Student Field Expeditions: Improving conceptual understanding in Earth, Planetary and Space Science

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Background

As an involved educator teaching Earth, planetary and space science for many years within many different courses, I have had students involved in programmes through a range of external agencies and organisations including Mars Society Australia (MSA) [14], Scitech [15], Astronomy WA [10], Earth Sciences WA [11], the Gravity Discovery Centre (GDC) [13], Gingin Observatory [12], the Australian International Space School (AISS) [19] and the Victorian Space Science Education Centre (VSSEC) [17]. On several occasions students have been surveyed and informal feedback obtained, where they have found the activities to be interesting and have stated that it makes them understand the related science better.

I believe that the practical work in context enhances a student's content understanding to a greater extent than simply covering related theory and examples out of a textbook. Taking students out of the classroom theory; observing, investigating, collecting data, and then conducting their own research, is this a worthwhile use of time and effort?

To develop, administer and evaluate a student's appreciation and understanding of a key content area, within the Earth & Beyond outcome in Science, in a Year 10 Science class in Western Australia. The specific area links to the broad area of Earth, planetary and space science, specifically a topic about craters.

Abstract

The main aim is to investigate student's retention of scientific concepts by participating in extended excursions in the form of expeditions. This study will analyse student's knowledge and skills in key science content areas, with one group taking a theoretical approach, and the other a practical scenario. Each group's results will then be investigated, as a means of comparison.

The methods used will be linking to the overarching general research question, "How does participation in scientific practical fieldwork improve a secondary students understanding of Earth, planetary and space science concepts?"

This study generated quantitative measurements in the form of content testing, which will outline the background research and projected future studies for added pedagogical change in the teacher-learner processes within a classroom.

Keywords

Space Science Education, NASA Spaceward Bound, practical fieldwork, Middle School, STEM, Guttman Structure, student expeditions, National Curriculum.

Rationale

Through my own personal experiences in conducting research in the field, specifically after attending Spaceward Bound in the Mojave in 2008, I gained an appreciation of an extended field exercise as a research tool. As an educator, keen to enhance the opportunities provided to my students, planning began and funding sort to take groups of Year 10 students into the field for an extended excursion.

Upon receiving confirmation of a grant totalling $1500 from Earth Sciences Western Australia (ESWA), which enabled subsidised transport and accommodation, serious planning got under way. The opportunity that was going to be provided to these students was effectively a student Spaceward Bound. The activity was going to factor in the different facets of space science research, including technology, historical, research and analysis, with the students having to propose, conduct and quantify research being done in the field. This is in addition to keeping a log in a scientific journal and linking in the many aspects of the exercise, including inspecting deep space tracking installations, a renewable energy wind farm and sites of impact craters.

For all discussions with the students, the activity was referred to as an expedition and the participating students were instructed in the different phases and requirements of an expedition. For a full appreciation and therefore a successful expedition, students were required to research key elements, present individually and as a part of a group to the class and to take an active role in the planning of the event and determining what aspect of research they will follow.

It is an important aspect to consider the larger implications of providing a real research opportunity for the students and one that engages the student's minds and spirits. In Western Australia, from 2001 to 2006 there was a 4% decrease in the number of Year 12 students studying at least one Tertiary Entrance Examination subject from 13,206 to 12,663 [4]. If we examine the Quantitative Sciences, seen unfortunately by many as not relevant to their current interests, future study and career and therefore opting out early, as expressed in recent surveys of students completing TEE Subjects, enrolments in Physics decreased by 17%, Biology decreased by 8% and even Mathematics, specifically Calculus by 17% [4]

Making a connection to changes in the focus of teaching and learning as outlined in the Progress Maps through the Curriculum Framework [6] and to catering and examining students' abilities, may have been a means to re-invigorate the areas that have seen dwindling numbers. As stated within the *Status and Quality of Teaching and Learning of Science in Australian Schools* [7], that the greatest priority is to improve the quality of school science in the compulsory years of secondary schooling so that all students can experience a science education that will make a difference in their lives and attract our best young minds into science research and careers to make Australian industry internationally competitive.

This initial research into examining ability through practical tasks, aims to examine the use of a specific piece of Earth Science laboratory work equating this to a baseline measurement for more advanced field studies and to measure the differences in scientific knowledge, skills and application of key concepts. Students were questioned on specific areas to ascertain their prior knowledge, then the appropriate laboratory work was organised. From classroom observations and from many years of experience, it is my belief that laboratory work and keeping students engaged and interacting with their learning within a middle school science classroom is essential. Practical work should be seen as a valued and essential component of the programme for student learning and generate progressive pedagogical practices that incorporate extended field studies for secondary students.

Data generated has suggested that laboratory work and utilisation of these skills improves content retention as outlined by Kwari and Mtetwa, [21] specifically, 'that active learning is a situation where knowledge is directly experienced, constructed and acted upon and by engaging in something more than just listening, students aren't just remembering facts, but are physically doing something more than just participating.'

Certainly if students are engaged in hands-on activities, conducting experiments that they have devised, sampling the environment and analysing and processing the results, I would believe that this form of active learning will enhance the learner's permanent knowledge base and understanding of earth science concepts.

As stated by Stohr-Hunt [22], students who engaged in hands-on activities every day or once a week scored significantly higher on a standardised test of science achievement than students who engaged in hands-on activities once a month, less than a month, or never. With the direct comparison of one group of no practical work with another that will have ample opportunities, at least 3 chances to do hands on task, I anticipate this background research will prove relevant to this study.

