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Improving Basic Electrical Principles in Motor Apprentice Education

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Abstract

The objective of this project was to develop a set of both theoretical and practical electrical exercises/assessments in the form of a diagnostic test to assist motor apprentices with their course work as well as helping to improve their core skills of basic electricity and electronics during attendance of their ten week, Phase 6 motor apprenticeship off-the-job training course at the Dublin Institute of Technology.

The diagnostic test was conducted in two stages, one at the beginning of the ten week training course and the second one towards the end of the ten week course. Data obtained from the diagnostic test provided useful information regarding strengths and weaknesses in this subject area.

Key words: assessment, electricity and electronics, motor apprentices

Introduction

Many motor trade apprentice students enter the later years of their studies ill prepared for the level of material encountered. This is due to several factors including the level and knowledge of basic electricity and electrical/electronic principles. A lot of basic material in these areas has been covered during earlier years of their training, but by the time students reach the final year of their apprenticeship (Phase 6) it is not safe to assume that they have a full grasp of the basics required (Monks 2010).

Enormous advances in electronic technology throughout the 1980s and 1990s have brought about many changes in the status of automobile electricity and electronics. Changes are driven by safety as well as environmental reasons. Electronic control plays a major part in the operation of the modern internal combustion engine with regards to efficiency of operation as well as emission control. Electronics have also been integrated into vehicle steering and braking systems for safety reasons.

Apart from the above mentioned, both hybrid as well as full electric vehicles are now commonplace in today's society. Due to the requirement to study vehicle technology throughout an apprenticeship, as well as electrical/electronic systems playing a paramount role in the operation of all vehicle systems, both the standard and level of electricity and electronics increases as a motor apprentice progresses through their apprenticeship (Taylor and Freeman 2011). It is therefore critical that these students have a full grasp of this subject both during and, more importantly, towards the end of their apprenticeship.

The main benefit of this project is to help improve the core skills of motor apprentices in order to reflect modern changes and advancements in modern motor vehicle technology.

Project Outline

The test is divided into two stages. Stage one takes place at the beginning of the ten week off-the-job training period and each student during this time first completes a set of theory based electrical/electronic exercises. Immediately after this each student then proceeds and builds each actual circuit/exercise that have been designed by myself to match as closely as possible the motor apprenticeship syllabus, which the students are required to study on a training board, and from this take various measurements on the live circuits that match those of each theory exercise (see Figure 5.1 below).

Stage two takes place towards the latter end of the ten week course and replicates the activities undertaken in stage one. The intermediate period between both testing periods gives students time to revise/master their core electrical/electronic basics, as well as allowing me to monitor their progress (Carr, Bowe and Ní Fhloinn 2010).

Although the students were made aware of the test, it was not communicated to them the importance of the test as no test marks gained can be included as part of their actual end of training course/assessment marks. Also any testing periods were carried out at random without any prior test notification in order to observe student performance in such circumstances.

