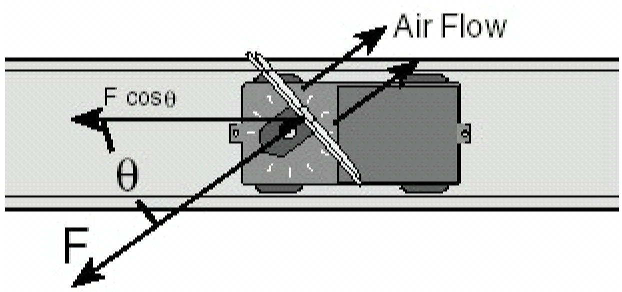
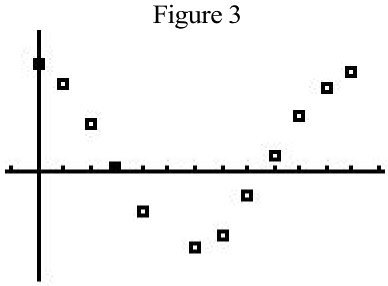


Figure 3



One of the advantages of this experiment is the fact that the dual force sensor can measure both, pull and push. When the airflow is directed backwards, the force sensor measures negative force. I always ask students "What is the meaning of the negative part of the graph and what does it tell us about magnitude and direction of the thrust force?" This question creates a very rich discussion in class and helps students to make connections between hands-on experience of how fan cart moves and increasing and decreasing behavior of cosine graph.

The activity also opens several opportunities for further explorations, for example, you may ask students to convert degrees into radians and find sine regression. For the sample data presented on Figure 3, the regression equation is $y = 0.83 \sin(.97x + 1.74)$. Ask them to plot sine regression equation along with the function $y = 0.83 \cos(0.97x)$. Do these functions describe the same graphs? Is it possible for the same graph to have different equations? Ask students to explain their statements using properties of right triangle and definitions of sine and cosine. Or you may want to ask them the meaning of the horizontal shift of 1.74 in the expression for the sine regression and help them to realize that this just represents the co-function identity: $\sin(x + \pi/2) = \cos x$.

In this experiment we combine fun and engaging activity for students with rigorous mathematics. We help them to make connection between "making sense" real-life situation, how does airflow affect the motion of a fan cart, and properties of an abstract mathematical object, cosine graph. I learned that after my students did this experiment, they never had problem with recalling that cosine is a decreasing function in the 1^{st} quarter period, that it has maximum at zero degrees and zero value at 90^0. All they needed was to think of a motion of a fan cart and position of the fan. Can we explore properties of the sine graph using fan cart – absolutely yes! The fan cart also comes with the sail, an attachment that you place on top of the cart. Students can measure the angle of the sail instead of the angle of the thrust force, and they will get sine graph instead of cosine graph. And the best part is this comment from one of my student: "Can we play with FUN cart again?"

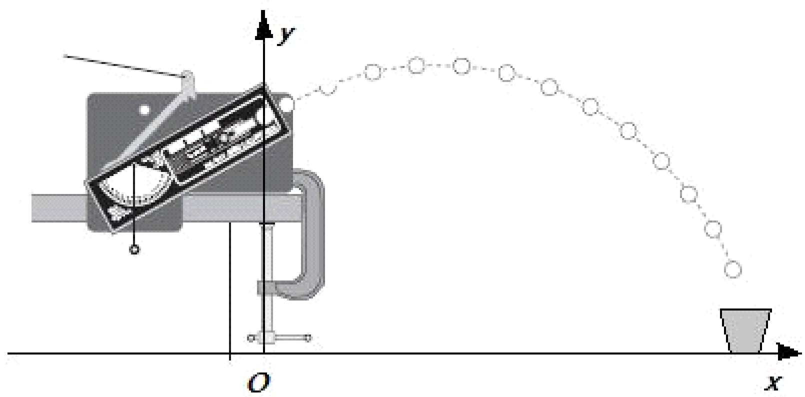
Equation of Parabola. Catch the Ball.

