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ABSTRACT

Understanding students' challenges about using microcomputer based laboratories (MBLs) would provide important data in understanding the appropriateness of using MBLs in high school chemistry laboratories. Identifying students' concerns about this technology will in part help educators identify the obstacles to science learning when using this technology. This study seeks to answer these two questions: (1) What advantages and challenges do students encounter during MBL activities? and (2) What are the views of high school chemistry students regarding the use of MBLs as a learning tool? The findings of the study included: (1) MBLs do not necessarily promote learning for all students; (2) special attention should be given to slow paced learners; (3) students feel challenged by MBL generated graphs; and (4) teachers should constantly be on the look out for graph anomalies that may simply be the result of misplugging of probes in the interface which may cause further graph interpretation confusion. (Contains 24 references.) (MVL)

Chemistry Students' Challenges in Using MBL's in Science Laboratories

by

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CHEMISTRY STUDENTS' CHALLENGES IN USING MBL'S IN SCIENCE LABORATORIES

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Introduction and Literature Review

Increasingly, many educators have reported that new technologies can enhance students' performance and motivation. As one example, Hodson (1996) suggests several reasons for using technology in laboratory settings:

> Motivating students by stimulating interest and enjoyment; teaching laboratory skills; assisting concept acquisition and development; developing an understanding of scientific inquiry and developing expertise in conducting inquiries; inculcating the so-called scientific attitudes; encouraging social skill development. (p. 756)

Above statement by Hodson above indicates the importance of technology in preparing students for lifelong learning. In this sense, incorporating Microcomputer Based Laboratories (MBLs) into instruction have potential to foster students' learning of the scientific content and help them be better prepared for the workplace where technical and social skills are very important.

As new technologies such as MBLs become available to education, researchers, educators and experts in science teaching seek ways to effectively incorporate the new technology into curriculum. In this regard, many researchers have conducted studies to determine the impact of real-time data collection on understanding the scientific content. As an example, Nakhleh &Krajick (1994) focused on the influence of MBLs on students' content knowledge. They concluded that students using MBLs had increased their levels of understanding about acids, bases and pH above students using the more traditional laboratory approaches (using pH meters or indicators). In a separate study, students using MBLs required less time to understand the relationships between the content, the theory and the actual data collected, when compared to students using traditional laboratory techniques (Friedler, Nachmias & Linn, 1990; Settlage, 1995). In a study with third grade students, Settlage and his colleagues found that MBLs enhanced the children's science learning specifically by increasing the ways and forms of doing scientific inquiry. . In another study, Mokros & Tinker (1987) indicated that MBLs could help students in gathering and analyzing data, generating questions and sharing their opinions and results. In the same study, they found that students are better at interpreting the findings of their experiments when they use real –time data collection than when they construct their own graphs.

Also, many science educators(e.g., Linn & Hsi, 2000) support the idea that MBLs provide with a strong medium for the discovery and exploration of scientific knowledge. Because with MBLs, data collection and the graphic representation of data can be handled in almost no time, thus allowing students more time to focus more on the interpretation of data (Rogers, 1995).

Furthermore, Nakhleh & Krajick (1994) reported that some MBL-related activities can have positive impacts on students' concept mapping skills. In the same study, students using MBLs had more unrelated items in their concept maps. Glasersfeld (1993) suggests that these unrelated items or links should be considered the products of successful thinking which, in most cases, is more important than "correct answers". This so-called "sophisticated level" of involvement with technology leads to "sophisticated levels" of information processing that involves reconstructions and constructions of meaning.

Reviewing the literature, McRobbie & Thomas (2000) summarized the ways that science students use of MBLs as to:

(a) explore and understand workplace applications of science (b) develop skills of investigation, reflection, and analysis (c) generate and refine conceptual change (d)find solutions to problems, and (e) to pose questions for further. (p. 1)They further reported that by using MBLs in their laboratory activities science teachers could provide collaborative and authentic learning opportunities for their students. In another study with third grade students, Settlage (1995) found that MBLs enhanced the children's science learning specifically by increasing the ways and forms of doing scientific inquiry.