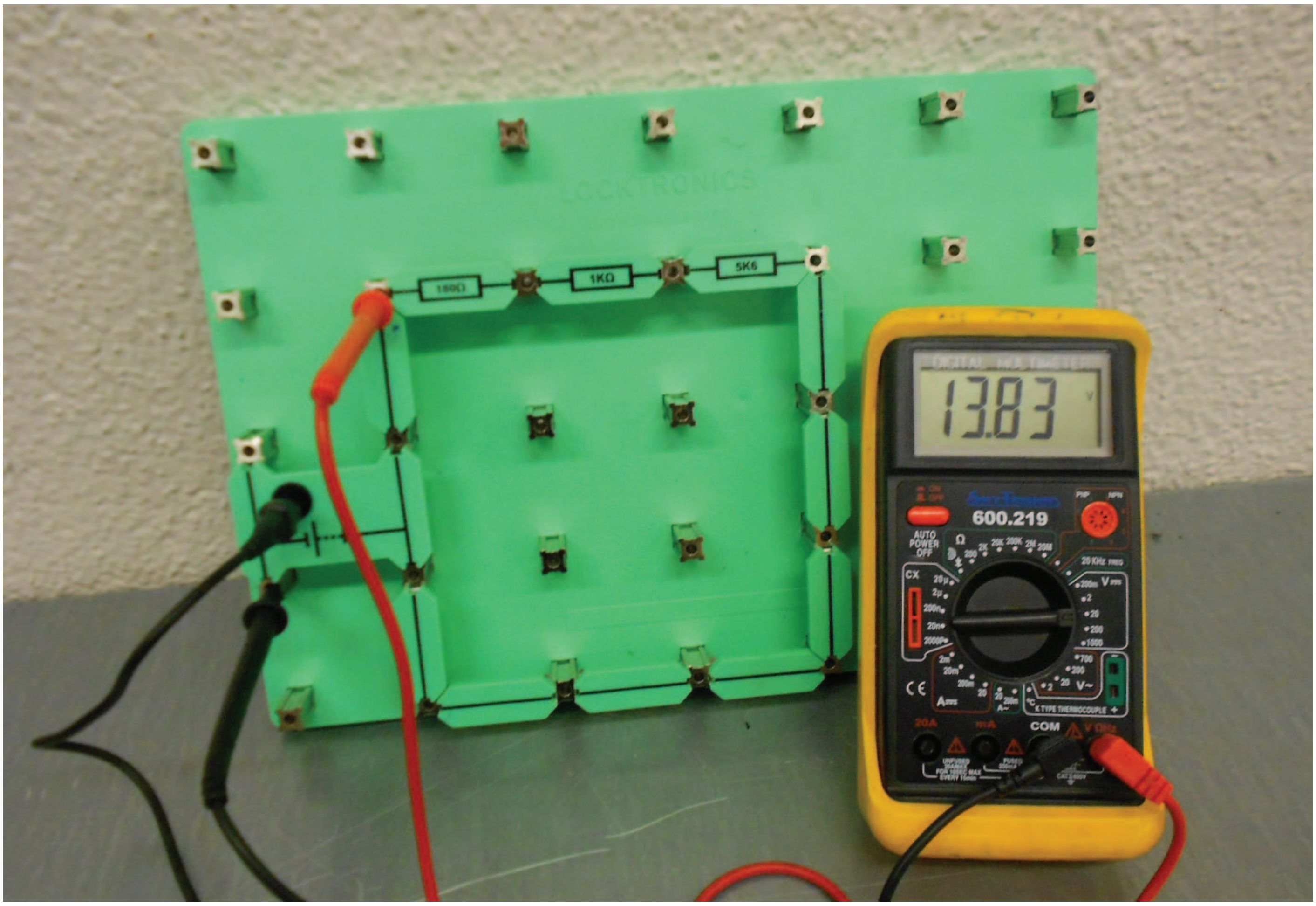

Figure 5.1: Live circuit being tested

Test description

The diagnostic test has been developed in order to help improve core electricity and electronic skills in final year motor apprentice students at the Dublin Institute of Technology (Sheridan 2012). The test consists of both theoretical and practical elements constructed by myself and sub-divided into four separate sub sections/circuits, different sections/circuits have different amounts of questions set at different levels that are designed to challenge students in different ways just as if they were diagnosing an actual electrical/electronic fault on an actual vehicle. The structure of the test is outlined in Table 5.1 below.

Test	Topic	Number of questions
Test 1	Resistors circuits	10
Test 2	Potentiometer circuit	5
Test 3	Transistor circuit	5
Test 4	Relay circuit	30

Table 5.1: Test topics and numbers of questions

As can be seen from Table 5.1 test sections on potentiometer and transistors have five questions each. In modern vehicles these circuits are normally integrated into much larger circuits and for this reason the level of actual testing is limited (Carr, Shiels and Ní Fhloinn 2008).

