Space Science and Education: Sparking, Signing and Securing The Space Generation

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Abstract: The study of Space Science in the modern classroom is a stimulating topic that develops key understandings and suitable learning outcomes within a Secondary School. The topic permits the educator to challenge the students with key principles in the traditional areas of Astronomy and then extend this knowledge base with applied research that links to all branches of Science; Physics, Chemistry, Biology and of course the Earth Sciences. In the 21st Century, where the accumulation of knowledge is rapid and the learner is often in a situation that requires the ability to apply these skills to a scenario, it is important that topics have connectivity and are multi-levelled. Through the application of Space Science, pupils enhance their understanding of a diverse range of theories and progress through assigned project work that promotes an academic research culture and develops life-long learning. This enhances the respect and appreciation of science as a worthwhile and vital area that can be studied beyond secondary school and create a natural interest that will create the next generation of scientists and engineers.

Keywords: Outcomes Based Education, Curriculum Framework, Austronauts, Middle School Space Science, Information and Communication Technology, Secondary School Project work, MARS, ASISTM

Introduction

All people have a natural tendency to be curious about the natural world, some people ponder in amazement of its complexities and others take the bold step of investigating what they observe in the attempt to quantify their knowledge. Within education, we attempt to harness this interest and direct the student's energies to analyse those details to gain a greater understanding of our world. This paper will examine how to enhance current educational pedagogy with investigating research and development project work that leads students to be inquisitive and to make connections between essential science content and experiments being conducted by real scientists, thus fostering a sense of ownership and understanding of the scientific process.

Outcomes Based Education

Within Western Australia, through the Curriculum Council, the state government has enacted the Curriculum Framework (1). The Curriculum Framework (CF) is a working document that demonstrates the shift in educational pedagogical thinking to an outcomes based approach. The focus on outcomes represents a major shift in school curriculum from a focus on educational inputs and time allocation toward one that emphasises the desired results of schooling. The CF establishes learning outcomes for all students, regardless of who they are, which school they attend, where they are from, or what approach their school takes to help them achieve their outcomes.

The traditional school model is then broken down into 8 Learning Areas (9 for Religious Schools), these formerly were known as subjects. Each Learning Area (LA) has its own distinct flavour, but when considering the education of the whole person, we begin to consider the student as a learner as distinct from being a member within a specific subject or even year grouping. The Learning Areas established are; Arts, English, Health and Physical Education, Languages other than English, Mathematics, Science, Society and Environment and Technology and Enterprise. Each of these has a definition and rationale as applied to that LA. Each LA is then further broken down into Learning Outcomes, which then themselves have individual aspects that are each required to be covered and than reported on.

As the predominant discussions in this paper are related to the Science LA, we will examine the Earth & Beyond outcome within the Science LA. The description for Earth & Beyond reads that 'Students understand how the physical environment on Earth and its position in the universe impact on the way we live.'(1)

This is then broken down into three further aspects, being; Sustainability of life and wise water resources, Earth forces and materials and the Relationship between the Earth, our solar system and the universe. It is from here that teachers ensure assessment items cover all three of these aspects, not necessarily all at once, but to ensure reliability in accurately relaying a student's achievement all aspects are covered at least twice. To look for depth and scope, teachers in a Catholic School would refer to the Progress Maps (2). For example, students at a Level 4 (within an eight level key), which is typically end of Middle School, beginning Senior School stage, within the aspect of 'relationship between the Earth, our solar system and the universe', students are expected describe the seasons, the effects of the Earth/Moon relationship, eg tides and begin to apply how this may effect fishing, boating or other industries that rely upon the ocean.

Currently this is the framework by which educators work from to ascertain the depth of understanding within a concept strand in their LA. As with this form of classroom practice, it is imperative to focus the attention on the learner and not the teacher. Obviously, neither party can be forgotten as the education process flows in both directions for the Learning and Teaching process to succeed.

Within the environment of Middle School, which loosely translates to the first few years of traditional secondary schooling there are ample opportunities to stimulate and inspire the students into research topics in the field of Space Science and develop discussions and project writings that will compliment a standard curriculum and guide the learner into an area of expertise where they are able to impart their knowledge to other people.

