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Improving Core Mathematical Skills in Motor Apprentice Education in Ireland

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ABSTRACT

In order to enter into an apprenticeship in Ireland a qualification in mathematics is not essential. Throughout their apprenticeship many motor trade apprentices find that many past mathematical weakness resurface. In addition to this the level and standard of mathematics increases as apprentices progress through their training.

A maths diagnostic test has been developed and sat by a selection of Motor Mechanic apprentices attending off the job training at the Dublin Institute of Technology during the 2011 to 2012 academic year.

The results of this test indicate that many students experience difficulty with mathematically related subjects. The test was then repeated by the same students mid way through the course in order to review their progress. In the intervening period students were encouraged to study a series of online resources. A full statistical analysis and discussion of the results is presented here.

INTRODUCTION

The educational minimum entry level in order take up an apprenticeship in Ireland is five passes at junior stage at second level education. During second level junior stage education mathematics is one of the subjects studied. However it is not compulsory to pass this subject in order to enter into an apprenticeship in Ireland. Therefore after successfully entering into an apprenticeship students may re-counter past mathematical weakness when they begin the off-the-job training stages of their apprenticeship.

During an apprenticeship the level and standard of mathematics increases. This becomes a particular problem when an apprentice reaches phase 6 level as this is the highest level at which an apprenticeship may be studied at off-the-job level in Ireland. See table 1 below.

Phase	Description
Phase 1	On the job
Phase 2	Off the job (20 weeks)
Phase 3	On the job
Phase 4	Off the job (10 weeks)
Phase 5	On the job
Phase 6	Off the job (10 weeks)
Phase 7	On the job

Table 1 : Irish apprenticeship system

At phase 6 apprentices find the level of mathematics difficult for the following reasons :

1. The duration between phase 4 off-the-job and phase 6 off-the-job maybe as much as two years.
2. Both the level and standard of mathematics during an apprenticeship gets progressively harder and reaches its peak level at phase 6.
3. Any previous problems encountered with mathematics during second level education may re-surface again.

DUBLIN INSTITUTE OF TECHNOLOGY

The Dublin Institute of Technology act of 1992 saw the establishment of the Dublin Institute of Technology. Previously to this six separate colleges existed in Dublin. Their origins date back to 1887 when technical education was first established in Ireland.

The Dublin Institute of Technology is a third level institute the largest of its kind in Ireland and caters for full time students studying undergraduate courses at levels that range from undergraduate, higher certificate, ordinary and honours degree. As well as post graduate students studying courses at diploma, masters and doctoral levels apprentice education is also catered for within the Dublin Institute of Technology.

In the 21st century the Institute continues its long establishment in technical education.

IRISH APPRENTICESHIP MODEL

In Ireland in order to become a recognized craftsperson an individual must complete an apprenticeship. FAS who are the national training authority in Ireland designate all trade areas under the scope of the statutory apprenticeship system. This system is organized by the Department of Education and Skills in co-operation with FAS, trades unions as well as employers. The certification and awarding body for apprenticeship in Ireland is FETAC (Further Education and Training Council).

The Irish apprenticeship system is modular based consisting of seven modules in total. Modules alternate between periods of both, off-the-job as well as on-the-job training. This system of apprenticeship has been in existence since the mid 1990s having succeeded the previous day release system.

The curriculum for each apprenticeship is designed to meet industry agreed pre-specified standards. The Irish apprenticeship system is both a classroom and workplace demand driven program that is aimed at providing as well as developing the skills of the apprentice in order to suffice the needs of industry.

LIGHT VEHICLE MECHANIC COURSE

The course I teach on is entitled Light Vehicle Mechanic. I teach it at phase 6 level and it is ten weeks in duration including assessments. The content is a mix of 50% theory based classroom work and 50% workshop/lab work. The course requires apprentices to study six different modules as listed in table 2 below. At the end of the ten week period they will be assessed in these same areas.

Module	Module Title
Module 1	Petrol Engine Management
Module 2	Steering and Suspension
Module 3	Braking Systems
Module 4	Transmission Systems
Module 5	Body Electrics
Module 6	Diesel Systems

Table 2 : Light vehicle mechanic course modules

TEST DESCRIPTION

The online test is constructed from ten different sub areas of the course having a mathematical/calculation type content. A bank of questions has been generated and computer software generates at random one question from each sub area. As well as the online test a series of online course materials relating to the test topics have also been developed as an aid to students. These are available on request from the author. The online test has ten questions in total. Table 3 below lists the topics covered by the online test.

Question	Topic
1	Binary Numbers
2	Specific Heat Capacity
3	Compression Ratios
4	Gear Ratios
5	Percentages
6	Adding Fractions
7	Ratios
8	Ohms Law
9	Electrical Power
10	Electrical Circuits

Table 3 : Test question numbers and topics covered

See appendix below

TEST RESULTS

The test result as presented in table 4 below. The table gives the topic associated with each question number and the results are displayed as a percentage of the number of students who got that particular question correct both on their first as well as their second attempt.

It may be observed from the table that there was a significant increase in the percentage of students who got the binary numbers question correct on their second attempt of the diagnostic test. At the first attempt 37.5% answered this question correctly, whereas all students correctly answered the question the second time that they sat the test. This is an increase of 62.5%.

In four other question areas (Percentages, Ratios, Ohms Law, Electrical Circuits) all students managed to pass the question on their second attempt. In only one area question 4 (Adding Fractions) was there no improvement. This would suggest that more work is required by the students in this area. The most difficult area of the test was question 2. The topic covered here is specific heat capacity. An improvement of only 12.5% was recorded here.