Thirty questions were allocated to the relay circuit as this circuit in various different forms is present in all modern motor vehicles and it is probably the one circuit that is most troublesome and therefore requires the most attention from an educational/training point of view.

The resistors circuits topic consists of ten questions. Resistors are a fundamental part of any electrical/electronic circuit in the sense that their purpose is to control levels/amounts of electricity in the many circuits in which they are located. For this, reason ten questions, and not five as for potentiometer and transistor topics, were adequate here. Apprentice motor students would have studied this material during their previous off-the-job training at Phase 2 and Phase 4. At Phase 6 level many lecturers assume that students have a full grasp of this subject, but in some cases this is not so. A selection of sample resistors questions from the diagnostic test are shown in Figure 5.2 below.

Measure and record below the resistance of each of the three resistors.

R1 value ______________________________

R2 value ______________________________

R3 value ______________________________

Figure 5.2: Sample resistors questions

The theoretical aspect of the diagnostic test features a simple diagram containing all relevant components and test points associated with that particular circuit, as illustrated in Figure 5.3. As can been seen in Figure 5.4 there is a corresponding exercise sheet which asks the test participant to determine the expected electrical value at a certain test point in that circuit. Each student must therefore be able to read the circuit diagram before attempting to answer the questions, this being another core skill that must be mastered.

After successfully completing each theory test the student then proceeds to build the actual live circuit by using as a guide the simple diagram associated with that circuit. This provides the student with an additional challenge. In order to test the live circuit correctly and obtain the correct results, the circuit must first be constructed correctly.