"The Russian Space Agency guided Mir back to Earth on March 23rd, 2001. Fragments of the huge spacecraft splashed down in the South Pacific Ocean just as ground controllers had planned - it was a flawless re-entry. No one was hurt. On the contrary, onlookers who saw Mir's blazing fragments described it as the experience of a lifetime!" (The End is Mir 2001). The scientists had to calculate details of the Mir's trajectory before it entered Earth's atmosphere and plan control of the station that would allow the Mir's pieces to fall into the ocean.

In this experiment students will perform a similar task at a much smaller scale. They will need to find equation of the trajectory of a ball launched off the table under the angle in order to predict the ball's height at any position and catch it in a cup. This is a classic physics experiment, but when used in an algebra class along with right goals and questions it provides an excellent opportunity for students to explore properties of parabolas.

In order to complete this experiment you will need a projectile launcher (PASCO) or any type of toy that would shoot a ball at a constant initial speed, three ring stands, meter stick and a plastic cup. The setup of the experiment is shown on Fig. 4. The first task that I ask of students is to determine the least number of different points on the trajectory (path) of the ball they need to know in order to predict location of the ball at any point of the path. Mathematically we are asking students to determine experimentally how many points is sufficient and necessary in order to define a parabola uniquely. Students start with measuring coordinates of the launching point. The question they have to answer first " Can you predict where will the ball land on the floor if you know coordinates of the launching point?" I usually ask students to come up with the equation of parabola through the launching point and using that equation to predict the position of the ball on the floor. At this stage of the activity some of my students used $y = a - x^2$ to start with and found a by plugging in launching point. They check if their equation works by trying to place a cup at the predicted position, and find out that this is insufficient information. After they find the landing point by trials and errors, they record coordinates of the second point. The question is still open: "Now that you have coordinates of two points on the part of the ball, do you have enough information to predict at what height above the floor will the ball go through a ring mounted on a stand located at a specific position?" Students repeat prediction process, trying to model equation of parabola with 2 points and use it for prediction. Students may create an equation by trials and errors or start with familiar form of quadratic, like $y = ax^2 + b$, or by using quadratic fit option on the calculator. They are again learning that having coordinates of 2 points is insufficient for determining unique equation of parabola and are forced to use experimental trial and error approach until they determine coordinates of the 3rd point.

Figure 4



At the next step of the investigation, they determine equation of parabola based on coordinates of three points they found from an experiment. They realized at this time that they can only come up with one equation of parabola, but not all of them are sure why this is the case. So, experimental check is necessary. We keep the cup on the floor and 1st ring stand in positions they found in previous trials. The 2nd ring stand is placed in a new position and students calculate the height of the ring in order for the ball to go through the ring. With the small ball, PASCO launcher, and careful calculations, the ball goes through both rings and is caught in the cup. Loud cheering and clapping usually express the students' joy. So, what have we accomplished so far? Students determined that you must have 3 points in order to determine parabola uniquely. Now we can have several mathematics tasks for them: find equation of parabola based on 3 points by different methods:

* Substitution of x and y values into a general form of quadratic function, $y = ax^2 + bx + c$ and solving for a, b, and c. By the way, it is also a great place to make a connection to this form of quadratic polynomial, 2nd degree polynomial has 3 constants that need to be determined; linear polynomial requires 2 constants, cubic polynomial requires 4 constants, etc. Students can determine this pattern on their own.

* Using matrices to solve system of equations for a, b, and c.

* Using quadratic fit to find equation of parabola passing through three given points. In this case students will need to enter three pairs of points into Lists and use quadratic regression option on the calculator.

