
AC 2012-4699: ENHANCING LABORATORY EXPERIENCES WITH PORTABLE ELECTRONICS EXPERIMENT KITS

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Enhancing Laboratory Experiences with Portable Electronics Experiment Kits

This paper presents the latest findings from using a custom portable electronics experiment kit (PEEK) in electronics courses offered as part of a general engineering program. Each PEEK includes National Instruments (NI) LabVIEW® virtual instruments running on a laptop, a portable NI myDAQ® personal data acquisition device, a Rapid Analysis and Signal Conditioning Laboratory (RASCL) unit, and supporting peripheral components. These tools provide a new form of laboratory experience that frees students from traditional benchtop settings and expands laboratory activities into more ubiquitous learning environments. Two electronics courses in a general engineering curriculum (*ENGR 3014—Circuit Analysis* and *ENGR 3050—Instrumentation and Controls*) were piloted for this NSF CCLI (TUES) project. The first course was offered twice; the latter once. Outcomes assessed within the ABET framework include students' ability to (a) apply math and science, (b) conduct experiments and interpret data, and (e) solve problems. Experimental and control groups were compared with respect to these outcomes. This paper focuses on the modified laboratory experience and the assessment of its effectiveness as a supplement to previously published work related to this project. It summarizes observed benefits from the use of these tools, such as more efficient task completion, the flexibility to complete tasks that remain unfinished during the scheduled laboratory session, and the ability for students to achieve laboratory objectives at their individual paces. Meanwhile, results from these general engineering courses remind that one must be cautious when considering employing to students who do not have sufficient background in electric circuits.

A. Introduction

As part of a two year CCLI (TUES) project, this paper describes the continuing work of using a Portable Electronic Experiment Kit (PEEK, see references [1-4]) in two courses (*ENGR 3014—Circuit Analysis* and *ENGR 3050—Instrumentation and Controls*) in a General Engineering program. In the project, each student was given a set of PEEK, with which they were asked to prepare laboratory assignments before lab times and complete unfinished hands-on work afterwards. The first year's experience has been reported in [1, 5], where the toolset was tried in the first course (*ENGR 3014*). Learning outcomes were evaluated with multiple instruments including: instructor's observation, modified Pittsburgh Engineering Survey, and embedded FE (Fundamentals of Engineering exam) questions. The first year's experience revealed several pitfalls, such as overwhelmed students, tool complexity, etc. These initial findings suggested multiple changes in the second round trial. Supplement to the authors' earlier publications [1-3, 5], this paper emphasizes these changes and reports new results.

B. Project Description

A portable electronic experiment kit (PEEK), as shown in Figure 1, includes National Instruments (NI) LabVIEW® virtual instruments running on a laptop, a portable NI myDAQ® personal data acquisition device, a Rapid Analysis and Signal Conditioning Laboratory (RASCL) unit, and supporting peripheral components (please see [1, 4] for details). These tools provide students opportunities to work on circuits/instruments-related experiments without access to traditional laboratory equipment, offering unprecedented flexibility in time scheduling and learning paces.



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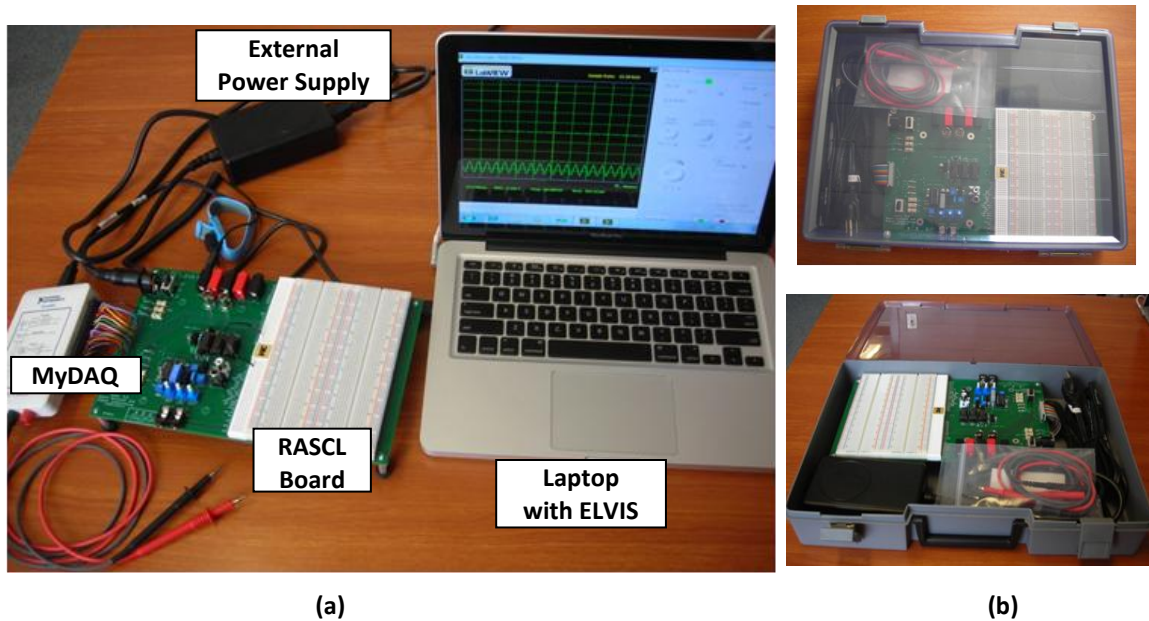