More schools incorporate MBLs into their science laboratories in each year (MacKenzie, 1988; McRobbie & Thomas, 1998) as MBLs have the potential for positively affecting students' laboratory experiences in science classes by providing them with an opportunity of gathering accurate data that can be displayed and analyzed in real-time (Lapp & Cyrus, 2000; Linn, 1998; Nakhleh & Krajcik, 1993; Pena & Alessi, 1999;). Also, it is believed among educational stakeholders that adopting MBLs for use in school science curricular activities may alter the traditional ways of doing experiments by students and teachers (McRobbie & Thomas, 1998; Pena & Alessi, 1999; Thornton & Sokoloff, 1990).

As seen above many studies report the gains as a result of MBL usage in science laboratories however research so far does not provide compelling evidence that usage of MBL technology necessarily increases the learning outcomes (Lazarowitz & Tamir, 1994; Mcrobbie & Thomas, 1998). Although there are many studies conducted on MBL usage in educational settings, very few have directly investigated MBL usage in science laboratories from the students' perspectives. For successful implementation of MBLs into schools, McRobbie & Thomas (1998) strongly suggest that educators should take into account the teachers' and students' beliefs, concerns and views as these beliefs and concerns greatly influence teaching and learning. In this regard it is my hope that understanding students' concerns about this technology will in part help us identify the obstacles to science learning by using such technologies.

Thus, reviewing the early and recent literature compelled me to think about the appropriateness of using MBLs in the laboratories. I believe understanding students challenges from their perspective would provide important data as to understand their appropriateness in high school chemistry laboratories. Identifying students' concerns about this technology will in part help educators identify the obstacles to science learning by using such technologies. Also, understanding what MBLs are good for from student perspective would enhance a science teacher's ability to better incorporate MBLs into a science laboratory. Students' concerns and views about MBLs would provide valuable feedback for teachers as to finding effective ways of using this type of technologies.

Research Questions

In this study I sought answers to the following research questions:

1. What advantages and challenges do students encounter during MBL activities?
2. What are the views of high school chemistry students regarding the use of MBLs as a learning tool?

Methodology

The nature of this study made qualitative techniques that focused on interpretative inquiry appropriate. In this paper, I used the term interpretive inquiry interchangeably with the term constructivist or naturalistic inquiry (Guba & Lincoln, 1989). Interpretive research methods can be useful for examination of "what is happening" in a particular social setting, such as a classroom. Interpretivism tries to describe meaning attached to the situation and look for the patterns of meaning by guidance of a relativist philosophy (Guba & Lincoln, 1989; Creswell, 1994; Stake, 1995).

Guba & Lincoln describes an interpretive research as being a hermeneutic process. The purpose of hermeneutic process is to expose the constructions of the variety of concerned parties, open each to critique in the terms of other constructions, and provide the opportunity for revised or entirely new constructions to emerge. In this study, I completed hermeneutic circle (Guba & Lincoln, 1989) process by re-structuring the interviews and developing a more sophisticated meaning through my research.

The study reported here is a interpretive case study which relies on interviewing and observing . The nature of the questions asked in this study made qualitative techniques that focused on interpretative inquiry appropriate. In this paper I tried to describe meaning attached to the situation and looked for the patterns of meaning by guidance of a relativist philosophy (Creswell, 1994; Guba & Lincoln, 1989; Stake, 1995). In this study the researcher sought to generate an understanding of the multiple perspectives coexisted amongst the students (Creswell, 1994).

<u>Participants</u>

Thirty-three students from two high school level AP Chemistry II classes and their teacher participated in this study. There were 15 students in the first section (Fourth period) and 18 in the second (Fifth period). Eight groups of students (seven pairs and one alone in the fourth period and six pairs and two groups of three in the fifth period) were engaged in the MBL activity. The students involved in this study were 11^{th} and 12^{th} grade students.

