**A study of the effectiveness of a short duration STEM education initiative using Rodni, a creative animatronics kit, and Arduino micro-controllers with school pupils aged 9 years to 14 years.**


## Abstract

A survey of 304 school pupils aged 9 to 14 years showed a significant improvement in attitude towards coding and technical projects following a 1-2 hour workshop using Rodni a creative animatronics kit.
The workshops were conducted in 14 state and public schools, led by a STEM ambassador.
A high level of pupil engagement was observed.


## Introduction

Despite the increasing importance of software in developed economies children have little exposure to the underlying technologies and the career possibilities involving them.
Many of the solutions available to address this issue are either refined to a stage that children are putting together "black boxes" or have an entry barrier high enough to put children off the subject before they can become interested.
The Rodni project was developed to address this by giving children the opportunity to try hands-on creating, electronic circuit building and software coding with a shallow learning curve and immediate tangible feedback. The project is designed at a level that children can believe that this is something they could do themselves at home.
This paper studies what impact a short class workshop has on pupil's attitudes towards coding and technology.

## Materials

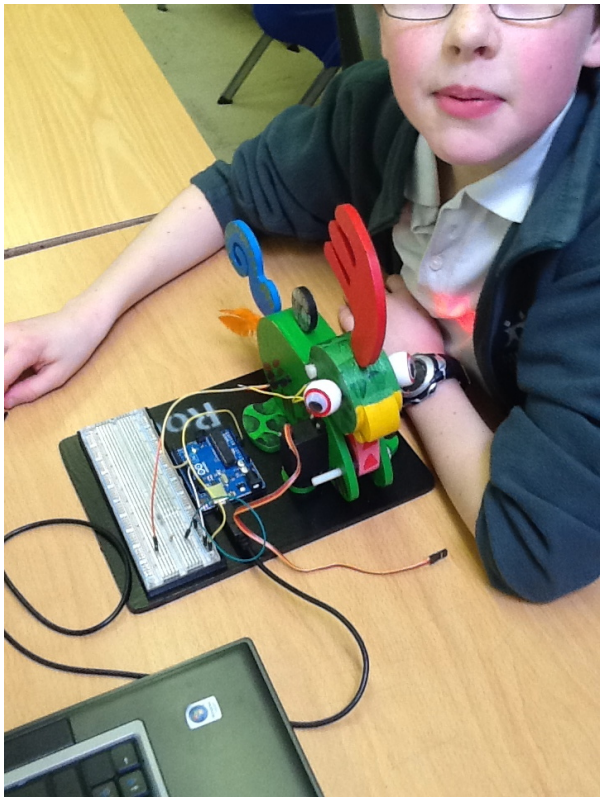
The Rodni kit comprises a multitude of wooden parts that can be used to construct an animatronic animal with a wide variety of design choices for the pupil. The kit also contains all necessary electronic components and Arduinos. The open source Arduino IDE is used to programme the micro-controllers using the inbuilt example codes as a basis for experimentation.
There is also an accompanying instruction booklet and slide set in various formats for leading the class through the workshop. A trouble-shooting sheet is also provided.

**Method**

The project ran from January-July 2013.

Participant schools from the state and private sector were identified by the staff at STEM Team East. Rodni workshops of 1 to 2 hours duration were offered free of charge on the basis that a pre and post workshop questionnaire would be completed by each pupil. Pupils ranging from 9 to 14 years old and both gender were included. Kits to build12 Rodnis, sufficient for up to 36 pupils were provided.

Schools provided their own PCs and the school IT staff pre-loaded the open source Arduino IDE software. All schools had a video projector that was used with a slide show to lead the workshop. All other materials were provided within the Rodni kit.



Prior to the workshop each pupil completed a 3 question survey, ticking the most appropriate box from 1 to 10 for each question, 10 being most positive.

The questions were:

“How much fun do you think writing computer software would be?” (1 Boring, 10 Lots of fun).

“How interesting are technical projects to you?” (1 Boring, 10 Very interesting).

“How interested are you in trying robotics projects as a hobby?” (1 Never, 10 Very interested)

The same 3 questions were repeated at the end of the workshop with the addition of:

“What do you think of the Rodni project?” (1 Boring, 10 Very interesting).

