Motivation:
Motivations for this project were multilayered:
Previous personal teaching experience had shown that students have had difficulty “blurring” the lines between mathematics and science, viewing them as distinctly different subjects without overlap and unable to see the commonality between processes used in both subjects. Additionally, it did not appear that students were developing an understanding of how specific skills in either maths or science were in fact a generic skill applicable to both. For example, linear relationship and graphing techniques as explored in both the Cartesian Planes and Algebra topics were applicable to the presentation and analysis of discrete data collected during science experiments.
The assumed level of student ICT literacy at both middle and senior school level was overestimated. For example, stage 1 SACE Physics students that still required instruction in the difference between discrete and continuous data and from this, lacked understanding of the appropriate choice of form for data representation (i.e. scatter plots versus line graphs).
Generalised student difficulty in communicating their understanding of the “how” and “why” of their learning, especially with respect to explaining their thought processes and application of knowledge. This was not confined to high school students. The issue had also been encountered during previous teaching experiences in Foundation, First and Second year Physics and Engineering courses at the University of South Australia.

Purpose:
As an introduction to Cartesian co-ordinates, year 8 maths students will use the ‘Scratch’ software platform to create an algorithm and program. Their programs will cause a sprite to move through quadrants in a specified sequence that draws planar shapes, whose lines are described by linear relationship rules. This activity will be supported by the use of excel for creation of tables of values from rules and equations. A pre-activity questionnaire and post reflective literacy component will complement the unit, providing students with the opportunity to communicate their understanding of what they have learnt and applied, how they learnt it and why they have learnt it.
An expected outcome of this unit will be the transference of specific maths knowledge to a broader, generalised understanding of the range of possible applications. i.e. maths is not just about sums in a workbook, but is how we learn the tools and processes used in many different everyday applications and careers, as well as development of generic skills. For example, cross curricula application such as transfer of scatter graph skills required for various science topics applications found within all science subject year levels.
Points to note:
It is envisaged that this unit of work will become a common assessment task for the year eight cohort at Seaton High School.
Some success has previously been achieved with a year 10 maths studies Directed Investigation on Algorithms, using consumer maths as a basis to extend student understanding of the topic as a specific example of the broader concept of iterations, recurrence relationships and algorithms and providing students with the opportunity to communicate this.
In contrast to previous years, this unit of work will be taught before the Algebra topic. (Algebra was considered to be an enabling topic required to be introduced prior to Cartesian co-ordinates).

ACARA Links:
Australian Curriculum Content Description:
Mathematics “Plot linear relationships on the Cartesian plane with and without the use of digital technologies completing a table of values, plotting the resulting points and determining whether the relationship is linear finding the rule for a linear relationship”
Science “Processing and analysing data and information. Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships, including using digital technologies as appropriate.”

Methodology:
Phase 1: Establishment of base knowledge, (x, y) notation/terminology.
Students are introduced to the concept of 2-dimensional (x, y) ‘addresses’ on the Cartesian Plane to accurately describe position through an activity based on ‘The Simpsons’ cartoon characters.

Phase 2: Extension of base knowledge, relationship between (x, y) pairs determines line orientation, communicate understanding.

Students are given an activity based in Excel in which they explore the different outcomes for different fixed relationships between the ‘x address’ and ‘y address’ for several sets of numbers. As part of this process, students extend their understanding of Excel software by seeing the commonality between (x, y) co-ordinates and the address of a cell in their spreadsheet. Tasks within this activity increase in complexity and also involve an introduction to the use of rules (formulas) to create the sets of numbers as well as how to effectively and appropriately visually represent these rules and relationships (graphing). Literacy is also addressed by the task requirements of having to explain the connection between the visual representation and the relationships graphed.

Phase 3: Student application of knowledge to the Scratch software platform.

Students were given a task that involved them writing an algorithm to draw a particular geometric shape on a grid background in Scratch. Once the algorithm was completed, students were then asked to write their algorithm as a project program in Scratch and then run their project.

Phase 4: Student reflection on the what, how and why of their learning.

Students were given a reflective literacy task which provided them with the opportunity to state and describe learnt facts, processes and application, as well as reflect and evaluate on their learning.

Outcomes:

Students from the 2014 year 8, 810 mathematics class completed both a pre and a post unit survey in addition to the post activity reflection journal. They were also assessed on their knowledge and application of the topic via a class test. The test examined their ability to recall and apply as well as interpret and analyse graphs and information and then communicate their understanding. This test had also been given to the year 8, 809 mathematics class in 2013, who had been taught Cartesian Co-ordinates via more traditional (paper and pen) methods. The results for the two classes were analysed for basic statistical measures of centre and spread and then compared. The context for the two classes should be noted: Context for the data: It should be noted that the 2013 class was a mainstream year 8 mathematics class where the less able students were in a numeracy program and were therefore not included. The 2014 class was the “B” SHIP class and had a proportion of students in the gifted art program at Seaton High School, as well as some students with advanced English and language skills.