Most of the students involved in this study were already familiar with MBLs. They had used MBLs for collecting and analyzing data in their earlier science laboratories. However, only nine students did not have previous experience with MBLs. Ali, Durmus (pseudonyms) from the fourth period, and Emin and Yasemin (pseudonyms) from the fifth period were selected as the focus group students for more intense study than others. These focus groups were selected to be typical of others in the class and to comprise students who were cooperative. Students were provided with enough MBL stations to work in groups of two. It was assumed that students would work cooperatively in their investigation.

MBL Activity

Students performed an experiment about solubility of Vitamin C in orange juice using both pH and temperature sensors. For this activity, I prepared the experiment worksheet and named the document "MBL Activity" (Appendix B). Worksheets were reviewed by the teacher before the students performed the activity in the lab.

In the MBL Activity, students were asked to find the relationship between the temperature changes and the solubility of acids. Students used orange juice as the main material of the activity rather than using other acids or acidic solutions. The MBL system used in this study was composed of a Texas Instruments (TI) 83 plus calculator, a Vernier interface and probes. For the purpose of the MBL activity, students used the pH and the temperature probes.

Data Sources

In order to elicit the students' views and perceptions I designed a questionnaire and a semi-structured interview protocol with a number of open-ended and some close-ended questions.

Questionnaire

In the "MBL Activity Questionnaire" (MBLAQ), students were asked about their experiences of using the MBLs. Most of the questions were of an open-ended nature, in which I asked the students' perceptions of MBLs. Questions in the MBL Activity Questionnaires included:

(1) What impact, if any, did this MBL experience have on your engagement into the activity?

(2) In your experience, what are the advantages and the disadvantages of using the MBL?

The purpose of using MBLAQ was to generate one source of empirical evidence regarding the general views and perceptions of each student who performed the MBL Activity. Thus, I used MBLAQs as a central source of data in this investigation to better understand the overall perceptions of the students. Thirty-three questionnaires, fifteen in the forth period and eighteen in the fifth period, given to the students a few minutes before the class ended. Twenty-three of the questionnaires (ten in the fourth period, thirteen in the fourth period classes) were returned

In the MBL Activity Questionnaire, I asked the students to compare strengths and weaknesses of using traditional lab equipments and MBLs. They were asked about their opinions on the impact of using MBLs regarding their engagement into the activity. Students were also asked to elaborate on the successes and challenges they encountered with the use of MBLs during the experimentation. The questionnaire contained eight open-ended questions about students' perceptions of using MBLs. The patterns and themes that emerged from students' responses to those questions were used to guide the development of my interview questions.

Interviews

Interview protocols were designed to encourage the participants to speak freely about their perceptions of using MBLs. The interview questions focused on the following themes:

1) Participants' past experiences using MBLs;
2) Participants' successes and challenges using MBLs;
3) Participants' perceptions of advantages and disadvantages of using MBLs; and,
4) Participants' future plans on using MBLs.

Interviews are principally used in case studies to elicit rich descriptions and interpretations in the participants own words (Bogdan & Biklen, 1992; Yin, 1994). Semi-structured, in-depth interviews were used to explore the perceptions of the stakeholders so that they could describe their perceptions of the process they were experiencing.

I selected participants on the basis of those who volunteered. Interviews with the participant students occurred in the teacher's office adjacent to the classroom. Before interviewing the students, I asked the teacher's permission to release those students from the class for a minimum of thirty minutes.

The interviews were conducted in a semi-structured format allowing the researcher to be flexible in following up the given responses. The focus of the interviews was to learn the students and the teacher's views about using MBLs in the lab and how they affected their lab experiences. I used quotes from students' responses on the MBLAQ as prompt to:

1) Represent their views;
2) Provide evidence to support my interpretation of their ideas; and,
3) Provide context for readers to judge the quality of the interpretation made by the researcher.

Since the students worked in the laboratory in groups of two, I interviewed them as a group. Groups were also selected on the basis of degree of interest in the activity. Paying attention to dynamics the *hermeneutic circle* in this research, I asked the first focus group students to nominate (Guba & Lincoln, 1989) another group who might have a different perception than they had held.