The children were also asked to make a written comment on:

1) “What was good about the project”

2) “How could the project be improved”

The children, in groups of 1 to 3, were then led through the workshop using the presentation available at http://www.lowbot.co.uk/STEM_Education/overview.html

The phases of the workshop were as follows:

1) Discuss the importance of software in modern life
2) Build a Rodni
3) Where appropriate the pupils were able to take photographs of their creations
4) Open the Arduino IDE on the PC
5) Open the Blink example and discuss the code, upload to the Arduino and note the blinking on-board LED
6) Discuss LEDs, resistors and the use of breadboards. Wire the LED circuit to the Arduino pins. Note that the heart is now "beating"
7) Experiment changing pin numbers and timing delays. Discuss syntax
8) Challenge pupils to make the heart make a short-long "beat" rather than a constant flash
9) Discuss what real-life applications there are for this code/electronic set-up.
10) Wire the servo in the neck and open the servo sweep example
11) Discuss the code and upload - head starts sweeping up and down
12) Adapt code to simplify it, then experiment with changing timing and sweep angles
13) Discuss real-life applications for this
14) Wire a potentiometer to the Arduino and load servo knob example - head position is controllable with potentiometer
15) Load ReadAnalogVoltage example. The voltage from the potentiometer can now be read on the the PC. Explain how the voltage divider works and how this is driving eh servo through the code
16) Substitute a module linking the light sensitive resistor in Rodni's head for the potentiometer and demonstrate that a sensor works in the same way as the potentiometer
17) Load Servo knob example. Note that Rodni's head now moves in reaction to light levels
18) Present ways in which this can be explored at home using inexpensive commercially available Arduino experimentation kits

Depending on the time available and the ability of the class the workshop was finished at stages 11) or later.

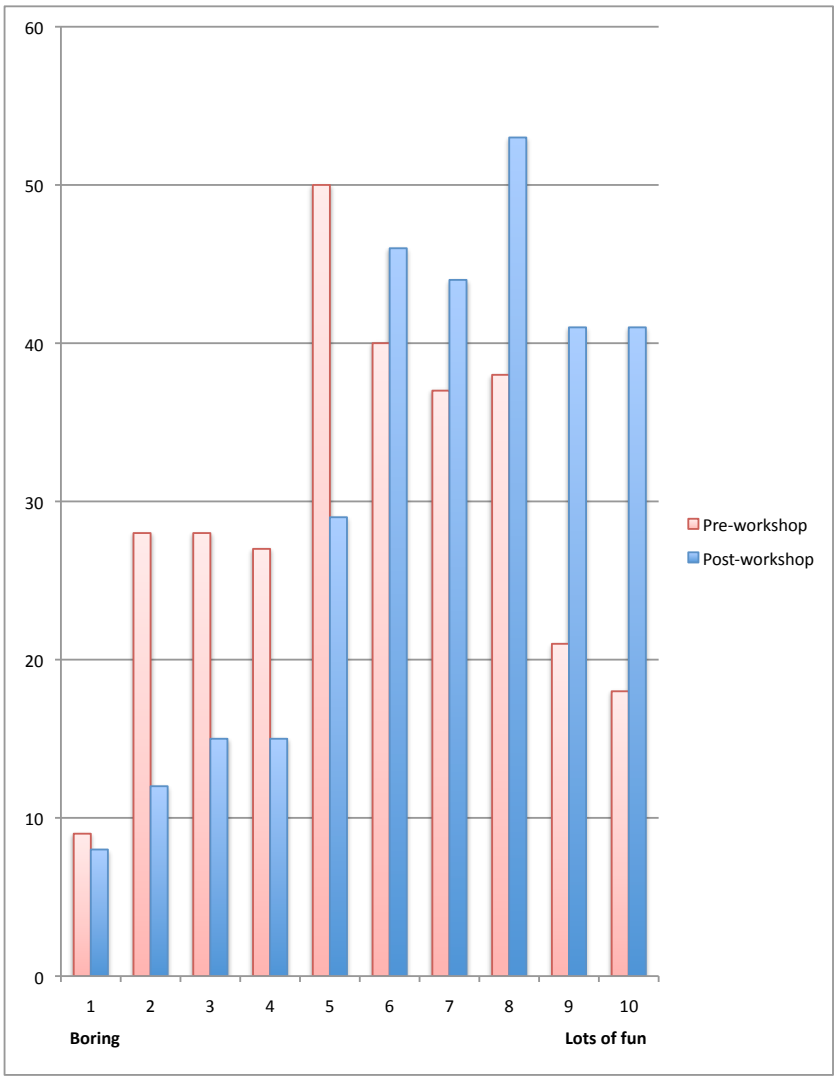
Individual school reports were written for each workshop and supplied to the teachers.

The results were statistically analysed by comparing the % of pupils in the top 4 brackets and the % in the bottom 4 before and after the workshop. The z-Test was applied.