Here are other tasks and questions that I ask students in this experiment:

1. It is known that motion of any objects is directed along the tangent line to the path of the motion. Confirm that for your equation at the initial point:

   a. Measure the launching angle and determine its tangent

   b. Use calculator and graph the equation of trajectory that you found

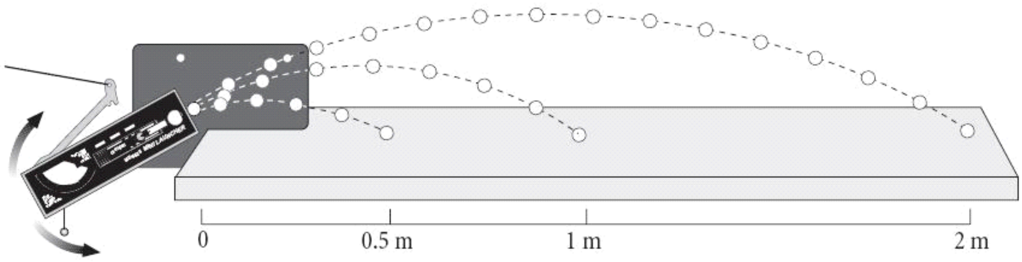
   c. Zoom in and calculate slope of the tangent line at the launching point

   d. Compare calculated and measured values of tangent

2. Use parametric equations for the projectile motion, measure initial speed of the ball with Vernier Photo Gate, and confirm that two parametric equations for the motion of the ball produce the same parabolic trajectory as the equation you found earlier.

This experiment can also be used to study symmetry of parabola, but adjusting launcher to shoot at the level (Fig. 5) and asking students to explore the distances from the vertex position to the launching and landing points.

Figure 5



ASSESSMENT

One of the most important goals of assessment is to make it a learning tool for the students. If students know how to prepare for the laboratory experiment, what they need to know before they come to class on the day of the experiment, and how their lab reports will be assessed, they will do much better job in class and on the written report. Whenever these activities are used as laboratory experiments, it is recommended that students will write laboratory reports to present their data, calculations, and analysis.

I have developed assessment tools to reduce amount of time that teachers will have to spend for grading of lab reports and at the same time to help students to learn how to write laboratory reports. The assessment of the experiment includes two parts. The first part is pre-lab performance based assessment (*see Performance Based Assessment form*). It includes set of questions that students should be able to answer **before** they start an experiment and scoring rubrics. In many cases, that also means that students are expected to complete necessary calculations prior to the data collection. The performance based assessment form is provided to students at the time when laboratory experiment is assigned. Teacher has an option of using this form for students' self-evaluation, peer evaluation, or for interviewing students before or during the experiment, and assessing students' preparation with or without the grade. In my classes each group of students go through the questions offered in the *Performance Based Assessment* form together before I assess their knowledge of the experiment they are about to do. When I work with the group of students, I ask each student in the group randomly 3-4 questions, so that all students in the group cover all questions on the form. Each student in the group is assessed individually. These interviews could occur a day before the experiment, at the beginning of the experiment, or during the experiment.

The second part of the assessment is written laboratory report (*see Assessment of Laboratory Report form*). All students should know requirements for the laboratory reports before they turn them in. The Assessment of Laboratory Report form is designed to provide students with the checklist/criteria that they can use when preparing written reports after completion of the lab. Students use this form for self-evaluation and peer evaluation, and it becomes a learning tool for them. I expect that each student check his/her laboratory report against this checklist. Then, I require students to have their lab report evaluated by their peers. Usually, students have their lab partners to evaluate the lab reports. This evaluation does not include grading by the peers or evaluation of the contribution made by each member of the team. The purpose of the peer evaluation is to allow someone else to go through the lab report and check it against the criteria, make comments and suggestions for the author of the lab report to revise and perfect their work before it is turned in to the teacher. Each student (or group) is asked to turn in an original draft of the lab report with comments and markings made by the peers, checklist from the peers and final revised copy. I assess the final copy of the lab report using the same form. This three-step evaluation allows me to teach student to check their work before turning it in, to learn from each other and to succeed in lab report writing. At the same time, standardized expectations force students to develop a uniform structure of the lab reports; self and peer evaluation reduces amount of careless mistakes and omissions in the lab report, and all that facilitates teacher's grading and reduces time necessary for grading.

