The use of computer-based simulation packages in open and flexible learning: 'the electronics workbench'

Joachim Wetterling, Betty Collis, Jef Moonen and Joao Oliveira

Developing manipulative skills through simulated environments: issues for distance education

There are many aspects of vocational education that involve hands-on manipulation of instrumentation, either as the goal of the training task itself or as a integral part of overall functional development in a professional area. In these cases, providing students with practice opportunities and supervised feedback requires access to specialised equipment. Flexibility of time and place in terms of student interaction with such equipment becomes difficult if not impossible to accomplish and thus the development of manipulative skills via a distance education paradigm becomes difficult to organise.

Various compromise strategies are possible; for example, supervised practical experiences with actual equipment through cooperative arrangements with employers or trainers in the student's own setting and available at a time appropriate to the student might be individually organised. However, this is complex to arrange with regard to central organisation and to quality control. Or as another permutation, students could be required to occasionally come to a supervised setting for their hands-on experience. However, both of these options infringe on the principles of flexibility of time and space and may prevent target clients from participation in the distance education program.

Another option is to investigate the use of simulated practice environments, by which students in their own time and place can receive feedback from a computer program relative to their development of performance skills but without the need of the actual apparatus needed for performance in the actual workplace. In some cases, computer-based simulations are able to provide such practice and such feedback. In this study we investigate the particular case of a computer-based simulation of an electronics workbench for improving the scope of distance learning for practical and manipulative skills.

In particular, we have asked: to what extent can a computer-based simulation software package for electronics instruction called The Electronics Workbench (EWB)[1] replace laboratory-based skills training in distance education settings involving skill development with respect to the design and construction of electronic circuits?

Electronics education and the Dutch Electronics Workbench Study

The Electronics Workbench

The purpose of the EWB simulation package is to teach the theories of analogue or digital electronic circuits by providing practice with simulated models. The test instruments in the program have many of the basic controls found in the 'real' laboratory situation. It is possible in EWB to perform experiments building simulated electronic circuits (both analogue and digital) on a simulated workbench, where feedback is given as to the behaviour of the circuit when simulated charges are sent through it. The level as well as the size and complexity of the circuits can vary and different measuring instruments can be applied to the test of the constructed circuits. Various display and transfer options are possible to save and further study the results of the circuit-building experiences. The user interface in EWB is mouse driven (but keyboard use is also possible), and uses windowing techniques. The package comes with on-line help options, organised in a hypertext-linked interrelated text which is capable of being adapted by the instructor. All of this results in a training experience similar to that which the students would get if they were using real circuits.

EWB was developed in the context of a multifaceted program to stimulate and support the use of computers in Ontario, Canada, schools. The task of EWB was to be a software package, ready for use in Ontario vocational educational settings, that would essentially simulate an electronics laboratory, with both digital and analogue equipment, without requiring the substantial investment of fully equipped labs and qualified instructors for each vocational setting in Ontario. As an additional challenge, EWB was required to equalise opportunity for quality electronics experiences in a province where there are two official languages and where portions of the population live in remote and distant small communities in a widespread area. Finally, the package had to run on various computer platforms and be as accessible and useful to an instructor in a remote centre with little electronics background as it would be to a specialist instructor in a large urban school. Thus the package must be 'portable' in the full sense of the term (Collis and De Diana, 1990) and also be perceived to be effective relative to its cost of use.

That the package is perceived as meeting these expectations can be supported by the fact that in approximately five years it has become widely used not only in Ontario settings, but throughout Canada and in more than 20 other countries in a variety of educational levels and settings. Such widespread use of a rather specialised educational software package is unusual (Collis, Moonen, Oliveira and Koenig, 1992).

Relating EWB to the research questions of the study

'The Electronic Workbench' can be seen as an example of a computer-based simulation package that could to be used in traditional vocational education to provide more flexibility in practical experiences. However, the flexibility of approach made possible by the package can also be a value in the distance education context to offer students opportunities to improve practical and manipulative skills in electronics away from traditional settings. Thus EWB can serve as a case study for examination of the research question in this paper.

The Dutch EWB Case Study

The Dutch government has been explicitly stimulating the use of computers in schools since 1984. In particular this support is being focused toward vocational education. In this context, EWB has been licensed for adaptation and use in middle-level vocational education throughout The Netherlands. Instructor training has accompanied the distribution of the software, through a series of 46 week-long courses attended by over 500 instructors from approximately 100 vocational education institutions from throughout The Netherlands

A questionnaire was sent to 384 of the instructors who had attended teacher training related to the EWB package. This questionnaire contained questions relating to the use of EWB in the learning setting; problems with hardware and software; perceived shortcomings relating to the content, user-interface and help-system of the package; the need for additional support for the use of the package; the fit of the package to the curriculum and training situation; the extent to which the package supplements or even replaces hands-on practice; and the costs of using EWB. Particular stress was given to the extent to which EWB could flexibly fit into various types of learning settings, including open settings similar to those utilised in distance education. In addition, interviews and a product analysis were carried out, as well as a number of other investigatory strategies in the one-year long case study.