Student Interviews

I conducted two types of interviews with the students. "Room Interviews" were conducted at the office of the teacher adjacent to the classroom. During the "Room Interviews" the office door was closed. In doing so, the students and I had the necessary silence and privacy for the interview process.

I called the second type of interview "On-task Interviews". These interviews were mainly comprised of conversations that the students and I had while they were performing the MBL activity. On task interviews were relatively short. The purpose of these interviews was to better make sense of the challenges students had while they were on task. Following questions were usually used to initiate these conversations:

1) How did you like the MBL collecting data ?
2) Are you having any problems?
3) Do you have previous experience using MBLs?

In order to conduct student "Room" interviews I asked the teacher to release the students from the class for a minimum of 30 minutes. The purpose of the "Room interviews" was to have an in depth understanding of students' perceptions of MBL. In these interviews I wanted students to elaborate on some of the issues that they had indicated during "on task interviews". The questions in "Room interviews" consisted of semi-structured questions some of which included in the "MBL Activity Questionnaire".

In addition to audio-taping the interviews with the focus group students, I also audio taped the conversations that I had with other students while they were on task. These relatively short conversations initiated by either the investigator or the students. The content of these small conversations varied from the subject matter of the experiment to manipulating the MBLs. These conversations provided me with the opportunity to have a better understanding of the common challenges that most of the students' had in using the MBLs.

Observation

I observed the students while they were performing the MBL Activity. The main purpose of this observation was to gain more insight into the difficulties that the students had during the activity. The observations recorded during the laboratory activity and analyzed at a later time. These observations were used to focus on the following points:

1. Students' participations to the activity.
2. Students' interactions during the activity.

I reviewed the observation field notes to develop a series of questions for use during the informal interviews. These questions were used to elicit information regarding the "how" of students' interactions with the MBLs observed in the classroom. Observations also provided evidence to support the assertions made in this investigation

Data Analysis

As suggested by some of the interpretive researchers (Guba & Lincoln, 1989; Yin, 1989; Creswell, 1994) I used coding procedure in order to analyze the data. After I read each transcript and questionnaire responses, I coded each perception or part of perception as to the category it best fit. The coding type for the proposed study was based on the perspectives held by participants and participants' ways of thinking about using MBLs (Bogdan &Biklen, 1992). Coding procedure was used to reduce the information into categories

The interview transcripts and the responses to the MBLAQs were analyzed to reveal the patterns of perceptions. Transcripts and responses to the questionnaire items were read, and any sentence or phrase that related to the students' and the teacher's perception of using MBL was highlighted. Each highlighted sentence or phrase was summarized in one or two words. Based on these summaries perceptions were assigned into five categories. Similarities and differences among the perceptions of the stakeholders were categorized.

Verification

Member checks were conducted to receive feedback and verification from the stakeholders. In the verification process I took the transcripts, organized them and asked subjects whether they agreed with them. After transcribing the interviews and adding my interpretations to each transcript I presented them to them to the participants for their inspection. I wrote a letter as the cover page of the transcriptions. In those letters I encouraged the participants to retract/augment/add to their commentary. I continued doing this process until they are satisfied that their reflections are adequately represented(Guba & Lincoln, 1989).

Ethics of the Research

All of the interviews were guaranteed anonymity. Pseudonyms were used for the students and the teacher. I recorded the stakeholders' responses and returned to each stakeholder with written-up reports of the interviews for verification. Each stakeholder then had the opportunity to change any statement attributed to him/her. Stakeholders were further given the copies of other stakeholders' constructions. The purpose of doing this was to give them the opportunity to modify their comments based on other constructions made by the members of the same community.

Participants volunteered to participate and had the right to withdraw from the study at any time. The identity of all participants is protected and pseudonyms are used in this report to protect confidentiality.