One more concern of assessment of laboratory experiments (or any group projects) is how to assess individuals within a group. There are different approaches to the group assessment. Due to the need to ensure that all students have a clear understanding of the material covered within each laboratory/project and to ensure a level of equity in the distribution of work, the laboratory assessment options are offered to students. My approach is to allow students to take responsibility on themselves and choose laboratory assessment option (*see Laboratory/Project Assessment Options form*) that better fits their needs and ability to work within a group. Students are expected to make the choice of an option before they turn in lab reports. My experience shows that about 70% of students usually choose 1st option, working together and submitting one lab report per group, while 30% of students choose 2nd option, working individually on the lab report and limit group work to experimentation only. There are a lot of factors that could affect students' choice of 1st or 2nd option. These factors could include day schedule that may or may not allow students to work together out of class, established personal relations between the students, small or large range of students' abilities and skills within the group, reputation of being responsible or irresponsible person, etc. The main advantage of allowing students to choose an assessment option by themselves is to shift the decision making process from the teacher to the students in forming groups and sharing the group work, and to provide students with the opportunity to develop responsibility for the shared work.

All assessment forms are provided here as an aid to the teacher when assessing students' work. Teachers may use these forms as it is or modify them to better fit the needs of their students.

CONCLUSION

These experiments are intended as supplementary activities. Any activity can be used as a teacher's demonstration, class exercise, or a laboratory assignment. Using an experiment as a demonstration allows a teacher to talk about real-life applications of mathematics without necessity to have multiple sets of equipment for the students groups. When activities are used as class exercise or laboratory assignment, students have an opportunity for teamwork and interaction with each other as well as learning skills of using measuring devices; however, any group work is more time consuming and usually requires at least one class period for completion of the experiment and additional time for pre-lab calculations and/or post-lab analysis. Some experiments may be divided up in parts and completed within two or three lessons. Teacher may use one part of the experiment as a class demonstration and another part as a lab exercise.

In teaching a particular topic, teacher has an opportunity to introduce the experimental activities in different place within the topic. Labs could be great exploration type introduction to a new topic that would be followed by the teacher's instructions and explanations. The experiments could also be used as review exercise. In some cases experiments allow for more engaging way to exercise algebraic skills necessary for successful learning of mathematics. Most commonplace of lab experiments is at the end of studied topic when students are expected to use what they learned for applications and problem solving.

Whatever place the experiments are used within the context, they can enhance students' learning of the mathematics, allow students to see real-life applications and allow the teacher to have performance-based assessment of students' understanding of learned material.

Please contact the author for a copy of the student lab handouts described in this article.

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APPENDIX

Student Name(s): ____________________________

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ASSESSMENT OF STUDENT PERFORMANCE

Laboratory and Technology Use

na = not assessed

nr = no response

4, 3, 2, 1 = see attached scoring rubric

1. Can the student clearly state the problem that is being investigated? nr 1 2 3 4 na

2. Can the student make predictions as to the outcome of the experiment(s) or analysis? nr 1 2 3 4 na

3. Can the student defend his/her predictions based on background information gained through preliminary research? nr 1 2 3 4 na

4. Can the student thoroughly describe the experimental procedure conducted or technology used? nr 1 2 3 4 na

5. Can the student explain the relevance of the experimentation in terms of real-world applications? nr 1 2 3 4 na

6. Can the student describe the quantitative or qualitative aspects to be explored during the laboratory? nr 1 2 3 4 na

7. Can the student describe how the measurements will be taken? nr 1 2 3 4 na

8. Can the student describe the laboratory or technology set up? nr 1 2 3 4 na

9. Can the student demonstrate the ability to use the equipment/technology properly? nr 1 2 3 4 na

10. Can the student identify possible sources of error? nr 1 2 3 4 na

_________/_________ = _________%

Student Total / Total Possible Percentage

Comments:

Scoring Rubric

Level 4

- The student demonstrates a clear understanding of the problem and investigations performed.
- The student's observations are valid and demonstrate attention to detail.
- The quality of the data analysis reflects his/her ability to utilize computer software in the data analysis.
- The design of experiments suggested by the student are well thought-out and scientifically accurate.
- All data are presented in an organized fashion, utilizing appropriately designed tables, charts, and graphs.
- Answers to questions are well thought out and supported by experimental data.
- In general, there are no false assumptions or misleading statements made by the student.
- The student recognizes the need for additional testing and provides appropriate suggestions related to the problem.
- The conclusions reflect the student's ability to effectively analyze experimental data and draw appropriate conclusions.
- The student shows a deep understanding of the technology being used.
- The student successfully proposes an explanation which clearly shows a relationship between his/her data and conclusions.