Within a modern curriculum, the processes in teaching are focussing more on the learners needs, with many groups, and individuals are investigating and publishing on these challenges.

One of the critical documents from an Australian educator's point of view is the *The Status and Quality of Teaching and Learning of Science in Australian Schools*, released in August 2000 [(7)]. This research report outlines many diverse recommendations including an awareness of science education, teacher education, and education standards all created after an in depth analysis conducted by a research team representing entities such as the Australian Science Teachers Association, Australian Academy of Science the Curriculum Corporation as well as tertiary institutes.

Conclusions drawn from this report describe the necessity to improve the quality of school science in the compulsory years of school so that all students experience a science education that will make a difference in their lives, and attract the best young minds into science research and careers to make Australian industry internationally competitive.

The report highlights that education at the end of the 20th century, no longer prepares individuals for a secure, lifelong employment in local industry or services. Rather, the rapid pace of technological change and the globalisation of the marketplace have resulted in the need for individuals who have a broad general education, good communication skills, adaptability, commitment to lifelong learning and an appreciation, acceptance and understanding of science as an integral part of the world we live in, as outlined by Goodrum, Hackling and Rennie.

Chris King [(9)] quotes research conducted in 2007 by the Earth System Science Initiative instituted in Israel, with its constructivist approach involving: child-centred teaching, integration of skills within the course content, the teacher as the mediator for knowledge, inquiry based teaching and multi-learning environments incorporating classroom, laboratory, outdoors and computer simulation. The 'science for all' approach discussed involved the teaching of broad and balanced science.

The effectiveness of the 'Earth Systems Science' approach, presented evidence for significant improvement in the understanding of biology, chemistry and physics in 11-14 year old Israeli students who had studied science in this integrated manner, compared with those that did not.

As this study will also be targeting this Middle School group, students actively participating in hands on practical work that is analysing 'Earth and Beyond' concepts should experience a flow on effect to content enhancement.

Through analysing this actual set of data, it is anticipated that the results will re-enforce the literature and demonstrate that students that are taught through an experimental context and focus will be able to perform to a higher level on a standard test. In addition, any results obtained may lead to further long-term research studying the difference in student behaviour, interest and knowledge after a science expedition.

The hypothesis

Class A will experience a greater mean difference between both assessments then compared with Class B. Stated Statistically, the Null hypothesis (Ho) is that there will be no difference between the mean differences for the control group and for the sample group (H_A) that there will be an observable difference [18].

Method: The Project

A simple multiple-choice assessment of 20 items was delivered to 2 different groups. The two groups will be homogenous, that is each group academically within Science and Mathematics have previously demonstrated that their performance is very similar. The multiple choice questions, which were modified from examples that have been utilised in previous years, with a number of different groups and are linked to items that are from the *Australian Science Item Bank* [1] and conform to the Earth & Beyond section of the *Progress Maps for Science* [5].

The aim here will be to piece together a base line knowledge level in 'Earth & Beyond', an often-misunderstood and misinterpreted science outcome, by students and teachers. The main aspects investigated were to identify the relationship between the Earth, our solar system and the universe. This means questions were asked about; our position in the solar system, planetary details, the Earth-Moon system, solar system objects, gravity, acceleration, impacts on the Earth and other off-world areas, surface structure of a planet, crater structures and types, ejecta material, extinction level events, mineral structural changes and terminology such as asteroids, meteors, meteorites and comets.

The above areas are all seen as vital knowledge strands for students achieving higher levels in middle school, beyond level 4, but the approach to ensuring student understanding is not specified nor is it quantified on exactly how that this should be assessed, feedback delivered or even reported.

By getting 2 classes of mixed ability Year 10 Science classes (each of between 25-30 students) to sit the initial assessment raw data was then obtained on student knowledge and manifest achievement in this task. The students were told that they were starting a new topic, as it was for their Earth Science course, but were not told that they will have an assessment straight away. This removes any chance of some students who may wish to read the relevant chapters in their textbook or even go back over Year 9 course material to inflate initial scores.

The two classes were then taught the same essential content in a different style. Class A was taught via a contextual approach, utilising practical work, use of experimentation and investigation.

The focus was to create craters and through measurement and management of variables, the students obtain experimental data on their own craters, from here the pupils then compare this with craters from around the world, on the Moon and Mars, analysing for similarities and differences.

At all times the key phrases and terminology were linked to their experimental focus and results, with use of satellite imagery, Moon and Mars pictures and photographs of impact sites for students to see the relevance of the acquired information and the significance of impacts.

Class B was then taught via traditional means of classroom notes, reading relevant chapters in their textbook and discussing the theory in class. At the end of this phase of the Earth Science topic, both groups sat a further test as a means for a comparison between their knowledge acquisition and prior knowledge.

This assessment contains the same basic definitions that were examined in the first test, where students were able to demonstrate their understanding in an extended format. Students were informed from the beginning of their topic that they will be tested at the end of the 2-week topic, therefore both groups were under actual classroom procedures, with their results processed and actually counting towards a level and therefore a grade on their end of year report.

Approach to analysis

Prior to the trial, it was foreseen that both groups should increase in their knowledge on key Earth & Beyond content areas, but what is intended to be measured is the difference between a theoretical class to a practical class.

As a means to analysis, comparisons of both class rank orders before and after the two-week topic and these results were placed on the same data matrix. After assessment 2, all the results were plotted again to investigate group position.

