

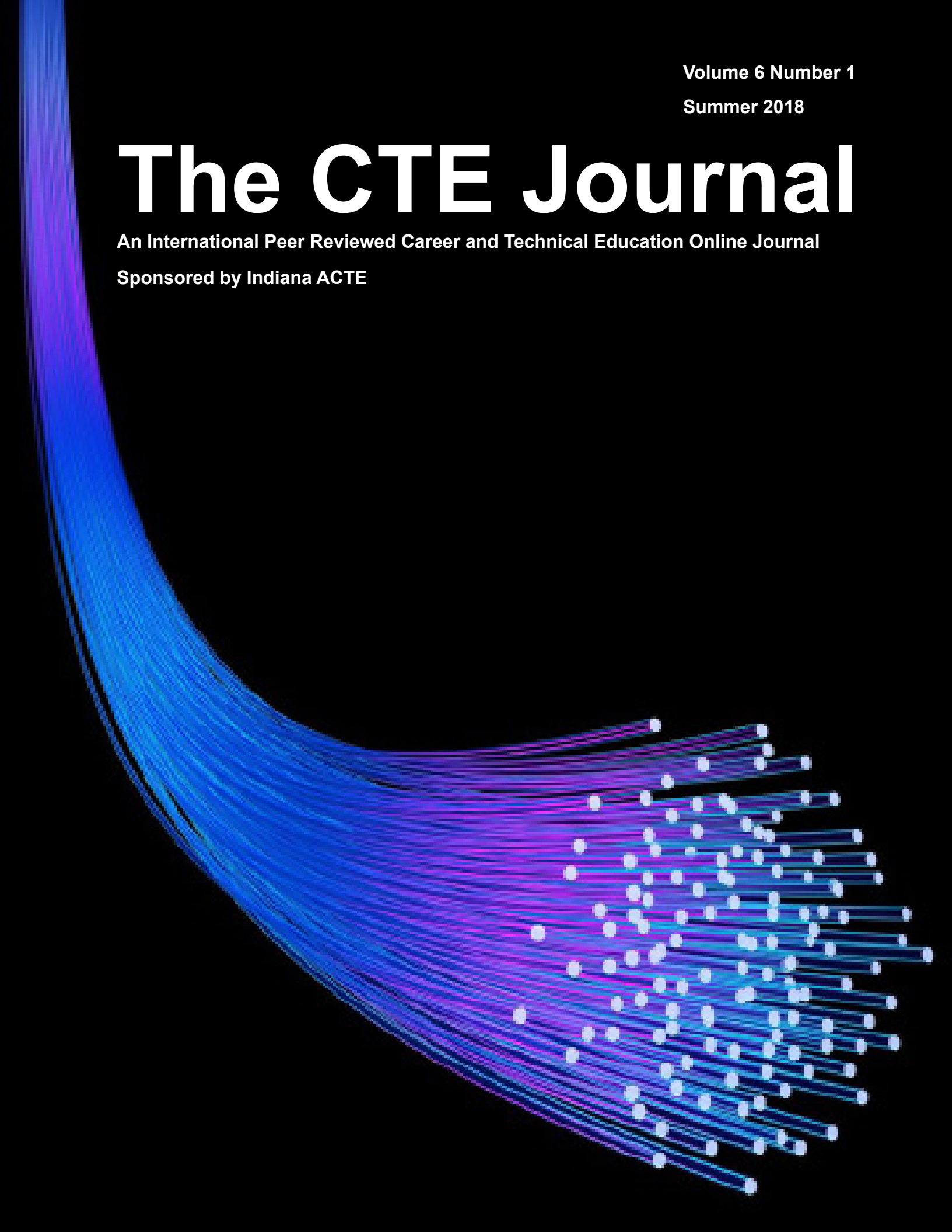
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## **The Utilization of an Alternative Welding Consumable Management Strategy in a School-based Agricultural Mechanics Course: A Preliminary Quasi-Experimental Study**

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### **Abstract**

Laboratory instruction remains prominent within school-based agricultural education programs (Phipps, Osborne, Dyer, & Ball, 2008), particularly in the realm of agricultural mechanics. Welding occupies a prominent content area within agricultural mechanics (Anderson, Velez, & Anderson, 2014). As such, consumable materials, such as welding electrodes, can occupy a significant expense within program budgets (Saucier, Vincent, & Anderson, 2014). Using a quasi-experimental design and guided by Ajzen's (1985) theory of planned behavior, this preliminary study examined the use of an alternative electrode management strategy and its effects on waste material production and cost to an agricultural education program. The results of the present study suggested that the use of the alternative micromanagement strategy resulted in minimal, negligible cost savings; however, the use of the micromanagement strategy did decrease the quantity of electrode waste. Perhaps agricultural education teachers should instead focus upon intensive micromanagement of consumable metals used during welding activities. The researchers suggest that agricultural education teachers should, in order to decrease consumable electrode costs, work to purchase electrodes directly from manufacturers instead of through welding supply distributors. The researchers recommend that this study be replicated in additional agricultural education programs. Replication efforts should develop and utilize a true experimental design.

### **Introduction**

Laboratory instruction remains a prominent teaching arena within school-based agricultural education (SBAE) programs (Phipps, Osborne, Dyer, & Ball, 2008; Shoulders & Myers, 2012). Within laboratory settings, students are granted opportunities to engage in critical thinking to solve problems, psychomotor skill development to enhance technical performance, and project-based learning to apply newly-learned skills and thinking to a physical apparatus (Phipps et al., 2008; Shoulders & Myers, 2012; Wells, Perry, Anderson, Shultz, & Paulsen, 2013). A wide variety of teaching

environments are used within SBAE, including greenhouses, livestock facilities, and agricultural mechanics laboratories (Phipps et al., 2008; Shoulders & Myers, 2012). Perhaps one of the most common laboratory facility, agricultural mechanics facilities are in a substantial number of SBAE programs across the United States (Burris, Robinson, & Terry, 2005; Shoulders & Myers, 2012; Shultz, Anderson, Shultz, & Paulsen, 2014; Wells et al., 2013).

Within agricultural mechanics laboratories, a variety of content is addressed that ranges from electricity, welding and metal fabrication, and carpentry, to plumbing, power machinery repair, and soil and water conservation (McCubbins, Anderson, Paulsen, & Wells, 2016; Shultz et al., 2014; Wells et al., 2013). This broad expansion and diversity of content is designed to allow for a considerable breadth of skills-based education that can be useful to a broad audience of students (Phipps et al., 2008). Further, this expansive list also provides a multitude of opportunities for career area exposure for students, ultimately broadening their horizons and expanding their thinking about future possibilities (Phipps et al., 2008). One such agricultural mechanics content area that has remained popular for both agricultural education teachers and students is welding (Anderson, Velez, & Anderson, 2014; Burris et al., 2005). As many programs include welding instruction as a considerable portion of the delivered content (Anderson et al., 2014; McCubbins et al., 2016), teachers must pay special attention to the role that the content area plays within SBAE programs, including budgetary decisions, equipment and facilities management, and student interests and engagement during instructional sessions (Phipps et al., 2008).

As described by Herren (2015), welding is the process by which heat is used to melt and join two individual pieces of metal together into one whole piece. This process is accomplished by using a welding machine that converts electrical energy into heat energy to melt metal at a specific location. The most common welding processes utilize an electrode that varies by process type, and can range from “[flux-] coated metal rods” (Herren, 2015, p. 389) to copper wire to tungsten, depending upon the welding process being used. Regarding welding processes, shielded metal arc welding (SMAW), gas metal arc welding (GMAW), gas tungsten arc welding (GTAW), and flux-cored arc welding (FCAW) are most often taught within agricultural mechanics laboratories in SBAE, with each process requiring specific equipment and materials necessary to complete its designated welding task (Herren, 2015). These significant differences between each welding process influence and dictate the actions that occur during each. For example, the SMAW process utilizes a flux-coated rod that serves as the consumable electrode, which burns and decreases in quantity available during the welding process, while the GTAW process uses a non-consumable tungsten electrode that can be used repeatedly, so long as the electrode is maintained and kept clean (Herren, 2015). The differences between welding process types and the equipment needed (i.e., electrodes and other consumables) to successfully perform each process have influence over the initial inputs, such as budgetary concerns, related to the teaching and learning of welding

content within SBAE program settings. For the purposes of the present study, the researchers have selected to focus on the SMAW process.

