

LEVEL 7 ASSESSMENT SPECIFICATION

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Scientific Literacy: the use of inference in today's classroom teaching.

Introduction

This paper has been written to explore the meaning of what is scientific literacy and some of the methodologies that are used to aid pupils to address and answer scientific literacy questions in School X and how a chosen method from educational literature can be used to aid the understanding and use of participants within the school. This paper will highlight the reasons behind the method being used to attempt to aid pupils in scientific literacy questions and how this aid can be seen in test results. School X is located in the south of Wales on the outskirts of its second largest city. The school is an English medium, mixed comprehensive school, that educates pupils aged from 11 to 18 that includes around 120 in the sixth form cohorts compared with around 1100 pupils enrolled at the school in total. The pupils currently enrolled in the school travel from a wide range of areas due to the location of the school and its catchment area. The emphasis on the need to develop the pupil's strength in scientific literacy is important in its own right. Pupils should be able to determine the required action and response needed from a question of scientific nature and not need additional aids to explain how to do so. The aim of this research paper is to address this need to understand scientific literacy questions in more detail and explore its importance.

Literature Review

Introduction of Scientific Literacy

With the fast and ever-changing environment that surrounds our world today, it is even more important that learners, (pupils, teachers, the public) are equipped with the skills and know how that is scientific literacy. Scientific literacy is just one area of importance for people to succeed in today's world as science is an integral part of their lives. Be it from the technology they use which is at arm's length, the way in which everyone communicates and travels, to the energy and food they consume. Science has and will always be the basis for technological progress. To go hand in hand with this, the aim of education in Wales and further is that citizens, pupils, teacher and beyond, become active and responsible in the use of this developing method of acquiring knowledge and of understanding of the problems faced by the community, the world today. The role of science education is that of which in the development in the understanding of knowledge of the surrounding world. To show this development, it is necessary that the educator has a familiarity with the scientific environment. One of the most integral aims of today's science education is the aim to develop the scientific literacy skills of its pupils. Here we are going to explore the bases of what are the skills of scientific literacy, how they are current curriculum implements scientific literacy into school life. From here the design of the proposed new curriculum will be explored and how the PISA results have influenced

changes here. The need for further development within Welsh schools and beyond will also be explored.

What is Scientific literacy?

To begin, understanding what is meant by scientific literacy is needed to explore the implementation. The term 'Scientific literacy' is that of one that can be interpreted many different ways as was stated here by Miller (1983);

"To be literate has two quite different meanings: to be learned, and perhaps what most people today mean when they speak of literacy or of being literate to be able to read and write."

So, it is no wonder why the term 'Scientific literacy' in the literature is defined in many ways. However, many of which all focus on the same key idea that scientific literacy is in essence, the ability to evaluate, to perform, comprehend and deduct information and ideas to develop a working understanding of the problem at hand in order to deliver on the required outcome. One such definition to agree with this is the OECD definition of scientific literacy as:

"the ability to engage with science-related issues, and with the ideas of science, as a reflective citizen", (OECD, 2013).

This, however, is a summarized meaning as many would further the definition as the ability of the citizen improved, (Gallagher & Harsch, 1997), (Bybee, 1997). Another such view on the meaning of this was stated by M. Viorel and D. Viorel (2015) paper;

"Science literacy describes the ability of an individual to understand scientific laws, theories, phenomena and things. This means the responsibility of each citizen to have the necessary scientific knowledge base to make practically any informed decision of his life."

The idea or meaning of scientific literacy has therefore been a confusing area to explore, however, below are a number of components that have been collected by Norris and Philips (2003), that all contribute to the term of scientific literacy:

- a. Knowledge of the substantive content of science and the ability to distinguish from non-science;
- b. Understanding science and its applications;
- c. Knowledge of what counts as science;
- d. Independence in learning science;
- e. Ability to think scientifically;
- f. Ability to use scientific knowledge in problem-solving;
- g. Knowledge needed for intelligent participation in science-based issues;
- h. Understanding the nature of science, including its relationship with culture;
- i. Appreciation of and comfort with science, including its wonder and curiosity;
- j. Knowledge of the risks and benefits of science; and
- k. Ability to think critically about science and to deal with scientific expertise.

As is discussed by Holbrook and Rannikmae (2009), that the term scientific literacy is that of many believe the idea of 'knowing science'. They also put forward that although an actual definition is somewhat clouded;

"the term 'scientific literacy' is used somewhat metaphorically. It thus goes beyond any notion of reading and writing, and few would claim that it refers simply to the ability to read scientific journals"

So, the use of the term can be seen to be used as a statement to drive change or improvement. Consequently, the use serves as an indication of the intentions of science education. Such as the current goal of the education of science appears to be expressed as scientific, or scientific and technological, literacy (ICASE, 2003; Norris & Philips, 2003).