Figure 1. The portable electronics experiment kit (PEEK): (a) kit setup and (b) PEEK with a case (Figure excerpted from [1]).

During Fall 2011, these toolsets were applied to laboratory activities associated with two courses: *ENGR 3014—Circuit Analysis* and *ENGR 3050—Instrumentation and Controls*; specifics of each are described below:

ENGR-3014 Circuit Analysis:

This class consisted of four sections, a total of 60 students, taught by two instructors (two sections each). One of the four sections (15 students) taught by a first instructor, was randomly selected as the experiment group. These students were given the PEEK to complete pre- and post-lab assignments outside the laboratory room. The other three sections (one taught by the first instructor and two by the second) served as the control group. The experimental and the control group completed similar labs and a four-week course design projects, as shown in the list below.

- Lab 1: Use of Electronic Test and Measurement Equipment*
- Lab 2: Use of Portable Virtual-Instrument-Based Electronic Equipment (Experiment group only)*
- Lab 3: Equivalent Circuits*
- Lab 4: Inverting and Non-Inverting Op-Amps*
- Lab 5: Summing Op-Amps*
- Lab 6: Charging and Discharging of RC Circuits (The two sections taught by the second instructor did not do this lab due to class cancelations because of hurricane Irene)*
- Lab 8: Course Project: Design of a Temperature Alarm (I)*
- Lab 9: Course Project: Design of a Temperature Alarm (II)*
- Lab 10: Course Project: Design of a Temperature Alarm (III)*
- Lab 11: Course Project: Design of a Temperature Alarm (IV)*

Among these labs, students in the experiment group were asked to build the basic circuits in advance whenever possible. For example, in Lab 6, they had their RC circuits built before meeting in the lab. Some of them were able to take advantage of the portable tool during the temperature

alarm design project (Lab 8-Lab 11, more details about this project can be found in [6]). The control group worked on the same lab/projects without this option.

Recognizing that this is the first time for many to build any electric circuits, and most of them have difficulties with translating a circuit schematic into a breadboard circuit with physical components, a tutorial video was prepared (http://winmedia.ecu.edu/umc/yaoj/peek_tutorial.mp4) and students were asked to watch the video to learn about different components of the PEEK and how to use it for the laboratory work. In addition, a student helper was assigned to assist in the labs. To help students work on experiment pre-/post- lab work, office hours were scheduled so that students could seek help if they need assistance with the PEEK tool.

ENGR 3050- Instrumentation and Controls:

One section (9 students) of this class was offered in Fall 2011. Laboratory work was comprised by three multi-week modules as shown below:

- LabVIEW programming
 - Basic concepts: front panel, diagram *3 weeks*
 - Data acquisition
 - Boolean logics
- Capacitive Displacement Sensor Design (see [7])
 - Transducer
 - Signal conditioning (555-based oscillating circuit) *4 weeks*
 - Data acquisition
 - Signal processing
 - Sensor characterization
- Coupled-tanks Level Control System Design (see [8])
 - Sensor/actuator calibration *5 weeks*
 - Dynamic system modeling
 - Controller design
 - Control system performance evaluation

In the Controls class, students used the LabVIEW software to program VIs required for the project, including user interface the displacement sensor and its related logic operations. A very brief LabVIEW video tutorial (http://winmedia.ecu.edu/umc/yaoj/labview_with_peek.mp4) was prepared, in addition to the PEEK video tutorial introduced earlier, to better help the students in this class to use the software.