## Results

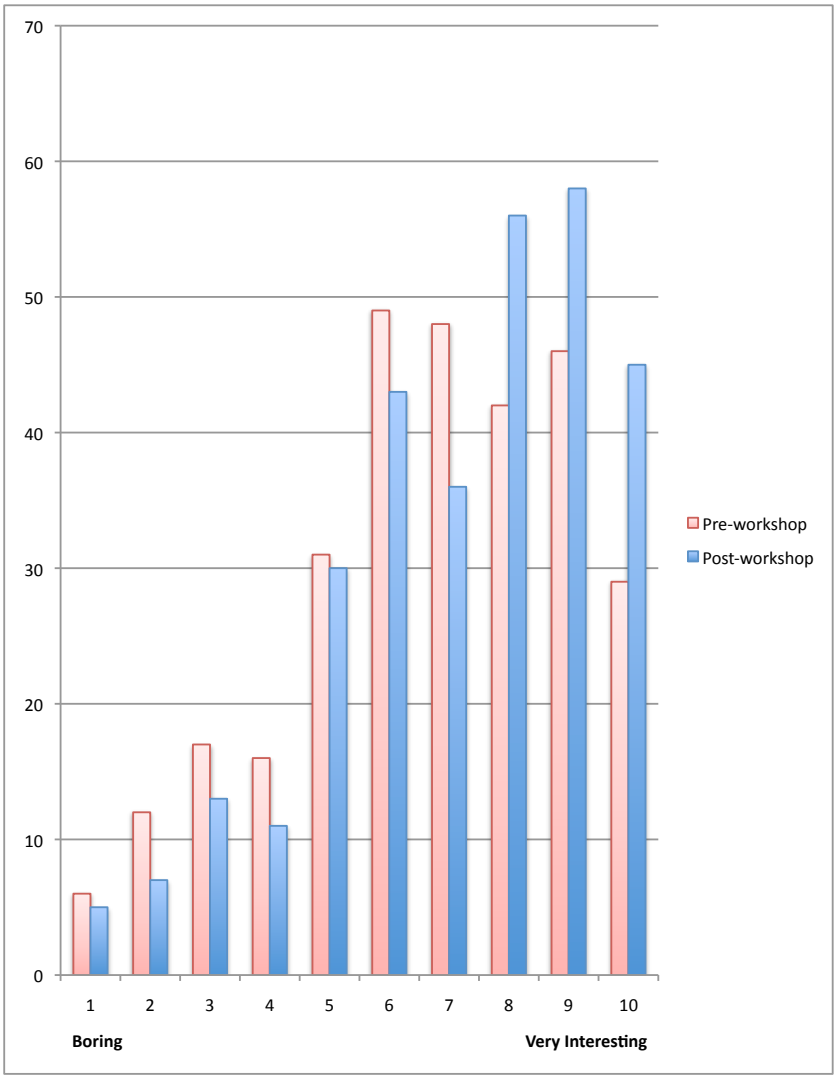
304 pupils from 14 schools participated in the study. 296 completed the pre-workshop survey and 304 completed the post workshop survey. The results are presented below.

