

ARE OUR TOOLKITS AS EXCITING AS WE THINK THEY ARE?

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Abstract

In a recent web teleconference that the senior author attended, it was reiterated that the instructor needs to be aware of his/her own learning style as well as the students' to reach all types of learners effectively. Without a conscious effort, the instructor teaches in a style that is most comfortable for him/herself. This discussion elicited a query as to the effectiveness of the instructional tools used in class. The senior author has developed a number of "toolkits", computer simulations written in LabVIEW, to provide virtual laboratories in DSP and Communication Systems courses. He is quite enthused about these toolkits, but how do the students regard them? A questionnaire taken in last year's class resulted in positive comments as well as constructive suggestions. This paper will report on the students' involvement in the development of the Communication Systems toolkit through their feedback. It will summarize the reactions of two different classes at different institutions to the same toolkit. It will also report on the efforts taken to address the constructive suggestions and describe the effect of student involvement on the project on learning in the classroom from a student's perspective.

I. Introduction

As the senior author reflects on the development of electrical engineering education from his undergraduate years to its current state, he notes the proliferation of computer applications as the most significant development. A few years ago, he listed a number of applications that have become widespread computer tools in electrical engineering textbooks: Spice and its derivatives in courses that cover circuit analysis and electronics; MATLAB in Control Systems, Communication Systems and Digital Signal Processing (DSP)¹. In addition to these tools, graphical programming environments such as LabVIEW and HP VEE have become popular for many applications. The change in these tools since then has been the enhancement of the graphical interface. The C programming language, which replaced FORTRAN in the electrical engineering curriculum during the senior author's career development, has made the transition to Visual C++. MATLAB, which is the main staple of courses involving linear systems, has developed its graphical interface, namely, SIMULINK. PSpice, which is used to simulate analog circuits, now makes extensive use of graphical interfaces.

Given this computationally rich environment and his previous involvement with developing graphical computer aided tools for DSP in 1980s² and for laboratory instruction in the engineering undergraduate curriculum in 1990s³, it was a natural step for the senior author to

develop graphical computer-aided tools using LabVIEW when he started teaching DSP at his previous post in 2000-2001^{1,4}. He expanded the effort to Communication Systems in 2001⁵ and to Differential Equations in 2002⁶. His enthusiasm for these tools was reflected in his claims that “the instrument-like user interface of LabVIEW, its abundance of analysis VIs make it very attractive and inviting to implement most DSP routines”¹ and “LabVIEW’s graphical interface with live help windows and other visual feedback rendered this project achievable and enjoyable even for a freshman student programmer.”⁵ Finally, in their 2002 paper entitled “On the Aesthetics of Computer Aided Tools for Signal Processing” Tanyel and Adams investigated the notions behind aesthetics, addressed the role of aesthetics in engineering design and examined Tanyel’s preference of a graphical programming environment from an engineering design aesthetics point of view⁷. At this point it was clear that the choice of the toolkit was affected by personal preference.

While he was aware of his personal preference for the programming environment, the senior author attended a semester-long web conference⁸ which drew attention to learning styles. The first assignment in the conference was to take a learning styles inventory on the web⁹ and report on the results. The introductory session was devoted to this idea: It is important for an instructor to be aware of his/her learning styles as well as those of the students and to ensure that students with a variety of learning styles may benefit from the instructional environment that he/she has established. In fact, educational professionals should continually revise their educational philosophy seeing it as “a continuing process of thought and practice that becomes richer, deeper as [they] develop professionally”¹⁰.

Such considerations elicited the natural question: “Whereas the instructor is enamored by this environment he has created, how do the *students* view it?” At the time (Spring 2003), the Communication Systems Toolkit was being utilized in a class of three students. For such a small number of students, an open-ended essay type survey was administered since that would be more helpful than a multiple-choice survey. When the senior author changed institutions, he had the opportunity to teach the same course to a class of eight in the following Fall semester and the same survey was solicited. This paper will compare the responses of students to the Communication Systems toolkit at both institutions, namely Dordt College and Geneva College as well as describe the effect that the student response has had on the development of the toolkit. Section II will present a brief history of the toolkit and the conditions it was used at both institutions. Section III will highlight some of the features of the toolkit and relate the toolkit to Felder’s model of learning styles⁹. Section IV will report on the results of the survey. Section V will entail comparisons, conclusions and future direction of the toolkit.