From here, the students manifested academic growth in demonstrated ability was viewed to see any change in location on the continuum. Will the student's position in the class change due to the teaching style and methodologies?

For analysis, the rank order and the data for the students were placed into a Guttman ordering, that is will Class A students be above or below their prior rank order compared to Class B [23] This data was then examined to see any emerging patterns.

Also looked at was the class mean for both groups to obtain an understanding of differences that may have eventuated for both groups and individuals within the class, which is as a comparison to the test, how much did an individual's score change for each class?

It is envisaged that the results and analysis obtained will be useful for classroom practitioners when approaching an area such as 'Earth & Beyond', in areas with modules in Earth, planetary and space science to be able to make judgements about what may be the most appropriate means to proceed to obtain the greatest understanding and content retention.
I also intend to link this research to other areas of interest, such as developing practical laboratory work and extended field experiences to enhance a student's appreciation, excitement and understanding of modern science and scientific practices.

As in 2008 and 2009, next year students at St Joseph's School will be embarking on a science expedition. In 2010 the plan once again is to complete an expedition following the model outlined by NASA Spaceward Bound, this will cover technological, historical, cultural and analytical phases. The participants will be engaged in real science, not textbook generated exercises and will need to prepare, conduct and measure variables in the field and then take this new knowledge and apply it back in the classroom [24]. It is envisaged that sites that can be examined will include the European Space Agency centre at New Norcia, Perth International Telecommunications Complex, John Glenn Memorial Park at Muchea, the Gravity Discovery Centre, Nambung National Park incorporating the Pinnacles and Lake Thetis, Emu Downs Wind Farm, Cervantes to Lancelin road project and a few evenings of astronomy viewing and taking measurements.

This Student Spaceward Bound Under the Southern Cross will have key research areas that the students will nominate to complete. As in 2008, a Department of Conservation and Land Management application to conduct survey work in the National Parks area will be finalised permitting samples being taken from the Pinnacle region and particularly in and around Lake Thetis. Students will be monitoring the area and completing a series of biological samples for in-situ observation with a limited portable laboratory set-up including indicators, probes (pH, temperature, conductivity, dissolved solids) and microscopes. From here other samples will be taken for further investigation back at the school laboratory, including monitoring growth from designated sites in sterile agar plates. With some established data from the previous expedition in this site, comparisons will be made to changes in growth rates and other qualitative and quantitative measurements.

As well as the scientific recording at these areas, which will lead to written reports and perhaps as in 2008 science presentations, the students will develop an appreciation of general space science. At locations such as the European Space Agency centre and Emu Downs Wind farm, it will raise student's awareness and potentially broaden their appreciation for areas that are linked to space science, spin off technology and potential career pathways. It may even lead to a whole new thought process and connections for the attending students creating a new sense of direction with science and their studies in general [3].

This appreciation will be measured in a similar manner to what occurred for this in-class investigation, where students will be measured in key content areas before and then after the student science expedition and to make comparisons of their level of knowledge with a group of similar students that did not participate in the field expedition, but were taught in class via a traditional series of lessons linked to documented theory and book-based research. It is my belief that research in this area will document better understanding of student's content, able to process the context for their knowledge and increase student's motivation for science in general.

Experimental alterations

Due to limitations with the constraints placed upon the teaching-learning cycle in a school, the intentions of having a full 2 week teaching cycle, which is a total 8 periods to each group (one period being approximately 50 minutes depending on the cycle), could not occur. In the end each group had allocated a total of 4 periods, with Group A doing the practical work and group B the theoretical work. The interruptions came from various aspects, such as a school Mass and Feast Day, an interschool sporting competition and an outside (non-science related) guest speaker being allocated during designated science lessons. Therefore, to ensure some form of time uniformity between both groups a decision was made to keep both groups to 4 timetabled periods.

What also became evident, is that a number of students had to be removed from the samples due to a number of reasons, including not being present for either the initial or follow up assessment, being away for a number of lessons where vital practical or theoretical information was provided or in one case, where a student was present for both tests, but away for every single class in between due to illness. A further anomaly had to be removed when in Class A. One student, who finished last in Assessment One, finished with the highest rank order for Test Two. After interviewing this student, nothing unusual was obtained that could explain this situation, he simply stated that he really didn't know much about the topic initially, really enjoyed the practical work and thought that creating many different types of craters 'was really cool', which when the result in test 2 was discovered, this became most evident. For the nature of this study this respondent was removed, but this sort of result could be investigated as a part of different research, aimed at investigating other variables for another study. This further analysis of this student and his change in behaviour through observed scores would be an area that I would consider engaging, certainly having an increased score of some 15 points, 50% of the allocated marks for the second test is of interest, just not for this statistical study. Perhaps certain types of students are more-inclined to gain the greatest amount from class techniques such as these.

Effectively with these limitations, the data analysis and any drawn conclusions come from 19 students in Class A and 18 in Class B. Very similar numbers for comparative purposes, but when Class A has a total of 27 students and Class B has 25, there was a significant decrease in both samples due to the interruptions as mentioned.

Preliminary outcomes

First phase of the data analysis involved marking Assessment A and Assessment B, both out of 20 (multiple choice). I then ranked all students in each group according to their raw score out of 20 and identified their class position. Then from their raw score in the second assessment (out of 20), I ranked all students once again.

In addition, means were calculated (out of 20) for each of the groups. The mean of Class A for Assessment One is 8.68, which after Assessment Two increases to 12.16, a difference in the means of 3.48. For Class B, the mean after completing Assessment One is 9.33 and then after sitting Assessment Two has shifted to 11.17, a difference of 1.78.