Results

Data from this study suggested that the teacher and most of the students alike valued the MBL activity, enjoyed participating in it and wanted to use MBLs in their future labs. In line with literature findings, almost all of the students in this study believed that MBL lessened the time and labor required for collecting, analyzing and displaying the data. The teacher and 24% of the students who wanted to use MBL also stated that they did not want to use MBL for all labs.

My data suggested that most of the students (91%) wanted to use MBL in their future labs because they thought it is an effective way of collecting, analyzing and displaying the data. The teacher and 24% of the students who wanted to use MBL also stated that they did not want to use MBL for all labs. Almost all of the students in this study believed that MBL lessened the time and labor required for collecting, analyzing and displaying the data.

Students' Main Challenges Using MBLs

Students gave mixed responses to the immediacy of the data. Some students stated that receiving immediate feedback from the MBL reinforced their learning and promoted their engagement with the experiment while others believed that the immediacy of collecting, analyzing and displaying data with MBLs made them struggle to understand what was really going on in the experiment

My data revealed that the class did not build a general consensus about the affect of MBLs on their engagement into the activity. Some of the students indicated that MBL promoted their engagement into the activity while others stated that it inhibited their engagement. Furthermore, students engagement differed at different stages of the MBL activity.

As with Emin, Yasemin thought that better understanding of subject matter would influence the effective use of MBL in the science laboratories.

> Yasemin: We used a radiation probe in physics. I did not understand that either. Our teacher explained how to do it. Ok, push this button and the numbers were there. (On task interview, October 25, 2000)

> Yasemin: ....If I did understand what exactly I was doing in the lab, that would have helped too. If I do not understand what is going on in the lab I do not understand the data collecting. It makes me more confused. (Room interview, October 30, 2000)

In this regard, Friedler, Nachmias & Linn's (1990) reported that familiarity with the subject matter of an MBL experiment increase student learning gains. Students involved in their study used MBLs to understand the relationship between a number of variables in a heating experiment. They found that students score gains found to be increased from 49% to 90% when students performed the a similar heating experiment using MBLs for the second time. They further stated that when new variables introduced to the same heating experiment students' score gains decreased.

<u>Immediacy of Data</u>

Immediacy of Data inhibited some students understanding of subject matter As an example, although Yasemin recognized that processing data with MBLs was faster than doing it with traditional techniques, she stated that she would occasionally prefer doing it by hand with traditional techniques. She thought doing it by hand would save her time "to think" and give her more time to "internalize" what she was doing. She did not feel like the MBL helped her making connections between her pre-existing knowledge and the subject matter of the activity because she felt that gathering data in real time lessened her time to personalize the information.

Moreover, she indicated that gathering data in real time was a lot faster than she needed. Above data suggest that considering the limitations stemming from 50 minutes class period time, MBLs seems to be not suitable for slow learning students

Pre-requisite skills prior to using MBLs

Some students felt like they needed to poses pre-requisite skills prior to using MBLs in their scientific investigations. Ali suggested that using MBLs in investigations might be too complicated for some high school grade levels. He mentioned, for example, (in the case of graphing) that using MBLs might not be a good thing for 9th or 10th grade students because those students might lack the basic skills of graphing, such as not knowing how to plot the graph. He thought that MBLs were more appropriate for advanced classes where students would already have the requisite skills of graphing. He indicated that understanding the MBL-generated graphs was not a problem for him because he had already learnt graphing skills in his Chemistry 1 and mathematics classes. Ali said that, in order to use MBLs more effectively, students should take some other courses to gain the skills necessary to analyze the data. In line with the MBL literature he also called attention to the point that students first had to have sound basic graphing skills in order to benefit more from the MBL generated graphs.

> Ali: For this class I think it[using MBLs in scientific investigations] is good. But I do not think if it was like a Chemistry 1 class, it might not be good because the kids might not have a background. We [Chemistry 2 students] took Chem. 1 so we kind of have a more background in analyzing the data. So, you know it is like in the math class. When you are getting calculus, they do not go over Algebra 1. (Room interview, October 26, 2000)

> Ali: For like the automatic graphing, people might say we should not do this. The kids should first learn the basics. They should not use it in the earlier classes. These are more suitable for later classes. (Room interview, October 26, 2000)

Ali believed that he and most of his friends in the AP Chemistry class had already mastered the basic graphing skills. Therefore, he thought there was nothing wrong with using automatically generated graphs.