II. History with the Toolkit

At Dordt College, DSP is taught in the Fall semester and Communication Systems is taught in the Spring semester of the senior year. Both are 3-credit courses with no additional laboratory time. At the time, both courses were taught by the same professor. Students were exposed to LabVIEW programming and the DSP toolkit in the Fall and continued to hone their

programming skills for the Communication Systems toolkit in the Spring. The DSP toolkit was introduced in Fall 2000. Communication Systems toolkit was developed in the summer of 2001 upon the suggestion of the class that had just taken DSP with its toolkit. In other words, the request for a Communication Systems toolkit, developed in LabVIEW, was made by students who had used this graphical language in a similar situation. The initial routines were coded, under close supervision, by an atypical engineering freshman who already had another undergraduate degree in Business Administration. It was used in class for the first time in Spring 2002 and again in Spring 2003. At both iterations, the toolkit was used for demonstrations in lectures, special hands-on sessions and was available for student projects that developed other tools for the toolkit. The first survey was taken at the end of the 2003 offering at Dordt College.

At Geneva College, Communications Systems is currently taught in the Fall semester of the senior year. It meets for “lectures” three times a week and has a three-hour laboratory period in addition. DSP is taught in the following Spring semester by a different professor. The textbook, coverage, demonstrations and assignments for the Communication Systems course offered this year were the same as those at Dordt in 2002 and 2003. The difference was that on days with demonstrations, the class met in the computer lab so that the students would have a chance to follow the instructor on their computers. Since students at Geneva did not have a prior chance to learn LabVIEW, the lab period was initially used to teach LabVIEW, and then for mini projects and, finally, a more substantial project similar to the one at Dordt.

III. Communication Systems Toolkit and the Felder Model of Learning Styles

Communication Systems studies how information is transmitted. It is a highly abstract course emphasizing the processes used in transmitting information as opposed to design and analysis of equipment used. It makes use of mathematical models for signals and their interactions with such equipment as modulators, demodulators or regenerative repeaters. The toolkit is a collection of simulations for the generation of signals, different modulation and demodulation schemes as well as utilities to display signals and/or their spectra at various stages of processing. We will use *Frequency Shift Keying (FSK)*, a relatively easy concept to describe, as an example. It is a technique used to transmit binary information over analogue media. The binary “1” is represented by a sinusoid pulse of a certain frequency and “0” is represented by a different frequency. Fig. 1 depicts the front panel of a virtual instrument that simulates FSK. This virtual instrument enables the student to input binary data by pressing/depressing a button (labeled “Input Bit” in Fig. 1), and to observe the binary bit stream superimposed on the analogue signal representing the binary data. The simulation is very visual and interactive, with input/output mimicking laboratory equipment that electrical engineers are used to manipulating.