An initial discussion point here is that students do generally improve after being a taught a topic, this I am sure is a relief to all educators. In Class A, all students showed some form of an increase in raw scores, with the highest increase out of 20 being 6, being recorded by three individuals. In Class B, apart from 3 students who scored exactly the same for the multiple choice items all others showed some form of improvement in raw score, with the greatest being an increase of 5. No student in either group, decreased in ability from the first to the second assessment.

As a part of this analysis, calculation of the standard deviation of the differences in the mean was employed and for Test A is 1.68 and for Test B is 1.52. Additionally, each class was then ordered in a Guttman-like pattern, where students were ranked from the highest to the lowest scores vertically and horizontally their responses, correct or incorrect, for each of the 20 multiple choice questions were recorded. Which also, provides a tally for each item, in each class (and added together) as a means of another analysis tool.

If we examine some of the patterns that begin to emerge, when we examine Item analysis (as provided in Appendix D) for Class A, it would appear that questions that are not following the Guttman structure are items such as 2, 4, 11, 13 and 19, with a number of respondents that scored low totals, being able to achieve a correct response in these items where class members that higher totals did not have successful responses. If we follow that through for the same test with Class B questions 2, 4 and 19 still show through with unusual patterns, as well as question 5 and 15, with the latter showing a bunching of incorrect responses in the middle scores.

These anomalies would be worth additional analysis for a more detailed study, very clearly, particularly items 2, 4 and 19 that are demonstrating inconsistencies for both groups. One avenue would be to pursue an examination of which choice the students opted for when they did get it wrong and perform an analysis on the incorrect choice, as both classes were showing irregularities with these items. At this point, the belief is that something within the wording of one of the incorrect items is drawing students of all abilities away from the right answer, or at least towards one of the incorrect ones.

From the item analysis it can be seen that there are questions that have proven tough for the students. In Class A, 1 student got question 12 correct (although it is noted that it was the top student), in Class B also only 1 student and also the top student. What I would be keen to see in the future if this trend were to follow, as this may be a good extreme top end indicator, perhaps suggesting a question that can determine an upper threshold for a cohort. Perhaps even the required understanding or theory is top end specific.

Examining question 17 for both groups shows a total of 0 students got this one correct. Effectively, not providing any useful class data or cut-offs, the possibilities are that the question is too hard for a standard homogenous Year 10 group, or is asking content that is not common or has been accessed in previous classes in Year 8 or 9. Without deliberating for too long on this question, this one asks for the lowest velocity for an impact of an object from space with the surface of the Earth. What I believed to be the distracter, item (a) as 9.8 km/s, ended up the choice selected by 17 students in Class A alone.

My inference is that there is confusion between the acceleration due to gravity and impact velocity, perhaps next time, placing the real answer (b-11 km/s) in a different position. Personally, I sense that students may have seen item (a) first, remembered a number that looked familiar and opted straight for it, without reading on, apart from a cursory glance, I will keep this in mind for future reference and potential investigation in further assessments.

It appears that by working the order of the questions, that there is some chance of creating a test that will start easy and progress by the end to be quite intense, obviously this will require more work and further studies, but one that could provide a neat, quick assessment, especially when you examine the Question analysis as provided in Appendix F. By looking over the combined results for Test One, it appears that there is a nice grouping of questions that all appear relatively easy for students; this is the group that includes questions 10, 1, 6, 5, 11 and 14, with these questions scoring 33 to 26 respectively. Then there is the next group, including questions 19, 14, 4 and 2 where responses in the range of 22 to 18 are noted, suggesting a low to medium intensity range. This is followed by questions 8, 9 and 13, with scores of 16, 15 and 11 suggesting to me a medium level of intensity. The next range of items increasing to a high level of intensity, with questions 7, 20, 18 and 13 scoring in the 9 to 5 correct range, highlighting a very high ability is required for success in these items. With question 16 and 12 being reserved for the ultra top candidates in a class sitting this assessment, with Question 17, with 0 student's right requiring further analysis of a re-worded variation as above to get its true indication of position and intensity.

Test Two demonstrated some similar anomalies and also the ability to be able to provide a ranking of question intensity. Where you have a number of questions, including 6, 10, 11, 4, 1, 17, 7, 14 and 2 that are relatively easy for most of the cohort and with questions 9, 5, 12, 8, 13, 20, 19, 3 and 16 demonstrating a mid range in ability and with Test Two a much smaller proportion of high level questions with the lowest correct being question 15 with a combined total of 9.

Perhaps a future consideration here is that with Test Two an examination and creation of a few more discriminating questions that can separate out the top students, but ensuring that at least some students are able to choose the correct response.

Using the data generated from the differences in means and the standard deviation it has been identified that the t-statistic is 3.211 and the probability is 0.0028. This would suggest that the expressed null hypothesis is possibly true and eliminating statistic guessing that the group of students that experienced a practical module demonstrated an increased score in a standard test at the end of the topic when compared to a group of students that approached the topic theoretically.

The implications of these findings results in a number of conclusions, including a more practical approach appears to be better for student understanding key content, using a series of experiments and investigations that link to key content appears to generate a greater level of understanding which results in higher scores and a reliance on science of practical work is an important tool for generating understanding.

Conclusion

Using the previously stated null hypothesis as a guide, it would appear that there is statistical evidence that the group that completed practical tasks, designed and conducted an experiment, measured variables an wrote up a laboratory report then sat the same standard test as a group that completed theoretical tasks only, demonstrated higher retention and manifested ability than the theoretical group.