Results of the Dutch Case Study

Full results of the case study are available from the authors on request. What follows is a summary with interpretive comments relating to different aspects of EWB.

In most schools the EWB package was used to illustrate theory and to support practical work in that direction. Often, the teacher used EWB as a demonstration package while explaining theory. Later, students did exercises using the package. Students also worked with the package outside of regular class hours.

The unavailability of real laboratories and the trend toward having less school time available, also makes the exploration of new approaches useful to the teacher. In general, the use of the package was clearly seen by the teachers as a useful supplement to 'real' laboratory work.

The respondents were frequently enthusiastic about the benefits of EWB use. For example, the 136 respondents indicated the benefits of EWB use for them as shown in the table below (numbers indicate number of respondents mentioning the benefit):

Time savings	48
Cost savings	35
Good educational value	50
Better running of practical experiences and experiments	86
Less assistance needed from teacher	47
Less demand on facilities for experiments	42
Other	12

The respondents made many comments about the software itself. Some of these related to its content, others to its design. The comments showed a great diversity of opinion. With respect to content, some respondents appreciated the simplicity of the software, both technically and conceptually, and that students could fairly easily work with the package independently and without prior training. However, this simplicity has the price of limitations in scope, which frustrated many of the respondents. By far the largest category of open response comments made by instructors was that of frustration over the fact that the software failed to offer various specialised aspects available to the students in their regular laboratory practice. However, the instructors showed no real trend in what they felt should also have been included in the simulated workbench, showing the degree to which instructors develop their own sense of what is important for practice and their expectation that instructional support materials should reflect this sense as closely as possible.

Discussion

Although our Dutch case study was not based directly on a distance education situation, the use of the package in the Dutch settings very much relates to the design of instructional materials for distance education. The package was flexible in terms of its application, both in terms of curriculum fit and fit with the instructional situation and student characteristics. The package was easily used by the students, with little need for direct help in its technical aspects. The package was apparently easy to install and use on different computers and in different settings. Students liked it well enough to work independently with it. Instructors in general felt the use of the package added to the learning experience for their students and could substitute for some direct manipulation and measurement activities in order to more quickly see or check the results of different experiments. All of these characteristics relate to the design of instructional materials for distance education and the more general question of strategies for teaching manipulative skills with the flexibility needed for distance education. The extent to which the materials bring flexibility into the traditional setting is also, in this case, a good predictor that the materials could be used in a larger variety of flexible and open settings such as those in distance education.

However, the experiences from the Dutch EWB study indicate that the package does not stand alone very well but needs accompanying instructional material, occasionally requires technical assistance, and is sometimes difficult to fit to the particular desires or requirements of the individual instructor. In particular, the comment was frequently made that such a package should not be a replacement for hands-on experience, but rather, a supplement to it. However, this comment was made by instructors working within generally well-equipped institutions; the reaction from instructors or students with no opportunity to access adequate equipment might well be different. We have no way to test this reaction from our sample in this study.

The need for adequate support materials to accompany the use of EWB, in either traditional or distance settings, is predictable, and is a need that is already familiar to designers of instructional materials for distance education who by training recognise the importance of closely integrated instructional materials. Educational software producers familiar with traditional settings where a teacher is always present to support students' use of software will need experience in developing integrated support materials for independent and flexible use of electronic learning resources; the considerable experience of distance educators can make an important contribution here. Users of computer-based simulation software in traditional instructional settings have long ago learned that such software should not be used in isolation but needs careful instructional integration. In the case of electronic simulation materials for flexible and distance use, this guidance will have to come much more from the integrated support materials than from the tutor, another example of how the design skills in the distance educational community will make a contribution to the better design of instructional materials for traditional settings.

The problem with occasional technical failure in the software or, more specifically, of the software in certain hardware-printer combinations, is a more critical problem with electronic instructional materials for flexible and open learning. Telephone calls to one's tutor in another location may not be adequate to explain a system that doesn't work and 'hot-line' support for technical problems may be too expensive to provide in a 'just-in-time' fashion.

The use of EWB in the context of open-ended education, such as in the case of the Espoo-Vantaa Institute of Technology in Finland, can provide additional suggestions for the integration of simulation software into overall learning packages involving the acquisition of manipulative skills. At this institute EWB is one of the components of a multi-media, multi-opportunity learning package where trainees can choose from an array of learning materials and follow their own learning paths using a range of teaching and learning opportunities.

Experiences with the simulation package The Electronics Workbench have provided a useful framework for a broader consideration of an important area of instructional design and delivery – how resources might be developed for distance-delivered training in an area such as electronics where costs of actual hands-on practice are high. We believe there is good potential for support of manipulative skills training in a flexible or distance setting if the simulation software supporting such practice is well designed for its purposes and carefully integrated with other support materials.

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[1] The Electronics Workbench (software and documentation) is available from Interactive Image Technologies, 700 King Street, Toronto, Ontario Canada, M5V 2Y6.

References

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