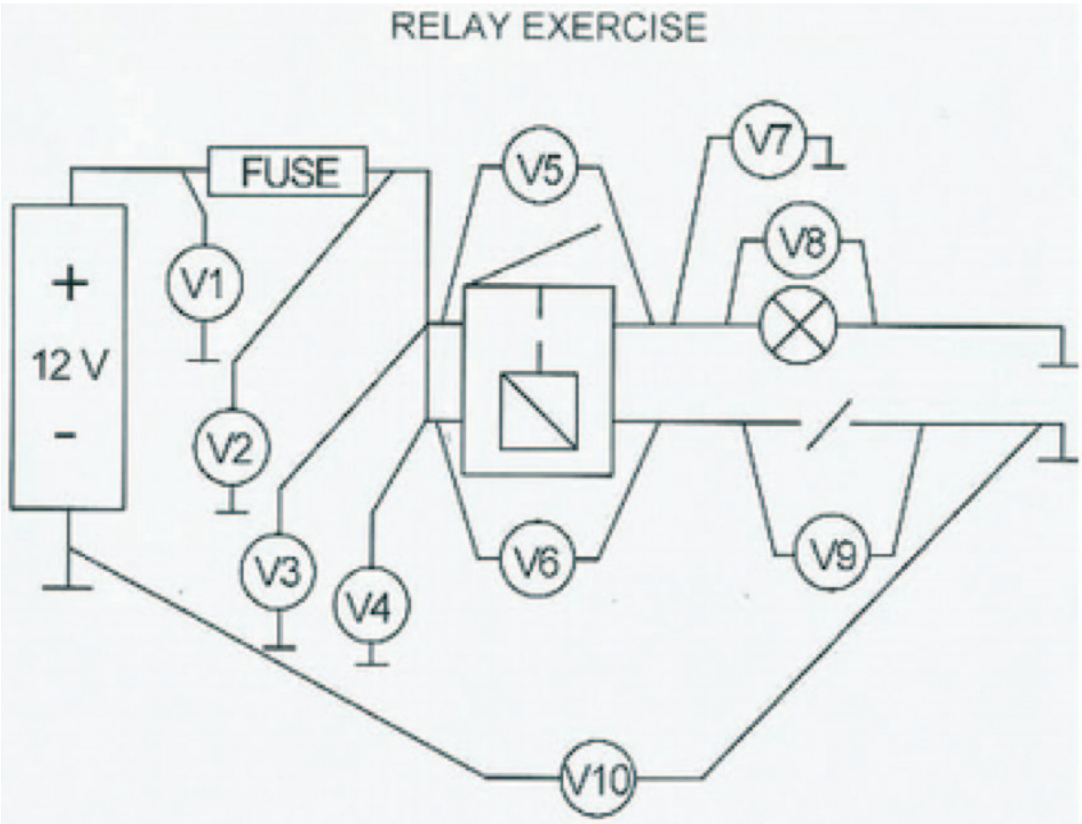

Figure 5.3: Relay exercise

Determine the expected voltage at all voltmeter positions in the diagram when the switch is open as well as closed.

Switch Open		Switch Closed	
V1		V1	
V2		V2	
V3		V3	
V4		V4	
V5		V5	
V6		V6	
V7		V7	
V8		V8	
V9		V9	
V10		V10	

Determine the expected voltage at the selected voltmeter positions in the diagram when the fuse is blown.

V1	
V2	
V10	

Determine the expected voltage at the selected voltmeter positions in the diagram with the switch open if the bulb has blown.

V5	
V8	
V9	

Determine the expected voltage at the selected voltmeter positions in the diagram with the switch closed if the bulb has blown.

V5	
V6	
V7	
V8	

Figure 5.4: Copy of relay exercise test sheet

If the circuit is constructed correctly then there should be no problem in carrying out any testing and obtaining the correct results. Some students find this aspect of the diagnostic test easier to complete as it involves a degree of trial and error and forces them into a unique situation where they are required to use their practical industrial based skills in a classroom/educational environment in order to overcome a problem. In this way the diagnostic test manages to integrate both industry and classroom learning.

As mentioned above the diagnostic test is split in two equal parts, theory and practice. In order to monitor student progress through the course and to allow and encourage students to master their electrical/electronic basics the diagnostic test was also repeated towards the end of their course.

Overall Test Results

The overall test results for stage one are shown in Table 5.2. The table gives the topic and the number of questions associated with each topic; the results are displayed as a percentage of the number of students who correctly answered questions in that particular topic. In addition to this the theory test results in all topics for both stages one and two as a percentage of students who got questions correct in that particular topic are displayed below in Figure 5.5. Figure 5.6 displays the practical test results in all topics for both stages one and two as a percentage of students who got questions correct in that particular topic.

Topic	No. of questions	% Theory test	% Practical test
Resistors circuits	10	30%	99%
Potentiometer circuit	5	53%	77%
Transistor circuit	5	65%	93%
Relay circuit	30	72%	84%

Table 5.2: Overall test results for stage one

The overall test results for stage two are shown in Table 5.3 below. The table gives the topic, the number of questions associated with each topic and the results are displayed as a percentage of the number of students who got questions in that particular topic correct.

Topic	No. of questions	% Theory test	% Practical test
Resistors circuits	10	76%	89%
Potentiometer circuit	5	58%	80%
Transistor circuit	5	75%	92%
Relay circuit	30	79%	87%

Table 5.3: Overall test results for stage two

Stage two took place six weeks after stage one. It may be observed from comparing Table 5.2 and Table 5.3 that there was a considerable improvement in the resistors exercise topic; initially a 30% pass rate, then a jump to a 76% pass rate in this area. In all three other test topics only a slight improvement occurred.

Comparing stages one and two, it can be seen that the practical results improved only slightly in the topics of potentiometer and relay circuits, whereas results for resistors and transistor circuits fell slightly. This may be due to the fact that the students were not given any prior notification of the practical test. This was done in order to measure their performance when placed in an unknown/ surprised situation.