This research is by no means complete and there is scope for additional detailed research, investigation and even a re-wording and a potential restructure of some of the test items from Test A and Test B, but it would appear that from these classroom observations and from this initial data gathering exercise that utilising structured theoretical work to develop content is an extremely useful tool in the modern Science classroom.

To increase teacher awareness of these types of findings and my own classroom practice, I am interested in pursuing these tests with future year groups, to increase the statistical power from a greater data set with the modifications outlined to see if there is an increased test ability at the end of the topic. Potentially also, examining this at a different time of the year, to minimise the series of interruptions that decreased our sample size from already a small group.

In summary, I feel studies like this are essential and one that compliments the paradigm shift in Western Australian, and indeed international educational curriculum development from the teacher to the learner. Having students engaged in hands on practical activity always promotes interest in Science, but by examining the relevant literature and relevant research it may also indicate a way of increasing student's understanding and scientific literacy. It is also important for scientific research groups that perform education and outreach, such as Mars Society Australia, to take into account research findings that may lead to an increased ability to fulfil this role and also potentially to carve a niche into this type of professional development, whether it be dedicated towards teachers or students.

With all sectors of education progressing towards a National Curriculum by 2013, it is important for education planners and delivers to consider research findings such as these or indeed follow up studies in this area. Practical, hands on work in science allows students to interact with the theory and test for themselves the implications of monitoring and changing variables, whether that be in a one-off experiment, a long-term investigation or a project that may extend for a semester or longer. It will be important for real student learning and an increase in content and applications that provide linkages, such as those outlined in this document, for educators to provide opportunities and scope within the curriculum for classroom practices that have a solid background in practical, hands on work.

As further studies in this area are generated, it is envisaged to monitor students' understanding before embarking and after completing a piece of extended fieldwork. Once again the area will link to Earth, planetary and space science and will model the format that is used in NASA Spaceward Bound expeditions.

As discussed, this model has been utilised on one complete student expedition, with sections being used by various different groups for differing purposes. On each occasion students have been surveyed qualitatively, even unofficially and all evidence is pointing to increases in student content knowledge and understanding.

It is my belief that through applying these techniques to secondary and middle school classes and then monitoring the outcomes that what will be observed will be improved knowledge of key content, and also an interest in pursuing further studies in these areas.

If Australia is going to continue to contribute to the global community in the 21st Century it is imperative that we maintain a comparative advantage over our neighbours. With our modern world reliant upon technology and people need to design and maintain better systems, it is essential that students are motivated to accept the challenges that science, technology, engineering and mathematics have to offer. For students to progress down this path, they need to see that science is an active, exciting and real career choice and one where they can and will make a difference to the community around them. If educators and their administration see that by offering real practical work, such as in an area like space science, improves students outcomes, it will be a positive step for teachers, students and also for scientists. For the sake of our future, let's engage this generation to accept the challenges that science has to offer and continue the research and development needed to advance beyond tomorrow.

Appendices

A. Earth Science Assessment One
B. Earth Science Assessment Two
C. Results and Data-Class A and Class B
D. Item analysis for Class A
E. Item analysis for Class B
F. Question analysis

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Earth Science-Assessment One
Name___________________________________

Multiple Choice 20 Marks

Multiple Choice- <u>Circle</u> the correct answer, each question has only 1 response

1. The correct order of planets from the closest to the sun to the furthest from the sun is?
   a) Mars, Mercury, Saturn, Jupiter
   b) Mars, Earth, Saturn, Jupiter
   c) Mercury, Earth, Mars, Jupiter
   d) Mercury, Earth, Saturn, Jupiter

2. Which of these planets is smaller than the Earth?
   a) Neptune
   b) Mars
   c) Saturn
   d) Uranus

3. The main factor that effects the acceleration due to gravity of a falling body is?
   a) The mass of the object
   b) The mass of the planet
   c) The atmospheric pressure
   d) The types of gases present in the atmosphere

4. Which of these planets has the longest year?
   a) Mars
   b) Jupiter
   c) Mercury
   d) Venus

5. Mars rotates on its axis about the same rate as the Earth does. This means that?
   a) the Martian year is about the same length as the Earth year.
   b) the Martian day is about the same length as the Earth day.
   c) the temperature range on Mars and Earth are about the same.
   d) the seasons on Mars and Earth are about the same.

6. A piece of rock that is found on Earth and it has come from space is called?
    a) a comet
    b) an asteroid
    c) a meteor
    d) a meteorite

7. Herschel Crater is found?
    a) On the Moon
    b) On Mars
    c) On Mimas
    d) In California

8. Copernicus Crater is found?
    a) On the Moon
    b) On Mars
    c) On Mimas
    d) In California

9. Which of these craters is not located in Australia?
    a) Acraman impact
    b) Yallalie
    c) Dalgaranga
    d) Meteor crater

10. You can see more craters on the Moon than compared with the Earth because…
    a) The Moon is smaller
    b) The surface of the Moon is made up of different material
    c) There is no atmosphere or erosion on the Moon
    d) The Moon is older than the Earth and therefore suffered more impacts.