To further on this another such classification system was introduced by Shen (1975) with three main ideas and later developed by Trefil (2008) in the addition of a fourth category.

1. Cultural Scientific Literacy - means understanding the science by a person with average intelligence and education of a culture;
2. Civic Scientific Literacy- represents the level of scientific understanding necessary a person to make informed decisions with regard to legislation and public policy;
3. Scientific Literacy Practice - refers to scientific knowledge that a person needs to solve practical problems (for example, Determining the most efficient way to heat home);
4. Aesthetic Literacy and Consumer Science - indicates to what extent the understanding of scientific laws and phenomena enhances our appreciation of life itself through the intellectual beauty of scientific ideas. The necessity to be scientific literature in order to make informed consumer decisions.

This system includes aspects considered previously on the subject content knowledge along with the ability to apply this knowledge, however, this classification also beings in the social, cultural, the law, the ethical dilemma, etc. As was mentioned by Miller, (1983), the topic of scientific literacy has been the subject of a healthy debate over the last century and as can be seen, quite prominently remains so and will most likely continue to evolve as time goes on.

While the debate of the meaning of scientific literacy continues, the overall view on the matter comes down to two major ideas coming through. These being, one - those that hold that the knowledge of science as a central role, and two - those that view scientific literacy as an idea that is directed at its usefulness of society.

These points of view include that points mentioned earlier but the first view is the view most science teachers and schools take today. The view of there are key ideas or content that build into topics that are essential in science which forms a crucial component of scientific literacy. As was described by Maienschein (1998), this view is, in essence, a short term plan of knowing science and is further labelled as 'science literacy' to change the perception of it from a longerterm view of 'scientific literacy' of understanding. Maienschein also states that;

"Scientific literacy provides a necessary but not sufficient basis for making informed social decisions."

She recognizes as do much of the other literature mention thus far that scientific literacy is not only the knowledge and direct application of this knowledge but the influence of other social, cultural, ethical, etc. factors also play a key role in it definition.

The other main point of view views the idea of a longer term view which is an idea that scientific literacy is an essential requirement in the ability to tackle challenges no matter the pace and the ability to adapt if necessary to the conditions of these challenges. This focus sees scientific literacy align with the development of life skills (Rychen & Salganik, 2003). This view is more aligned with the idea that scientific literacy is a skill of reasoning in a social context. The skill, therefore, has minimal involvement with the content that is taught but giving the learners the skills in order to solve problems. Not the currently popular idea that science and scientific literacy is just providing learners with a career path in science or the teaching of academic science background for further education courses.

With this in mind, the two viewpoints have their merits but Gräber et al. (2001), see a continuum of views that stretch between the two extremes of subject competence and meta-competence. Another view mentioned earlier Bybee (1997), proposed a comprehensive hierarchical model. This model is very much driven by the discipline of science as the core influence.



Figure 1 - The Gräber model for scientific literacy

As can be seen in the Gräber model for scientific literacy (2001), illustrated in Figure 1. The model implies that scientific literacy is competency-based. The model suggests a balance between not only the content knowledge of science as a key driver but also considers ethical competence and various other competencies. The model shows that scientific literacy is much more than the knowledge one knows, and it includes the connect it has with others and includes aspects of human rights, tolerance, education for peace, gender equity, and the place of indigenous technologies), (Holbrook & Rannikmae, 2009).

The importance of Scientific literacy in schools

The importance of Scientific literacy is paramount in the betterment on the world. With the situation of the current state of the planet. It is at the utmost importance that every country aims for the improvement in the teaching of science and that pupils have the skills for careers in any field of science and engineering.

"Becoming scientifically literate produces skeptical, creative habits of mind that are valuable for everyone." - (Maienschein, 1998)

Development in further education and employment

With the limited size and resources available for Wales, it is only necessary that an overall plan is discussed on the use and implementation of science and scientific literacy in a further education setting. The universities and industries in Wales have begun to provide direction and leadership towards the strengthening of science and innovation, (Welsh Government, 2012). Universities across Wales are continuously in communication with leading members of Welsh education in the hopes of developing the skills needed to participate in the most basic of tasks in specialist science courses. Be these skills from the use or knowledge of some of the equipment used to the simple use of documentation of results in a technical report. These are basic skills that are required for these courses which in the majority of schools across the United Kingdom, schools are just not developing.

PISA (Programme for international Student Assessment)

The major influence on the need for scientifically literate learners in today's world other than the requirement for higher skilled workers is the Programme for international Student Assessment, (PISA). PISA evaluates education systems worldwide by testing the skills and knowledge of 15-year-olds in the key areas: reading, mathematics and science, (Welsh Government, 2014, OECD, 2013). The evaluation assesses the learner's ability to tackle real-life situations using the skills they have learnt in their education system. There are over 90 countries participating in the assessment to date which began in 2000. The evaluation occurs every three years and learners are tested in key subject areas of reading, mathematics and science, (OECD, 2018).

