Bridging the Gap: Sensor-Based Automation Across Grade Levels

Creighton Bryan
Garland ISD

Lee McMains
Aims Community College

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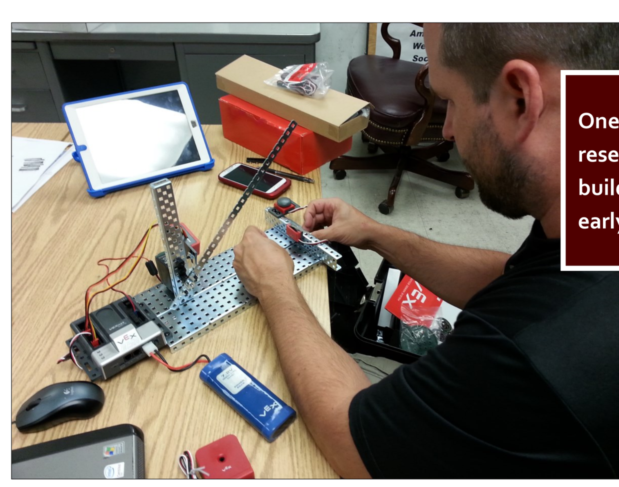
ABSTRACT

This research explores how to bridge the gap between high school robotics & automation courses and collegiate industrial automation courses. The expectation is that a firm understanding of sensor-based automation in high school better prepares students for college-level topics such as programmable logic controllers (PLCs) and instrumentation.

RESEARCH OBJECTIVES

Our objective was to design a lesson with hands-on activities and assessments that could be used to teach sensor-based automation in both high school and undergraduate college classrooms. The goal was to create a bridge between high school robotics classes and industrial automation at the college level.

The module's intent is to use classroom discussion and small-group activities to introduce input sensors and output actuators from commercial robotics and automation kits. We expect that the commercial microcontroller will be replaced with an industrial-grade PLC in advanced high school and college -level groups.



One of the researchers building an early project.

We wrote the lesson plan, activities, and assessments with an eye toward introducing vocabulary and skills that would enhance high school students' success in college.

METHODOLOGY

We began our research by identifying the skills we wanted our students to gain; we developed module objectives based on Texas Essential Knowledge and Skills (TEKS), Colorado Community College Standard Competencies (CCCS), and International Technology Education Association Standards (ITEA). From the objectives we built diagnostic, formative, and summative assessment tools. We built the lesson and activity using the *Teach Engineering* template.

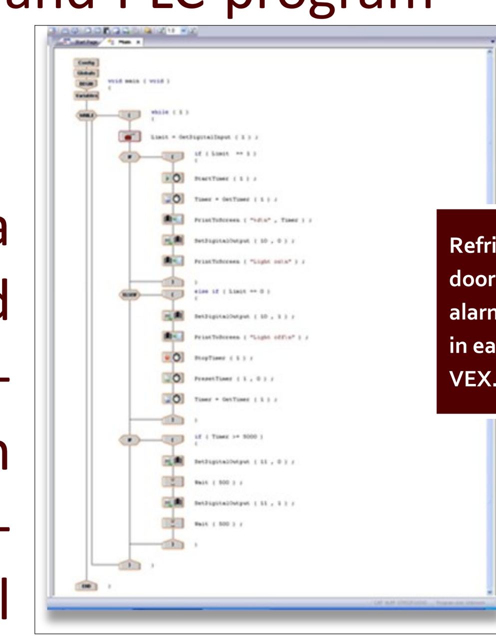
One of the researchers testing an early build using a PLC.

Group activity rubric.

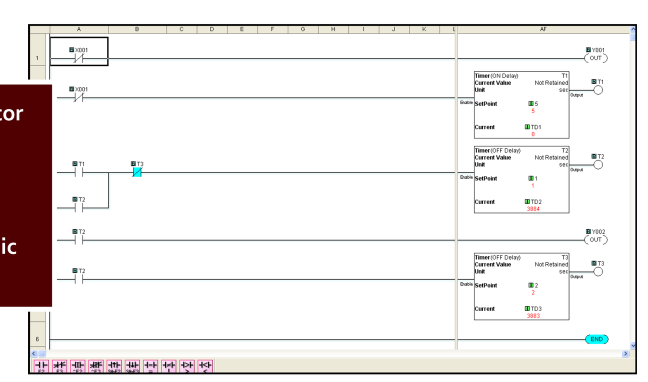
	Advanced	Proficient	Improving	Beginning
Input Identification (15%)	Correctly identifies a superior input device for the defined input parameter.	Correctly identifies a functional input device for the defined input parameter.	Is unable to identify which input device is best for the application.	Is unable to identify the function of available input devices.
ut Selection (15%)	Selects a superior input device from a list of available input devices.	Selects a workable input device, but not among the best choices for the application.	Selects a device that cannot sense the (defined) input parameter.	No input device is present.
tput Identification (15%)	Correctly identifies a superior output device for the defined output parameter.	Correctly identifies a functional output device for the defined output parameter.	Is unable to identify which output device is best for the application.	Is unable to identify the function of the available output devices.
Output Selection (15%)	Selects a superior output device from a list of available output devices.	Selects a workable output device, but not among the best choices for the application.	Selects a device that does not provide the (defined) needed response.	No output device is present.
Assembly (15%)	The system is assembled to function properly with no flaws in structural design.	The system is assembled to function properly with only minor (non-essential) flaws in structural design.	There is a major (essential) flaw in the assembly.	Components are not assembled.
Input-Based Decisions (15%)	Correctly uses data from the input device to modify the system's state.	Correctly uses data from the input devices to modify some aspect of the system's state.	Output is not dependent on input.	Logic processor is not programmed.
Submission Interview (10%)	Students provide superior answers to all questions.	Students provide sufficient answers to most or all questions.	Students provide sufficient answers to some questions.	Students are not able to answer the questions.