C. Assessment Methods:

In our previous report [1], we assessed students' learning outcomes with various instruments, including: using (1) a modified Pittsburgh Engineering Survey (attached as an appendix here) to understand how these personal electronic tools changed students' view of engineering as a profession; (2) FE targeted questions embedded in the final exam to discover possible benefits from the tools in helping students with applying math, science and engineering knowledge (ABET Outcome (a)), and solving engineering problems (ABET Outcome (e)); and (3) instructor observation and project reports to find out how students were able to conduct experiments and interpret data (ABET Outcome (b)).

Based on last year’s experience, while the modified Pittsburgh survey was still being utilized, other assessment measures were modified attempting to better reflect the actual effect of the new tools. First, the results from the FE embedded questions (on math application and problem solving) may not be closely associated with students’ laboratory experience; thus FE questions are not utilized this time. Second, due to the larger number of students in the class, instructor’s observation in lab became unpractical and was not used as an official assessment means.

Table I summarizes the assessment instruments utilized in the two courses: learning outcomes of both courses were assessed with end-of-semester survey; since only a trailing section of *ENGR 3050—Instrumentation and Controls* was offered and direct experiment-control comparison was not an option, less data were collected for this course. This section describes the assessment methods for *ENGR 3014—Circuit Analysis* in a greater level of detail. In addition to the two surveys conducted by both courses, questions more directly related to laboratory experience were included in the *ENGR 3014—Circuit Analysis* final exam to assess ABET outcomes (a), (b), and (e). The questions and the assessment rubrics are detailed next. Additionally, completion of a capacitor charging/discharging lab in both the experiment and control sections was recorded to see if the tool helped make the completion of the labs faster.

Course Number	Assessment Instruments
<i>ENGR 3014</i>	<ol style="list-style-type: none"> 1. Student learning objective self evaluation (End-of-semester survey) 2. Modified Pittsburg engineering survey (Pre and post) 3. Targeted questions (Final exam) 4. Laboratory completion time (In-lab timing)
<i>ENGR 3050</i>	<ol style="list-style-type: none"> 1. Student learning objective self evaluation (End of semester survey) 2. Modified Pittsburg engineering survey (Pre and post)

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ABET Outcome (a): Apply math/science:

Students were asked to find the current response of a series RLC circuit through solving a second-order differential equation. (Exam question shown below)

Rubrics for Outcome (a)

4 (Superior): the student was able to correctly solve the problem and present the results.

3 (Satisfactory): the student was able to solve the problem following the steps, including determining the form of the solution from damping conditions, find the constants in the solution from initial values, and present the results, but made minor mistakes in some of the steps.

2 (Below Expectation): the student succeeded some of the following steps, including determining the form of the solution from damping conditions, find the constants in the solution from initial values, and present the results, but failed the others.

1 (No Progress Shown): the student was unable to accomplish any of the steps, including determining the form of the solution from damping conditions, find the constants in the solution from initial values, and present the results, but made minor mistakes in some of the steps.

Question for Outcome (a)

A series RLC circuit is described by the following non-homogeneous differential equation:

$$L \frac{d^2 i}{dt^2} + R \frac{di}{dt} + \frac{i}{C} = 3.5$$

Find the response of the circuit when $L = 2H$, $R = 16\Omega$, and $C = 0.0333F$. Let $i(0)=3$; $di(0)/dt = 1$.

ABET Outcome (b): Use of equipment:

Students were asked a question about what is being measured (measure current and voltage) from reading a circuit schematic. (Exam question shown below)

Rubrics for Outcome (b)

4 (Superior): the student was able to correctly identify what's been measured.

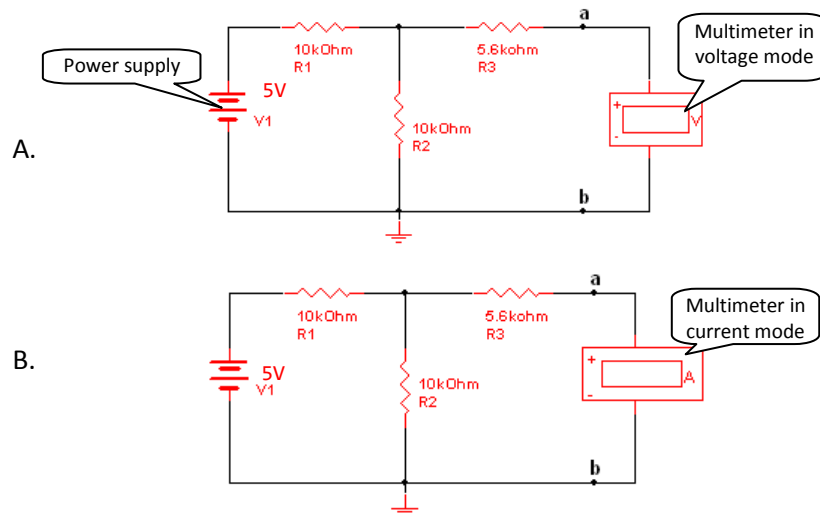
3 (Satisfactory): the student was able to correctly identify one of the two measurements.

