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Development of an improvised coil winding machine as instructional material

Hidalgo, Rogelio C.
Ilocos Sur Polytechnic State College, Philippines (rochid_1969@yahoo.com)
Azarias, Ranec A. ✉
Ilocos Sur Polytechnic State College, Philippines (ranecaz@gmail.com)
Baptista, Eric L.
Ilocos Sur Polytechnic State College, Philippines

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Abstract

The emergence of technology increases the demands for other sophisticated machines that could be used in troubleshooting and repair of these technologies. Among them is a coil winding machine; however, it is expensive in industries today. Such context merit developmental studies to help address the demand for similar but cheaper and quality machines. Through this descriptive-developmental research, an improvised coil winding machine was developed which was evaluated on the level of its utility by five (5) experts and five (users). Their evaluation revealed that the equipment made out of salvaged materials has a very high of level of validity. This made the researchers conclude that the improvised coil winding machine is economical and easy to make, and that it is useful, effective, functional, reliable and safe to use. Hence, the study recommends that the developed instructional material may be used by electrical shop and electrical instructor in winding coil form; the researchers may continue improving the machine which can be used for simpler and easier coil winding; the future researchers may conduct another study that shall incorporate other variables like digital counter for a more digital and advanced version of the equipment.

Keywords: coil form, coil winding machine, coil winder, electrical technology, instructional material

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1. Introduction

Technology in all aspects of life has continuously emerged as results of innovation or development. In terms of machine development, coils are some of the vital components of machines. Hence, coil winding machines are needed should there be problems on the coils of machines. In addition, the industry that deals with coil winders and coil winding processes has experienced significant growth and has expanded its application areas over the past 40 years. Armature Coil Equipment (2021) discussed that coil winding is the process of creating an electromagnetic coil using a sequence of loops, which is then employed in a range of industrial applications. Accordingly, coil winders are ideal for usage in components such as relays, chokes, solenoids, transformers, resistors, inductors, electric motors, and generators.

Furthermore, a coil winding machine is a machine that winds coils onto spools, bobbins, and other items. This coil winding machine is one of the various types of winding machines used in businesses today. Shafie (2017) detailed that coil winders are classed based on their speed and capacity. From multi-speed machines to medium, large, and extra-large machines, these machines fulfill a variety of functions. Accordingly, a coil winding machine's most common applications are winding coils for transformers, inductors, motors, and chokes. Nonetheless, coil winding machine design is influenced by a coil's complexity, material tension limitations, machine versatility, automation or operator intervention, manufacturing volume, and budgetary constraints.

Notably, one of the many applications of coil winding machine is on electric motors. Electric motors are essential part in our daily life as many systems, applications and services depend on them. Motor today have long service life and require a minimum level of maintenance to make sure that they perform efficiently. Motors have to be maintained on a regular basic because they need to be in operation all the time. One of the problems that are often encountered when using electric motors is burnt winding due to over loading. Motor needs to be rewound. Rewinding electric motor is a process of replacing burnt winding into its original coil forms, size of wire number of turns and connections. Hence, a rewinding machine is needed.

Interestingly, coil winding machine are more advanced and expensive. In fact, ebay.com (2017) posted that the price of coil winding machine is ranging from $36.50 (Php 1,825) to $4,841.09 (Php 242, 054.50). The cheapest are those that are manual and second hand while the expensive are the automatic and brand new. With this price range, this kind of technology is often unavailable in most areas especially those developing countries. That is why in an educational institution located in a developing country and that requires such technology, we cannot find any. Like in the case of colleges or universities offering electrical and electronic technology courses, students do not have this kind of technology. Moreover, motor rewinding as one of the imperative skills in electrical, electronic and mechanical technology needs coil winding machine for the skill to be mastered by the students. However, teachers teaching motor rewinding encounter problems on their actual motor rewinding due to lack winding machine. The students are using nails fastened on wooden wood or board. They usually do nail winding and the so called two-person-hand-to-hand winding methods in replacing the burnt windings. Hence, more often winding process and its outputs are not properly done and observed.

Furthermore, teachers teaching technology courses encounter problem in terms of scarcity of instructional materials (Azarias *et al*., 2019). Also, Aquino (2014) revealed that unavailability, and inadequacy and quality of materials are the problems encountered by faculty members in higher education in the Philippines. Dhakal (2020) supported the same problem. The lack of instructional materials affects the acquisition of skills in technology courses.