### **Cost Considerations for Laboratory-based Welding Instruction**

Available funding and budgets for agricultural mechanics laboratories can hold influence over the content taught, tools, equipment, and work materials available for use, as well as the utility of the laboratory facility itself (McKim & Saucier, 2013; Saucier, Vincent, & Anderson, 2014). As such, each of these factors can contribute significantly to the overall structure of agricultural mechanics education within SBAE programs (Saucier et al., 2014). As part of these financial considerations related to teaching materials, the overuse of consumables can devour a significant portion of program budgets if left unchecked (Saucier et al., 2014). Consumables used within agricultural mechanics laboratories are often costly (McKim & Saucier, 2013); thus, their efficient use is requisite. In terms of agricultural mechanics instruction, consumables within a welding unit can include welding gases, welding wire, filler rods, metal, and, in the scope of the present study, welding electrodes (Herren, 2015).

Recent research (McKim & Saucier, 2013; McKim & Saucier, 2012) has helped to describe the scope of laboratory management competencies of agricultural mechanics teachers. Interestingly, McKim and Saucier (2013) found that agricultural mechanics teachers' "...average [consumables] budget increased between 1989 and 2008, by nearly \$500" (p. 162), to an average total of \$2,900. However, this overall budget increase did not keep pace with inflation over the same period of time. As also noted by McKim and Saucier (2013), "...the average agricultural mechanics consumable supply budget would have needed to increase to \$4,349... to account for inflation alone" (p. 162). This inadequate increase in available funding can result in quite the challenge for agricultural mechanics instruction, quite possibly limiting prospective projects, content areas, and other means of teaching (Saucier et al., 2014). As the consumable supplies for teaching welding content are quite expansive and can include specialized tools and equipment (e.g., welding machines, wire brushes, etc.), metal for student practice plates and projects, safety equipment, as well as welding electrodes, these items and their effective and efficient usage must be factored into laboratory management and instructional planning.

Besides metal, electrodes remain the most largely used and expensive consumable item used within the process of teaching and learning of welding skills (The ESAB Group, 2000). Thus, the wide and efficient use of welding electrodes is vital in proper agricultural mechanics laboratory budget management. Regarding the efficiency of welding electrode usage, the welding industry has given considerable effort to minimizing consumable material loss (The ESAB Group, 2000). As the purpose of welding is the melting and joining of metals through the use of a heat-transferring electrode (Herren, 2015), filler metal within the electrode is deposited to help form and complete the weld (The ESAB Group, 2000). Thus, deposition efficiency remains a factor in electrode usage and management. Deposition efficiency is calculated based on the total weight of the weld metal deposited during the welding process divided by the

weight of the electrode that was consumed during the welding process (The ESAB Group, 2000). This formula, as defined by The ESAB Group (2000) can be expressed as:

$$\text{Deposition efficiency} = \frac{\text{Weight of weld metal}}{\text{Weight of electrode consumed}}$$

Understanding deposition efficiency, which does vary between electrode types and sizes (The ESAB Group, 2000), allows for a greater understanding of the consumption of welding electrodes and, as a result, welding consumables management. Any unnecessary loss of welding electrode can result in decreased efficiency of consumables usage, and thereby increase the costs associated with welding (The ESAB Group, 2000). Regarding this efficiency, the formula described by The ESAB Group (2000) and given below provides a method of mathematical calculation of welding electrode efficiency.

$$\text{Efficiency minus stub loss} = \frac{(\text{Electrode length} - \text{Stub length remaining}) \times \text{Deposition efficiency}}{\text{Electrode length}}$$

These factors ultimately provide great contribution to the costs associated with providing consumable materials (i.e., electrodes) for laboratory instruction in welding. As such, laboratory instruction quantity and quality can be greatly influenced by the resources available (McCubbins et al., 2016; McKim & Saucier, 2013). These resources, while including tools and equipment, certainly encompass consumable welding electrodes that, ultimately, are used by students during the welding process (Herren, 2015). However, in addition to the concepts given previously (i.e., deposition efficiency, etc.), the human capital factor (e.g., students enrolled in agricultural mechanics coursework) must be accounted for. Moreover, as secondary students have often had little welding exposure prior to agricultural mechanics courses, it could be expected that this particular group would consume a greater amount of welding electrodes than older, more experienced welders. In seeking to determine more efficient agricultural mechanics laboratory budget administration, the researchers explored the possibility of implementing an alternative method of welding consumables management.

### **Theoretical Framework**

To frame and guide the present study, the researchers utilized Ajzen's (1985) theory of planned behavior. Per Madden, Ellen, and Ajzen (1992), "[t]he theory of planned behavior (Ajzen, 1985) extends the boundary condition of pure volitional control... by including beliefs regarding the possession of requisite resources and opportunities for performing a given behavior" (p. 4). Further, this theory was selected based upon the notion of using an alternative management strategy to monitor students' use and consumption of consumable welding electrodes. A modified version of this theory is presented in Figure 1 below.

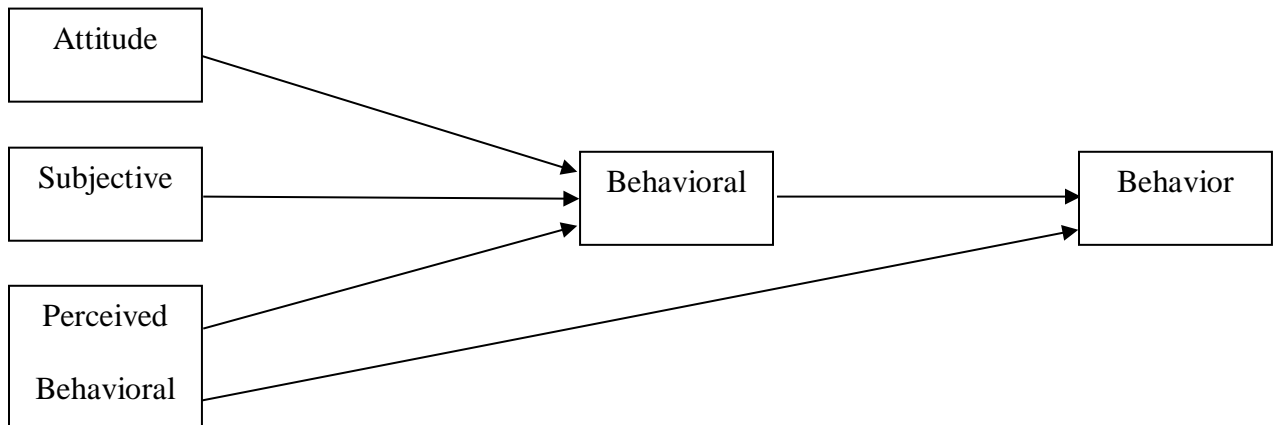


Figure 1. Modified version Ajzen's (1985) theory of planned behavior.

Regarding the utilization of this particular theory for the present study, the factors that were most focused upon were *Perceived Behavioral Control* and *Behavior*. As operationalized within the present study, *Perceived Behavioral Control* was described as the use of an alternative welding consumable management strategy to help control students' consumption of welding consumables (i.e., electrodes). *Behavior* was classified as students' performance of welding-related actions; in this instance, the output amounts (e.g., spent electrode waste) from actual use of electrodes during the welding process was the most specific item to be measured. However, the other factors of *Attitude*, *Subjective Norm*, and *Behavioral Intention* were also taken into consideration. *Attitude* was defined as the attitudes that the students within the present study had toward the welding process and their roles within it. *Subjective Norm* described students' perceptions of socially-based influences and pressures from their fellow students and their agricultural education teacher to engage in the course, its content, and activities associated with welding, while *Behavioral Intention* was regarded as motivation and perseverance to perform and follow through with the welding activities selected for the course. As each of these variables interact to produce some form of an outcome behavior, these elements, though not the primary focus of the present study, were still adequately defined and prepared for use.