The basic statistics calculated are displayed in the table below:

<table>
<thead>
<tr>
<th>Class:</th>
<th>Statistical Measure:</th>
<th>810 Mathematics Class 2014</th>
<th>809 Mathematics Class 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td></td>
<td>33.0</td>
<td>28.1</td>
</tr>
<tr>
<td>Minimum</td>
<td></td>
<td>29.5</td>
<td>16</td>
</tr>
<tr>
<td>Maximum</td>
<td></td>
<td>38.0</td>
<td>38</td>
</tr>
<tr>
<td>Sample Std. Dev.</td>
<td></td>
<td>2.8</td>
<td>6.5</td>
</tr>
<tr>
<td>Q1</td>
<td></td>
<td>31.0</td>
<td>23.5</td>
</tr>
<tr>
<td>Q2</td>
<td></td>
<td>32.75</td>
<td>28</td>
</tr>
</tbody>
</table>
Table 1: Comparison of the statistical measures for the two classes.

<table>
<thead>
<tr>
<th></th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q3</td>
<td>34.25</td>
<td>34.5</td>
</tr>
<tr>
<td>IQR</td>
<td>3.25</td>
<td>11</td>
</tr>
<tr>
<td>N</td>
<td>20</td>
<td>21</td>
</tr>
<tr>
<td>Mode</td>
<td>31,33</td>
<td>28,38</td>
</tr>
</tbody>
</table>

These statistical measures have been visually represented as both simplified box plots and normal distribution curves for easier comparison (see figures 1 & 2 below)

Figure 1: Comparison of box plots for the statistical measures in table 1.

Figure 2. Simplified representation of the normal distributions (data from table 1) for the two classes (2013 is red trace, 2104 is black trace).

Both sets of data for each visual representation are drawn on the same x-axis scale. Points of interest are the difference in spread between the two classes. Whilst both classes had more than one student achieve full marks, the difference in range of marks achieved between the classes is noticeable. In particular, with the box plot representation, where the middle quartile (Q2) represents the mid-point of the data sets (50% of the data is above and 50% is below this point), it can be seen that 100% of the 2014 data is within the upper 50% of the 2013 data. It is also interesting to note the level of understanding and application that students have achieved without having first been introduced to the topic of Algebra.

In addition to the test results, students were also asked to reflect and evaluate on the learning methodology. Some of the responses to some of the questions in this activity are interesting to consider:
Do you feel you have learnt the basics of how Cartesian Co-ordinates are determined?

Yes = 19  No = Zero

Do you think this was an appropriate way to lean and investigate how Cartesian Co-ordinates are determined and used?

Yes = 17  No = 1  I don’t know = 1

Explain your answer: (representative sample of responses only)

“because it made us actually use our knowledge to read and plot points on a graph. If we had just written notes I wouldn’t of known how to use the knowledge”

“like we got to learn about it then we got to test our learning on excel”

“its fun & best way to use new tech”

“using excel showed us how our co-ordinates are actually useful in some way and how they actually do something”

“I do not think it was completely necessary but it was a fun way to do maths”

Did this activity give you a ‘bigger picture’ of maths and society? (same student responses in the same order)

“I have found that company’s use graphs and data to manipulate people. I have also learnt that Cartesian plane is in any sort of software and games”

“I think it does give a bigger picture because a lot of computer things and games are made from them and so it’s a very useful and important thing in maths and science”

“Not really, but Scratch seems interesting so I am learning a bit more”

“Well I honestly don’t know what I think except that I don’t want anything to do with co-ordinates and Cartesian planes” [This from one of the students who achieved full marks in the test]

“I believe this activity gave me a mildly bigger picture of how maths can be used in other fields”

In general, the responses were positive and through other questions, most students had acknowledged the connection between GPS, maps and 3D printers to an application of Cartesian maths topics. All students were feeling an improved confidence in their ICT skills, ranging from slight to major improvement.

**Unexpected Outcomes Identified:**

As part of the Excel activity, students were given some free reign to explore. Once it had been established that particular relationships between the (x, y) co-ordinates would result in particular shapes and lines, students were asked to create a particular shape on a graph in Excel and then, once this was completed, given the option to complete a shape of their choice. Several students realised that not only could rules between sets of numbers create lines and shapes, but that plotting of (x, y) pairs in particular sequences could be used for creative endeavours. Students used their knowledge and applied it to the task of creating Fibonacci spirals and other complex shapes within their Excel workbooks. Some examples are shown below:
Figure 3: Fibonacci spiral, as drawn by a student in Excel using Cartesian Co-ordinate pairs.

Figure 4: Text drawn by a student in Excel using Cartesian co-ordinate pairs.

Figure 5: ‘Pony’ as drawn by a student in Excel, using Cartesian co-ordinate pairs.
**Future Directions:**
This unit of work was completed in the first weeks of term four. As such, the outcomes from this unit of work have not been presented to the science and maths faculties for discussion. It is envisioned that after presentation and discussion of any modifications/improvements with the faculty (especially with regards to NEP students), that this unit will be adopted as a common task and assessment for the year 8 cohorts in subsequent years.

**Summary:**
The year 8 maths topic ‘Cartesian co-ordinates’ has been taught within a different topic sequence and different methodology with respect to previous years. Students felt that they both understood, could apply and more importantly, have some creative input into the ‘what, ‘how’ and ‘why’ of their learning. Test results appear to show a narrowing in the spread of achievement in the topic, but more data sets would be required to confirm this.