Level 3

- The student demonstrates an understanding of the problem and investigations performed.
- The student's observations are valid and demonstrate some attention to detail.
- The quality of the data collected generally reflects his/her success at performing each experiment.
- The experiments suggested by the student are well thought-out, but may have flaws in scientific design.
- Most data are presented in an organized fashion, utilizing appropriately designed tables and charts.
- Answers to most questions are well thought-out and supported by experimental data.
- In general there are few false assumptions or misleading statements.
- The student recognizes the need for additional tests, but is unable to provide appropriate suggestions related to the problem.
- The conclusions reflect the student's ability to analyze experimental data and draw conclusions.
- The student shows a moderate understanding of the technology being used.
- The student successfully proposes an explanation which generally shows a relationship between his/her data and conclusions.

Level 2

- The student demonstrates some understanding of the problem and investigations performed.
- The student's observations are vague and lack attention to detail.
- The quality of the data collected reflects limited success at performing the tasks.
- The experiments suggested by the student are unclear or riddled with flaws in scientific design.
- The data are recorded in a disorganized fashion, with tables, charts and graphs poorly designed or missing.
- Answers to questions are not well thought-out or supported by experimental data.
- In general, the student makes both false assumptions and misleading statements.
- The student fails to recognize the need for additional tests.
- The student has difficulty analyzing experimental data and drawing conclusions.
- The student shows little understanding of the technology being used.
- The student fails to propose an explanation which shows a relationship between his/her data and conclusions.

Level 1

- The student demonstrates little or no understanding of the problem or investigations performed.
- The student's observations are poor or missing and show no attention to detail.
- The quality of the data collected reflects little or no success at performing the tasks.
- The experiments suggested by the student are difficult to follow , or missing.
- The data collected is haphazardly recorded, or missing.
- Answers to questions are implausible and not related to the experimental data.
- In general, the student makes many false assumptions and misleading statements.
- The student fails to recognize the need for additional tests.
- The student is unable to analyze experimental data and draw conclusions.
- The student shows lno understanding of the technology being used.
- The conclusions are unrelated to the experiments performed.

NAME OF STUDENT:______________________________

ASSESSMENT OF LABORATORY REPORT

Check each item present and circle the total for each category. na = not assessed, nr = no response

A. FORM OF THE REPORT (5 pts)	nr 1 2 3 4 5 na
_____ Title, objective(s), names of group members are included	
_____ Background information is provided and thorough	
_____ Hypotheses/predictions are stated	
_____ Diagram of set up with necessary labels is shown	
_____ Procedure is thorough and sequential, materials are listed	
B. QUALITY OF THE OBSERVATIONS/DATA (4 pts)	nr 1 2 3 4 na
_____ Accurate measurements/observations	
_____ Complete data table/list and qualitative observation	
_____ Correct units	
_____ Data consistent with the event	
C. GRAPHS (6 pts)	nr 1 2 3 4 5 6 na
_____ Appropriate title	
_____ Curve appropriate to data trend	
_____ Data points plotted accurately/shown	
_____ Appropriate scale with units is shown	
_____ Axes labeled with correct variables and units	
_____ Legend if more than one set of data included	
D. QUALITY OF CALCULATIONS (8 pts)	nr 1 2 3 4 5 6 na
_____ Mathematical relationship/formula stated	
_____ Necessary formula(e) derived	
_____ All steps are mathematically correct	
_____ Selected and substituted proper data into relationship	
_____ Calculated correctly	
_____ Units stated and used correctly in the relationship	
_____ Error calculation(s)	
_____ Results	
E. CONCLUSION (7 pts)	nr 1 2 3 4 5 6 7 na
_____ Consistent with scientific and mathematics principles	
_____ Consistent with objectives and hypotheses	
_____ Consistent with data	
_____ Relationship among variables stated	
_____ Sources of possible error identified	
_____ Specific questions are answered	
_____ References/Citations are provided	
	_______ / 30 = ______%
	Total Pts.