### Research Question, Purpose, & Objectives of the Study

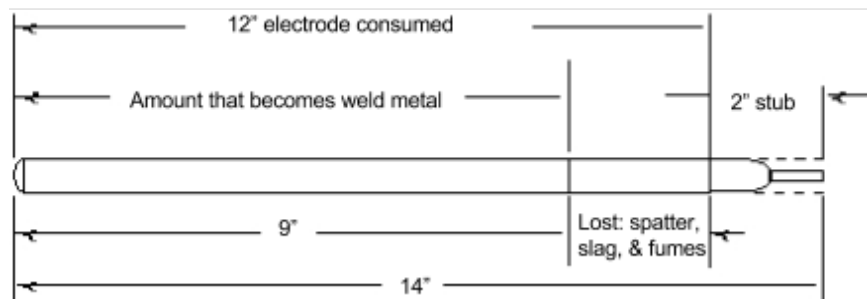
Based upon Ajzen's (1985) theory of planned behavior, the primary research question that guided the present study was: What effects, if any, would the use of an alternative welding consumable management strategy have on students' consumption of welding electrodes within a school-based agricultural mechanics setting? As such, the purpose of this study was to describe the effects that the use of an alternative welding consumable management strategy would have on students' consumption of welding electrodes. To address both the research question and this purpose, the researchers developed the following objectives:

- 1) Determine students' welding consumables usage when employing differing consumables management strategies.
- 2) Evaluate the cost-effectiveness of limiting students' access to using consumable welding electrodes.

## Methods

The present study was conducted during the 2015-2016 academic year within a section of the Agriculture III welding course at [SCHOOL] in [STATE], which had an enrollment of eight students ( $N = 8$ ). Regarding the student participants, all were junior- and senior-level students who ranged in age from 16 to 18 and had little prior welding experience. Three of the student participants were female ( $n = 3$ ), while five were male ( $n = 5$ ). At the beginning of the course, all students were given a course syllabus that detailed the activities and expectations within the curriculum, including details regarding the present study. The students were also informed that while class grades were to be assigned based on participation and successful completion of course welding activities, their performance in the present study (i.e., consumable electrode use) would not affect their grades at all.

This design for the present study was quasi-experimental in nature. Per Ary, Jacobs, and Sorensen (2010), quasi-experimental studies allow for quality research to be conducted when randomization of subjects cannot reasonably occur, such as within a school-based setting. Regarding the implementation of the study, the welding training experience was conducted over a period of 13 80-minute course meetings. Data were collected only during 10 course meetings that addressed welding. The agricultural education teacher, per the design of the study, dictated which part of the experimental process the students were participating in. The welding consumables management strategy varied by day, whereas on odd-numbered days, students were micromanaged and were not granted access to additional welding electrodes until each had less than two inches of its original length remaining. Otherwise, during even-numbered days, students were granted an unlimited allowance of welding electrodes. To provide clarity as to how the two inch length was determined, Figure Two depicts the use and deposition of a welding electrode during the welding process.





*Figure 2.* Welding electrode use and deposition. Reprinted from The ESAB Group (2000).

During the first three of the thirteen welding content-related course meetings, the agricultural education teacher covered a variety of topics pertinent to the welding content within the course. These topics included welding terminology, safety and personal protective equipment, welding machine set-up and use, metal types, welding positions and joint types, welding techniques and dexterity, and welding tools and equipment (i.e., bench grinders, etc.) and their usages. Students were also allocated time to practice using the welders and welding tools and equipment during the third course meeting.

Throughout the following 10 days, the experimental procedures of the study were implemented. During this time, all students had access to mild steel welding coupons that measured approximately one-eighth inch thick, three inches wide, and four inches long. The electrodes used in the present study were either E6011 or E6013, measured one-eighth inch in diameter and 14 inches long, were manufactured by the same electrode supplier, and were acquired at the same time to help provide congruency between the different electrodes. On the first of the 10 days, students were granted unlimited access to the welding electrodes and were assigned to work, in pairs, to develop their welding dexterity competencies, such as proper arc length, travel speed, travel angle, and work angle. Students also worked to practice creating and laying welding beads using different movement and patterning techniques that had previously been discussed during the prior three days.

During the welding activities, the agricultural education teacher observed students, critiqued welding techniques, and gave feedback to help facilitate skill development and growth. During clean-up activities at the end of this course meeting, students were instructed to place any spent welding electrode waste into a specially-marked and dated container. It should be noted that at the conclusion of each day during the study, the container of electrode waste material corresponding to that particular day was weighed using a triple beam balance. The triple beam balance was checked for accuracy and calibrated each day before use. Because the triple beam balance provided measurements in grams, these measurements were converted to ounces. This technique was repeated for the entire duration of the study.

On the second of the 10 days, students were once again assigned to work in pairs during the day's activities. In contrast to the day prior, students were not allowed to use welding electrodes at their convenience. Instead, students were only granted a new welding electrode when the current electrode had only two inches or less in length remaining, as determined by the agricultural education teacher. As during the first day of the experiment, the agricultural education teacher observed students, critiqued welding techniques, and gave feedback directly to the students. During clean-up activities at the end of this course meeting, students were instructed to place any spent welding electrode

waste into a specially-marked and dated container, congruent with procedures conducted during the prior course meeting.

During the third of the 10 days, students were instructed to work solo during the day's welding activities, which continued throughout the remainder of the study's allotted duration. Mimicking the procedures of the first day of the experiment, students had unlimited access to electrodes and coupons. Students were assigned to practice horizontal butt joint welds and were observed and provided critiquing and feedback by the agricultural education teacher. As during prior course meetings, students were instructed to place any spent welding electrode waste into a specially-marked and dated container during clean-up activities. On the fourth of the 10 experimental days, students once again worked solo to practice and compete horizontal butt joint welds and were observed and provided critiquing and feedback by the agricultural education teacher; however, as on the second day students were only granted a new welding electrode when the current electrode had only two inches or less in length remaining, as determined by the course teacher. As during prior course meetings, students were instructed to place any spent welding electrode waste into a specially-marked and dated container during clean-up activities.

Days five, seven, and nine (all odd-numbered days) continued under the same structure set forth in day three, while days six, eight, and ten (all even-numbered days) operated under the same procedures used in day four. However, the exception to this pattern was the students attempted more difficult welds during each successive course meetings. During the clean-up phase of each course meeting, students, as described previously, placed any spent welding electrode waste into specially-marked and dated containers. As depicted below, Table 1 details the course meeting number, primary activity conducted during each meeting, and the consumable electrode management strategy used during each course meeting.

Table 1.

*Course Meeting Number, Primary Activity, and Consumable Management Strategy Utilization*

Meeting / Study Day Number	Primary Activity	Consumable Electrode Management Strategy Used
1 / -	Introduction to welding, welding safety	-
2 / -	Safety test, dexterity practice activity	-
3 / -	Welding machine set-up, welding practice	-
4 / 1	Students worked in pairs; welding practice	Unlimited access
5 / 2	Students worked in pairs; welding practice	Limited access
6 / 3	Students worked solo; welding practice	Unlimited access
7 / 4	Students worked solo; welding practice	Limited access
8 / 5	Students worked solo; welding practice	Unlimited access
9 / 6	Students worked solo; welding practice	Limited access
10 / 7	Students worked solo; welding practice	Unlimited access
11 / 8	Students worked solo; welding practice	Limited access
12 / 9	Students worked solo; welding practice	Unlimited access
13 / 10	Students worked solo; welding practice	Limited access

*Note:* Unlimited access – students were not restricted in their use of electrodes;  
 Limited access – students could only use an additional electrode if the remainder of the prior electrode was less than two inches.

**Results**

Table 2 displays the lengths of the electrodes that were used during each day of the study. Study day number, the number of students participating, the total number of electrodes used, the shortest and longest electrodes measured at the conclusion of each day's welding activities, the average length of all measured electrodes used, and the consumable electrode management strategy employed each day are detailed below.

Table 2.