Similarly, the teacher also thought that students should not "jump ahead too fast" in using the MBLs. He thought that the students should already possess the skills of using an analog device, like a thermometer, so that they could make sense of what they are doing with MBL.

> Teacher: AP students know how to use an analog device and get the correct precision. They know that already, so why make them do it again. But if they would have got all those thermometer readings done a long time ago in middle school or elementary school, which we do not do enough, then this works great. (Teacher Interview, October 26, 2000)

> Teacher: What good is this if a kid cannot even draw a graph? I still have students in 10th and 11th grade that do not get the scaling right. How is that helping them if they cannot draw a graph? You need to make sure that they have got the basics. See, with my CHEM 1 I would not start out with using this. I would start out making them draw graphs and make sure that everybody knows how to draw a graph. Once they know how to draw a graph then we are not going to waste time anymore (Teacher Interview, October 26, 2000).

As seen above statements pertain to data analysis feature of MBLs. The teacher did not support the use of MBLs for all grade levels was teaching. Compared to 10th grade students the teacher found MBLs to be more suitable for 11th grade students as he thought 11th grade students would be more equipped with basic graphing skills. This statement further suggest that effective incorporation of MBLs into science laboratories as to analyzing scientific data is much more related to graphing skills of the students than their school grade level. Therefore, it would not be wrong to claim that the sooner students are furnished with graphing concepts the sooner they can make use of MBLs in their laboratory experiences for data analysis purposes.

Direct Experience with Data

Some of the students I interviewed felt that they were loosing direct experience with the data particularly while the MBL was collecting data. They said they felt like they had nothing to do other than just wait for the numbers come out of the MBL. They thought that they were indirectly dealing with the data, which caused them to feel bored and detached from the experiment.

As with some other students, Yasemin stated that she felt herself detached from the experiment while MBL was collecting data. She felt "passive" and bored to some extent, which influenced her further engagement into the activity.

> Yasemin: You are not really doing whole a lot you are just sticking the probes into orange juice and that is most of the activity that you do of course you also push the on button too. I do not know. Yeah, that was kind of boring. (Room interview, October 26, 2000)

> I felt less engaged, waiting instead for the MBL to collect data. (MBL Activity Questionnaire, October 25, 2000)

> At first it motivated me to jump right into the lab but then it took so long to complete the data on the calculator that I found myself waiting around. I became a little bored because the calculator was doing all the work. (MBL Activity Questionnaire, October, 25, 2000)

Emin had a somewhat different perspective on the engagement issue. He felt himself disengaged from the activity during some portions of the experiment. Consistent with his earlier statements, he said he felt disengaged at the beginning and then became more engaged through the end of the experiment, specifically during the analysis portion.

Sensitivity of Data Representation

One of the most common issue that the students did not understand about the graphing was the sensitivity of the graphing scale. Most of the students did not appear to understand the way that the MBL displayed the data. They appeared to be lost when they noticed the mismatch of what they were expecting and what the MBL displayed on the screen. As an example, Yasemin had difficulty in making sense of the MBL generated graphs. Contradictory to her observations, the MBL plotted the data as if it changed dramatically during the activity.

> Yasemin: Yeah, the only one thing I found really frustrating with the graph. Because it was like: What is this? What this showing to me? I thought that graph was totally meaningless because it was all about the same number. It was not changing that much I did not really see the purpose of the graph. (Room interview, October 26, 2000)

Some of the students I interviewed stated that even though they did not observe rapid changes in, for instance, the temperature, MBL graphs displayed the data as if there were big, rapid changes within small periods of time. Sensitivity in the display of the data appeared to be the leading cause of misunderstanding. Those students who had problems initially felt comfortable with the graphs when they were told that the fluctuations and rapid changes on the graph was because of the sensitivity of the graphing scale.