Space Science Project work within Middle School

As students are keen to investigate the universe around them and with the media Science-fiction bombardment to ignite the senses, we can add to that glimmer by providing worthwhile and relevant research topics that are accessible to this student group and create connectivity to actual research and development. As suggested in the 'The Status and Quality of Teaching and Learning Science in Australian Schools' it is through collaboration between organisations that will enhance education and therefore improve the retention rates of students studying Science and Technology based subjects beyond their compulsory requirement' (3)

At St Joseph's School, in Northam, Western Australia, our model of Middle School currently sees this implemented in Years 8-10. With a LA, such as Science occurring in four 50-minute cycles per week. The school itself is situated in the Wheatbelt, 96 km East of Perth. It is within the 50 minute Science lessons where the students would conduct, experiment, investigate and develop their areas of research. One of the key areas of Year 10 Science is the field of Space Science. This topic is seen as a vital connection linking the traditional branches of Physics, Chemistry, Biology and Earth Sciences through various research opportunities.

Within this curriculum area at the Year Ten level, St Joseph's School has developed an extensive Space Science programme, which is growing in intensity since first being implemented in 1996. The humble beginnings of the project saw the purchase of a 114 mm telescope and the Co-curricula formation of a school based Astronomy Club and in more recent years implementation of Information and Communication Technology (ICT) based research applied to historical, pure and applied Astronomy and Space Science.

The area of Astronomy has traditionally been spoken about as a part of the Earth & Beyond outcome. What occurs at St Joseph's School now, is the whole area linked to Space Science has extended this approach and students generate ideas and concepts as part of the topic that combines these related ideas and introduces the concept of an 'Austronaut', that is an Australian Astronaut. As part of the research and development work, the students realise that the actual members that go into space are a small proportion of the whole team, with each aspect from design and construction to monitoring and analysis playing pivotal roles.

Traditional versus 21st Century

In a traditional context a classroom was established by the teacher, with a programme of work set sequentially using one textbook. At key parts, experiments were performed to highlight an aspect of the theory, or to verify that the answer that was already in the student's book was correct. At an early middle school level, this approach is still seen as thrilling with students often excited about handling 'real' scientific equipment that most Primary Schools have no access to or more often these days unfortunately, staff not adequately trained with the knowledge and skills to instruct students in these areas.

Upon establishing the base skills with the students, the novelty of 'real' Science begins to wear thin with traditional experiments tending to follow a 'cookbook' approach, where students through active reading of the chapter are often able to find the solutions. The fresh enthusiasm at the beginning of Middle School is often drained out by the end of Middle School, with students less engaged and often less motivated to apply research and study into their Science studies, perhaps even feeling a lack of worth or relevance for Science in general. Certainly there once was interest in science, but perhaps a lack of clear communication that generates an understanding in pupils to where a career in Science, Technology, Engineering or Mathematics (STEM) may lead them, thus leading students away from careers based on scientific principles to areas that are more high profile, such as sporting, legal or careers in the media. This misunderstanding is global and has caused concerns for educators in many countries. (4)

In a 21st Century approach, what can be offered now in classrooms within a Curriculum Framework is an opportunity for students to learn content within a context. With a framework to work within and not a specific syllabus, opportunity exists for teachers to plan a module of work that is open and not prescriptive. Though understanding and interpretation of key components that are typically covered and outlined within the Curriculum Framework, a themed piece of work linking content to actual research skills can be established.

In a topic that is themed, teachers and students can allow for connectivity between theory, practical and the real world. The aim of a theme is to provide scaffolding to wrap all the essential knowledge and skills onto. Students can be provided with a scenario and through investigation, project work and of course vital theory classes, students can research areas of interest and provide results and conclusions that can be valued by their peers and the community in general, thus providing a vital link between the school and the general population. It has been commented that young students feel less engaged with their Science courses and the result is a decline in enrolments in STEM based areas in Senior School and University Undergraduate classrooms, particularly at a time when Australia is calling for more scientific and technical skills (5). Additionally this provides students with cues that demonstrate how science is used in the real world and where they themselves may be working in the future.