*Electrode Lengths Recorded Per Day of Study (Measured to Nearest 1/32")*

Study Day Number	Number of Students Participating	Total Number of Electrodes Used	Shortest Electrode Measured	Longest Electrode Measured	Average Length of All Measured Electrodes	Consumable Electrode Management Strategy Used
1	8	9	1 <sup>3</sup> / <sub>32</sub> "	13 <sup>1</sup> / <sub>8</sub> "	5 <sup>3</sup> / <sub>8</sub> "	Unlimited
2	7	16	3/4"	3 <sup>1</sup> / <sub>4</sub> "	1 <sup>5</sup> / <sub>8</sub> "	Limited
3	7	11	3/4"	13 <sup>3</sup> / <sub>4</sub> "	2 <sup>5</sup> / <sub>8</sub> "	Unlimited
4	8	23	13/32"	2 <sup>3</sup> / <sub>16</sub> "	1 <sup>1</sup> / <sub>16</sub> "	Limited
5	8	11	9/16"	10 <sup>5</sup> / <sub>32</sub> "	2 <sup>5</sup> / <sub>32</sub> "	Unlimited
6	8	9	3/4"	4 <sup>1</sup> / <sub>16</sub> "	1 <sup>13</sup> / <sub>16</sub> "	Limited
7	5	17	7/16"	2 <sup>9</sup> / <sub>32</sub> "	1 <sup>3</sup> / <sub>16</sub> "	Unlimited
8	6	15	9/16"	2 <sup>15</sup> / <sub>32</sub> "	1 <sup>3</sup> / <sub>32</sub> "	Limited
9	7	16	3/8"	1 <sup>15</sup> / <sub>16</sub> "	1 <sup>3</sup> / <sub>16</sub> "	Unlimited
10	6	17	1/2"	7 <sup>7</sup> / <sub>8</sub> "	1 <sup>19</sup> / <sub>32</sub> "	Limited

*Note:* Unlimited – students were not restricted in their use of electrodes; Limited – students could only use an additional electrode if the remainder of the prior electrode was less than two inches.

Data from Table 3 provide a comparison of electrode use between consumable electrode management types (e.g., unlimited access or limited access). Per the design of the study, all electrode waste was measured and totaled at the conclusion of the study.

Table 3.

*Comparison of Electrode Waste between Consumable Electrode Management Strategy Types (Measured to Nearest 1/32")*

	Consumable electrode management strategy used	
	Unlimited access	Limited access
Total length of all electrodes:	140 <sup>23</sup> / <sub>32</sub> "	108 <sup>21</sup> / <sub>32</sub> "
Total number of electrodes used:	64	79
Average length of all measured electrodes:	2 <sup>3</sup> / <sub>16</sub> "	1 <sup>3</sup> / <sub>8</sub> "

*Note:* Unlimited access – students were not restricted in their use of electrodes; Limited access – students could only use an additional electrode if the remainder of the prior electrode was less than two inches.

Table 4 details the total weight of all electrode waste material generated during each day of the study. Using a triple beam balance, electrode materials were weighed at the conclusion of each day of the study.

Table 4.

*Weight of Electrode Waste Material Collected Per Day of Study*

Study Day Number	Number of Students Participating	Total Number of Electrodes Used	Weight of Electrode Waste Material (In Ounces)	Consumable Electrode Management Strategy Used
1	8	9	2.99	Unlimited access
2	7	16	1.62	Limited access
3	7	11	1.80	Unlimited access
4	8	23	1.55	Limited access
5	8	11	1.38	Unlimited access
6	8	9	0.95	Limited access
7	5	17	1.38	Unlimited access
8	6	15	1.06	Limited access
9	7	16	1.34	Unlimited access
10	6	17	1.73	Limited access

*Note:* Unlimited access – students were not restricted in their use of electrodes;  
 Limited access – students could only use an additional electrode if the remainder of the prior electrode was less than two inches.

Data from Table 5 detail a cost comparison between differing consumable electrode management strategies as well as electrode purchasing sources. These sources included purchasing from a welding supply distributor as well as purchasing directly from an electrode manufacturer.

Table 5.

*Cost Comparison between Differing Consumable Electrode Management Strategies and Electrode Purchasing Sources*

Consumable Electrode Management Strategy Used	Total Weight (In Ounces)	Cost of Waste Materials from Consumables Distributor	Cost of Waste Materials from Consumables Manufacturer
Unlimited access	8.85	\$1.27	\$0.55
Limited access	6.94	\$1.00	\$0.43

*Note:* Unlimited access – students were not restricted in their use of electrodes;  
 Limited access – students could only use an additional electrode if the remainder of the prior electrode was less than two inches.

**Conclusions, Discussion, & Limitations of the Study**

The underlying purpose of the present study was to describe the effects that the use of an alternative welding consumable management strategy would have on students'

consumption of welding electrodes. Data pertaining to objective one of the study, determining students' welding consumables usage when employing differing consumables management strategies, indicate that the differences between each management strategy did not differ greatly in terms of waste materials produced, though fewer electrodes were used when the limited access strategy was utilized, as could be expected. Regarding objective two, the evaluation of the cost-effectiveness of limiting students' access to using consumable welding electrodes, the cost savings between each management strategy were minimal at best. More specifically, savings of \$0.27 and \$0.12 were seen when purchasing electrodes from a welding supply distributor and a welding supply manufacturer, respectively.

The results of the present study indicate that developing a protocol to provide a form of behavioral control (i.e., the use of an intensive welding consumable micromanagement strategy) can help to sway the behaviors (e.g., limiting the use of consumable welding electrodes) of those involved. These findings are in congruence with Ajzen's (1985) theory of planned behavior. Further, this micromanagement strategy practice could provide a new method of developing students' abilities to self-regulate and more frugally manage limited supplies. This improved practice aligns with Roberts, Harder, & Brashears (2016) suggestion that more innovative practices, concepts, and ideas can yield practical results within agricultural education settings, including SBAE. For example, though considerable fiscal savings were not yielded in the present study, consumable electrode usage decreased through the use of the limited access micromanagement strategy. Perhaps the use of this management strategy over a longer period of time (i.e., over a full semester or academic year) with a larger population of students would yield greater cost and electrode waste savings.

It should be noted that, in accordance with Table 2, there was significant variation in welding electrode lengths throughout the duration of the study. It could be assumed that as students began to gain additional experience in the welding process, their efficiency in using electrodes would have improved over time. However, some of these results seem almost contradictory in nature, especially during the latter half of the experiment. Perhaps the participants within the present study experienced the Hawthorne effect. As described by Leonard and Masatu (2006), the possibility exists that these students deliberately adapted their behavior so as to influence the results of the present study. It is conceivable that direct contact with the lead researcher of the present study, who was also the program's agricultural education teacher, may have created a desire to perform the welding activities in an atypical fashion. This should be recognized as a limitation of the present study.

Regarding additional limitations of the study, it should be noted that because the population of this study was only one class that consisted of eight ( $N = 8$ ) secondary students, these findings are not generalizable beyond this population. Moreover, the short duration of the study, the use of subjects from only one SBAE program, the accounting of the possibility of the Hawthorne Effect, and the lack of randomization of subjects

contribute to this list of limitations as well. Future replications of this study should work to control these factors whenever possible. It should also be noted that weld quality was not addressed within the present study. The agricultural education teacher noted that when the micromanagement consumables management strategy was used, the student participants' weld quality produced appeared to deteriorate. As such, if the fiscal savings between each management strategy were minimal and weld quality suffered, perhaps the use of an intensive micromanagement strategy, in this particular case, actually harmed the student participants' development and acquisition of welding skills.

### **Recommendations for Practice & Research**

Regarding recommendations for welding instructors, the researchers suggest that welding teachers work directly with welding supply manufacturers to procure consumable electrodes. As described within the present study, some differences in costs existed between purchasing from welding supply distributors versus from manufacturers. Teaching budgets could benefit greatly from these potential savings (McKim & Saucier, 2013; Saucier et al., 2014). Also, the researchers, based upon the results of the present study, recommend that teachers proactively manage metal utilization instead of consumable electrode usage during SMAW training. As metal for welding could be expected to cost more than any other welding-related consumable, budgets should be protected with effective and efficient practices that best utilize available resources (McKim & Saucier, 2013; Saucier et al., 2014). Further, more intensive management of consumable materials used in welding activities may influence the practices and management methods used by students. As secondary students will be taking roles within the workforce in the near future, perhaps developing resource conservation practices at an early age could positively influence these behaviors in the future, potentially aiding future employers in controlling costs. Roberts et al. (2016) described how new and innovative practices can bring about positive change in a variety of environments. Perhaps the teaching and use of intensive management strategies could help to fit within this role as well.