2 (Below Expectation): the student was unable to identify either of the two measurements.

1 (No Progress Shown): the student didn't answer the question.

Question for Outcome (b)

What do the two meters in the following figures measure?



- In Figure A the voltmeter measures the open voltage between nodes a and b; In Figure B the ammeter measures the open current between nodes a and b;
- In Figure A the voltmeter measures the short voltage between nodes a and b; In Figure B the ammeter measures the short current between nodes a and b;
- In Figure A the voltmeter measures the open voltage between nodes a and b; In Figure B the ammeter measures the short current between nodes a and b;
- In Figure A the voltmeter measures the short voltage between nodes a and b; In Figure B the ammeter measures the open current between nodes a and b.

ABET Outcome (b): Data Interpretation:

Students were asked to determine the output of two operational amplifier-based comparator circuits. This is part of their "Temperature Alarm" course project. (Exam question shown below)

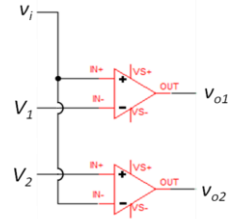
Rubrics for Outcome (b)

- 4 (Superior): the student was able to correctly determine all outputs.
- 3 (Satisfactory): the student was able to correctly determine 3-5 outputs.
- 2 (Below expectation): the student was able to correctly determine 1-2 outputs.
- 1 (No Progress Shown): the student was unable to correctly determine any outputs.

Question for Outcome (b)

In the following comparator circuit, $V_{s+} = 10V$, $V_{s-} = -10V$. Also note that $V_2 < V_1$. Fill out the output voltage when the input voltage is in the ranges specified in the table.

	V_{o1}	V_{o2}
$v_i > V_1$		
$V_1 > v_i > V_2$		
$v_i < V_2$		



ABET Outcome (e): Engineering problem solving:

Students were asked, using provided resistors and a voltage source, to design a circuit that can provide a specified voltage. The students need to be able to solve the problem with a voltage divider and express their work by drawing circuit schematic with resistor values clearly marked and the output voltage terminals clearly labeled. (Exam question shown below)

Rubrics for Outcome (e)

- 4 (Superior): the student was able to solve the problem with a voltage divider, correctly calculate the resistor values, label these values to the schematic, and mark the output voltage node.
- 3 (Satisfactory): the student was able to solve the problem with the voltage divider idea, but had minor mistakes in calculating the resistor values, labeling these values to the schematic, and marking the output voltage node.
- 2 (Below Expectation): the student was able to come up with the voltage divider idea, but failed to complete all of the following: resistor value calculation, schematic labeling, etc.
- 1 (No Progress Shown): the student was unable to come up the voltage divider idea.

Question for Outcome (e)

You are given a 5V source and a box of resistors with values shown in the table below. Use the provided parts to design a circuit that can provide a voltage of 3.5V. **You must draw the circuit schematic with resistance values clearly labeled and the 5V, ground, and the 3.5V node clearly marked.**

10 Ω	15 Ω	47 Ω	100 Ω	150 Ω	270 Ω	330 Ω	470 Ω	510 Ω	680 Ω	820 Ω	1 k Ω
1.2 k Ω	2 k Ω	3 k Ω	3.3 k Ω	4.3 k Ω	5.6 k Ω	6.8 k Ω	10 k Ω	12 k Ω	15 k Ω	20 k Ω	33 k Ω
47 k Ω	51 k Ω	100k Ω	200k Ω	330k Ω	510k Ω	1.0M Ω	2.0M Ω	5.1M Ω	10 M Ω		

D. Results:

The data collected with the instruments described in the previous section are compiled and presented graphically in this section. For *ENGR 3014—Circuit Analysis*, Figures 2, by comparing the experiment to control group, illustrate students' subject opinions on how they had achieved the course objectives defined in the syllabus (instrument: end-of-semester survey). Figure 3 compares the experiment and control groups and shows how the students' perception of engineering as an academic discipline and professional career "improved" before and after the semester (instrument: modified Pittsburgh engineering survey). Figure 4 is the side-by-side experiment/control comparison of the assessment results from target questions in the final exam. Figure 5 displays the completion time of the Capacitor Charging and Discharging lab.