**How much fun do you think writing computer software would be?**



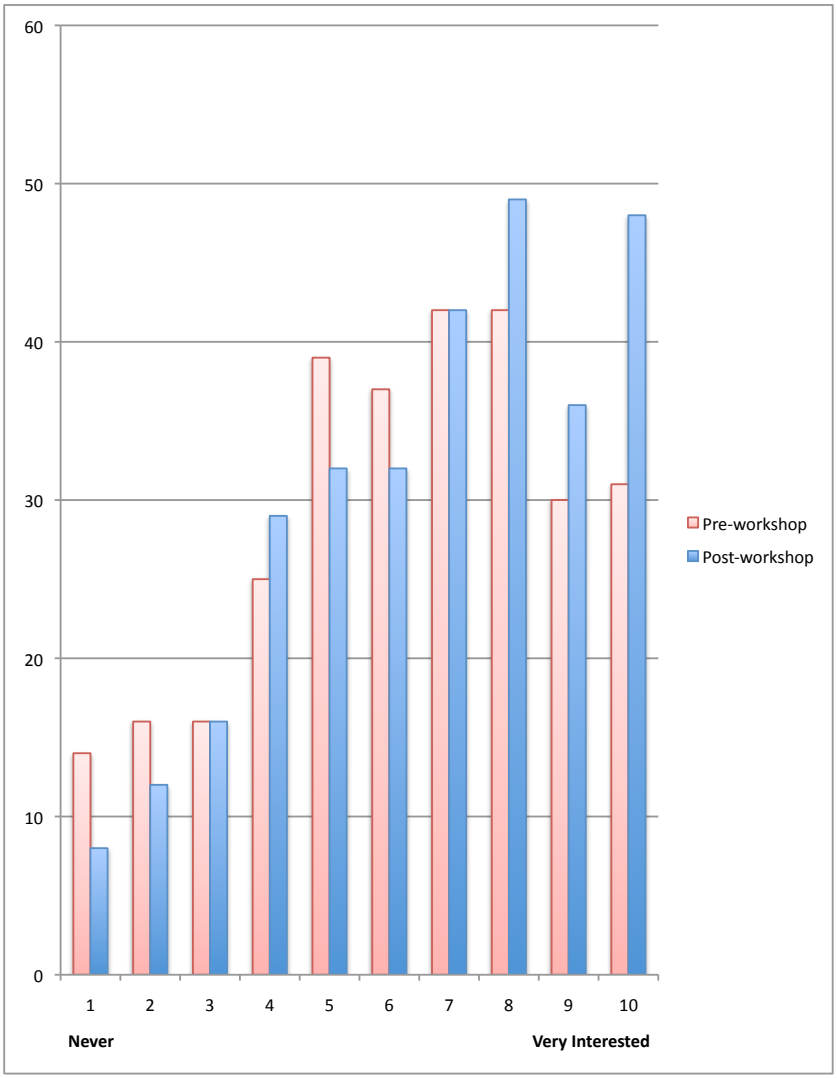

There were 31% of the pupils in brackets 1-4 in the pre workshop survey compared with 16% post workshop. This 49% decrease is significant to 99%.
There were 39% of the pupils in brackets 7-10 in the pre workshop survey compared with 59% post workshop. This 51% increase is significant to 99%.
The workshop increased significantly improved the attitudes of pupils towards writing computer software.

**How interesting are technical projects to you?**



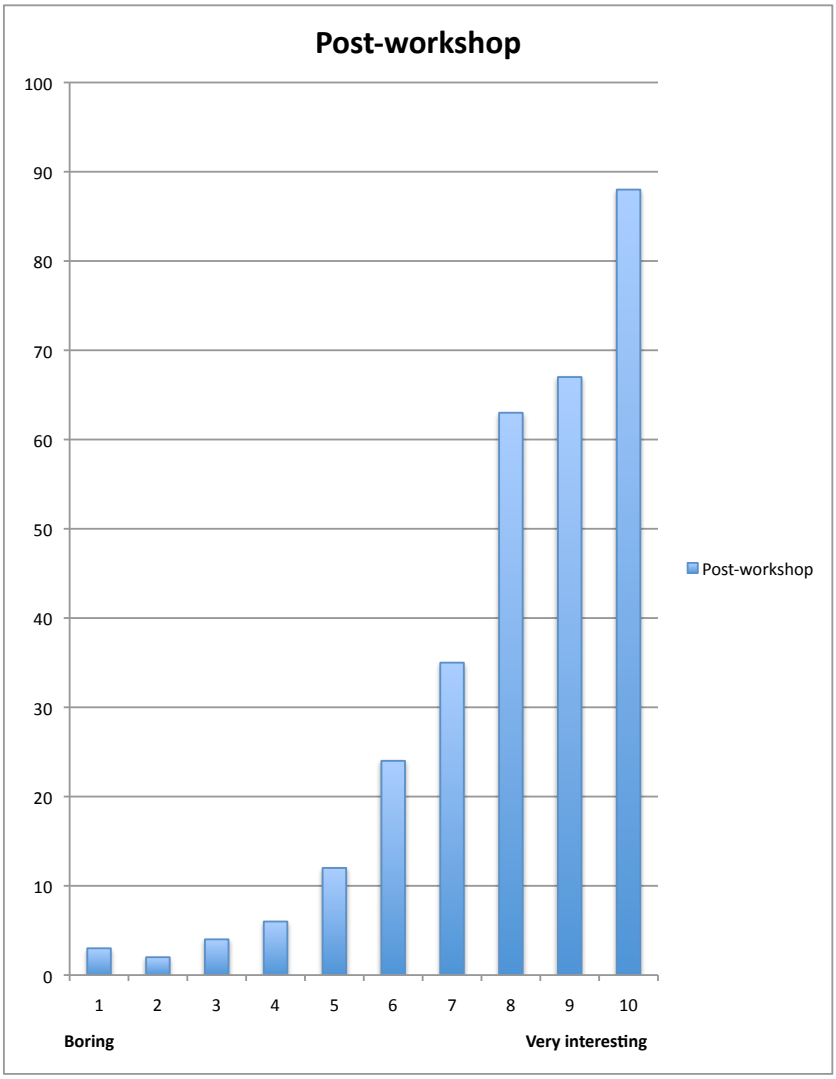

There were 17% of the pupils in brackets 1-4 in the pre workshop survey compared with 12% post workshop. This 30% decrease is significant to 90%.
There were 56% of the pupils in brackets 7-10 in the pre workshop survey compared with 64% post workshop. This 14% increase is significant to 95%.
The workshop significantly increased the interest of the pupils in technical projects.