Recommendations for post-secondary welding personnel, teacher educators, and industry-based practitioners and educators vary slightly. Regarding professionals involved in post-secondary welding instruction, perhaps the abovementioned management strategies should be implemented into post-secondary laboratory settings as well. Such actions could help to reduce laboratory teaching expenditures, as well as communicate the importance of resource conservation and management. Teacher educators may also find value in such practices as well, as the need for effective laboratory management is constantly present (Saucier et al., 2014). Further, as laboratory instruction includes additional environments and contexts beyond welding (Phipps et al., 2008; Shoulders & Myers, 2012), perhaps developing effective consumables management competencies of preservice teachers would be suitable as a part of teacher preparation. Moreover, developing a conservation-based mindset within preservice teachers could aid in laboratory teaching cost management skills during the early career teaching phase. Industry-based practitioners and educators could also implement and

emphasize management strategies that work to reduce materials consumption when training novice employees as well as customers. Such practices could grant greater cost controls that may, over time, provide a significant return on this training investment.

For future research endeavors, the researchers suggest that this study be replicated using a true experimental design. As described by Ary, Jacobs, & Sorensen (2010), experimental research allows for a more concrete method “for demonstrating cause-and-effect relationships” (p. 271). Through helping to control for selected elements of internal validity, randomizing subjects would increase the overall rigor of a replication of the present study, as well as provide an increase in the quality of the data collection process (Ary et al., 2010). Also, future replications should seek to use multiple laboratory environments and be conducted over a longer period of time (i.e., a nine week-quarter, a semester, or an academic year) so as to further increase the size and scope of the study. The researchers also advise that future replications should consider examining an intensive management strategy focused upon metal usage so as to examine the effects associated with conserving metal during welding training procedures.

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## **Prospects of Internet of Things in Education System**

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### **Abstract**

The rapid growth of production of low power, small, inexpensive computing hardware, and its availability makes it possible to embed it in any physical objects and connect these objects to the Internet. These objects are called Internet of Things (IoT). IoT can interact with anything, anytime, and anywhere bringing people, processes, data and things together. It is used to ease some of our daily activities and gradually touching every facet of our lives, opening new opportunities for growth and innovation. While it is expanding in many sectors, it is gaining grounds in educational sectors opening enormous opportunities to facilitate teaching and learning processes. This paper introduces IoT technology, its potential application in education system, and discusses benefits and challenges of IoT. IoT technology would promote a smart education system or intelligent learning environment.

### **Introduction**

The internet is a constantly evolving and a multifaceted tool consisting of vast range of information resources and services to serve billion of people worldwide. People primarily use the Internet, specifically the World Wide Web (WWW), as a tool for communication and information gathering. Internet access or online activity mirrors much of what people do in physical space—chat, play games, share pictures and videos, and shop (Sanders & Burt, 2016). As Internet progresses, four major technology revolutions have occurred. Pew Research Center (2014) mentioned three technology revolutions: broadband communication technology, mobile communication technology, and social media technology.

Four major technologies that revolutionized Internet are:

- a) Broadband Communication Technology
- b) Mobile Communication Technology
- c) Social Media Technology
- d) Cloud Computing Technology

The next technology revolution is Internet of Technology (IoT). The broadband communication technology is a high-speed internet technology that is always on. People spend more time online these days playing games, watching videos, and themselves become content creators. The rise of broadband communication technology changed the way people got information and shared it with each other. Mobile communication technology through smartphones, tablets, laptops, made any time-anywhere access to information. Social media and social networking has affected the way that people think about their friends, acquaintances, and even strangers. They allow people to plug into those networks more readily and more broadly – making them persistent and pervasive in ways that were unimaginable in the past (Pew Research Center, 2014). Cloud computing technology introduces on-demand computing services like application, storage, processing etc., over the internet on pay-as-you-go basis eliminating the need to build and maintain in house computing and networking infrastructure. It utilizes the resources in most cost-effective way by outsourcing data to a third party, which are available on demand basis over the internet.

The next step of technology revolution is the Internet of Things (IoT) and this represents the most potentially disruptive technology revolution of our lifetime (Feki et al., 2013). This technology is the beginning of an emerging era where ubiquitous communication and connectivity is not a dream or challenge any more. IoT focuses on seamless integration of people and devices to converge physical realm with human-made virtual environments (Buyva & Vahid, 2016). It is revolutionizing the way people live and work through new and innovative services greater than that of internet.

### **Internet of Things (IoT)**

The term “Internet of Things” was first coined by Kevin Ashton during his presentation about radio frequency identification (RFID) in Procter & Gamble (P&G) in 1999 (Ashton, 2009). Since then, IoT has been a rising trend in information technology (IT) arena attracting attention from various world communities including consumer electronic industries, business, government, and academia. These world communities have their own interpretation of IoT and defined IoT appropriate for their application. There is no single agreed definition of IoT. This is because IoT covers wide range of technologies, processes and applications. According to Rose, Eldrige, and Chapin (2015), IoT generally refers to scenarios where network connectivity and computing capability extends to objects, sensors and everyday items not normally considered computers, allowing these devices to generate, exchange and consume data with minimal human intervention.

Gartner, Inc. (2016) estimated that 20.4 billion connected things will be in use worldwide by the end of 2020. Gartner, Inc. (2014) also mentions that a typical family home could contain more than 500 smart devices by 2022. This means very soon everything around us will become smart and an enormous amount of information will be exchanged between devices and people. While it is expanding and transferring every aspect of

human activity, it is also affecting the education system. This will open many potential opportunities of teaching and learning experience for both students and educators.

The Cisco systems forecasts IoT in education system has a 10-year net present value of US\$175 billion, which will be used for the personalized instructions, data collection for making efficient decisions and decreasing the overheads on the educational resources (Selinger et al., 2013).

### **IoT in Education System**

In recent times, the advent of internet and social media technologies have dramatically changed education system. It has changed the way of interaction between educators and students with the aid of digital technologies that helps to improve teaching and learning process. Educators are continuously exploring opportunities and possibilities for application and services that can enhance teaching and learning process. Digital technologies such as multimedia projectors, interactive smart boards, and content management had already revolutionized teaching and learning systems. Content management tool, a centralized software application, which provide course creation, delivery, management, tracking, reporting, and assessment, made reality of distance education and online courses. Educational systems embracing learning environment methods rather than focusing only on the learning contents, in a peer-learning environment is quite important (Kamar & Ali, 2017).

Abbasy and Quesada (2017) says IoT is transforming traditional education system into a scalable, adaptable with rapid dynamic changes, flexible and more efficient e-learning with a topology where the huge number of physical and virtual interacting objects are involved in the process of learning. Making use of IoT in learnings systems would open up new pathways to proffer effective learning. It helps to create energy-efficient and cost-efficient education system through automation of common tasks outside of the actual education process. The influence of IoT can be seen in many aspects of education from student engagement in learning and content creation, helping teachers in providing personalized content and improve student outcomes (Wellings & Levine, 2009).

IoT is one of the aspect of technology that have major applications in STEM education (Lakshminarayanan & McBride, 2015) namely:

- a) Virtual Reality
- b) Personal electronic systems aka 'clickers'
- c) Flipped classrooms
- d) Mobile learning 'm-learning'
- e) Massive Open Online Courses "MOOCs"
  - i) Khan Academy
  - ii) Google Apps for Education
  - iii) Coursera
  - iv) edX
  - v) myHomework

- f) Internet of Things “IoT”
- g) Cloud Computing

### **Internet Access and Smart Devices**

Internet access is a necessity not a luxury (Zondervan, 2018). So, learning places, classrooms, schools, are provided with wireless internet access for mobile devices used by educators, learners, and staff.

Access to the internet provides connectivity to many smart devices. Smart devices such as smart phones, tablets, wearable devices, smart whiteboards, smart table, attendance tracking, are becoming more commonplace in the classroom. Smart devices throughout the school send data and receive instructions over the wifi network. This makes physical environments of classroom smarter and more interconnected than ever before.

### **Smart Classroom**

Classrooms deployed with IoT devices can be used to monitor and measure students’ performance and efficiency. For example, IoT devices can automatically track the student’s attendance. Teachers and educators can also conduct exams and assignments digitally. Students well-being can also be monitored with IoT wrist bands during athletic activities. Inside the classroom, airflow, air quality, temperature, and humidity can also be constantly monitored and optimized in every possible learning space. This will keep the facilities functioning smoothly and support higher level of personalized active learning for students.