Clearly, developing instructional materials is important for the effectiveness of the teaching and learning process. In reality, teachers can use instructional materials (IMs) to help students learn and enrich their learning experiences (Aquino, 2014). For effective and purposeful teaching and learning activities, the teacher must prepare and employ relevant and adequate materials (Dhakal, 2019). Instructional resources are unquestionably important for skill acquisition because they give structured knowledge, realistic examples, and hands-on practice opportunities. They assist learners in understanding concepts, applying procedures, and ultimately achieving mastery. Effective materials can make complex abilities more accessible and promote deeper knowledge. In such light, this study was conceptualized.

With the mentioned situations above and enthused by the need to address those situations, the researchers found it interesting and necessary to improvise coil winding machine that shall serve as instructional material in coil form winding. The said instructional device shall provide easy operation and inserting of wire on stator slot, that eliminates scratches during coil forming process forming coil, and that is affordable. They hope that through this study, electrical technology students could be given an alternative machine that they could use in their major courses especially in learning the pertinent skills in coil winding.

1.1 Theoretical Framework

This study was theoretically framed using John Dewey's Experiential Learning Theory and John Piagets' Cognitive Constructivism. Both theories, in a nutshell, put premium on learning by doing and the vital role of hands-on activities in technology course instruction. John Dewey's Experiential Learning Theory serves as a foundation piece of literature when discussing experiential learning. This theory emphasizes the importance of learning through experience, rather than just passive reception of information (Dewey, 1938). Roberts (2003) discussed that upon completion of an experience, learners have the knowledge and the ability to apply it in differing situations. Thus, they have created new knowledge and are at a different level of readiness for continued acquisition and construction of new knowledge.

In his theory, Dewey argued that education should not be merely about memorizing facts and theories but should involve active participation. Learning is most effective when students engage in hands-on activities that relate to real-life experiences. In Dewey's view, the role of the teacher is to facilitate learning rather than to be the sole source of knowledge. Teachers should create environments that encourage exploration and inquiry, guiding students as they engage with and reflect on their experiences. Educators might design curricula that integrate real-world problems and projects, allowing students to apply their knowledge in practical ways. This could involve project-based learning, internships, or community service.

Meanwhile, Cognitive Constructivism comes from the work of Jean Piaget and his research on cognitive. Constructivism is a philosophy of learning founded on the premise that, by reflecting on the experiences, we construct our own understanding of the world we live in (McLeod, 2024). Each of us generates our own "rules" and "mental models" which we use to make sense of our experiences. Learning, therefore, is simply the process of adjusting our mental models to accommodate new experiences. Likewise, the theory subscribes to the idea that learners construct knowledge for themselves, each learner individually and socially constructs a meaning as he or she learns (Elliott *et al*., 2000). The theory was used to measure the experiential learning and implies a participatory process by students, who interact with their environment to solve the situation that is being set out to them.

Finally, both theories posit that teachers can use strategies that promote active engagement, such as group work, simulations, role-playing, and hands-on activities. Incorporating opportunities for reflection and discussion can deepen students' understanding. Dewey and Piaget supports student agency by allowing learners to take an active role in their education. This can foster a sense of ownership and responsibility for their learning process. Creating a learning environment that encourages experimentation, exploration, and dialogue can align with the theories' principles. Classrooms might be designed to be more flexible and adaptable to various learning activities. Overall, the theories have had a lasting impact on education by highlighting the importance of active, meaningful learning experiences and the role of reflection and problem-solving in the learning process. His ideas continue to influence contemporary educational practices and pedagogical approaches.

2. Methodology

Research Design - The study employed a developmental research design. Richey *et al*. (2004) stated that developmental research involves the production of knowledge with the ultimate aim of improving the processes of instructional design, development, and evaluation. They also posited that such research is based on either situation-specific problem solving or generalized inquiry procedures. Accordingly, the most common types of developmental research involve situations in which the product-development process is analyzed and described, and the final product is evaluated. It is to note that developmental researchers employ variety of research methodologies. Finally, the design is appropriate to answer the problems of the study because the focus was developing an instructional material to improve instruction.