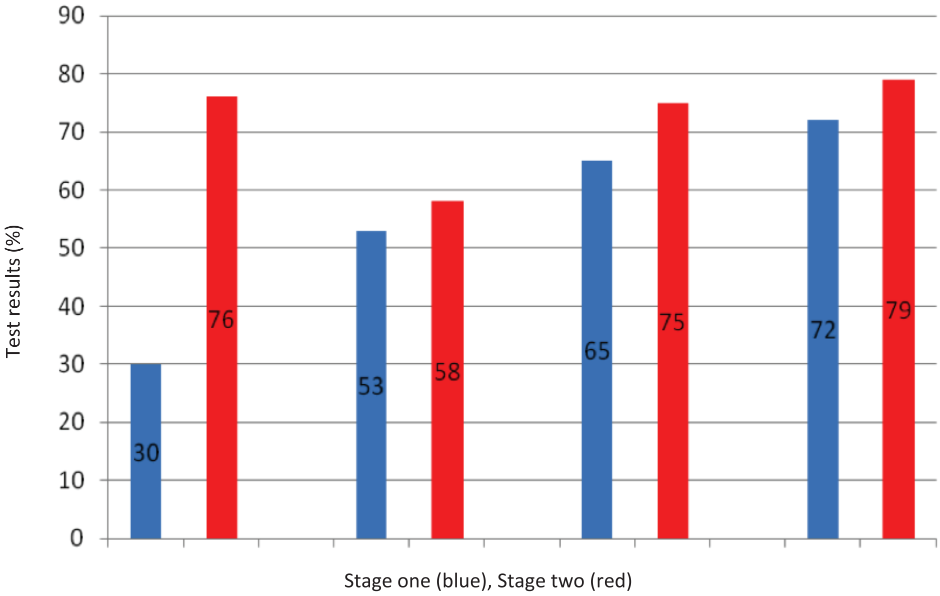

Figure 5.5: Theory results from both stages

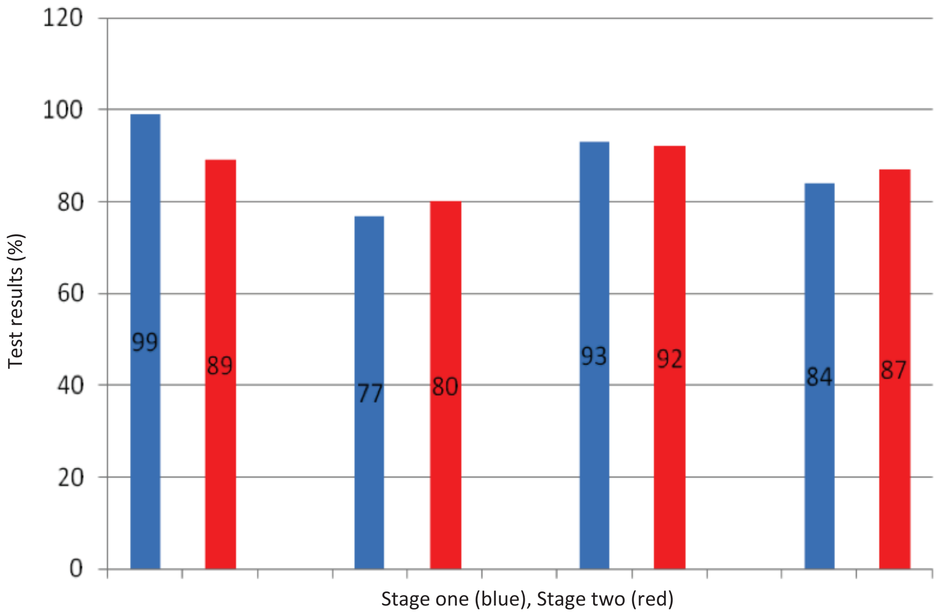

Figure 5.6: Practical results for both stages

Individual Student Test Results

Table 5.4 below shows the test results for each individual student as a percentage of questions answered correctly for combined test topics at each test stage. As can be seen in the table the lowest percentage score recorded was 39%. This was by student 5 and it occurred the second time that this student sat the theory test. This was a marked decrease in this student's theory result as a score of 54% was obtained the first time student 5 sat the theory test. The same student performed much better at the practical element of the diagnostic test. First time round 86% was achieved, increasing to 92% on the second attempt.