### **IoT Devices for Smart Classroom/School**

Many different types of IoT devices are available easily on the market these days. For example, smart devices like eBooks, tablets, fitness bands and wearables, virtual and augmented reality headsets, smart lights, smart locks are common in smart classroom. Some other common IoT Devices include:

- Multi-touch tables (smart table)
- Smart white boards
- Student Smart ID Cards
- Facial Recognition Cameras
- Smart Cameras
- Attendance tracking systems
- Smart HVAC System
- Smart Temperature Monitoring
- Smart Lighting
- Telepresence Robots
- Smart School Bus
- Smart TVs, CCTVs
- Connected Sports Equipment

### **Potential IoT Applications in Smart Classroom/School**

With proliferation of the IoT devices, smart and intelligent learning environment, we can revolutionize the entire field of teaching and learning process. Following are some potential IoT applications that can enhance operation efficiency of every type of learning environment:

- As students walk into the classroom, student's attendance could be logged automatically using a smart device such as the Nymi, a wearable "smartband" that uses the wearer's ECG pattern to authenticate student's identity (Meyers, 2014).
- Touch boards could be connected to the internet, where information can be downloaded directly on to the board and instructor and students will be able to interact by touching objects on the boards.
- Smart cards could be used to gain access into the college premises, labs, classrooms, libraries, canteen etc.
- Student's submitted work could be maintained and could be analyzed to give customized advice for students.
- RFIDs, Beacons, wifi could be used to identify students entering campus with automatic notifications regarding the availability of the library books, his day wise schedules, etc.
- RFIDs, Beacons could be also used for indoor location tracking and automatic attendance.
- Smart camera and facial detection could be used in automatic attendance.
- Automatic control of temperatures in labs and lab equipment could be achieved.
- Customized alerts could be sent about the student's abnormal behavior or any types of security and personal privacy issues arises, administrators can reach out and act more quickly to resolve issues.
- Smart devices could be used to alert staff and providers to service equipment before a problem occurs.
- Personalized learning at a student's own pace and intellectual ability could be achieved easily.

### **Benefits and Future Possibilities**

Following are the benefits of IoT in the education system:

- It allows schools to improve the safety of their campuses, keep track of key resources, and enhance access to information.
- It creates smart lesson plan for anytime, anywhere access.
- It optimizes the cost of heating, ventilation and air-conditioning (HVAC) system. Auto opening/closing of windows, smart registers and blowers to control the conditioned air-flow based on the occupancy (number of persons) in the classrooms create intelligent HVAC system. It maintains the comfortable room temperature without wasting the energy.

- It optimizes the cost of lighting based on the room occupancy and the natural lighting from windows and door by automatically turning on/off/dim the lights.
- It provides aid to educators by minimizing manual works like automatically turning on projectors, dimming the lights when slides shows are active etc.
- It helps to enhance the performance of each students.
- All the information from each sensor over the period are collected and stored in the cloud or database which can be analyzed to find more efficient ways.
- It provides personalized and adaptive education which is a customization of education that allows student what they need.
- It allows context-aware ubiquitous learning environment.
- It enhances collaboration among educators and learners.
- It improves learner's performance.
- It increases learner's accountability.

Selinger, Sepulveda, and Buchan (2013) termed the Internet of Everything (IoE) as the next step in the evolution of smart objects - interconnected things in which the line between the physical object and digital information about that object is blurred.

According to Evans (2013), IoE brings together people, process, information, and things to make networked connections more relevant and valuable than ever before-turning information into actions that create new capabilities, richer experiences, and unprecedented economic opportunities for businesses, individuals, and countries. The expected developments and benefits of IoE support in educational purposes (Selinger, Sepulveda & Buchan, 2013) in 2017 are presented as:

- Scale teachers and best quality of instruction-any device, anywhere;
- Scale content recordable and replicable instruction any time, any venue;
- Learn at your own pace, focus on relevant content only, richer interactive content;
- Access to crowd-sourced content, ability to customize curriculum;
- Data driven decision-making and continuous improvement.

### **Challenges of IoT in Education**

Currently, IoT is one of the main accelerators of technological innovation, being one of the areas with greater potential of transformation of society and the economy. As such, all the involved stakeholders, ranging from technologists to developers, companies, and users, face several challenges that remain to be tackled (Hassan et al., 2018). Some of the challenges in education system are as follows:

- Lack of generic frameworks of context-aware ubiquitous learning environment.
- Needs to rethink existing pedagogical theories like cognitive theory, constructivism etc.
- Educators reluctance to adopt new technology.
- Difficulty in maintaining secrecy and privacy of the IoT devices.
- Cost of deploying IoT may be expensive.
- Some IoT devices and applications are not compatible making it difficult to deploy.

**Conclusion**

The use of IoT technology will open the doors for new and innovative education system. Sooner, the idea of smart education and intelligent learning system will become a reality. There are also numerous other possibilities in education system along with technical (may be non-technical, not sure?) challenges which still remain to be addressed.

There are enormous values in the adaptation of IoT system throughout the education system. Use of this technology will open the doors for new and innovative education system to be more relevant and effective, and the idea of smart education and intelligent learning system will become reality.

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## **Electrician Career Exploration via a Ceiling Fan Electrical Box Rough-In Activity**

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### **Introduction**

Electricians are involved with reading technical schematics that assist with the installation of wiring, controls, and lighting. They also inspect electrical problems and make repairs with the use of equipment and hand tools. This article includes a ceiling fan electrical box rough-in activity, which is one way to try out a real-world task that electricians often engage in. Prior to contemplating advanced study to become an electrician, participating in a hands-on activity such as this one would be one way to determine if a career as an electrician would be for you.

### **Responsibilities Electricians**

When structures are constructed, they require the installation of electrical power, lighting, and control systems. Electricians are involved with these installations. After the structure is completed, these items must be maintained. When problems occur, an electrician is the individual who trouble shoots the problems and makes the repairs. These repairs are made by using tools and equipment such drills, screwdrivers, wire strippers, saws, ammeters, and voltmeters (U.S. Department of Labor, 2014).

### **Becoming an Electrician**

Earning a high school diploma is a requirement. After high school, additional training can be obtained at a technical school. Graduates of a technical school can apply this experience toward an apprenticeship and receive credit for the training. Electricians typically receive training during a four to five year apprenticeship program. The apprenticeship consists of technical training as well as on-the-job training. The technical training takes place in a classroom where students learn how to read prints, learn electrical theory, math, code, and safety strategies. After the apprenticeship is completed, an electrician is classified as a journey worker and can do electrical work in accordance with licensing stipulations (U.S. Department of Labor, 2014).

### **Pay and Benefits for an Electrician**

The U.S. Department of Labor (2014) provides wage information as of 2012 for electricians. The 2012 median annual pay is \$49,840 per year. Salary.com (2014) reports the median annual salary for Electrician I as \$43,825 or an hourly wage of \$21.00 per hour. This source indicates that there are additional benefits that include bonuses, 401k/403B, disability insurance, healthcare insurance, pension, and time off. This can bring the total compensation from \$43,825 to \$64,637 annually.

### **Job Outlook for an Electrician**

The U.S. Department of Labor (2014) reports job outlook data current as of the year 2012 regarding electricians. The number of jobs in 2012 was stated as 583,500. The job outlook from 2012-2022 has a growth rate of 20%, which is faster than average when compared to all occupations. The employment change from 2012-2022 is estimated at 114,700.

### **Ceiling Fan Electrical Box Rough-In Activity**

This activity details the procedural steps necessary to install a ceiling fan electrical box rough-in, which is a real-world electrical task. The pictures included with the procedural steps were taken at 1332 East Jackson Street, Muncie, IN 47305 being built by Muncie Area Career Center Building Trades and Electrical Students. The home being constructed is a joint effort between the City of Muncie Community Development, Muncie Homeownership & Development Center, Muncie Community Schools, Muncie Area Career Center, and the Ball State University Design Studio. The funding was provided by a grant from Community Development. The project is handled by the Muncie Homeownership Center. In addition, the Muncie Homeowner Center assists low-income families who are first-time homebuyers with completing all of the steps that are part of the home purchasing process. The Ball State University students who are part of the Design Studio designed the project blue prints.