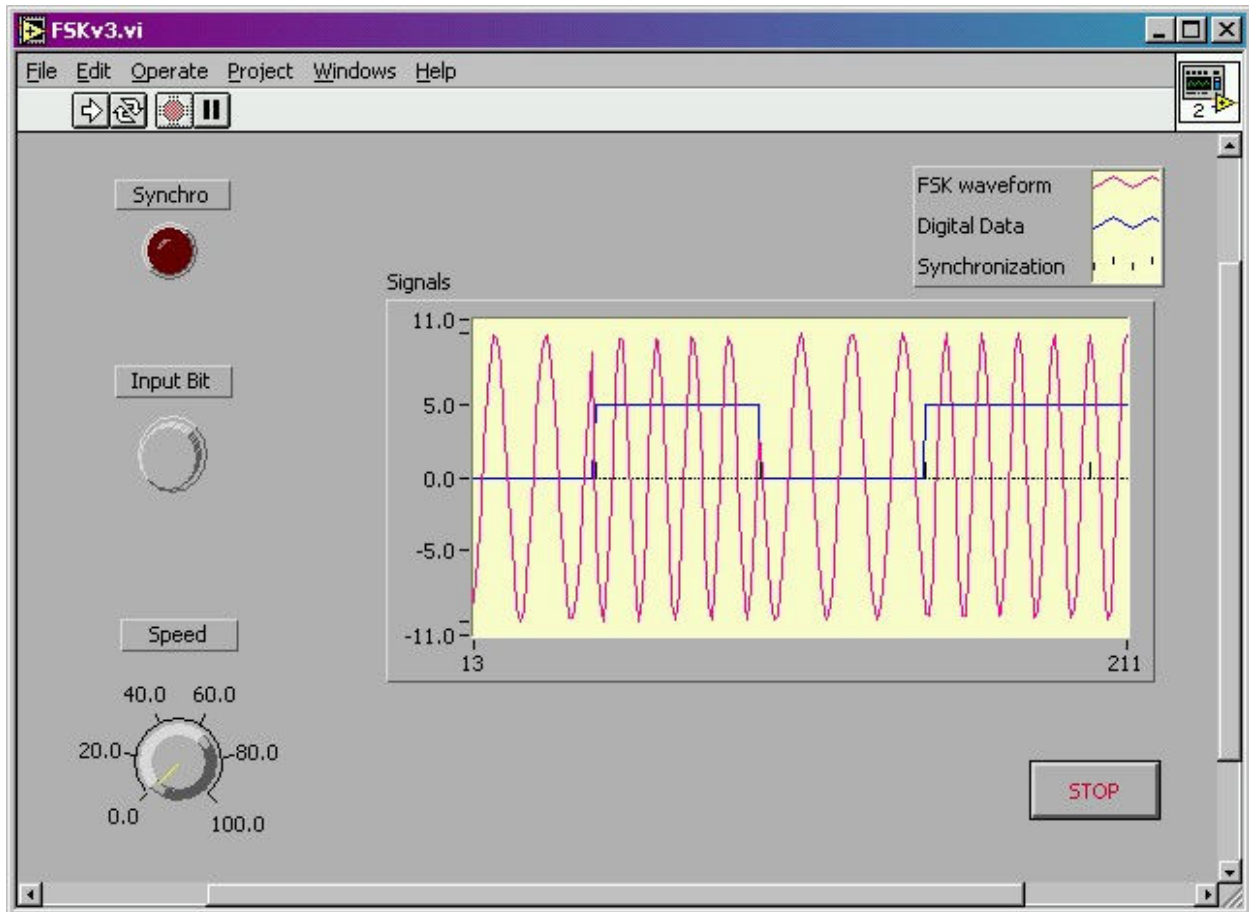


Figure 1: Operation of a virtual instrument demonstrating the frequency-shift-keying technique.

Felder warns engineering educators that mismatches may exist between learning styles of students and teaching styles of professors, resulting in diminished learning and possible dropout in his 1988 paper¹¹. Felder's model of learning styles has five scales (each with two dimensions): Perception (sensory - intuitive), input (visual – auditory, later renamed verbal¹²), organization (inductive – deductive), processing (active – reflective) and understanding (sequential – global). The organization scale was removed from the index of learning styles to discourage deductive presentation¹².

Sensory learning entails observing and gathering data through the senses while intuitive learning is through indirect perception. In this scale, the toolkit enhances sensory learning.

Visual learners prefer sights, pictures, diagrams, symbols whereas verbal learners depend on words (spoken or written). The toolkit enhances the visual aspect of learning.

Active learners convert information into knowledge through active experimentation (discussing, explaining or testing the information) while reflective learners examine and manipulate information introspectively. In the way the toolkit is currently used, it favors active learners.

