

## **Electronics WorkBench<sup>®</sup> and PSPICE<sup>®</sup> computer-aided design systems as educational tools for second and fourth-year university courses in Electronics**

**Martin P. Mintchev, Brent J. Maundy**  
**University of Calgary, Calgary, Alberta, Canada T2N 1N4**

### **Abstract**

The progress in development of comprehensive computer-aided design (CAD) tools for electronic systems is related to the efficiency of teaching both introductory and advanced courses in electronics at university level. Rapid development of graphical user interface (GUI) created opportunity to convert a personal computer into a virtual electronic development site and thus significantly simplify the applicability of these CAD systems in academic environment. The aim of this study was to compare both qualitatively and quantitatively the student utilization of two of the most popular CAD systems available on today's market, Electronics WorkBench and PSPICE. Twenty-nine second-year students and thirty four fourth-year students taking introductory and advanced courses in Electronics (Department of Electrical and Computer Engineering at the University of Calgary) volunteered to participate in the study, which examined the efficiency of their usage of the two systems in various assignments. The majority of junior students favored exposure to both systems, while the majority of senior students preferred Electronics WorkBench because of its quick learning curve and well-developed GUI environment. We conclude that visual CAD systems for electronic design are very well accepted by students.

### **1. Introduction**

The progress in computer-aided design (CAD) tools for designing and analyzing electronic systems is of vital importance for the educational process in electronics at the university level [1, 2, 3]. For many years PSPICE (MicroSim Corporation, Irvine, California, U.S.A.) has been considered an industry standard and many university textbooks based their practical and illustrative examples on it [3-5]. However, in recent years the rapid development of Graphical User Interface (GUI) for personal computers made possible the evolution of the CAD systems for electronics towards a "bench-like" approach which simulate in real time the workplace of an electronic designer producing a computer-based physical model of the tested circuit and using virtual electronic instruments (power supplies, voltmeters, ammeters, function generators, oscilloscopes, Bode plotters, etc.) while examining this physical model. A pioneer in this approach was Interactive Image Technologies Inc. (Toronto, Ontario) which offered a GUI version of a CAD system even before graphical-based operating system for IBM PC compatibles was available [6]. Their product called Electronics WorkBench became one of the strongest competitors of PSPICE on the market. Not surprisingly, the newer 7.1 version of PSPICE utilized

also to a certain extent the “bench-like” approach, offering both GUI and real-time simulations. At present, instructors notice that more and more newly published textbooks utilize either the Electronics WorkBench alone [6], or offer comparative examples based on both PSPICE and Electronics WorkBench [7-9]. However, no comparative qualitative or quantitative evaluations of both competing products from educational perspective has ever been offered. The aim of this study was to qualitatively and quantitatively evaluate PSPICE version 7.1 (MicroSim Corporation, Irvine, California, U.S.A.) and Electronics WorkBench version 5.0 (Interactive Image Technologies, Toronto, Ontario, Canada) by asking a number of second and fourth year electrical engineering students to utilize both products in their routine course work.

## 2. Methods

### 2.1. *The students*

Twenty nine second-year students taking the introductory electronics course ENEL 343 (Electric Circuits II) and 34 fourth-year students taking the advanced course ENEL 569 (Electronics for Instrumentation) volunteered to participate in this study. Both courses are part of the regular undergraduate curriculum of the Department of Electrical and Computer Engineering at the University of Calgary [10].

### 2.2. *Qualitative comparison*

The two versions of PSPICE and Electronics WorkBench were installed on 20-station IBM-PC Pentium 100 network based on Windows NT environment (Microsoft Corporation, Redmont, Washington, U.S.A.). Both systems were equally available to all participating students. The 4th year students have been exposed solely to PSPICE in their earlier years of education, while 2-nd year students were just starting to utilize a CAD system for electronic design.

Students from both groups were given a series of comparative assignments and were asked to advise the respective instructors if they were asked to choose which of the two CAD systems should be purchased by the Department what their choice would be and why. The opinions were expressed anonymously in writing as purely qualitative statements and impressions. Several answer options were listed: (1) PSPICE; (2) Electronics WorkBench; (3) Both; (4) None of the two; (5) Cannot determine. Verbal justification of the choice of each individual student was also encouraged.

### 2.3. *Quantitative comparison*

The students were also asked to record the time it took them to prepare the assignments using PSPICE and WorkBench. The two times were separately compared for the second-year students who had some preliminary exposure to PSPICE one semester apart from their Electronics WorkBench exposure, and for the fourth-year students who had at least one and half years exposure to PSPICE. Average development time per student per CAD system was calculated by adding the development time for each assignment using the given CAD system and dividing by the number of assignments. In the case of the second year students the assignment was deliberately made 25% longer in Electronics WorkBench compared to PSPICE by 1) asking the

students to do additional simulations on top of those jointly done between Electronics WorkBench and PSPICE, and 2) taking into account circuit size limitations in the student edition of PSPICE. The overall average development time per CAD system was calculated as the average development times from all students were added together and divided by the number of students. Standard deviations from the two overall averages were obtained as well.