Population and Locale of the Study - The study was conducted in a state college in Ilocos Sur, Philippines. The respondents of the study were the five (5) experts in the field of electrical technology, and five (5) users. They respondents were chosen using purposive sampling; hence, criteria were set. For the experts, they must be electrical major, and holders of NC II that is related to electrical technology. For the users, they are engaged in electrical maintenance and other related practices in electrical technology such as being line man and barangay electrician.

Research Instrument - In gathering the imperative data, the researchers utilized a questionnaire adapted from the study of Trinidad *et al*. (2020) that focuses on the level of validity of a developed machine or device in terms of its technical performance, economic or financial viability, environment soundness, political stability, and social acceptability. Modifications were made to suit with the purpose of the study. Finally, it underwent validity and reliability tests.

Analysis of Data - In the treatment of data, mean was used to determine the level of validity of the improvised coil winding machine in terms of its technical performance, economic or financial viability, environment soundness, political stability, and social acceptability.

3. Result and Discussion

3.1 Design of the Improvised Coil Winding Machine

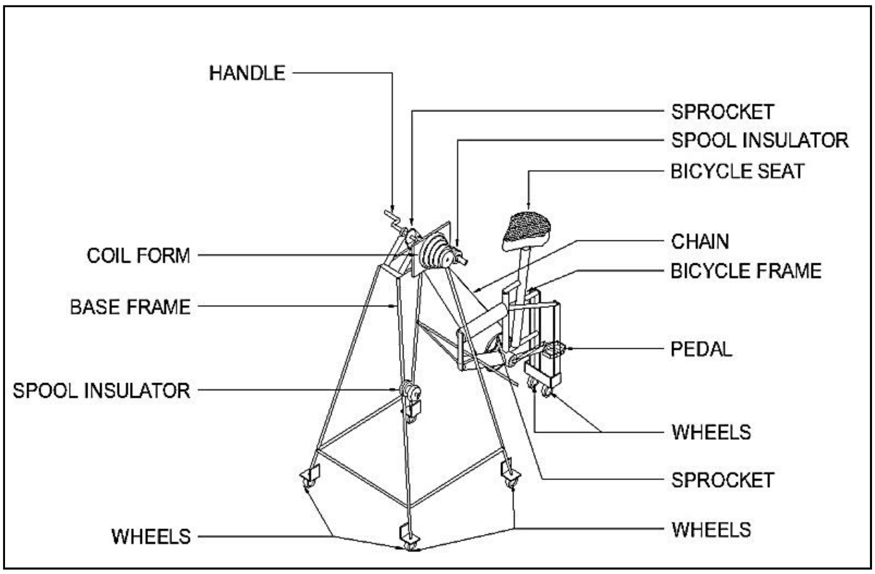

Figure 2. Design of the Coil Winding Machine as Instructional Material

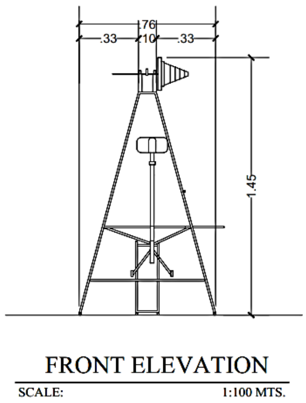

Figure 3. Front Elevation

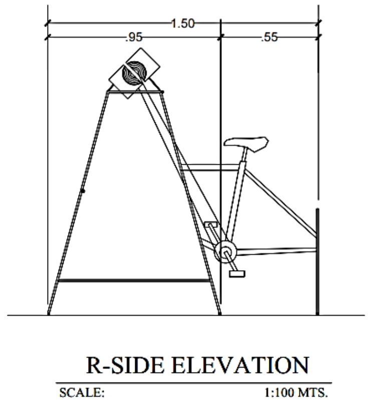

Figure 4. Rigth Side Elevation

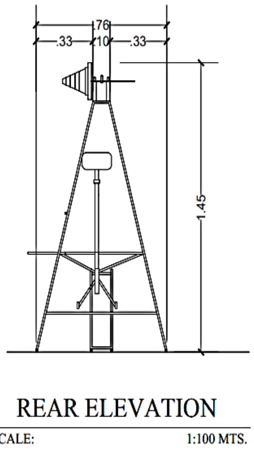

Figure 5. Rear Elevation

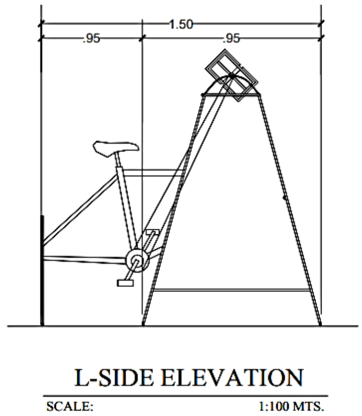

Figure 6. Left Side Elevation

The figures show the design and labels of the different parts of the improvised coil winding machine as an instructional material. Figure 1 shows the whole view of the instructional material. Notably, Figures 2 to 5 shows the perspective of the instructional material in terms of front elevation, rigth side elevation, rear elevation, and left side elevation respectively. Finally, the design allows the use of hands and feet in winding through the holder near the plate and the pedal.

3.2 Fabrication Phases in Fabricating the Improvised Coil Winding Machine as Instructional Material

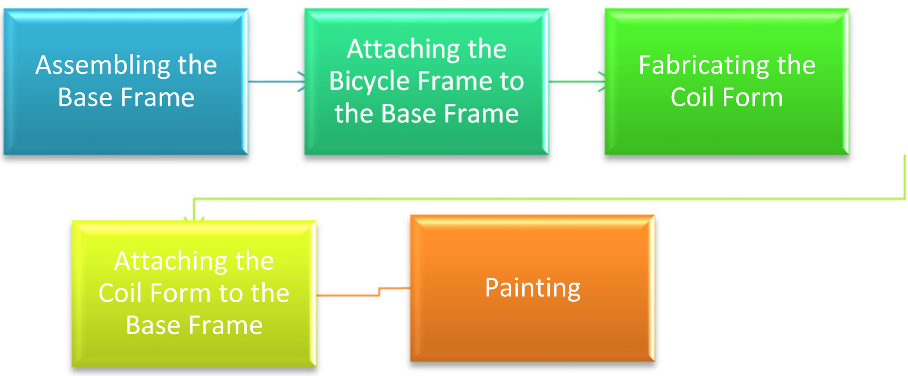

Figure 7. Phases of Fabrication