1. I am able to analyze DC circuits
2. I am able to find Thevenin and Norton equivalencies
3. I am able to analyze AC steady-state responses of resistance, inductance, and capacitance
4. I am able to perform calculation of transient responses of capacitors and inductors
5. I am able to analyze AC circuits in the frequency domain
6. I am able to perform DC and AC steady state power calculations
7. I am able to construct circuits on breadboards and perform electrical measurements
8. I am able to use MATLAB to analyze engineering problems and present results

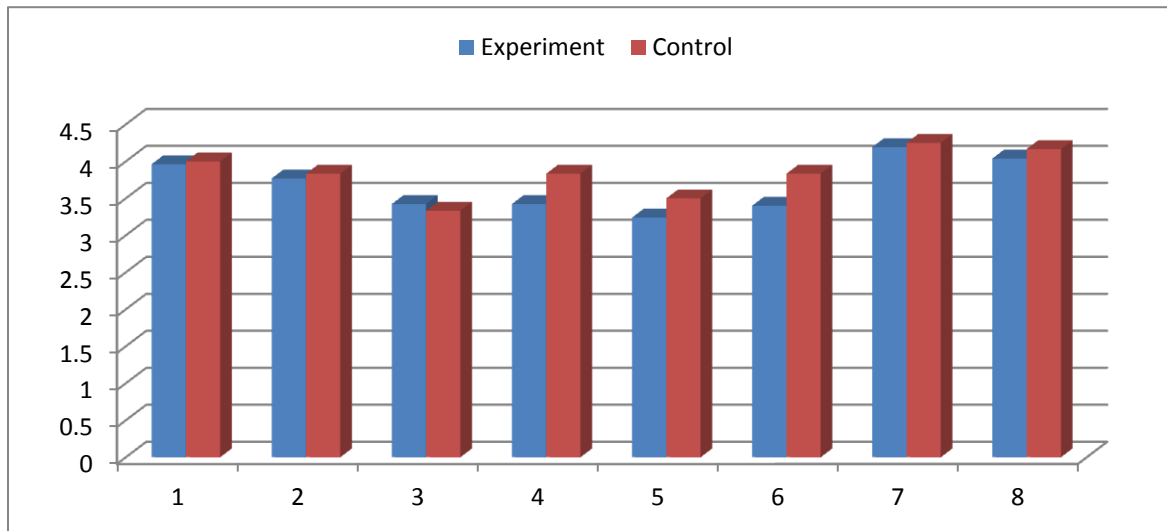


Figure 2. Student course objective self evaluation for ENGR 3014.

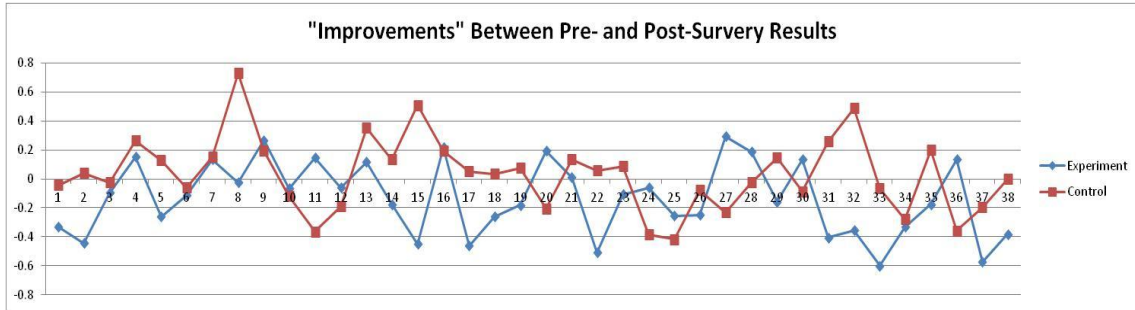


Figure 3. Changes of students' responses to Pre- and post- Modified Pittsburgh Engineering Survey for ENGR 3014.

1. Ability to build a voltage divider to provide a specified voltage source
2. Ability to use multimeter and other equipment
3. Ability to interpret experiment data
4. Ability to solve differential equations
5. Ability to use MATLAB in circuit design projects.