Comments:

LABORATORY ASSESSMENT OPTIONS

Due to the need to ensure that all students have a clear understanding of the material covered within each laboratory and have an adequate understanding of how all of the laboratories and projects relate to each other; and to ensure a level of equity in the distribution of work, the following options have been developed:

Option 1. Three Heads Are Better Than One

1. Each lab/project group will consist of no more than three students.
2. All students are required to participate equally in the performance of each lab/project.
3. Group members will share the research, development, analysis, and writing of the report equally.
4. The group will submit one laboratory/project report.
5. All group members should use the laboratory report/project checklist to ensure that they have included all the necessary components into their report.
6. A peer critique along with the first draft should be attached to the final corrected report. A peer critique must be performed using lab report/writing project assessment.
7. If the group chooses this option, the group members should be aware that every member of the group would receive the same grade for their efforts.

Option 2. Then I'll Do It Myself!

1. Each lab/project group will consist of n more than three students.
2. All students are required to participate equally in the performance of each lab/project.
3. Group members will share data acquired during lab experiment. No sharing is allowed for the writing projects. Each individual student will research, develop, and analyze **all** portions of the lab/project.
4. Each group member must submit individual lab/project report.
5. All group members should use the laboratory report/project checklist to ensure that they have included all the necessary components into their report.
6. A peer critique along with the first draft should be attached to the final corrected report. A peer critique must be performed using lab report/writing project assessment.
7. Each member of the group will be graded individually.

Lab/project groups cannot change the assessment option after laboratory report/writing project has been turned in for a grade. All group members should know what assessment is chosen before starting the lab/project. In case of conflicts/problems within the group, group members should seek an advise from the teacher as early in the work as possible.

Eurasia Journal of Mathematics, Science and Technology Education
Volume 2, Number 3, December 2006
www.ejmste.com

ASSESSMENT REFORM IN SCIENCE: FAIRNESS AND FEAR; Benny H. W. Yung

Phillip A. Towndrow
Aik Ling Tan

BOOK REVIEW

Printed in the Netherlands by Springer
Date of publication 2006
ISBN 1-4020-3374-5 (HB)
ISBN 978-1-4020-3374-2 (HB)
ISBN 1-4020-3408-3 (e-book)
ISBN 978-1-4020-3408-4 (e-book)

Set against the background of changes in work organization and technology, a recurrent concern for social and cultural planners is how to identify and address objectives in an unstable and unpredictable world. For many, education is a key lever for social, cultural and political change and the periodic (often frequent) restructuring of an educational system is justified as a way of dealing with present and future economic and social demands (cf. Lauder, 1997).

One area of increasing interest and concern for those who are both involved in and subject to educational reform is the shift towards using assessment as a tool for improving teaching and learning. This movement, as noted by Black and Wiliam (1998), turns attention away from restricted forms of testing where there are imperceptible links to learning experiences towards more rounded and learning-based procedures. This phenomenon is exemplified most aptly by changes in the assessment of practical work in science where there is growing appreciation of the limits of one-time, high-stakes, practical examinations. In an effort to grow and improve practices, school-based marks and assessment systems relating to laboratory work are in the ascendancy. But while these efforts resonate with international initiatives that foresee science classrooms as sites of student-centred inquiry, more needs to be known about whether teachers have the capacity to understand and enact the reforms that are passed down from on high as designed and expected.

Benny Yung's book titled, Assessment Reform in Science: Fairness and Fear, is a report of research findings relating to teacher professional development and the concordance of teachers' knowledge and beliefs about science (specifically the nature of science), the purpose of

ISSN: 1305-8223

practical work and science pedagogy in the enactment of mandated assessment reform. Situated within the Hong Kong education system—a context which is described as 'examination-led'—Yung offers a case-driven account of how ten teachers taught and assessed advanced-level biology at high-school level through a continuous marks-based scheme called the Teacher Assessment Scheme or TAS for short.