The best student improved their test results as they progressed through the course. Beginning with a score of 76% in the theory test at stage one, student 11 obtained a result of 88% the second time the theory test was taken. Student 11 scored 94% rising to 96% in the practical aspect of the diagnostic test.

Student	Stage 1 theory	Stage 1 practical	Stage 2 theory	Stage 2 practical
1	54%	90%	82%	82%
2	74%	84%	74%	84%
3	74%	86%	82%	96%
4	52%	88%	76%	88%
5	54%	86%	39%	92%
6	52%	84%	74%	84%
7	74%	86%	84%	96%
8	74%	88%	58%	92%
9	58%	88%	80%	88%
10	42%	86%	56%	92%
11	76%	94%	88%	96%
12	56%	86%	80%	86%

Table 5.4: Individual student test results

Conclusion

By allowing students to sit the diagnostic test at the start of their period of off-the-job training they quickly understood the task facing them. By making the students aware that they would re-sit the diagnostic test sometime towards the later stage of their course allowed them a period of time at their own discretion to prepare for this second test. However it was pointed out to the students before they sat the test that any marks obtained in the diagnostic test could not be added to marks obtained by them in their official apprenticeship assessments.

Apart from this an improvement in most of the topics covered by the diagnostic test was made apparent after the test was sat the second time with the exception of some of the practical topics at stage two.

In order to improve further core electrical/electronic skills in motor mechanic apprentices the diagnostic test could be made a fully integrated part of their syllabus and in order to motivate students the marks obtained by them could be made part of their overall course results. However the main difficulty with the implementation of a diagnostic test is that FAS the national training authority in Ireland is the primary provider for apprentice education in Ireland at the present time, whereas Institutes of Technology including the Dublin Institute of Technology are classed as secondary providers. However, even in the current model of apprenticeship with no credit allocation for a diagnostic test it can be seen that such a test proved useful to students as is reflected by their test results.

Recommendations to DIT

1. Allocate time in the timetable of all lecturers involved in the teaching of electricity to motor apprentice students in the School of Mechanical and Transport Engineering so that students may sit both theory and practical aspects of the diagnostic test with the aim of improving their understanding of basic electricity and electronics.
2. Integrate the diagnostic test into course work for full time students who are studying the subject matter of automotive electricity/electronics in order to give them a better understating of the subject matter and, as an incentive, award course/assessment marks accordingly.

Proposed Future Work

In order to enter into a motor apprenticeship in Ireland a qualification in electricity/electronics is not essential. However it is critical that motor students have a full grasp of the subject matter both during and towards the end of their training due to the level and complexity of electrical and electronic systems that form part of the modern motor vehicle. Many motor apprentices therefore find the subject matter difficult because they have never studied it before. Also the level and standard of the subject area increases as students progress through their apprenticeship.

I propose that the diagnostic test outlined above focusing on the areas of electricity and electronics should be given to all apprentice motor students at the beginning of their Phase 6 off-the-job training course in DIT during the academic year 2013–2014.

By allowing students to sit the diagnostic test at the start of their period of off-the-job training course they quickly understand the task facing them. The results obtained from the diagnostic test should quickly indicate students that may encounter difficulty with electrical related subjects.

I propose that the same test then be given to the same group of students mid-way through the same course in order to judge progress made through the course and to better identify those who have an extreme difficulty with the subject matter.

It is my intention that any students participating in the diagnostic test during the academic year 2013–2014 will be given prior notice of the test in order to gauge their performance.

For the long term, the syllabus for the trade of motor mechanic is due to be reviewed in late 2013. It is my intention to propose to FAS that the above diagnostic test be included as part of any revision of the current syllabus.

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