### **Equipment and Materials Required**

Safety glasses  
Hard hat  
Framing hammer  
16D nails  
Marker  
Tape measure  
Speed level  
Drill  
Phillips head bit  
2 1/2" triple coated deck screws  
3/4" drill bit  
Ceiling fan rated electrical box  
1/4" nut driver bit  
Roll of 12/2 electrical wire  
Diagonal pliers  
Electrical staples

Procedure

1. Using a tape measure, determine the distance between two of the trusses so that a board can be cut to span the distance in the horizontal position between the trusses. The board will be used for mounting a ceiling fan rated electrical box.

**See Figure 1.**

**Figure 1**



2. Using a tape measure and marker, make a mark at  $7/8$ " from the bottom of the truss so that the board can be mounted correctly in the vertical position between the trusses. **See Figure 2.**

**Figure 2**



3. Using a hammer and a 16D nail, secure the board between the trusses with a nail on one side. See **Figure 3**.

**Figure 3**



4. Using a speed level, confirm that the board is level between the trusses. See **Figure 4**.

**Figure 4**





5. Using a hammer and a 16D nail, secure the board between the trusses on the other side. **See Figure 5.**

**Figure 5**

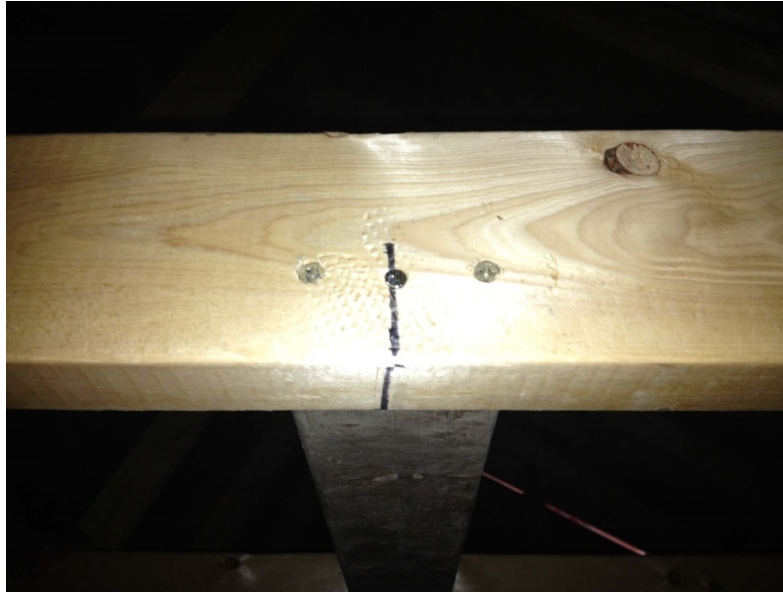


6. Using a drill with a Philips head bit and 2 ½" triple coated deck screws, install one screw on each side of each nail that was previously used to secure the board between the trusses. The screws will provide additional reinforcement. **See Figure 6 and 7.**

**Figure 6**



**Figure 7**



7. Using a drill and a  $\frac{3}{4}$ " drill bit, drill a hole in the center of the board to allow an electrical wire to pass through. **See Figure 8.**

**Figure 8**



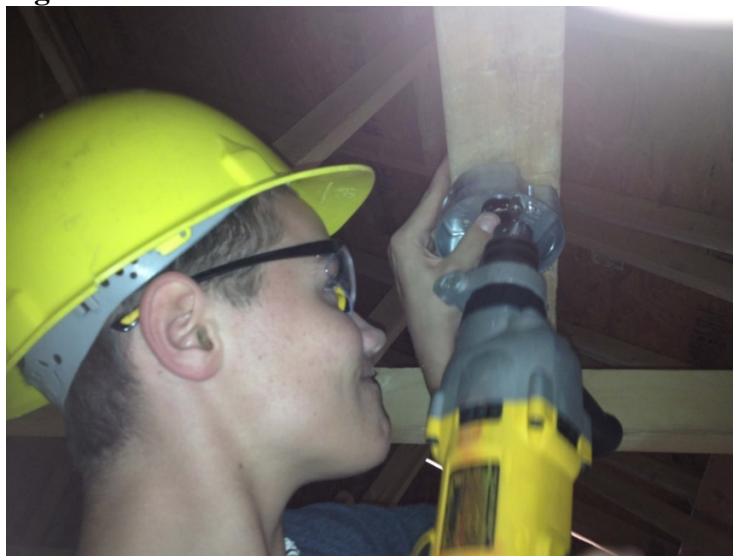
8. Because 5/8" drywall is being installed on the ceiling, the electrical box must be marked at 5/8" inch so that it will line up flush with the drywall once it is installed. **See Figure 9.**

**Figure 9**



9. Position the ceiling fan rated electrical box hole over the hole that was just drilled through the board. Using a drill and a 1/4" nut driver bit, install the three 1/4" bolts that come with the ceiling fan rated electrical box to secure the box to the bottom of the board. **See Figure 10.**

**Figure 10**





10. Run 12/2 electrical wire from the switch in the room through the attic and to the ceiling fan rated electrical box. **See Figure 11.**

**Figure 11**



11. Using diagonal pliers, cut the 12/2 wire so that it can be passed through the ceiling fan rated electrical box. **See Figure 12.**

**Figure 12**



12. Curl the 12/2 electrical wire inside the ceiling fan electrical box so that after the drywall is installed in the home the ceiling fan can be attached to the wiring with wire nuts. **See Figure 13.**

**Figure 13**



13. Secure the 12/2 electrical wire to the top of the rafters using electrical staples. **See Figure 14.**

**Figure 14**



14. This figure below features the partially completed construction project with teachers Mr. Jeremy Penrod and Mr. Dan Hubble with Muncie Area Career Center Building Trades and Electrical Students at the 1332 East Jackson Street, Muncie, IN 47305. **Figure 15.**

**Figure 15**



### **Conclusion**

If inspecting electrical problems and making repairs with the use of equipment and hand tools sounds interesting, you may want to further investigate a career as an electrician. Immersing yourself in a hands-on activity such as the ceiling fan electrical box rough-in project described in this article may be a good way to determine if this career is for you. With a growth rate of 20% from 2012-2022 and a median annual salary ranging from \$43,825 to \$49,840 (depending on the data source), this is a career that appears to be lucrative and have a bright future.

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## **Construction Scheduler - Career Exploration**

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### **Abstract**

As an industry, construction is one of the most diversified arenas, requiring a variety of individual specialties working on the same project. The diversification of these experts, however, is not the only facet to be considered, a construction project also requires a wide range of products, methods and systems to be implemented in the process. With this rich variety of products, services, and caliber requirements, students in the field of construction management need to consider, at an early phase, what area they wish to see themselves working in when they graduate. In order for them to make a careful consideration and an informed decision, students need to understand the qualifications necessary for each of these different fields of expertise and the expectations from professionals working at these different areas. As such, the purpose of this paper is to provide a broad view on the skills required to become a planner/scheduler in a construction company, and what it takes to be successful in this area of the construction profession. This paper also includes valuable insights through interviews with two experts already working in this important field.

### **Introduction**

For any construction project to be successfully completed, scope, cost and time for the project must be properly managed as these three are interrelated. Each impact on any of these three main areas of the project parameters will affect the other two. Managing the project timeline must start with a time plan that is set in the beginning of the project by project schedulers. This time plan should reflect the requirements of the owner of the project and scope or how complicated the project is in addition to the available funding and resources. When this time plan is developed and agreed upon among the project stakeholders including the owner, the engineer of record and the contractor, it becomes the reference schedule document that is to be respected and followed by all parties for the project to achieve its goals. Deviations from this time schedule usually leads to disputes between the project stakeholders in addition to possible additional project costs.