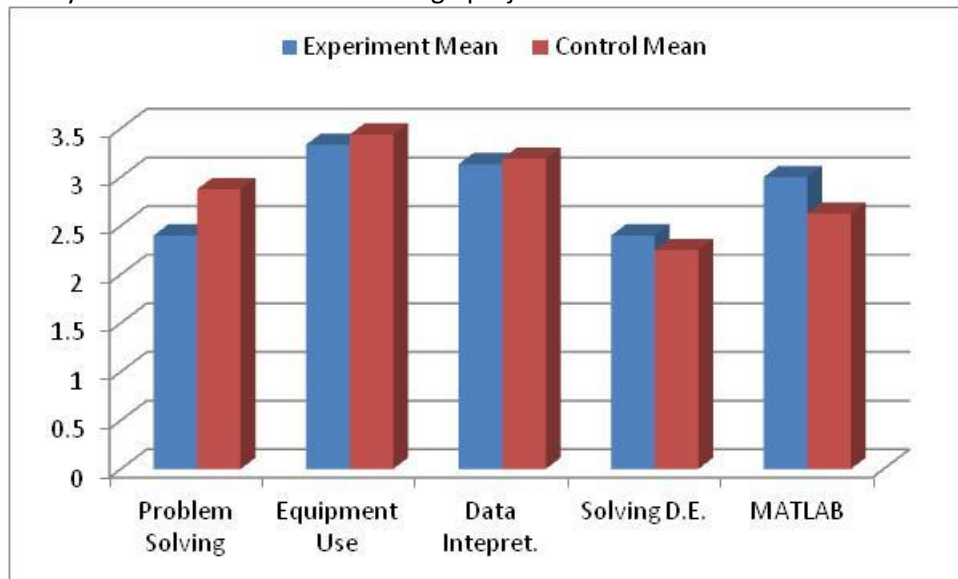


Figure 4. Learning outcomes assessment results from target questions in final exam.

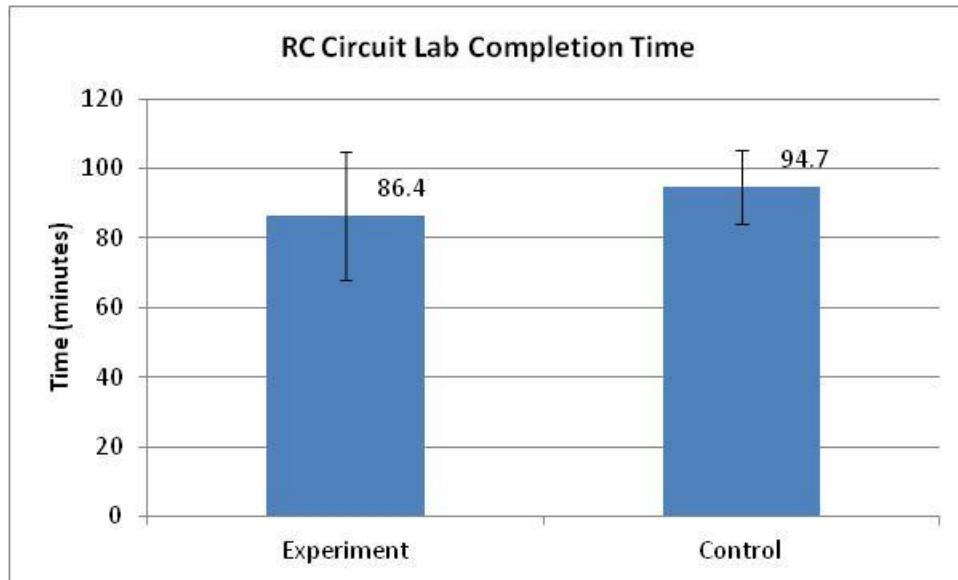


Figure 5. Completion time of the Capacitor Charging and Discharging lab in ENGR 3014.

For *ENGR 3050—Instrumentation and Controls*, only the pre- and post-survey results from the modified Pittsburgh survey are shown in Figure 6.