Sequential learners master the material in small steps arranged in a logically ordered progression. Global learners would like to see the whole picture; once they “get it”, they may even apply the material successfully to problems that sequential learners would not venture. The toolkit is neutral in this dimension. Whereas a demonstration utilizing the toolkit may approach the topic at hand globally, the topic itself may be one step in the logical progression.

From this analysis, one can expect that a sensory, visual, active learner would appreciate the toolkit more than an intuitive, verbal, reflective learner. Since the professor happens to be well balanced in the active-reflective scale, balanced in sensory-intuitive scale (verging on sensory) and a visual learner (see Table 1), the toolkits he has created using the graphical LabVIEW environment and his preference for this environment may reflect his particular learning style.

IV. Results of the Surveys

In the Dordt survey, the instructions were given orally. The students were given about half an hour and were asked to write freely. They were told to elaborate especially on: whether the simulations were helpful, whether they were detrimental in any way, any ideas for improvements on the toolkit and whether the design of a simulation (their project) was helpful. The students spontaneously chose to reply under four headings: 1) Were the simulations helpful? 2) Were they detrimental? 3) Ideas for improvements 4) Was the design of a simulation helpful?

1) Were the simulations helpful?

All three students gave affirmative answers to this question. One thought visualization was an advantage. Two also mentioned the interactive nature of simulations: “[They] are indeed advantageous because they allow immediate answers to ‘what if’ questions.” “The ability to change input parameters in a split-second allows for better comprehension. In the book, you just see a snapshot...”

2) Were they detrimental?

All three students thought they were not detrimental, although one alluded to the possibility of distraction: “They can be detrimental if they do not allow one to concentrate on the effect at hand and they confuse it with other considerations. This did not happen too often, however.”

3) Ideas for improvements:

The main themes were: a) having access to the demonstrations as the professor presented them: “Playing around with the parameters gives a better understanding than just seeing them.” b) better organization c) a tutorial on the simulations.

4) Was the design of a simulation helpful?

The answer to this item was a resounding yes. One student even made connections to the DSP class they had previously taken: “Doing the project, I did learn quite a bit more about delta-modulation, especially related to the concept of oversampling rates which we covered originally in DSP.”

	Class Average	Professor
Act-Ref	0.1	1
Sen-Int	-4.1	-3
Vis-Vrb	-5.6	-5
Seq-Glo	-3	-9

Table 1: Comparison of the aggregate Genevan class learning styles to the professor's.