Any construction project has a variety of specific tasks which are managed by certain specialists for the project to be successfully completed. As with any other project, scheduling is one of the key elements in a construction project. Construction projects rely on timely delivery of tasks with efficiency and high level of planning. Therefore, it is the scheduling specialists job to ensure that all of these interdependent components are coordinated and managed properly. A construction project depends on schedulers to build a timeline of the project from start to finish, and fill in the details in between, for start of



each particular task and the amount of time necessary for it to be completed. As an example of a challenge, a certain working area may be needed by a number of varying activities in the same instance. It is therefore one of the construction schedulers tasks to be able to optimize the facilitation of that work area in a way that it does not have a negative impact on project performance. These types of situations are also known as 'space-time' conflict problem in a construction site environment (Mallasi *et al*, 2009). This is why these activities are sequenced, where one can not initiate without the previous being completed or started if there is clear interdependence between these activities. Another important aspect in construction management is the correct selection and allocation of resources such as; labor, plant or equipment used, these selections also have to take into account the restrictions on the the site and the type of work to be commenced (Jaskowski & Sobotka, 2006).

### **Responsibilities of Construction Scheduler**

The task of construction scheduling is mainly towards activity sequence optimization and resource allocation (Zhou *et al*, 2013). The responsibilities of a typical construction scheduler include creating a master plan for a project, which includes timelines, needed sources, putting the tasks into an order and listing the responsibilities of each team member. As mentioned previously, a project scheduler must be proficient in the use of software applications to record and track the projects progress. Schedulers also make updates to the daily tasks of the construction project, take notes and enter the progress in the software and give feedback to the team regarding the effects each task has on the overall completion and timeline of the project.

In addition, the start time of each activity cannot be later than its latest start time in order to finish the project within the demanded duration (Guo *et al*, 2010).

To elaborate more on these responsibilities, schedulers in the construction industry perform various tasks and the different project phases. This starts with the very beginning of any project, the early planning phase, which is done by the project owners or developers to study the project. In this phase the time plan is very conceptual, where the owner or the developer needs a high-level estimate on the time frame of the target project. In this case the scheduler will use his/her experience and use historical records for projects with similar level of complexity and similar built-up area to come up with rough time plan. In this phase, the schedule is very approximate and can vary significantly based on the design of the project. In this case, the scheduler is employed by the owner or the developer company.

When the project goes into the design phase, where the architect and engineers work with owners and developer on schematic design, followed by detailed design and preparation of construction documents or bidding documents, it is common that owners, especially in big and long-term projects, re-examine the time plan that was originally envisioned. This effort of time planning is also at a high level but with more realistic information in hand based on specific designs, systems and project details that can help the schedule develop a work breakdown for the project tasks, where the project construction activities can be

broken into main elements like different buildings within a complex or various floors in a building or systems of a building per floor including structural, electrical, mechanical and architectural systems.

When the owner is satisfied with the designs and is ready to float bidding documents in the market to obtain contractors' proposals, contractors studying the project usually go into another phase of time planning where they examine whether the required time frame is achievable, or they need to advise the project owner otherwise. Depending on the size of the project, how risky the project is and how important the project is for the contractor to get, the level of schedule detailing at this level will be determined.

If the contractor is awarded the project, then a detailed schedule must be developed. At this phase, all activities of the project must be defined by the scheduler. The schedule then determines the duration for each activity based on the resources that can be allocated and the productivity rates for the crews and equipment that will be used. After defining the activities and their durations, relationships between activities must be established to identify the right sequencing and understand the critical path, which is the sequence of activities that will take most time and will define the end date of the project. There are various methods that are used to run this process including the Critical Path Method (CPM). Schedulers use software including Primavera and Microsoft Project to help with this process. In many projects, the owners will request certain formatting of these detailed schedule so that they can easily follow them during the project. When this detailed schedule gets approved by the owner and engineer of record, it becomes part of the contract between the owner and the contractor and the different parties should respect and follow that approved schedule. The schedulers are also requested to update these schedules based on the actual scenarios on sites and any changes that can happen to the sequence of works due to any unforeseen reasons.

Another task that can be requested from the scheduler, depending on the owner's requirement, the company's own procedures and the complexity of the project, is loading the resources that are needed to complete each activity to the software that is used. This means that the scheduler needs to define the number of crews required, sometimes the materials and cost, for each construction activity and link them to the respective entry at the software. This helps the schedule to run reports that shows the project status periodically throughout the project for time and cost control.

### **Pay and benefits for a scheduler**

According to Payscale.com, the salaries for a construction schedulers range anywhere from \$47 thousand to \$120 thousand, and the median salary is \$75,821 in 2017. Top 15% of professional scheduler can expect to earn anywhere from \$100 thousand to \$120 a year (Payscale.com, 2017).

### **Interviews with two professional schedulers, scheduler A and B**

This section includes interviews with current professional construction schedulers A and B, who were asked to share their opinions and expertise.

Both professionals were inquired about the amount of time they have been in this industry. Scheduler A replied that he has been working in the field of construction for little over six years, while scheduler B indicated that he had been working as an estimator for two years before becoming a scheduler, and he has been a scheduler for two and a half years now.

They were then asked about their typical work day and to provide an overview of their daily tasks. Both schedulers described their typical work days in varying fashions, but both had similarities when it came to the dynamics of their typical work hours. Both have to be at constant contact with project managers and suppliers to work through scheduling dilemmas, which according to scheduler B could take up anywhere from 10-100% of a scheduler's work week. Nonetheless, Scheduler A emphasized the task of being detail-oriented and sequence planning and stated that *"if there is a typical day within scheduling it is working within a team of Project Managers and Supers developing detail to better define a sequence of work on that project"*.

About the challenges both have faced as schedulers in construction projects, both scheduler A and scheduler B emphasized the importance of communication and understanding, and the value of easily comprehensible information. Moreover, scheduler A stressed that when schedules are created, the true owners of the schedule are the project teams, and underlined importance of them understanding the schedule. Scheduler B, on the other hand, mentioned the fact that while schedulers come up with a plan, the information is compiled from many varying sources, therefore this information needs to be clear and understandable for a number of different people; owners, subcontractors, construction management, project controls. Scheduler B states that *"if someone picks up your schedule, they should be able to clearly understand where the project is current at."*

It is important that an individual enjoys doing his or her job, hence when enquired about the aspects that bring satisfaction, both scheduler A and scheduler B noted, that they get it from working with their peers on the sequencing of a particular project and when the superintendent of the project shows gratitude for providing help to manage the progress in the field. Scheduler B added *"Another highlight is the opportunity to look through the drawings and understand the challenges of so many projects at once. Most of the schedulers at Hunt have 4-6 projects at once."*

Scheduler A and scheduler B discussed the skills and competencies required to become successful in the field of scheduling for construction projects, naming several critical areas students need to focus on. Both have underlined the importance of effective communication both verbal and written, time management, problem solving, attention to detail ability to correctly read the drawings and specs, being able to read contracts and

understanding construction processes. Scheduler A added *“Also the understanding that protecting the companies risk is also what you are evaluating as well. Keeping your company out of litigations from a scheduling stand point is key.”*

When asked about the importance of having interpersonal skills in their field of work, both Scheduler A and scheduler B agreed that in order to be successful in the field of scheduling, it is very useful to have good interpersonal skills. Having these skills paired with the ability to effectively communicate the progress of the project to a number of different parties, and being able to work with different groups of people at the same time is greatly useful.

Scheduler A and scheduler B were then asked about the key competencies recommended to the students in the CM. Both specialists recommended focusing on verbal and non-verbal communication skills, software knowledge, presentation skills, time management, enhanced with ability to read and understand specs and drawings.

Both specialists then talked about the challenges in the industry, they mentioned several aspects. The schedulers work involves compiling information from different sources, which means working with people from different industries and personalities and working through the schedule as these individuals understand it differently and have their own perspective. It is important to work towards being on the same page when it comes to small details. Scheduler B also noted the challenge of balancing act of *“working for project controls and working with the operations team. You are a layer of oversight while also working with the operations team”* he went on to mention, that this particular aspect can be tough at times.

### **Conclusion**

The task of efficient scheduling and execution processes for a construction project is challenging (Konig & BeiBert, 2009). These tasks and responsibilities are immensely important, because they deal both with the budget and timeframe. Thus, there is always a huge demand for skillful schedulers who will work closely with the construction manager and the team, to make sure that everything is executed properly. Scheduling is undoubtedly a challenging task, but it also comes with high rewards in the forms of satisfaction of being able to see how a well-organized and scheduled project runs smoothly, how one can intervene and adjust and make corrections to make sure that the project is completed.

### **References**

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