Yung's study was guided at the outset by one broad and four ancillary questions which need to be borne in mind continually if one is to make full sense of the researcher's rich descriptions and detailed analyses. The main question was (page 4): What relationship existed among (i) secondary science teachers' classroom practice, (ii) secondary science teachers' beliefs about science, teaching and learning, and (iii) their understanding of the school-based assessment reform in practical science? The sub-level inquires were (page 5):

1. What were the characteristic features of secondary science teachers' classroom actions in TAS?
2. What personal understanding/perceptions did secondary science teachers have of TAS (in the context of classroom teaching)?
3. What were the secondary science teachers' beliefs about science, teaching and learning?
4. What were the relationships among teachers' beliefs about science, teaching and learning, their understanding of the TAS reform, and the ways they implemented the reform inside their classrooms?

It is the researcher's hope that his responses to these questions will convey to readers the context of his study and assist in the identification and subsequent understanding of variables that impact on teachers' attempts to adapt in the face of a changing assessment landscape.

In total, the book is made up of fifteen chapters and includes two appendices which explain the theory underlying and methodology of the study in detail. There is a complete list of references, an index and a highly complementary foreword contributed by Professor Derek Hodson of the Ontario Institute of Studies in Education at the University of Toronto, Canada.

The first three chapters provide an introduction to the topic of research and its treatment. In Chapter One, Yung explains the background to the study and its rationale. Data sources are identified and methods of analysis are overviewed in a non-technical, approachable manner. A number of suggestions are made concerning the use of the book and the order in which the chapters could be read depending on the reader's purposes(s). Following Chapter Two, which provides information about the Hong Kong educational system and TAS, Chapter Three presents a largely quantitative portrait of how the researcher's informants enacted TAS. The principal unit of analysis proposed is the frequency of dialogic interactions between teachers and students during the conduct of practical work. The major finding reported is that teachers who were more concerned with assessment related issues in their laboratories tended to interact less often with their students than those teachers who were not. The pedagogic and conceptual implications ensuing from this discovery are developed and exploited in the rest of the book.

In Chapters Four to Eleven, eight narrative-based case studies are presented that describe teachers' personal, educational and professional backgrounds, their espoused beliefs about science, practical work and pedagogy and characteristic features of their classroom practices. Each case is supported with interview and lesson transcripts and includes a useful summary at the end.

It is immediately noticeable that the teachers' practices in the case studies are markedly different but this effect is deliberate and managed. Each case can be seen to move along a continuum of practice that might be best described as learning or pedagogically focused at one end towards instruction and assessment focused at the other. Later, Yung attempts to transcend this dichotomy by offering a more nuanced and subtle view of his data but elements of divergent practice persist.

As far as the cases are concerned, Allan (Chapter Four) is portrayed as idealistic and enthusiastic. His focus was to cultivate a pragmatic attitude in his students by prompting them to think, cooperate and solve problems. Allan's enacted practice is said to match his espoused beliefs particularly well. He interacted the most with his students and allowed them to discuss among themselves. He offered assistance on an individual basis believing that the TAS regulations gave him the warrant to do so in the name of promoting investigative work.

John (Chapter Eleven) on the other hand placed a lot of emphasis on preparing students for public exams. Through his transmission approach he used TAS to convey information and rank students according to their ability to conduct practical work under the strictest of conditions.

And then, somewhere in between Allan and John lies Dawn. She is depicted in Chapter Seven as a friendly visionary who wanted to get her students through their exams but at the same time valuing the learning of science for its own sake. Interestingly, the narrative about Dawn (not Dawn's narrative, it is important to note) is perhaps the most appealing. We are told that she was skeptical of TAS at the beginning, but modified her view once she began to reconstruct her teaching practices based on her students' feedback. There is hope here and a signaled way forward about enacting TAS productively.

In Chapter Twelve, Yung offers a preliminary analysis of his cases but this is more than a first cut; it is a carefully constructed link from the previously-presented data to the rest of the book. The pivot is provided when the teachers' combined beliefs and aspirations are reduced and tabulated (see Table12-1, pages 152-155) to further reinforce the tensions that arose when teachers were caught between the dual roles of teaching and assessing in school-based assessment schemes. A key question for subsequent investigation is also drawn out at this point: why were the teachers' interpretations of TAS so different?