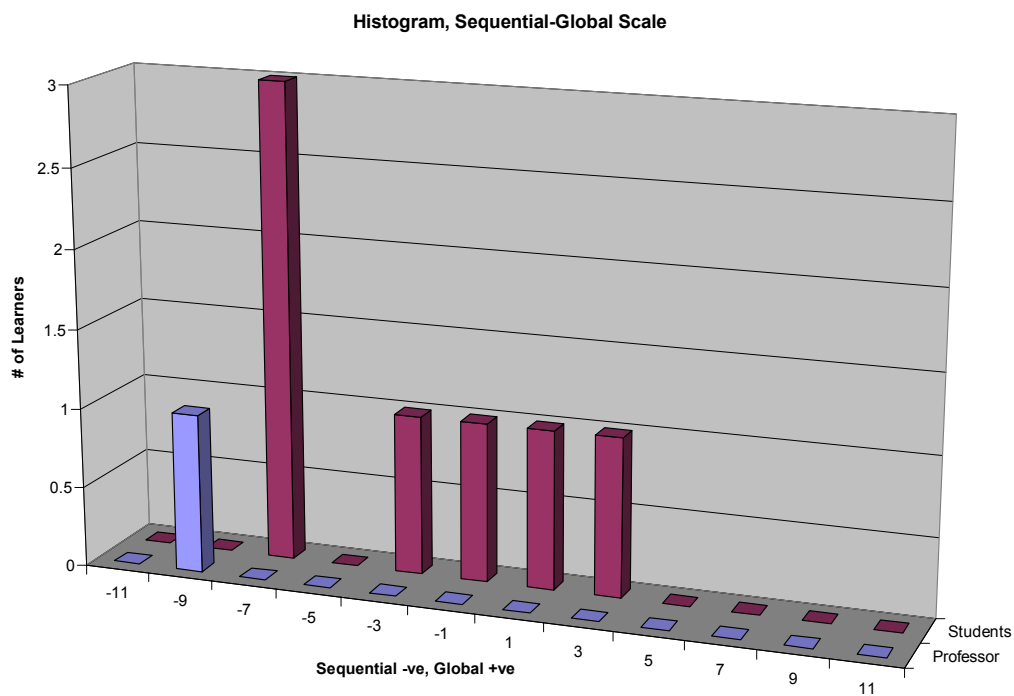


Figure 2: Histogram of the Sequential-Global scale of the Learning Styles Inventory comparing class results to the professor's.

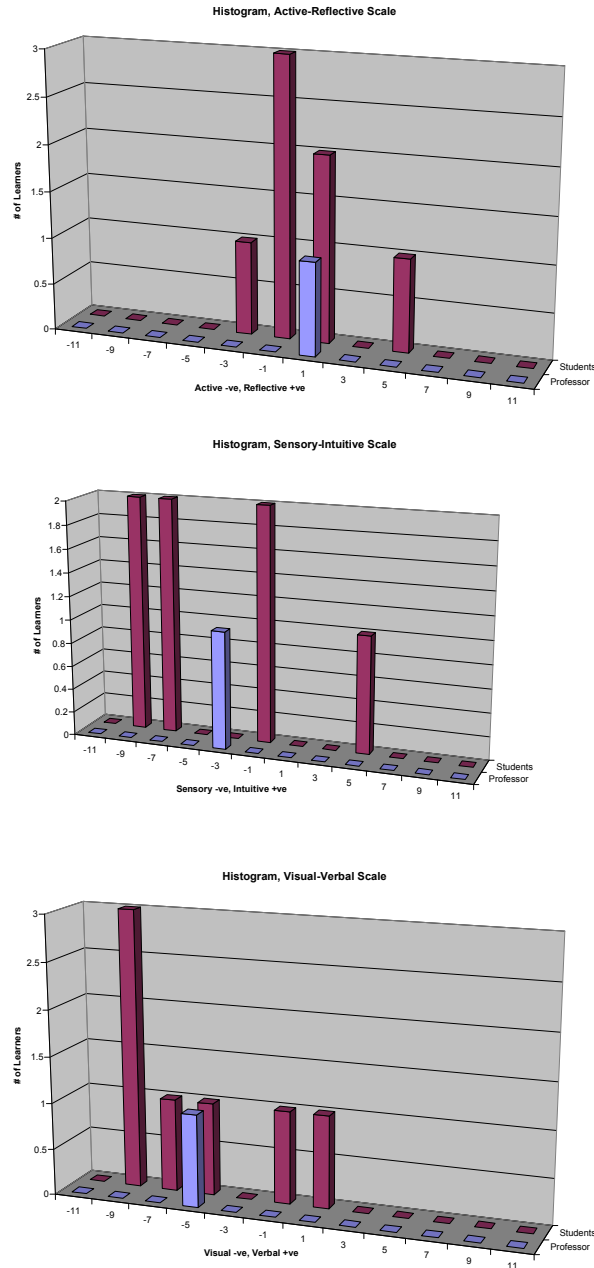


Figure 3: Histograms of the Active-Reflective, Sensory-Intuitive and Visual-Verbal scales of the Learning Styles Inventory comparing class results to the professor's.