We performed literature reviews and researched sensor and actuator theory, as well as microcontroller and PLC programming methods.

We built a public garage barrier using a fischertechnik kit. We then replicated the project twice: once with a VEX microcontroller and another with an Allen Bradley PLC. We then designed, assembled, wired, and programmed identical refrigerator door light & alarm projects using VEX and a CLICK PLC.



Refrigerator door light and alarm written in easyC for VEX.



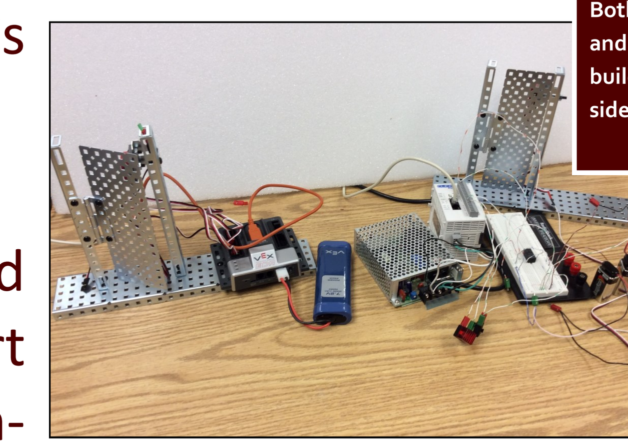
Refrigerator door light and alarm written in ladder logic for PLC.

The PLC builds gave us several chances to hone our electronics and troubleshooting skills and learn more about timers.

RESULTS & CONCLUSIONS

An automated system made from a commercial robotics kit is distinctly different from one using a PLC. Build & wire times for a commercial kit are very short and the programming is more involved. Programming a PLC is straightforward, and requires significantly greater build & wiring times.

The lower investment & difficulty associated with commercial robotics kits make them well-suited to introduce concepts in high schools. Advanced electronics theory & increased costs make PLCs better-suited for colleges.



Both VEX (l) and PLC (r) builds side by side.

The module that we developed will stretch students' comfort zones and help them develop important science & engineering skills that they may apply immediately upon entering the college system.

REFERENCES

1. "91083 E-Tech Module." *Fischertechnik Products*. Fischertechnik GmbH. Web. 10 June 2014. <http://www.fischertechnik.de/en/desktopdefault.aspx/tabid-20/38_read-30/usetemplate-2_column_pano/>.
2. "Introducing MOSS." *Modular Robotics*. Modular Robotics Incorporated. Web. 10 June 2014. <http://www.modrobotics.com/moss/>.
3. "CLICK PLC User Manual." *CLICK PLC User Manual*. Automation Direct. Web. 3 July 2014. <http://www.automationdirect.com/static/manuals/c0userm/c0userm.html>.
4. "MicroLogix 1000 Programmable Controllers." *User Manual (Bulletin 1761 Controllers)* (1998) *1761-6.3, MicroLogix 1000 Programmable Controllers*. Rockwell Automation Literature. Web. 30 June 2014. <http://literature.rockwellautomation.com/idc/groups/literature/documents/um/1761-um003_-en-p.pdf>.
5. "Sensors - Robot Accessories - Products - VEX - VEX Robotics." *VEX Robotics*. Innovation First International. Web. 10 June 2014. <http://www.vexrobotics.com/vex/products/accessories/sensors>.
6. "Get Involved: Submit Curriculum."*TeachEngineering - Resources for K-12*. Web. 17 June 2014. <http://www.teachengineering.org/submit_curricula.php>.

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Mentor: Dr. Sheng-Jen "Tony" Hsieh   Graduate Assistant: Yunyi Wang