### 3. Results

#### 3.1. Qualitative comparison

While the majority of the second-year students found Electronics Workbench easy to utilize and more user-friendly, they were hesitant to recommend Electronics WorkBench alone as a preferred CAD system and pointed out the possibility that PSPICE could offer far more sophisticated circuit analysis, which they were not aware of, or were not asked to perform. An interesting observation among the second year students was that they found wiring up circuits in Electronics WorkBench more difficult compared to PSPICE with its relatively simple Manhattan geometrical layout structure. Six out of the 29 second-year students (17%) indicated a preference for Electronics Workbench, while 4 other students (14%) choose PSPICE alone. Twelve students (41%) indicated that the availability of both CAD systems would enhance the learning process better, and 7 students could not determine any particular preference or could not give any specific recommendation. These findings are summarized on Figure 1.

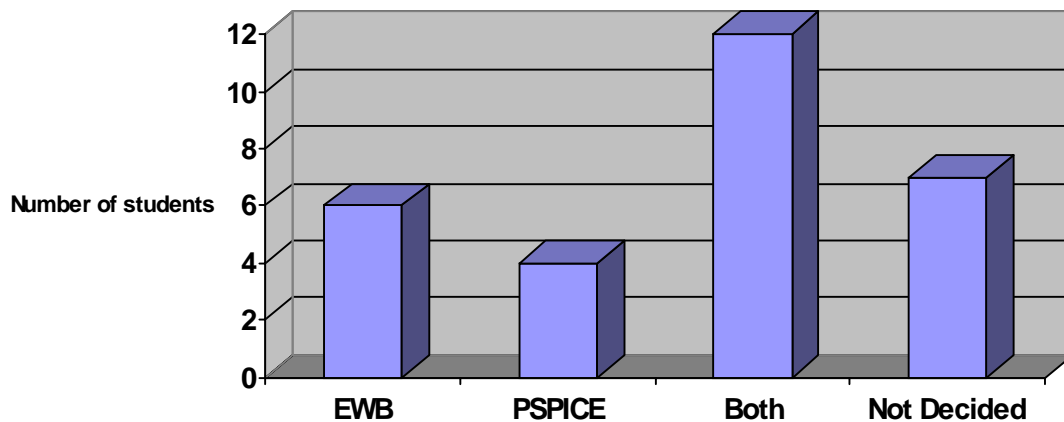


Figure 1. Distribution of preferences among the second-year students. Recommendations for utilization of both programs dominated.

Fourth-year students were more inclined to recommend Electronic Workbench over PSPICE although they had an extensive preliminary exposure to the latter in their junior years. In fact, 24 of the 34 fourth-year students (70.5%) recommended the use of Electronics WorkBench, five (14.7%) preferred PSPICE, three (8.8%) suggested that both systems should be utilized, and two (5.8%) did not indicated any preference citing limited knowledge of the full capabilities and limitations of the two systems. The results from the evaluation of the two CAD systems by the fourth-year students are shown on Figure 2.

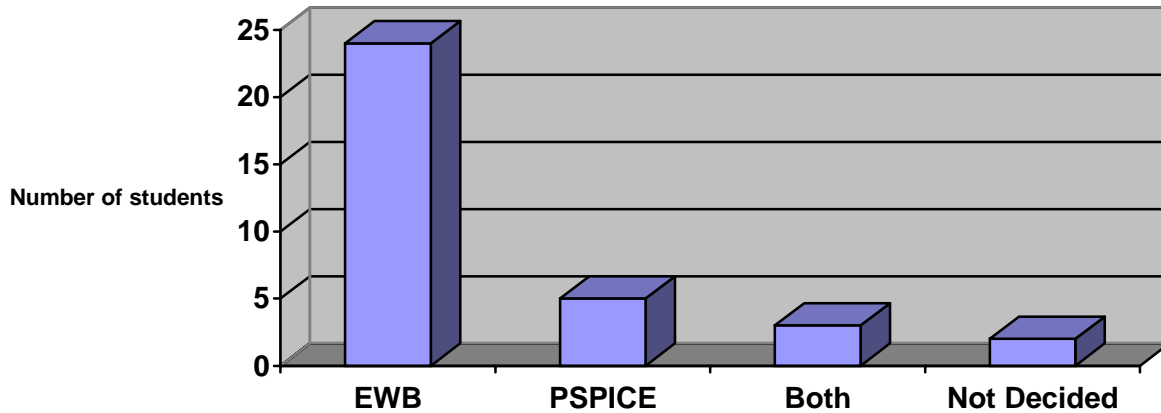


Figure 2. Distribution of preferences among fourth-year students. Preference of Electronics WorkBench was predominant.