At Geneva, the students and the professor took the Learning Styles Inventory provided by Felder and Soloman⁹ at the beginning of the course. Table 1 summarizes the comparison of the average of the seven students who took the inventory to the professor's learning style. The table reveals that the average student is very similar to the professor on every scale except Sequential-Global. We should note here that in the original scoring, there are no negative numbers. Each scale has

two dimensions with odd positive numbers from 1 to 11. The explanation mentions that if one's score on a scale is 1-3, one is fairly well balanced on the two dimensions of that scale. In order to be able to average numbers, we assigned the left dimension of each scale (Active, Sensory, Visual and Sequential) negative numbers of the same magnitude as the original. With this change, we can restate the above as "if the absolute value of one's score on a scale is 1-3, one is fairly well balanced..."

On the Sequential-Global scale, the professor has a strong preference in sequential learning. The histogram in Fig. 2 shows that three students have a moderate preference for sequential learning while the rest are fairly well balanced. On the Active-Reflective scale, the professor is well balanced while 6 of the students are balanced and one is reflective. On the Sensory-Intuitive scale, the professor is balanced verging on sensory while 4 students are sensory, 2 are well balanced and one is intuitive. On the Visual-Verbal scale the professor has a moderate preference for the Visual dimension and the students either have a moderate to strong preference for the same or are well balanced (see Fig. 3). As the analysis of the summary table and histograms reveals, the students' learning styles were similar to the professor's and we could expect a student reaction to the toolkits similar to that of the professor's.

The Geneva survey was more regimented than the Dordt one. Since the Dordt students had used headings, the Geneva survey had these headings on separate sheets and the students were asked to respond to these essay-type "questions". The Geneva survey had one more item asking for any other comments. All eight students responded.

1) Were the simulations helpful?

The answers were unanimously affirmative. Almost all of them concentrated on the visual help the simulations provided.

2) Were they detrimental?

The answers were generally negative. One student warned about the dangers of the computer performing all calculations: "When you're adjusting the settings and watching the waveforms change, you don't have to think too much about what you are doing, so I usually forget what the simulations were about shortly after class is over." One was vehemently negative: "Never! ... More is better!"

3) Please express ideas for improvements in future inclusion of simulations in this class:

The themes were: better organization and a manual in agreement with Dordt responses and more simulations, even demonstrating simpler concepts as well as more projects.

4) Was the design of a simulation helpful?

The response was a very unanimous affirmative. One student asked for more: "I think there should be like 2 or 3 simulation designs that we did at the end. I feel it lets the students be creative while learning." They were appreciative of the fact that it "force[d] [one] to actually learn how the communication methods work."

5) Please include any other comments here:

This one had three blank responses and two general comments. Two mentioned organization here and one suggested to have class in the computer lab for all periods and reiterated the request for more projects.

V. Discussion

The Communication Systems toolkit was produced upon student demand. As such, it is not surprising that it drew enthusiastic response from students at two different institutions. Comparison of Learning Styles Inventories of this year's class with that of the professor revealed that the instructor and the students were, for the most part, similar. The similarity in learning styles may help explain the shared enthusiasm for the toolkit by both this year's students and the professor.

The request for access to the demonstrations while they were being utilized has been met this year, although it may have brought its own problem with it: "I think I missed a lot of what you said about the simulations because I was either looking for them or trying to see how they worked," says one student. The work on the manual has already started with a senior design project and we have even larger goals for the next phase of the senior design project. One objective is that the work on the Advanced Toolkit Manual for intermediate to expert LabVIEW users will be completed. We plan to do this by developing help documents that explain the process in simple terms so that anyone looking at a program file will understand its operations. We also feel the need to develop a template of standard input and outputs for variables. In other words we will be determining a standardized way that instruments will be passing signals from one subVI (subprogram) to another. Another goal is to fully understand how complete the toolkit based on the Communication Systems (ELE 409) class syllabus. We will be looking for concepts it covers and then make sure that the toolkit includes examples of these major concepts.

The students report that the simulations help them understand the concepts covered in the course. If nothing else, they help in gathering enthusiasm for the course. The projects enable students to have a sense of ownership in the course. With all this exposure to LabVIEW, they also get the side-benefit of familiarity with yet another programming environment. With all these benefits, we will be happy to be plugging away at improvements to the toolkit every year.

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