

**Development and Evaluation of a Variable-Frequency Drive Trainer for use in a University  
Agricultural Electricity Course**

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## Introduction

Through the years, as American agriculture has developed, it has become gradually dependent on mechanization (Hunt, 2001). National professional standards (American Association for Agricultural Education, 2017) call for curriculum which “demonstrates awareness of cutting edge technology in agriculture” (p. 2) and “teach[es] students how to use technology appropriate to the agricultural industry” (p. 2). Considering this challenge, educators are tasked to ensure that their curriculum is relevant to the ever-changing environment present in agricultural mechanics (Shultz, Anderson, Shultz, & Paulsen, 2014). However, many school-based agricultural education programs lack the tools, equipment, and finances to effectively teach the current curriculum (McCubbins, Wells, Anderson, & Paulsen, 2017), much less more advanced applications.

Educational trainers are used to expose students “to relatively complex scenarios in a safe learning environment” (Wright et al., 2018). In this study, we sought to develop and evaluate a low-cost variable frequency drive trainer and laboratory activity for use in an undergraduate agricultural electricity course. Commercially-available VFD trainers such as the LearningLab (Dugger, IN) VFD trainer range in cost from \$2,595 to \$2,861, depending on the vendor, making it difficult for agricultural systems management programs to provide class quality trainers for student laboratory use. Due to this high cost of VFD trainers, we determined a need to develop and evaluate a low-cost (under \$600) VFD trainer and activity that would allow programs on limited budgets to provide several units for student use.

## Methodology

We developed the VFD trainer by using a Lenze (Uxbridge, MA) SMVector ESV371-1S model VFD and a Leeson (Grafton, WI) model C4T34FB5B 208-230 VAC three-phase motor. A complete list of materials and description of the VFD trainer can be found in Teekell, Hilaire, and Johnson, (2017). The laboratory activity required students to make basic calculations to find and set minimum and maximum frequencies of motor speed. Students’ then were required to program the VFD to set a 5-second motor acceleration and deceleration times. Next, students calculated and programmed the current output percentage so the VFD would provide the motor with overload protection. Lastly, students operated the motor, recorded the VFD output frequency, measured motor RPM with a digital tachometer, calculated and set the display frequency multiplier so the VFD displayed indicated motor RPM.

All students ( $N= 23$ ) enrolled in AGME 3173 during spring 2018 received classroom instruction in basic VFD operating principles. Immediately following completion of the activity, students ( $n= 21$ ) completed a voluntary seven item Likert-type survey (1 = strongly disagree and 4 = strongly agree) designed to assess their previous experience with VFD (two items) and their perceptions of the effectiveness of the VFD trainer and associated laboratory activity as a learning experience (five items). A panel of three experts in educational research and technical education examined the survey and deemed it to possess face and content validity. *Post hoc* analyses determined coefficient alpha reliabilities of .85 and .87 for the summated scales measuring students’ prior experiences and perceptions of educational effectiveness, respectively.

## Results

Students enrolled in AGME 3173 reported little exposure to VFDs prior to the classroom study and completion of the trainer-based laboratory activity. The mean score of the two item scale measured familiarity was 1.67 ( $SD = 0.97$ ) with median and modal score both being 1.0. This indicated that students disagreed that they had prior experiences with VFDs prior to the laboratory activity. Upon completion of the laboratory activity, students agreed that the VFD trainer and activity were effective in helping them learn and understand VFDs. The mean score on the five item scale measuring effectiveness was 3.51 ( $SD = 0.58$ ) with a median score of 3.60 and a modal score of 4.0. This indicated students were in agreement that the trainer and laboratory activity were effective in helping them learn and understand the operation and programming of VFDs. Table 1 summarizes responses from students for previous exposure to VFDs and perceptions of the learning ability by scale and item.

**Table 1.**

Student ( $n = 21$ ) perceptions of previous exposure to VFDs and effectiveness of trainer-based laboratory activity

<b>Summated Scale</b>			
Individual Item	<i>M</i>	<i>SD</i>	<i>Mdn</i>
<b>Previous Experience</b>	<b>1.67</b>	<b>0.97</b>	<b>1.0</b>
I was familiar with VFDs <u>prior</u> to this class.	1.76	1.04	1.0
I had hands-on experience with VFDs <u>prior</u> to this lab activity.	1.57	1.03	1.0
<b>Educational Effectiveness</b>	<b>3.51</b>	<b>0.58</b>	<b>3.6</b>
The hands-on experience with the VFD trainer increased my understanding of this technology.	3.52	0.81	4.0
I know more about VFDs as a result of this laboratory activity.	3.62	0.50	4.0
Using the VFD trainer helped me learn about this technology.	3.62	0.59	4.0
I feel confident that I have a basic understanding of VFD theory.	3.33	0.87	4.0
I feel confident I understand how to operate a VFD.	3.48	0.75	4.0

*Note.* Based on a scale where 1 = strongly disagree and 4 = strongly agree

## Summary and Conclusions

We constructed a safe, functional VFD trainer for a unit cost of \$534.70. This trainer when constructed with the materials listed above came in at a cost of approximately 20% of the retail cost of a commercially available VFD trainer. Survey results indicated that students possessed little prior knowledge or experience of VFD indicating a need for a hands-on experience and operation due to the growing importance of VFDs in agriculture. The results also indicated that this laboratory exercise was an effective learning experience for students in AGME 3173. Finally, we concluded that the VFD trainer and lab activity were economical and educationally effective additions to our undergraduate agricultural electricity course. We intend to construct three additional trainers for use in future semesters. The addition of more VFD trainers will allow us to expand the scope of our lab and still allow the students to finish the activity in a two hour lab period.

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