Chapter Thirteen presents three differing views of fairness relating to TAS implementation mined from the data. It was found that the teachers' discourses were dominated by, and their classroom actions were pre-eminently influenced by, the notion of fairness. However, they did so in three qualitatively different ways: (i) fair in the sense of assessing students on a fair basis; (ii) fair in the sense of not jeopardizing students' chances to learn the subject matter while they are being assessed; and (iii) fair in the sense of not depriving students' of opportunities of receiving all-round education. It was concluded that for teachers to implement the new assessment scheme successfully their existing understanding and beliefs concerning assessment had to be challenged and opportunities provided for them to come to terms with the philosophy of the new assessment scheme. Most importantly, the teachers themselves had to undertake such a learning process.

In our opinion, Chapter Fourteen, 'Teacher Professionalism and Policy Interpretation' is perhaps the most insightful of Yung's analyses. He revisits five of his cases to show the bases upon which his informants derived their interpretations of TAS. What emerge are threshold points in the teachers' capacity to make discretionary judgements in their classrooms relating to assessment. To substantiate this point, a binary division is presented this time between teachers who were either low in confidence and self-worth motivated to those who used the assessment reforms to generate learner and learning-based solutions to classroom challenges.

Chapter Fifteen recaps the research questions and presents an overview of findings in the study. Of particular interest are Yung's views on what could be done to assist teachers in raising teachers' professional consciousness and confidence in dealing with assessment reforms. A role is identified for continuing professional development that engenders collaboration and sustained effort and there is certainly scope for considerable expansion of these notions for both experienced and novice practitioners alike. There is also an identified need for changes in curriculum, pedagogy and assessment to go hand-in-hand; this point has a distinctive ring for readers who know Bernstein (1975).

IIn our opinion, Yung highlights successfully the complex nature of school-based assessments in science practical work. In particular, the excerpts and vignettes presented in each of the chapters are excellent in helping the reader to appreciate and understand the dilemmas and conflicts science teachers can face in the decisions they make in teaching, learning and assessment. Furthermore, the author is commended for the systematic way in which his data were presented and analysed making it easy to compare his informants' beliefs, espoused theories and enacted practices.

Most important and powerful is that this book brings across the many interpretations and realisations of the same policy change that are possible by different teachers. This phenomenon should signal to policy-makers some of the factors that need to be taken into account to ensure the success of school based assessment in science laboratories. Meaningful learning experiences can only be formed if teachers are aware of their own beliefs and also those of others in the same profession. Awareness and comparison can lead to constructive dialogue between teachers which will lead, hopefully, to more thoughtful implementation of change. In short, the detailed description provided in this book helps to fill the pedagogic gap between the rhetoric of policy and actual classroom practice. This gap appears to be present in many areas of science education and its reforms these days.

On the downside, the book is somewhat repetitive in places. This is due, in part, to the recursive nature of the researcher's data analysis procedures but it seems to us that each successive sweep through the material depletes its richness and raw vibrancy. That said there is on more than one occasion an invitation from Yung to his audience to take on the role of co-analyst in the interpretation of his data (see page 273). This is an attractive call to participate but one would have to bear in mind that even with the author's care in presenting defensible arguments for his interpretative work, what we, as readers, see of the data is pre-selected and processed. Yung's analytic tools have left permanent marks and subtleties in the cases. Nevertheless, the researcher describes his theoretical framework and data collection methods thoroughly in the appendices. Interested readers, therefore, have sufficient information to consider replicating the work done in their own contexts.

In conclusion, we believe that Yung's book is worth reading. But in light of the author's commitment to contributing to the teacher professional development literature, we contend that the measure of this book will be determined largely by its catalytic impact beyond the context of the reported research findings. Yung's deliberate presentation and sequencing of material is meant, in our opinion, to provoke the reader to not only reflect and evaluate but to act on his or her practices in a transformative manner. In short, this book demands the reader's personal engagement, and we hope for the sake of all learners of science in high schools that this happens.

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Phillip A. Towndrow and Tan Aik Ling

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ISSN: 1305-8223