Physics Learning and Microcomputer Based Laboratory (MBL) - Learning effects of using MBL as a technological and as a cognitive tool*

Jonte Bernhard
Linköping University, Campus Norrköping, S-60218 Norrköping, Sweden.

Abstract

Different cases of physics instructor's implementations of Microcomputer Based Laboratory (MBL) in physics teaching have been studied. When implemented as a technological tool only poor learning results were observed while when MBL were used as both a technological and cognitive tool good learning results were observed. New technology thus does not necessarily lead to better learning. When developing and implementing computer aided learning we must focus as much on the cognitive aspects as on the technological aspects. Also we must focus on instructors conceptions of teaching and learning since this affects their understanding of curricular reforms and lead to transformations of original developers educational intentions.

Background, Aims and Framework

Microcomputer Based Laboratory (MBL) was introduced into physics teaching more than one decade ago (Tinker 1996). An attachment of a sensor to a computer creates a very powerful system for collection, analysis and display of experimental data. Today several systems, specially developed for schools and undergraduate courses, are commercially available for different computer platforms. In a Microcomputer Based Laboratory (MBL-lab) students do ***real*** experiments, not simulated ones, using different sensors (force, motion, temperature, light, sound, EKG…) connected to a computer via an interface.

According to several studies (for example Tinker 1996, Thornton 1987, 1989 and 1997, Thornton and Sokoloff 1998, Hake 1997, Laws 1997, Bernhard 2000a and 2000b, Hamne and Bernhard 2000) MBL is very effective in fostering a good functional understanding among different groups of students. According to a presentation by Euler and Müller (1999) at the ESERA-conference in Kiel 1999 MBL is the only method in physics teaching using computers with a proven positive learning effect. Bernhard (2000c) have proven that MBL can give long-lived conceptual understanding. The good result of using MBL is attributed to the real-time display of experimental results and graphs. Because data are quickly taken and displayed a predict – observe – explain cycle (POE) and "cognitive conflict" is easily implemented.

The question thus arises: Is the reported good learning effects of MBL due to inherent properties of the MBL-technology or is the educational implementation crucial?

Methods and Samples

The results of different implementations of MBL-labs in introductory university level physics (mechanics) courses (25 – 40 students) at a smaller Swedish university were studied. The conceptual tests Force Concept Inventory (FCI, Hestenes ***et al*** 1992) and Force and Motion Conceptual Evaluation (FMCE, Thornton and Sokoloff 1998) were used as pre- and post-test. In Case I (Mechanics I) MBL-labs were

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implemented in active engagement mode using a POE-cycle in a course for engineering students. In Cases II and III MBL-labs were used in a course for pre-service teachers. In Case II (Preservice 98/99) the MBL-labs were implemented as “formula verification labs” and in Case III (Preservice 99/00) the collision lab from Case II were changed into POE and active engagement mode. In Cases II and III MBL were mainly used as a technological tool (measurement, processing and display of experimental data) whereas in Case I MBL were used both as a technological and as a cognitive tool (sense making).

Results

When implemented (Case I) in active engagement mode using POE and “cognitive conflict” MBL achieves good learning results. In Case I both male and female students achieve the same normalised gain [Normalised gain (Hake 1997) is defined as gain divided by the maximum possible gain] measured by the FCI-test. In Cases II and III (MBL using formula verification labs, except for the collision lab in Case III) poorer learning results were obtained compared to Case I. However for Newton 3rd law understanding, as measured by the FMCE-test, there is a significant difference between Case II and Case III. In Cases II and III identical lab-equipment using MBL-technology were used in both versions of collision lab. However the educational approach chosen was different. Case III used an active engagement approach and Case II a formula verification approach. As can be seen in fig 1 there is a large learning difference. The formula verification approach even led to negative learning in the case of contact forces. A detailed analysis of data has shown that the formula verification approach has been especially disadvantageous for female and for poorly prepared students. Other studies (Bernhard 2000c and Hamne and Bernhard 2000) have shown that the observed difference can not be attributed to different student backgrounds (engineering students versus pre-service teachers).

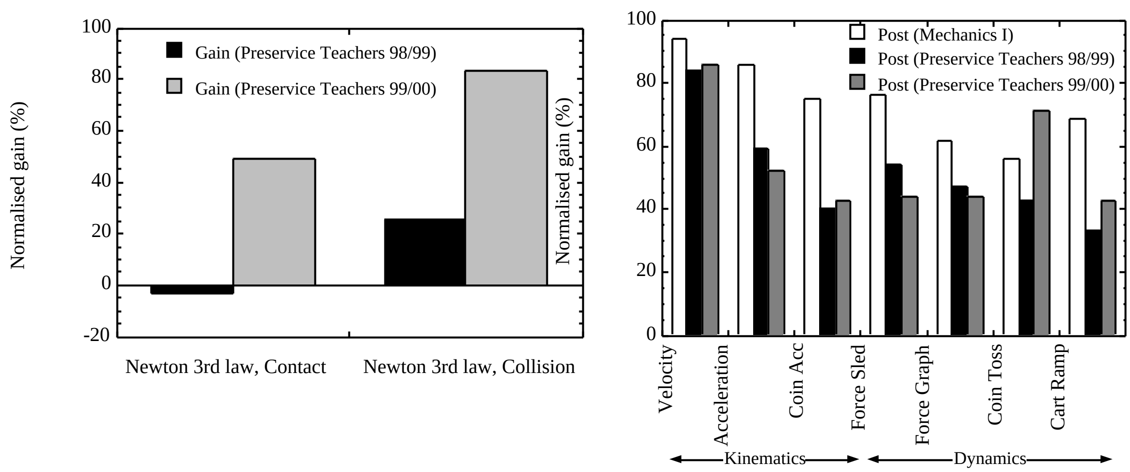

Fig 1. Student learning gains in different conceptual areas of mechanics according to the FMCE-test.

Conclusions and Implications

MBL-technology, and other forms of computer aided learning, can not be implemented as only a technology. The educational implementation is of crucial importance and hence there is no definite answer to the common question if computers help to achieve “better” learning. Another conclusion is that we, when developing new curricula, must be as aware of instructor’s conceptions of teaching and learning as we in teaching and curriculum design must be aware of student’s preconceptions. Physics instructors perceive the intentions of a curricular reform or the advantages of an educational tool through their own understanding and conceptions ("misconceptions"?) of teaching and learning. In active engagement curricula using MBL-tools these tools are intended to be used as booth a technological and a cognitive tool. However, many instructors, perceive the MBL-tools as only a technological tool [see also similar results by Sassi (2000)]. Tinker (1996, page 3) points out: "***It is not usually advantageous to simply replace a traditional lab with an equivalent one using MBL. This kind of 'substitution' policy is easiest for schools to implement, but the result of such a substitution is often a simple lab made more difficult and expensive by the inclusion of computers with no educational gain. The MBL context adds capacity and flexibility that, to be exploited requires the lab to be reconceptualized, giving students more opportunity to explore and learn through investigations. This, in turn, often requires a change in teaching style that takes time and institutional commitment***".

To achieve positive learning effects, when using computer aided learning, we must focus as much on the cognitive aspects as on the technological aspects.

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