Question	Topic	% Correct 1st Attempt	% Correct 2nd Attempt
1	Binary Numbers	37.5	100
2	Specific Heat Capacity	50	62.5
3	Compression Ratios	37.5	75
4	Gear Ratios	75	87.5
5	Percentages	75	100
6	Adding Fractions	62.5	50
7	Ratios	75	100
8	Ohms Law	87.5	100
9	Electrical Power	75	75
10	Electrical Circuits	62.5	100

Table 4 : Test results

STUDENT INDIVIDUAL RESULTS

Table five below shows the test results of each individual student as a percentage of questions answered correctly on both first as well as second attempts. The results of six students improved the second time that they attempted the test. In only one case was there no improvement with that particular student obtaining the same percentage mark on both test attempts.

One student obtained a lower score on their second attempt, while one student scored 90% on their second attempt, this being an increase of 90% from an initial mark of zero on their first test encounter.

Student	% Correct 1st Attempt	% Correct 2nd Attempt
1	70	70
2	90	80
3	70	80
4	50	90
5	80	90
6	0	90
7	70	90
8	80	90

Table 5 : Table of individual student results

STATISTICAL ANALYSIS

We performed two paired t-tests to see if the improvement in the individual student marks and the improvement per subject type was significant. The analysis can be seen below in table 6.

	Individual Student marks	Individual topics
Average test 1	63.75	63.75
Average test 2	85	85
T-test	$p = 0.097$	$p = 0.012$

Table 6 : Statistical analysis

We see that the improvement in the individual students is significant at p=0.097 and the improvement in the individual subjects has a p=0.012

CONCLUSION

Mathematics is one of the subjects studied during second level education in Ireland. However it is not compulsory to hold a qualification in this subject in order to enter into an apprenticeship. This is more than often encountered as being a disadvantage by both apprentice students as well as their educators. The diagnostic test sat by a selection of motor mechanic apprentices studying the subject at phase 6 off-the-job level at the Dublin Institute of Technology highlights this fact.

By allowing students to sit the diagnostic test at the start of their period of off-the-job training and quickly understand the task facing them. By making the students aware that they will re-sit the diagnostic test towards the later stage of their course allows them a period of time to prepare for this second test. By having access to a series of accompanying on-line training resources students are more prepared for the test the second time round.

When students were presented with both sets of test results they were then in a position to review their progress. An improvement in most of the topics covered by the diagnostic test was made apparent after the test was sat at the second time with the exception of the question relating to adding fractions. This highlights that more work is required in this area.

In order to improve mathematical skills in motor mechanic apprentices the diagnostic test could be made a fully integrated part of the syllabus and the marks obtained by test participants 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 are the primary providers for apprentice education in Ireland, 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 allocated for a diagnostic test we see a significant improvement.

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Doing as Learning : "Its not like maths at school here its to do with what you're doing"

J. Britan, S. Grief

APPENDIX

Question 1

Indicate from the options listed below the correct answer to the following question :

Binary number 110 converted into decimal is :

A = 2

B = 4

C = 6

D = 8

Question 2

Indicate from the options listed below the correct answer to the following question :

The water pump of a certain engine cooling system circulates coolant at a rate of 15 litres per minute. The inlet temperature at the cooling system radiator is 97ºC and the outlet temperature at the cooling system radiator is 85ºC. Calculate the amount of heat energy passed to the coolant in one minute ?

Assume 1 litre of coolant = 1 Kg

Take specific heat capacity for coolant as 4200 J/Kg ºC

Note

You should use the formula provided below.

Energy = Mass x Temperature Change x Specific Heat Capacity

A = 756000 KJ

B = 75600 J

C = 756 J

D = 756 KJ

Question 3

Indicate from the options listed below the correct answer to the following question :

Calculate the compression ratio of an engine using the following information in order to calculate your answer :

$\pi = \dfrac{22}{7}$ Bore = 10.5 cm   Stroke = 10 cm

combustion chamber clearance volume = 39.775 cm³

A = 21.7 : 1

B = 22.7 : 1

C = 12.7 : 1

D = 14.7 : 1

Question 4

Indicate from the options listed below the correct answer to the following question :

If the crown wheel rotates at a speed of 185 rpm and the outer half shaft rotates at a speed of 191 rpm, what is the speed of the inner half shaft ?

A = 179 rpm

B = 189 rpm

C = 199 rpm

D = 191 rpm

Question 5

In a sample of components 2.3% were rejected. If a total of 46 are rejected, the number in each batch is

A = 460

B = 2000

C = 20

D = 200

Question 6

Is 1/2 + 2/3 equal to

A = 7/6

B = 6/7

C = 3/7

D = 3/6

Question 7

An alloy contains copper, zinc and nickel in the ratio 2 : 3 : 5. The mass of zinc in 20 kg of the alloy is

A = 5 kg

B = 6 kg

C = 8 kg

D = 7 kg

Question 8

If a circuit is supplied by 14.4 volts has a resistance of 4 ohms is the current flow :

A = 4 amps

B = 0.36 amps

C = 36 amps

D = 3.6 amps

Question 9

If a glow plug draws 18 amps when first switched on and its resistance is 0.75 ohms how much power will it consume :

A = 243 watts

B = 24.3 watts

C = 2.43 watts

D = 2430 watts

Question 10

If three 4 ohm resistors are placed in a series circuit that is supplied with 12 volts then the current flow in the circuit will be :

A = 1 amp

B = 4 amps

C = 12 amps

D = 11 amps