11. The significant object found in Antarctica in 1984 is called?
    a) ANT00084
    b) ABC00179
    c) ALH84001
    d) AUS00184

12. The name of the theory that suggests that life on Earth originated from other objects in space is called?
    a) Accretion Theory
    b) Big Bang Theory
    c) Astrobiology
    d) Panspermia

13. Which of these periods of geological time occurred most recently?
    a) Carboniferous
    b) Cambrian
    c) Cretaceous
    d) Jurassic

14. The impact that allegedly caused the death of dinosaurs on Earth occurred in?
    a) Devon Island, Canada
    b) Yucatan Peninsula, Mexico
    c) Grimsey Island, Iceland
    d) Port Arthur, Tasmania

15. The impact that allegedly caused the death of dinosaurs on Earth occurred?
    a) 550 million years ago
    b) 150 million years ago
    c) 65 million years ago
    d) 50,000 years ago

16. In which of the following would you not expect to find any evidence for impact craters?
    a) Venus
    b) Charon
    c) Titan
    d) Io

17. The lowest velocity for an impact of an object from space with the surface of the Earth is?
    a) 9.8 km/s
    b) 11 km/s
    c) 20 km/s
    d) 70 km/s

18. What is an impact basin?
    a) an impact crater that has a rim diameter greater than 300 km
    b) the bottom layer or zone of a crater
    c) a crater that is deeper than 200 metres
    d) an impact crater that is located at the bottom of the ocean floor

19. A metallic meteorite would probably always contain the element?
    a) Copper
    b) Iron
    c) Brass
    d) Carbon

20. A tektite is?
    a) a specific type of meteorite
    b) a piece of the Earth's surface, which is thrown into the air after an impact
    c) a meteorite that has left no trace, but left a crater that is between 50 and 100 million years old
    d) a very small meteorite

Earth Science-Assessment Two

***Name*___________________________________**

Multiple Choice 20 Marks

Multiple Choice- <u>Circle</u> the correct answer, each question has only 1 response

1. The correct order of planets from the closest to the sun to the furthest from the sun is?
   a) Mercury, Saturn, Jupiter, Mars
   b) Mercury, Earth, Jupiter, Saturn
   c) Mercury, Mars, Earth, Jupiter
   d) Mercury, Earth, Mars, Pluto

2. Which of these planets is larger than the Earth?
   a) Neptune
   b) Mars
   c) Mercury
   d) Venus

3. The main factor that affects the escape velocity of an object is?
   a) The mass of the object
   b) The mass of the planet
   c) The atmospheric pressure
   d) The types of gases present in the atmosphere

4. Which of these planets has the shortest year?
   a) Mars
   b) Jupiter
   c) Mercury
   d) Venus

5. When it is 9 am in Northam in the middle of winter, Singapore, which has a similar longitude, will?
   a) Also be at 9 am.
   b) Be at 3 pm.
   c) Be in the middle of winter.
   d) Be experiencing darkness.

6. A piece of rock that is found orbiting between Mars and Jupiter is called?
    a) a comet
    b) an asteroid
    c) a meteor
    d) a meteorite

7. Schrödinger crater is found?
    a) On the Moon
    b) On Mars
    c) On Mimas
    d) In California

8. Copernicus Crater is found?
    a) On the Moon
    b) On Mars
    c) On Mimas
    d) In California

9. Which of the below are not types of craters?
    a) Simple crater
    b) Complex Crater
    c) Complex impact crater
    d) Meteor crater

10. You can see more craters on the Moon than compared with the surface of Mars because…
    a) The Moon is smaller
    b) The surface of the Moon is made up of different material
    c) There is no atmosphere or erosion on the Moon
    d) The Moon is older than Mars and therefore suffered more impacts.

11. ALH84001 is what type of object?
    a) asteroid
    b) meteorite
    c) comet
    d) satellite

12. The name of the theory that suggests that life on Earth originated from other objects in space is called?
    a) Accretion Theory
    b) Big Bang Theory
    c) Astrobiology
    d) Panspermia

13. Which of these periods of geological time occurred most recently?
    a) Carboniferous
    b) Cambrian
    c) Cretaceous
    d) Jurassic

14. The impact that allegedly caused the death of dinosaurs on Earth occurred in?
    a) Devon Island, Canada
    b) Yucatan Peninsula, Mexico
    c) Grimsey Island, Iceland
    d) Port Arthur, Tasmania

15. The impact that allegedly kick started modern biological evolution occurred approximately?
    a) 550 million years ago
    b) 150 million years ago
    c) 65 million years ago
    d) 50,000 years ago

16. The impact that kick started modern evolution can be located in?
    a) South Australia
    b) Death Valley, USA
    c) Devon Island, Canada
    d) Mexico

17. The average speed for an impact of an object from space with the surface of the Moon is?
    a) 9.8 km/s
    b) 11 km/s
    c) 20 km/s
    d) 70 km/s

18. Figure 1 (<u>above</u>) is showing what type of ejecta pattern?
    a) scattered
    b) petal
    c) impact
    d) lateral

19. Large craters are defined as those that…?
    a) Have a large ejecta pattern.
    b) Have a diameter greater than 50 km.
    c) Have a raised edge or rim.
    d) You can still locate part of the original impactor.