Space Science Module

The general progression of a Year 10 unit of work begins with an analysis of our place in the universe and having an understanding of the workings of our solar system's energy source, the sun. It is here that an examination of the structure and material makeup of the sun along with the nuclear synthesis reactions of a star are analysed. Students then will progress to compare and contrast details between the Terrestrial and Jovian planets, providing feedback to other class members on surface conditions, atmosphere, changes over time, chemical composition, moons and any mission data-past, present and future. As often as possible the links are made to conditions here on Earth and thus using their concrete every day understandings as a platform to add concepts.

Directed study then turns to examination of other stars. Students work through information on a star's life cycle, luminosity, light spectrum, models of energy transference and interpret plots on a Hertzsprung-Russell diagram to gain knowledge on age and life span of stars. This giving the students a sense of scale, distance and age of stars and how a star's life cycle would effect orbiting bodies. This is where the attention then turns back to the planets.

To gain a sense of our current understandings, the pupils can then research from a historical perspective key developments in Astronomical discoveries such as the introduction of the telescope, the impact of Newton's Laws of Motion to Space Science, discovery and application of Spectra and the field of plate tectonics. By having a sense of past knowledge, students gain a better appreciation for our current scientific knowledge and understandings. When examinations continue on the objects in the solar system, we look more closely at our Moon and Mars. To supplement class work in the standard planetary details the students research areas and provide presentations in Martian evolution, Terraforming and Water on Mars. With the recent enthusiasm displayed by the National Aeronautics and Space Administration and the European Space Agency into getting back to the Moon as a stepping-stone to Mars, all information imparted is topical and heightens the interest in this area.

In addition to the knowledge base provided, the students also go through instruction on presentation techniques highlighting preparation and delivery techniques, with this being an integral component of the review and assessment cycle and thus demonstrating the need for sound communication skills in the area of Science. At all times students are encouraged to challenge themselves to delve deeper into their topic and thus a sense of constant improvement is maintained and a state of scientific openness between the teacher, student and class is established.

A key area of any astronomical topic is to be able to recognise and appreciate the night sky; this in itself has been a crucial part of Space Science. Understanding the motions of the stars, the phases of the moon and simple celestial navigation are all areas that are studied at varying degrees of depth.

Further research takes the students to their area of interest, with extended research areas including 'the effects of micro-gravity on the human body', 'improving specialist crop yields for off-world missions', 'extremophiles', 'energy management issues' and 'future vehicular designs for Mars'. At each stage the pupils are expected to define each component of the topic they introduce, explain scientific principles behind these then apply this understanding to everyday examples and uses, for example when examining the effects on the human body during space travel make connections with similar ailments, as found in our 'older' population as a consideration for our ageing nation. With the increasing necessity for our population to become adept at utilising technology, information is gathered, catalogued and disseminated via an appropriate ICT means, such as slideshows and multi-media formats with some instruction required with some of the high-end technology such as animations.

It is with these extended areas of research that the pupils are able to increase their depth of knowledge and therefore make connections to many of the outcomes at a higher level. For example, with the examinations into the surface of Mars, often this leads to a study of past, present and future missions with discussions on some of the research that was conducted or is planned. With examining these missions, explanations occur on choice of site with a compare and contrast analysis of each area's merit for robotic vehicular access and type of potential findings. Students are able to focus on type of vehicle design or techniques involved with establishing a base for terraforming, thus linking physical, chemical and biological sciences within the broad topic of Space Science. Additionally, making the link to the spin off factor with all research, by being able to apply this research to areas outside of space science, such as with plant growth data and linking to areas of the world that are already suffering from a reduced capacity for food production, developing a sense of sustainability and wise resource usage.

Fig.1: Students actively engaged in the rocket construction activity

Rocket Launches

Imbedded within the course are practical opportunities for the students to experience Space Science. A key aspect early in the year is the construction and launch activity where the students utilise class time to build a small rocket. Throughout the project students develop the concepts of flight, data manipulation and measurement, with experimental procedures in variable control followed. From a project such as this, as well as the interest it generates, links are made to Physics concepts such as Newton's Laws of Motion, motion analysis, forces, energy, momentum, velocity, acceleration and the all important altitude. Other practical ideas within a Space context that provide a strong content application are examining collisions between objects and extending the data to a planetary lander, looking at re-creating lunar and Martian craters and predicting angles, velocities and energy transformations from the impact and using knowledge of solubilities and spectra analysis to identify substances present in 'extra-terrestrial' rocks. Each of these utilise skills and content that is easily comprehended by middle school students and with apparatus available in all Secondary Laboratories.