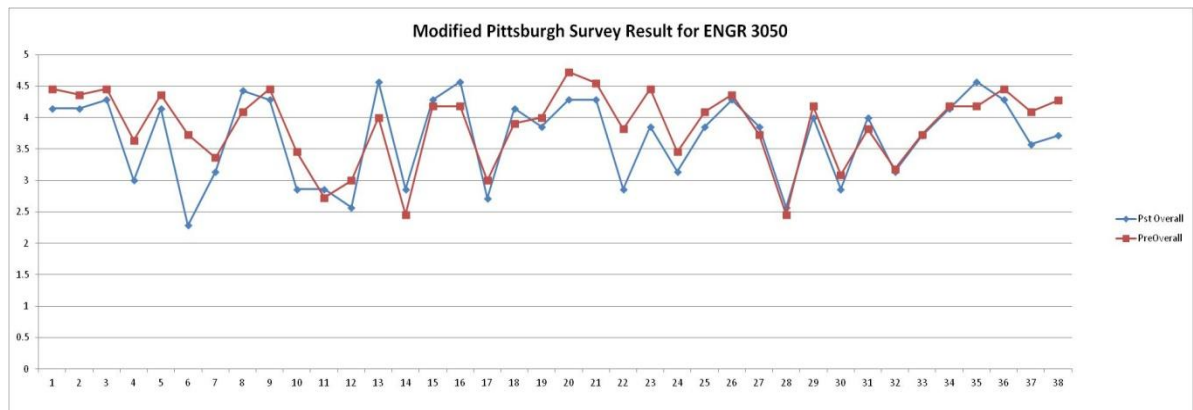


Figure 6. Students' response to the pre- and post- Modified Pittsburgh Engineering Survey for *ENGR 3050*.

E. Discussion

Several positive points can be observed from the results summarized in the previous section. From Figure 5, we noticed that averagely the experiment group needed less time to complete the Capacitor Charging/Discharging lab than the control group, meaning that the tool did help them build the circuits and observe the charging and discharging waveforms. After completing all the laboratory steps, most of the students in the experiment group were able to move to higher level discussion as hoped: the charging/discharging process is not only studied by observing current and voltage changes on oscilloscopes, but also from the energy conversion perspective (i.e., energy stored in the capacitor when being charged and dissipated by the resistor and heat generated when discharged). A more interesting point is, as indicated in the figure, the standard deviation of the completion time for the experiment group is larger than that of the control group, suggesting students preparation with the tool varied greatly, while the control group could conduct this lab more consistently. For those students who had prepared well, it took them only one hour to

finish the required work; for the others who did not take advantage of the tool, it actually took them longer time than those without the tool, possibly because of the extra level of complexity involved in using the portable tool.

A similar completion time observation was made in *ENGR 3050—Instrumentation and Controls* class, although exact amount of time was not recorded: we have been using the first three lab sessions to train LabVIEW for 5 years. This was the first time that students, with LabVIEW installed on their laptops, were able to complete programming tasks within half of the time that these labs required in the past.

It has also been observed that students in the experiment group were more active and asked more questions during the semester. This is probably because that the new tool involved more challenges, which, from a different perspective, were learning opportunities. These opportunities enriched students learning experience. In some activities, it took the experiment group more time than the control group to achieve the same objectives. The extra time spent might actually result in enriched learning.

When we examine Figures 2, 3 and 6, however, comparison of experimental and control groups and pre- and post-semester results do not suggest that the introduction of the PEEK did not significantly change student learning. Multiple speculations may explain these results: (1) teaching and learning is a complex process sensitive to many factors and laboratory tools are only one of the many. The contribution of the new tools could be completely masked by the other factors; (2) the assessment instruments, although both subjective and objectives ones are carefully selected here, might not measure laboratory learning effectively, confirming the conclusion that the assessment of laboratory work is tricky made in [9].

Figure 4 shows that in the three assessed areas (voltage divider, equipment using, and data interpretation) that are more closely related to electronic hand-on laboratory, the experiment group did not do as well as the control group; whereas in the other two areas (differential equation and MATLAB) they outperformed the control group. It appears that the experiment group students are at least as competitive as their control counterparts. A further investigation of both groups' GPA (see Figure 7) confirmed this: the average GPA of the experiment group was actually slightly higher than that of the control group. We may have to conjecture, although the authors are reluctant to make such a point, that the introduction of the PEEK toolsets (which are understandably not as mature as their benchtop commercial counterparts) might have somewhat puzzled this group of general engineering students, many of whom had not had any circuit's background and were simply unable to take advantage of these tools to the extent one would hope.