Figure 6 manifests the different phases in fabricating the improvised coil winding machine as an instructional material. As gleaned from the figure, the fabrication process has five phases. Phase 1 is on assembling the base frame. Phase 2 is attaching the bicycle frame to the base frame. Phase 3 is fabricating the coil form. Phase 4 is attaching the coil form to the base frame. Phase 5 is painting which is the last phase; here, the finishing touches for the machine was done.

3.3 Level of Validity of the Improvised Coil Winding Machine as Instructional Material

Table 1
Level of Validity of the Developed Instructional Material

Indicators	Mean	DR
1. Level of Technical Performance		
1.1 Durability of the parts		
a. The parts are aligned and welded properly using the correct materials.	4.80	VHV
b. The parts are durable and do not easily breaks.	4.80	VHV
Submean	4.80	VHV
1.2 Safety of Operation		
a. Safety precaution are indicated in the equipment/device.	4.60	VHV
b. The equipment/device has operating manual.	4.60	VHV
Submean	4.60	VH
1.3 Speed and Accuracy		
a. The fittings of the movable parts are accurate.	4.60	VHV
b. Alignment and assembly are accurate.	4.60	VHV
Submean	4.60	VH
1.4 Simplicity		
a. The equipment/device provides a better alternative than the manual way.	4.80	VHV
b. Simplicity of the design derives the use of common and readily available materials.	5.00	VHV
Submean	4.90	VH
1.5 Precision of Design and Appearance		
a. The equipment/device performs efficiently than traditional way.	4.80	VHV
b. The design is effective terms of function.	4.60	VHV
Submean	4.70	VH
1.6 Portability		
a. The equipment/device is comparatively like and easy to transport from place to place.	4.60	VHV
b. The equipment/device is not bulky and storage does not require too much space.	4.40	VHV
Submean	4.50	VHV
Submean	4.68	VH
2. Economic/Financial Viability		
a. Maintenance. The equipment/device does not require complex cleaning repair and maintenance.	4.60	VHV
b. Affordability. The equipment/device is not expensive and affordable to the user.	4.40	VHV
Submean	4.50	VH
3. Environmental Soundness		
a. The making of the equipment/device does not pose threats to environmental sustainability.	5.00	VHV
b. The equipment/device does not pose hazards to human welfare.	4.80	VHV
Submean	4.90	VH
4. Political Stability		
a. The equipment/device matches the objectives and interest of the target end users.	4.80	VHV
b. The equipment/device meets the technology, regulatory, requirements and stands for its utilization.	5.00	VHV
Submean	4.90	VH
5. Social Acceptability		
a. The equipment/device serves the needs of the majority of those whom it seeks to benefit.	4.40	VHV
b. Gender acceptability. The equipment/device can be operated by both sexes with ease and precision.	4.80	VHV
Submean	4.60	VH
Grand Mean	4.72	VH