Fig. 2: Mid construction: applying the vital flight surface components

As often is the case in a Secondary Science Laboratory, use is made of various local institutions to supplement theory and enhance the in class experience. Some of the Space Science excursions have incorporated studies into robotics, gravity waves, cosmology, optical astronomy and time travel. The students having ample opportunity to experience and gain knowledge on areas of interest and personal research.

Future directions

A few directions intended to develop further in the future are to increase connections with Scientists in space science related research fields, a possibility here will be to utilise and extend a concept of using a grain silo as the base for a Mars Analogue Research Station (MARS), as outlined in the co-authored paper by Georgia Bowen at AMEC 2006 (6). This project would encompass many Learning Areas and the application of a vast array of skills, knowledge and capital. Connections have been established to introduce this concept with a cluster of 5 Western Australian Schools (encompassing Catholic, Independent and Government Schools at both the Secondary and Primary levels), along with Mars Society Australia as the essential scientific partner, thus being able to provide expertise in engineering, mission planning, human factors and habitat design. As the Tertiary partner, discussions and liaising were also conducted with the Muresk Institute of Agriculture, the Avon Valley Campus of Curtin University of Technology. All connectivity is in accordance with the Federal Government's Australian School Innovation in Science, Technology and Mathematics (ASISTM) Project.

The ASISTM Project is expected to encourage innovation in Australian schools by fostering of a culture of innovation in schools, the development of an elevated capacity and predisposition for innovation in school students, improved levels of coordination of Science, Technology and Mathematics teaching and liaising between primary and secondary schools and to have increased collaboration between Australian schools and science organisations, universities, business and industry and other organisations. The end state of participation in this programme is to see a growth in numbers of students undertaking Science, Technology and Mathematics teacher education, changes and improvements in teachers' approaches to, and techniques in, teaching Science, Technology and Mathematics, to improve Science, Technology and Mathematics student learning outcomes, enhanced student interest and engagement in the learning of Science, Technology and Mathematics and most importantly to see increased numbers of senior secondary school students interested in, and engaged in Science, Technology and Mathematics study and to redirect their career pathways into these areas and specialist Education programmes. (7)

As reported in the MARS Concept paper at the AMEC 2006, the site location would have seen placement of this facility at the Northam Campus of Curtin University of Technology. This would have permitted linkages between the secondary and tertiary sectors, particularly within the fields of Agriculture, Environmental Science, Horticulture and Applied Biosciences, all specialist areas of this University Campus. It is envisaged that combined research projects between these year groups of students would lead to published papers, conference proceedings and perhaps even academic credit quantified on an awarded certificate, such as the Western Australian Certificate of Education and be recognised and used for Advanced Standing towards an academic qualification.

Further directions at a secondary level are to enhance modelling exercises to include habitat modules and lander designs, returning to applied astro-photography with inbuilt measurement of data and examining plant and food growth experiments for an extended duration. Investigations of other types of funding through Government and Non-Government sources are currently being undertaken.

Fig. 3: Rocket Launch success: Austronauts in the making

Conclusion

The end product is that as part of their Science Curriculum the students obtain a high depth of understanding in the area of Space Science that permits connectivity to all branches of Science and indeed other LA. It is essential as educators in the 21st Century to provide a real, dynamic and inspired platform for the students to learn in. Through the use of a general area such as Space Science, the students attain a wide range of knowledge and an appreciation for the extent and range that the study of Science dictates. Having a classroom that promotes inquiry and incorporates use of Computer Based Technology is essential in the modern world and one that must be used by students to locate, store and impart their knowledge. At the end of their topic, the students have a real context for which to attach their content and are able to apply the theories in a practical manner. Students are inspired to continue Science related studies and have a clear understanding that Space Science is not just Astronomy, but has so many inter-related facets through the vast spin-off technologies and discoveries. The next generation of Space Scientists starts here in a school classroom; perhaps with that spark of inspiration, we may even see new 'Austronauts' in the making.

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