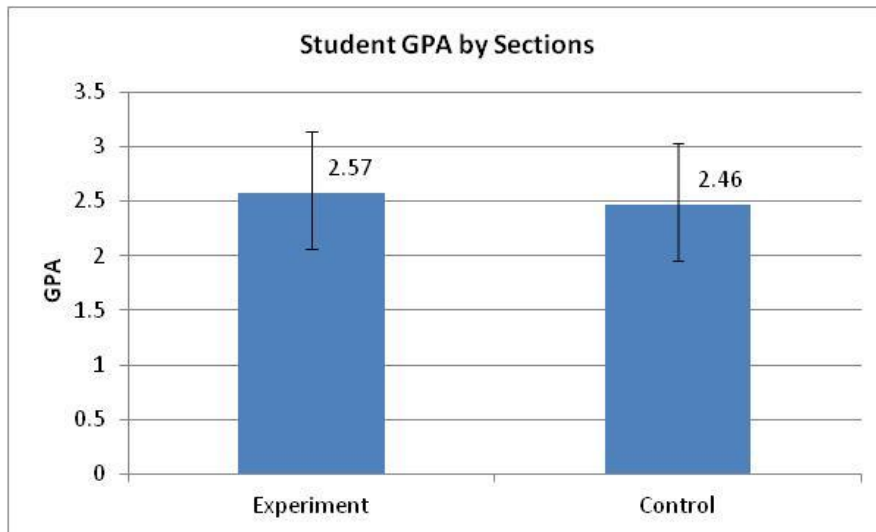


Figure 7. Students' GPA average for the ENGR 3014 class.

F. Conclusions

This paper presents a two-year experience of using portable experiment kits to expand student laboratory learning from centralized setting to a distributed environment. Two courses in a general engineering program were piloted with this tool. From the results, we found that these tools, when students take advantage of them, can be very helpful and provide more flexibility and richer learning experience. Observation showed that *ENGR 3050—Instrumentation and Controls* students felt more comfortable using these tools than *ENGR 3014—Circuit Analysis* students. After exploring various assessment instruments, the project also found that assessment of student laboratory learning can be tricky: assessment results from collected data might not sensitive to the impact from employed technology interference. After two years of working with these personal, portable tools, the authors are more cautious when attempting to apply similar tools to general engineering students, especially to lower level courses. However, the authors still firmly believe that the transformation of engineering laboratory learning will play an important role in order to meet challenges identified in [10].

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Opinions on Engineering Survey

(This survey is modified from the Pittsburgh Freshman Engineering Survey[®])

This is a survey to elicit your, as an Engineering student, opinions and feelings about engineering. Please do not spend more than 5 minutes to complete the questionnaire, so work as quickly as you can. For each statement about engineering, please fill in the number that corresponds to how strongly you disagree or agree with the statement.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. I think that engineering is a rewarding career.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
2. I think that studying engineering is rewarding.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
3. The advantages of studying engineering outweigh the disadvantages.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
4. I don't care for this career.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
5. The future benefits of studying engineering are worth the effort.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
6. The rewards of getting an engineering degree are not worth the effort.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
7. From what I know, engineering is boring.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
8. Engineers contribute more to making the world a better place than people in most other occupations.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
9. Engineers are innovative.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
10. I will have no problem finding a job when I have obtained an engineering degree.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
11. Engineering is an exact science.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
12. I enjoy taking liberal arts courses more than math and science courses.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
13. As a future engineer, I can do something to improve the welfare of society than most other professions.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
14. I am studying engineering because it will provide me with a lot of money; and I cannot do this in other professions.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
15. I am studying engineering because I am interested in making things happen; and I cannot do this in other professions.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
16. Engineers have contributed greatly to fixing problems in the world.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
17. An engineering degree will guarantee me a job when I graduate.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
18. Engineers are creative.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
19. Engineering involves finding precise answers to problems.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
20. I enjoy figuring out how things work.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
21. Technology plays an important role in solving society's problems.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
22. Electronics is my thing; I love it.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
23. I feel I know what an engineer does.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
24. Studying in a group is better than studying by myself.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
25. I feel hands-on skills are my strength.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
26. I have strong problem solving skills.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
27. I am good at using electronic gadgets.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
28. Most of my friends that I 'hang-out' with are studying engineering.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
29. I feel confident in my ability to succeed in engineering.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
30. I prefer studying/working alone.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
31. I am good at designing things.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
32. In the past, I have not enjoyed working in assigned groups.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
33. I am confident about my current study habits or routine.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
34. I consider myself mechanically inclined.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
35. I consider myself technically inclined.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
36. I enjoy building things and make them work.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
37. I enjoy solving open-ended problems.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
38. I enjoy problems that can be solved in different ways.	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5