Legend:

Scale	Statistical Limit	Descriptive Rating (DR)	Overall DR
5	4.19-5.00	Very High Validity (VHV)	Very High (VH)
4	3.44-4.18	High Validity (HV)	High (H)
3	2.63-3.45	Moderate Validity (MV)	Moderate (M)
2	1.82-2.62	Fair Validity (FV)	Fair (F)
1	1.00-1.81	Poor Validity (PV)	Poor (P)

Table 1 shows the level of validity of the coil winding machine as instructional material in terms of its technical performance, economic or financial viability, environment soundness, political stability, and social acceptability. As can be gleaned from the table, both the political stability and environmental soundness of the device got the highest mean rating of 4.90 which is described as *very high.* The rating on its political stability implies that respondents found the device appropriate to its intended use. The result also means that the device meets the standards of its end users (Trinidad *et al*., 2020). In terms of its environmental soundness, the result indicates that the instructional do not post a maximum environmental soundness. Likewise, the device adheres to environmental protocols; thus, meeting its contribution to the promotion of the usage of renewable energy.

On the other hand, the economic or financial viability of the device posted the lowest mean rating of 4.50 which is still described as *very high*. Though lowest, it is still high which indicates that the instructional material is affordable. Overall, the developed instructional material was found to be of *very high* validity as supported by the grand mean which is 4.72. This means that the device is functional, affordable, environment friendly, effective, and acceptable.

4. Conclusion

Based on the findings of the study, the study concludes that the improvised coil winding machine is economical and easy to make. In addition, the newly designed improvised coil winding machine as an instructional material is useful, effective, functional, reliable and safe to use. Scarcity of instructional materials can be addressed through innovation and research. Notably, the possibility of producing instructional materials for technology courses involves several implications that span various aspects of education, including effectiveness, accessibility, and engagement. Through developing instructional materials, teachers can create or adapt materials to address the specific needs, interests, and skill levels of their students, which can lead to more effective teaching and learning. Likewise, custom materials can help fill gaps in commercially available resources or address particular challenges faced by the class.

Furthermore, teachers can construct resources to ensure that content is consistent with curriculum standards and learning objectives, resulting in a more coherent learning experience. Notably, educational standards and curriculum can shift, and teachers can create new resources to keep up with these changes. Creating their own materials helps teachers to experiment with new teaching approaches and technology that may not be available in commercial resources. Creating items in-house can sometimes be less expensive than purchasing commercial resources, especially if the budget is limited.

Finally, creating instructional resources allows teachers to improve their skills in curriculum design, creativity, and resource management. Creating materials provides teachers control over their teaching tools and allows them to express their own teaching philosophy and style. Teachers can swiftly create or adjust materials to meet current classroom demands or obstacles, such as changes in student understanding or unanticipated disruptions. Nonetheless, designing instructional resources enables teachers to create a more personalized, engaging, and effective learning environment while also addressing individual requirements and limits in their classroom.

Recommendation - In the light of the findings and conclusions of the study, salient recommendations may be considered. First, the newly designed improvised coil winding machine as an instructional material may be used by electrical shop and electrical instructor in winding coil form. Second, the researchers may continue improving the equipment which can be used for simpler and easier coil winding. Third, schools should put premium into giving trainings and seminars to teachers on instructional material development for technology courses. Fourth, future researchers may conduct another study that shall incorporate other variables like digital counter for a more digital and advanced version of the equipment. Finally, future studies may conduct quasi-experimental study to test the effectiveness of the developed instructional material in enhancing the skills of learners in coil winding.