The students eagerly made numerous suggestions for improvement of both systems and we, as academics, can only hope that the respective companies would take some of these specific suggestions into account in their newer versions.

### 3.2. Quantitative comparison

The overall average development time for the second year students using Electronics WorkBench was  $2.85 \pm 0.71$  hours. When using PSPICE this parameter was  $2.53 \pm 1.29$  hours. These figures take into the account the additional 25% “work time” that students were required to do to complete the exercise in WorkBench. Even with the additional 25% overhead one can note that the results were comparable. The averages were obtained from one extensive assignment.

The overall average development time for the fourth-year students using Electronic WorkBench was  $1.32 \pm 0.48$  hours. When using PSPICE this parameter was  $2.11 \pm 0.51$  hours. These overall averages were calculated from four different assignments covering different aspects of electronic instrumentation.

## 4. Discussion

Although SPICE-based CAD systems for electronic design have determined the industry standard for many years, the current trend towards visual and more intuitive graphical user interface could be particularly beneficial in the educational process. The results from our study clearly indicate that the university students prefer to perform actual electronic design and study electronic circuits using CAD tools which are intuitive, easy to use and do not require slow learning curve. In that respect it would seem that Electronics WorkBench (Version 5.0) was preferred over PSPICE (Version 7.1) at undergraduate level. Note that this figure may be different at graduate level but no tests have been conducted. The undergraduate students, however, explicitly indicated in their

descriptive comments that learning a sophisticated and specific CAD system should not be a prerequisite for their utilization of the benefits of computer-aided design, and even might restrict their understanding of the material taught since the attention could deviate from studying the actual electronic circuitry towards studying and exploring the CAD system itself. They found that “bench-type” systems do have far steeper learning curve and in that respect they might be better educational tools. The fact that the more mature fourth-year students were particularly keen on pointing out the need to relate CAD-based design to actual physical design in a “bench-like” virtual environment is in our opinion an important factor in favor of more graphically-oriented and intuitive CAD systems which simulate the real design process in electronics. Although both second- and fourth-year students did not hesitate to point out numerous specific flaws in each of the CAD systems they were asked to explore, the majority of them clearly indicated preference towards visually-oriented systems and systems with steeper and intuitive learning curve.

## 5. Conclusion

Despite the fact that many students found specific inconveniences and flaws in the Electronics WorkBench CAD system for automated electronic design, it was very well accepted by both junior and senior university students. Many of the students who stated preference of PSPICE over the Electronics WorkBench indicated external reasons for their choice stating either the existing industry standard, some preliminary familiarity with the system, or subjective feelings that PSPICE is beneficial in the analysis of more complex electronic circuits, which, however, the students were not familiar with or were not asked to analyze. Second-year students indicated clear preference towards exposure to both systems, while fourth-year students were more inclined to recommend the “bench-like” approach utilized by Electronics WorkBench. The limited statistical analysis offered in this first comparative study of the performance of the two CAD systems in educational environment suggests that Electronics WorkBench can be regarded as a strong competitor of PSPICE as computer-aided design tool utilized in the academic process.

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**MARTIN P. MINTCHEV**

Martin P. Mintchev is currently an Assistant Professor of Electrical and Computer Engineering at the University of Calgary, Calgary, Alberta, Canada. He received his M.Sc. in Electronics from the Technical University in Sofia, Bulgaria in 1987, and his Ph.D. in Electrical Engineering from the University of Alberta, Edmonton, Alberta, Canada in 1994. Martin teaches fourth-year technical elective courses from the regular electrical engineering curriculum at the University of Calgary, entitled Electronics for Instrumentation and Digital Integrated Electronics. Recently he has been awarded the University of Calgary Student Union Teaching Excellence Award. Dr. Mintchev is a registered Professional Electrical Engineer in Alberta and is actively involved in joint research in the local industry.

**BRENT J. MAUNDY**

Brent J. Maundy is currently an Assistant Professor of Electrical and Computer Engineering at the University of Calgary, Calgary, Alberta, Canada. He received his B.Sc. in Electrical Engineering and M.Sc. in Electronics and Instrumentation from the University of the West Indies in Trinidad in 1983 and 1986 respectively, and his Ph.D. in Electrical Engineering from the Technical University of Nova Scotia in 1992. Brent teaches second year courses in electronics from the regular engineering curriculum at the University of Calgary, entitled Electric Circuits I and II. Dr. Maundy is a registered Professional Electrical Engineer in Alberta and is actively involved in industrial microelectronic research.