**How interested are you in trying robotics projects as a hobby?**




There were 24% of the pupils in brackets 1-4 in the pre workshop survey compared with 21% post workshop. This 13% decrease is not significant to 90% or more.
There were 49% of the pupils in brackets 7-10 in the pre workshop survey compared with 58% post workshop. This 18% increase is significant to 95%.
The workshop had no significant impact on those not interested in robotics but significantly increased the interest of those already interested.

**What do you think of the Rodni project?**




83% of the pupils rated the project in the top 4 marks. 29% awarded 10/10.
The project was well received.

The written comments ranged from enjoying building the Rodni, wiring up the electronics and also experimenting with the coding. A frequent comment was that they had never done anything like this before.
The most frequent improvement suggestions were that they should be able to take their Rodni home, that the the workshop should be simpler, that the workshop should be more challenging and that they would like to make the Rodni do more activities.
A frequent verbal teacher comment was that the pupils were engaged with the workshop.

**Additional result**

Chesterton Community College purchased 2 Rodni sets and started a girls robotics club following the workshop.The school project was subsequently awarded a prize for special scientific merit by Rolls-Royce. They are now continuing to apply for further funding to finance CAD/CAM machinery to further progress the project in the school. (1)

**Discussion**

This study was conducted during the early phases of the Rodni project and the results include the reaction to various "teething problems" that were resolved during the course of the study.
The most frequently encountered problem was with the erratic behaviour of Windows PCs with the USB drivers for the micro-controllers. It was common to lose communication ports during the class. These problems were resolved by, in order of action, changing the USB socket, restarting the Arduino IDE, restarting the PC. The pupils were tolerant of these issues and were able to fill any down time by either further enhancing their Rodni creation or preparing the electronic wiring for the next stage of the workshop.

The Arduino was used in the exercise rather than one of the other microcontroller/computer boards available because it has the lowest barrier to entry. There is no need for ancillary equipment apart from a PC (any OS). The IDE software contains a large number of libraries and examples and the coding language, based on C, is easy to read and understand. For those pupils who wish to take their interest further the Arduino is inexpensive, readily available and well supported with kits and on-line projects on sites such as Instructables.com and Make.com. It is ideal for physical projects, those wishing to explore video and internet connected projects can progress to more advanced boards such as Raspberry Pi once they have gained confidence in coding. The Arduino board is often used as an enabler of the Raspberry Pi for physical projects.

Building the Rodnis was seen by the pupils as a fun exercise and caused excitement, resulting in a good level of engagement. This lifted the electronics and coding exercises to a more emotive level because they were bringing their Rodni to life.
Pupils had varying levels of ability but very few had any previous experience of coding or of wiring electronic circuits. The workshop was led by a STEM Ambassador and in some cases a further Ambassador supported the students. This proved particularly useful for larger classes and where PC issues were experienced.

The workshops were effective in changing attitudes to coding. The pupils had little prior experience and the workshop achieved its objective of making their first encounter a pleasurable one. It is desirable that the first encounter with coding doesn't reinforce any preconceptions that this is a difficult activity. The rapid and tangible feedback with the Rodni flashing and moving was important in this respect as it has more impact that just changing visuals on a computer screen.

Teachers considered the workshops worthwhile with several booking further workshops and considering building this project into the curriculum as an introduction to computing. The students were engaged and this was seen as a useful step towards implementing a structured IT curriculum. The workshop bridged the disciplines of D&T and IT and some schools saw the possibility of building their own parts in an integrated learning exercise.

No analysis of gender differences was made. The results from individual schools is available.

## Conclusion

The Rodni workshops were effective in engaging pupils and in changing attitudes to coding.

## References

(1) Dave Timney, http://scienceprize.rollsroyce.solutions.investis.com/Admin/PreviousEntries/StatusReportSubmitted.aspx?TeacherId=4524&CourseId=463

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The Perse School Cambridge
St Faith's School Cambridge
St John's School Cambridge
St Peter's School Huntingdon
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