6. References

Abdalla *et al*., (2007). *Design and fabrication of low cost filament winding machine*, https://www.researchgate.net/publication/240421091_Design_and_fabrication_of_low_cost_filament_winding_machine

Alladdin Engineering and Manufacturing Inc. (AEMI), (2017). *Case study – coil winder* 8000KG, http://www.aladdinengmfg.com/case-studies/case-study-coil-winder/

Armature Coil Equipment (2021). *Reliable coil winding systems and automatic coil winding machines - since 1919*, https://www.armaturecoil.com/coil-winding-equipment/

Aquino, A. B. (2014). Extent of utilization, problems encountered and development of instructional materials by higher education faculty members. *IAMURE International Journal of Multidisciplinary Research*, 9(1).

Azarias, R. A., Azarias, R. A. & Supnad, M. K. M. (2020). Landscape of electronics instruction: Teachers' Teachi.ng difficulties and coping strategies. *International Academic Journal of Education & Literature*, 1(2)

Dewey, J. (1938). Experience and education. New York: Simon and Schuster.

Dhakal, K. (2020). Challenges of the use of instructional materials in teaching geography in secondary school. *Journal of Geographical Research*, 3. 10.30564/jgr.v3i3.2144.

Dhakal, K.R. (2019). Availability and utilization of instructional materials in teaching geography in secondary schools. *The Geographic Base*, 6, 32-41.

eBay Inc., (2017). *How to build a coil winding machine?,* http://www.ebay.com/gds/How-to-Build-a-Coil-Winding-Machine-/10000000205354641/g.html

ebay.com (2017). *Coil winding machine*, http://www.ebay.com/bhp/coil-winding-machine

Elliott, S.N., Kratochwill, T.R., Littlefield Cook, J. & Travers, J. (2000). *Educational psychology: Effective teaching, effective learning* (3rd ed.)**.** Boston, MA: McGraw-Hill College.

Ganesh, S.C. *et al.* (2016). Automatic coil winding machine. *Journal of Advance Research in Electrical Engineering and Technology,* 3 (2).

IEEE Xplore Digital Library (2016).Design and fabrication of a special purpose winding machine for ELM control coils of JET. *IEEE Transactions on Applied Superconductivity*, 26 (4). http://ieeexplore.ieee.org/xpl/RecentIssue.jsp?punumber=77

Ikhankar, P. et al., (2016). Automation in manufacturing of winding. *International Journal for Scientific Research & Development*, 4 (02).

Joshi, N.S *et al*., (2015).Design of automatic transformer winding machine. *International Journal for Research in Applied Science & Engineering Technology* (IJRASET), 3 (IV).

Kamble, R. & Mulik, P. (2015). Development of automatic transformer winding machine. *International Journal of Innovations in Engineering Research and Technology*, 2 (3).

NMB Technologies Corporation (NMBTC), (2014). *Motor coil winding machine*, http://www.nmbtc.com/nmb-component-applications/industrial/motor-coil-winding-machine/index.html

Poirier, A. (2017). *How to make a simple coil winding machine*, https://ourpastimes.com/make-simple-coil-winding-machine-7645238.html

Richey, R. C., Klein, J. D., & Nelson, W. A. (2004). Developmental research: Studies of instructional design and development. In D. H. Jonassen (Ed.), *Handbook of research on educational communications and technology* (2nd ed.) Lawrence Erlbaum Associates Publishers. pp. 1099–1130

Roberts, T.G. (2003). *An interpretation of Dewey's Experiential Learning Theory*. National Library of Education. United States of America.

Shafie, S.B. (2017). *Transformer rewinding machine with digital*, http://umpir.ump.edu.my/6527/3/SARINA%20BINTI%20SHAFIE%20%28CD7732%29%20-%20CHAP%201.pdf

Trinidad, A., Reymundo, J.J., & Real, A.R. (2020). *Coil spring compressor* (Unpublished undergraduate thesis). Ilocos Sur Polytechnic State College Santiago Campus.