While performing the MBL activity students at one station detected a graph anomaly and asked the teacher's help. The graph showing the relationship between the temperature of the orange juice and its pH did not match neither the teacher's nor student's expectations. On the contrary to their expectations, the line resulted from plotting pH against temperature was inversely displayed on the screen. When the student saw the anomaly in the MBL generated graph the following conversation took place between the teacher and the student.

> Teacher: You are right... So, temperature is going down pH is going up. How did you get a graph like this? …It is inverted. In other words, as I go this way… It is backwards. Temperature is going down, while the pH… goes up… which is right but it is backwards. (Classroom Conversation, October 25, 2000)

> Student: Temperature should be on the X axis. (Classroom Conversation, October 25, 2000)

Teacher: Right, so here temperature is going, but it is like… ph is here (x axis) temperature is here. (Classroom Conversation, October 25, 2000)

Student: Right. Temperature should be independent. Temperature should be X. (Classroom Conversation, October 25, 2000)

Teacher: But temperature…. As temperature goes up pH should be going down. Right? (Classroom Conversation, October 25, 2000)

Student: Yeah.

As seen above MBL graph anomaly seemed to facilitate student investigation of the relationship between graph and scientific concept being investigated. However, if it was gone undetected by either the students or the teacher, it might have lead to misinterpretation of the data and thereby misunderstanding of the scientific concept being investigated.

At the time of the experimentation the teacher did not have an explanation for the anomaly in the graph. However, later on, he figured out that the places of the probes should be reversed on the interface. As to function properly, the temperature probe needed be plugged in Channel 1 whereas the pH probe needed to be plugged in Channel 2 of the interface.

Conclusion

Tobin (1997) noted that, "The focus of whole-class activity must be on enhancing the learning of all students..." (p. 386). This study suggested that MBLs do not necessarily promote learning for all students. Some students may need extra help from the teacher in order to grasp the scientific concepts embedded in the MBL activities. Friedler Nachmias & Linn (1990) particularly emphasized the importance of teacher guidance in MBL experiments. They stated that with no guidance and support from the teacher students tend to confuse the relationship between the variables being investigated and thus achieving lower scores. Considerable amount of the students' problems were resolved with only a little help, which allowed them keep going. This study further suggested that special attention should be given to slow paced learners.

Some of the students indicated that they felt themselves doing nothing but waiting for the numbers to come out of the MBL. Data showed that this waiting affected students' engagement to the activity negatively. Jensen (1998) noted that "Challenge is important; too much or too little and students will give up or get bored"(p. 32). The students appeared to be less challenged while the MBL was collecting the data; therefore, they got bored or detached from the activity. Science teachers play a critical role in keeping students attention with the scientific concept being investigated. In order to keep the students actively engaged in the MBL activity it seems necessary that the teacher find effective ways of keeping students intellectually busy. One way of doing that could be asking "What if" questions which will require student thinking and prediction (Friedler, Nachmias & Linn 1990) and thus help them stay on the task.

Although there has been substantial improvements in the MBL technology in the last 10 years students challenges with regard to using MBLs seem to be very similar. As an example, ten years ago students at various levels of schooling had greatly been challenged by MBL generated graphs. They had difficulties particularly with respect to interpreting the graphs and thus understanding the scientific phenomenon embedded d in the MBL activity. Similarly, in my study students felt that they were challenged by MBL generated graphs.

As to lessen students' challenges, in line with the literature, this study suggested that a little teacher push and support is necessary, especially to facilitated students' understanding of the MBL generated graphs. This study further suggested that in an attempt to conduct experiments, using MBL more effectively, teachers should constantly be on the look out for graph anomalies that may simply be resulted from misplug of probes into the interface. Because as seen in this study such anomalies can easily lead to students' misinterpretation of data and thus misunderstanding of the scientific concept being investigated. Finally, as with other instructional technologies MBLs alone does not guarantee increased student learning. If not employed appropriately in scientific investigations they may lead to unwanted student achievement outcomes.

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