20. A piece of the Earth's surface that is thrown into the air after an impact and with an object from space is called?
    a) A Stony-Iron meteorite
    b) A tektite
    c) A Near Earth Object (NEO)
    d) Regolith

Name	Test 1	Rank 1	Test 2	Rank 2
SB	16	1	20	1
MG	13	2	15	3
MS	12	3	16	2
KL	10	4	16	2
LC	10	4	14	4
LM	10	4	11	7
BW	10	4	13	5
MC	10	4	12	6
SJ	8	5	14	4
JM	8	5	13	5
RB	7	6	12	6
SK	7	6	12	6
SS	7	6	9	8
KR	7	6	10	8
TN	7	6	10	8
SM	7	6	8	9
DB	6	7	8	9
CM	5	8	7	10
AH	5	8	11	7

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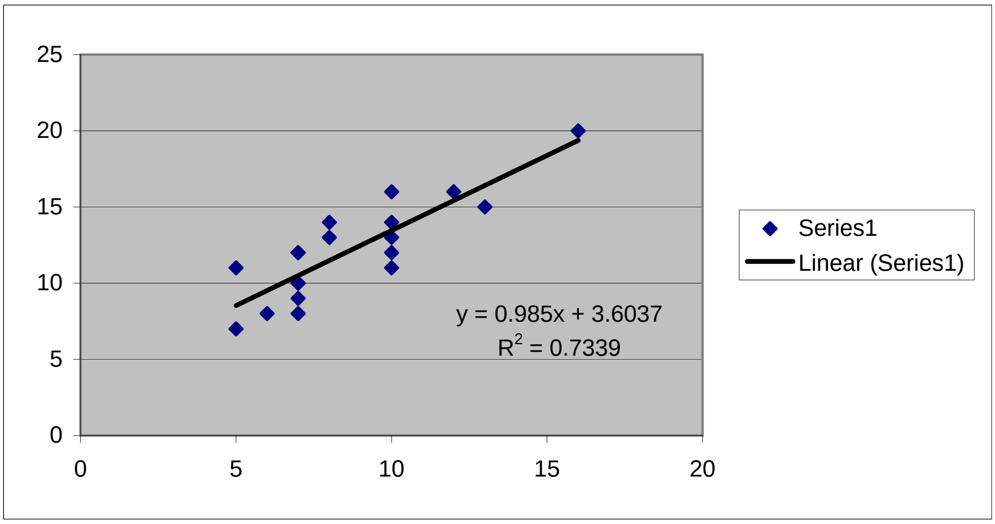
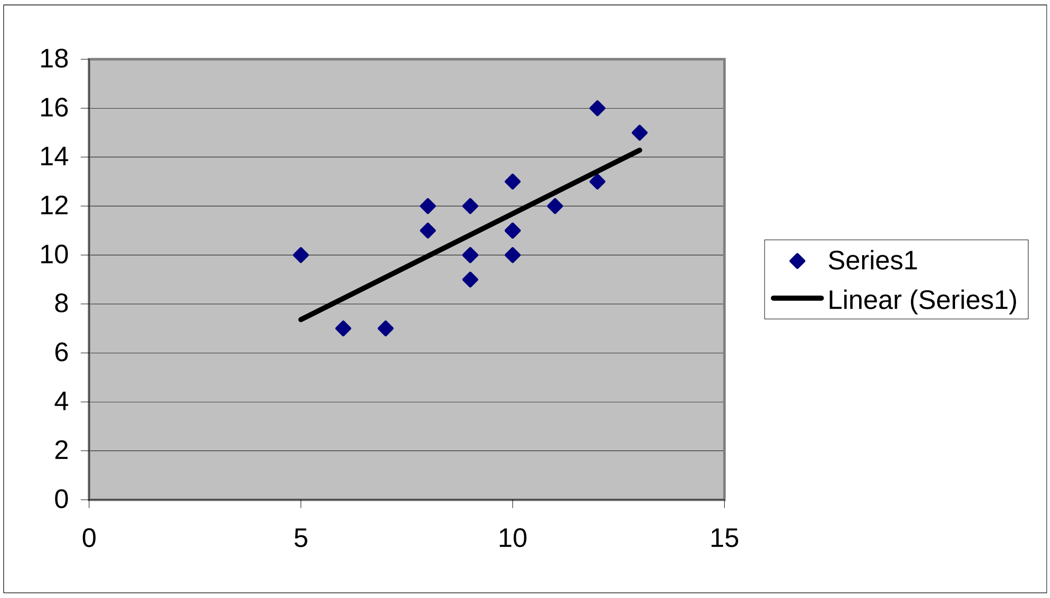


Class B	Test 1	Rank 1	Test 2	Rank 2
TA	13	1	15	2
JB	12	2	13	3
ZA	12	2	16	1
RB	11	3	12	4
KS	10	4	13	3
LH	10	4	11	5
SM	10	4	11	5
CW	10	4	10	6
JP	10	4	11	5
MB	9	5	12	5
LM	9	5	10	6
AK	9	5	10	6
SM	9	5	9	7
SO	8	6	12	4
CF	8	6	11	5
SH	7	7	7	8
PB	6	8	7	8
BH	5	9	10	6



Test 1

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**Total**
SB	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	16
MG	1	1	1	0	1	1	0	0	1	1	1	0	1	1	1	0	0	0	1	1	13
MS	1	1	0	1	1	0	0	1	1	1	1	0	0	1	1	0	0	0	1	1	12
KL	1	1	0	1	1	1	0	1	0	1	1	0	0	1	0	0	0	0	0	1	10
LC	1	1	1	1	1	1	0	1	1	1	0	0	0	0	1	0	0	0	0	0	10
LM	1	0	0	0	0	1	0	1	1	1	1	0	1	0	1	0	0	1	1	0	10
BW	1	1	0	1	1	1	1	1	1	0	0	0	0	0	1	0	0	0	1	0	10
MC	1	0	0	0	1	1	1	1	0	1	0	0	0	1	1	0	0	1	1	0	10
SJ	1	0	0	0	1	1	0	0	0	1	1	0	0	1	1	0	0	0	1	0	8
JM	1	1	0	1	1	1	0	0	0	1	1	0	0	1	0	0	0	0	0	0	8
RB	0	0	0	1	1	0	0	0	0	1	1	0	0	1	0	0	0	0	1	1	7
SK	0	0	0	0	1	1	0	1	1	1	1	0	0	1	0	0	0	0	0	0	7
SS	1	0	0	1	1	1	0	1	0	0	0	0	1	1	0	0	0	0	0	0	7
KR	0	0	0	0	1	1	0	0	1	1	1	0	0	1	1	0	0	0	0	0	7
TN	1	1	0	1	0	1	0	1	0	0	0	0	0	1	0	0	0	0	1	0	7
SM	1	1	0	1	0	0	0	0	0	1	0	0	1	0	0	1	0	0	1	0	7
DB	1	0	0	1	0	1	0	0	0	1	1	0	0	0	0	0	0	0	1	0	6
CM	0	1	0	0	0	1	0	0	0	1	0	0	1	0	1	0	0	0	0	0	5
AH	1	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	5
Totals	15	10	2	11	14	16	3	10	8	16	12	1	6	12	10	2	0	2	11	4	

No	19
Mean	8.68
Stan Dev	2.83

Test 2

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**Total**
SB	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	20
KL	1	1	0	1	1	1	0	1	1	1	1	1	0	1	0	1	1	1	1	1	16
MS	1	1	0	1	0	1	1	1	1	1	1	1	0	1	0	1	1	1	1	1	16
MG	1	1	1	1	1	0	1	0	1	1	1	1	0	1	0	0	1	1	1	1	15
SJ	0	0	0	1	0	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	14
LC	0	0	1	1	0	0	1	1	1	1	1	1	0	1	1	1	1	0	1	1	14
BW	1	0	0	1	1	1	1	0	1	1	1	1	0	0	0	1	1	0	1	1	13
JM	1	1	0	1	0	0	1	0	1	1	1	1	1	1	0	1	1	0	0	1	13
SK	1	0	1	1	1	1	1	0	0	1	1	1	0	1	0	0	0	1	0	1	12
MC	1	1	0	1	0	0	1	0	1	1	1	1	1	1	0	1	0	0	0	1	12
RB	0	0	0	1	1	1	0	1	0	1	1	1	0	1	0	0	1	1	1	1	12
LM	1	0	0	0	1	1	1	0	1	1	1	1	0	1	0	0	0	1	1	0	11
AH	0	0	0	1	0	1	1	0	1	0	1	1	0	1	0	0	1	1	1	1	11
TN	1	0	0	1	0	1	0	1	1	1	1	0	0	1	0	1	0	0	0	1	10
KR	0	1	0	0	0	1	0	1	1	1	0	1	1	1	0	1	1	0	0	0	10
SS	0	1	0	0	0	1	1	1	1	0	1	1	0	1	0	0	0	0	1	0	9
SM	0	0	0	0	1	1	0	0	1	0	0	1	0	1	0	1	1	0	1	0	8
DB	0	1	0	1	0	0	1	0	1	1	1	1	0	0	0	0	1	0	0	0	8
CM	0	0	0	0	0	1	1	0	1	1	0	0	0	1	0	0	1	1	0	0	7
Totals	10	9	4	14	8	14	14	9	17	16	16	17	4	17	3	11	14	10	11	13	

No	19
Mean	12.16
Stan Dev	3.25

Test 2	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
ZA	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	1	0	1	0	16
TA	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	1	1	0	0	0	15
JB	1	1	1	1	1	1	0	1	0	1	1	0	1	0	0	1	1	0	0	1	13
KS	1	1	0	1	1	1	1	0	1	1	1	0	1	1	0	0	1	0	0	1	13
RB	1	1	0	1	0	1	1	0	1	1	1	0	1	1	1	0	1	0	0	0	12
MB	1	1	1	1	1	1	1	1	0	1	1	0	1	0	0	0	1	0	0	0	12
SO	1	1	1	1	0	1	1	1	0	0	1	0	1	1	1	0	1	0	0	0	12
CF	1	1	1	0	0	1	0	1	0	1	1	0	1	1	1	0	1	0	1	0	12
LH	1	1	1	1	1	1	1	0	0	0	1	0	1	0	0	0	0	1	1	0	11
JP	1	1	1	1	1	1	1	0	0	0	1	0	0	0	1	1	1	0	0	0	11
SM	1	1	1	1	1	1	1	1	0	1	0	0	1	0	0	0	1	0	0	0	11
CW	1	1	0	1	1	1	1	0	1	1	0	0	1	1	0	0	0	0	0	0	10
BH	1	1	0	1	1	1	1	0	1	1	0	0	0	0	0	1	0	0	0	1	10
LM	1	1	1	1	0	1	0	0	1	1	1	0	0	1	0	0	1	0	0	0	10
AK	1	1	0	1	1	1	1	0	1	1	1	0	0	0	0	0	1	0	0	0	10
SM	1	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0	1	0	0	1	9
SH	1	0	0	0	0	0	0	0	0	1	1	0	1	1	0	0	1	0	1	0	7
PB	1	1	0	0	0	0	0	0	0	1	1	0	1	1	0	0	0	0	1	0	7
Totals	18	17	11	15	11	16	13	8	6	14	14	1	13	10	6	4	14	1	5	4	

No	18
Mean	11.17
Stan Dev	2.33