Development in the Welsh Curriculum

Now with a firm idea on what scientific literacy is and its importance in today's world. The next logical step to explore is how pupils progress in science in Welsh schools and how does scientific literacy play a part in the national curriculum. For pupils in Wales, it is essential to understand that science is an integral part of their everyday lives.

“Wales needs more well educated and qualified scientists of both genders to support our economic, social and environmental development. However, many more pupils will use science and scientific skills in their future careers. Whatever pathways your pupils take after they leave school, a sound level of Scientific Literacy is essential to prepare them for their lives in a rapidly changing world.” (Welsh Government, 2014).

Along with the involvement of PISA, the national curriculum provides the framework that all public school follow.

Welsh Government's influence relating to PISA results

With a view of the current curriculum in Welsh schools, it is only necessary to look at the current plans for developing the curriculum for the future. The use of the term 'scientific literacy', in the current state of Welsh education is that not enough is being done, and this can be seen in the 2015 PISA results. These low attainment numbers were the main purpose of this research idea to tackle or at least draw some idea of a method to aid with the improvement of these results. The PISA assessments have influenced many countries over the last few years and this is no different in Wales. The Welsh Government attempt to aid teachers in the delivering of skills and

subject content and scientific literacy is no different. In the teacher support materials, (2014), the implementation of the regional education consortium have been given guidance of the teaching support available in the teaching of scientific literacy at Key Stage 4. There are a range of tools that include a Matrix Comparison document for the use of tracking the three 2015 PISA Scientific Literacy knowledge areas against the currently delivered Key Stage 4 science qualifications in Wales. The use of this tool will aid in the review of the content that is being delivered and along with a development of the skills that may be required for the 2015 PISA assessment. This implementation will provide an important step in preparing pupils for the science curriculum and qualification changes going forward.

With the imminent arrival of the new 'Successful futures' curriculum, (Donaldson, 2015), the development here will focus on four purposes, which in the case of interest of scientific literacy focuses on many of the key ideas mention earlier. The implementation here then would go hand in hand with the potential improvement of scientific literacy in Wales.

From the exploration of the papers here, the need for the development in the skills learners need in order to become scientifically literate is paramount in the improvement in Welsh education. From these readings, one such area to begin exploring could be the way in which learner perceive the questions or problems being asked of them. So, it is only logical for this as a starting point as, if the learners can't comprehend the challenges then how can we expect them to reason and overcome the challenges being given to them.

School Policy, Practice and Diagnostics

To apply the research area to the school environment, it is only necessary to explore the current methods used within the current policies in place. With the guidance and resources made available, the school had no specific policy on the implementation of how to develop scientific literacy with the lessons. The readings on what is scientific literacy heavily support the case in the school from the viewpoint of teaching key ideas or content to fulfil a desired set of knowledge rather than the idea of developing the skills to tackle any type of problem, (Maienschein, 1998). With guidance from staff within the department, suggestions on the implementation of how to develop or at least, how to begin with the intervention research to be carried out. Using the resources available, i.e. the schemes of work, some guidelines were developed in order to conduct this research. Within the content from the scheme of work, the use of the existing subject knowledge would be used to develop the pupil's skill to avoid any other changing factors with the learners teaching and to keep the consistency with the content taught across the school cohort.

To answer the question of is there a need for this type of development of the learners scientific literacy skills, then as would be suggested by the readings of some views and my opinion then yes the current system is tailored to tackle specific content knowledge within the science curriculum rather than the ability to apply the skills being developed in these taught areas to other problems or challenges.

Methodology & Ethics

Outline

To follow the discussed above, it is only logical to begin at the starting point of learners improving their skills in scientific literacy, i.e. being able to solve problems within the science domain. One key concept in understanding the problem faced by being asked any type of question is how does one infer the need from the question. So it is only necessary that learners are given the tools to tackle any such challenge while avoiding the pattern of spoon feeding the answers to the learner which is commonly seen in educational systems across the world today.

Methodology

What is Positivism?

In order to provide a methodology to tackle the question at hand, one must first understand an approach to the development and study of the question. Here one such approach known as positivism will be explored. The term positivism is that of an approach to the study of society that uses the foundations from scientific evidence to show the nature of the operation. The approach was first termed in the 19th century by A. Comte, (1830 & 1865).

Comte theorized that establishing theories with the end goal of improving our world once these theories were clearly laid out. The approach was devised to discover the natural laws that applied to society. Comte view of the natural world, science as an essential step in the development of social science. This view on the importance of science is important in the approach to a research question in the field of science. Just as gravity is a universal truth we all experience in the physical world, Comte believed sociologists could uncover similar laws operating on the social level of people's lives, (Comte, 1830 & 1865).

With Comte study of philosophy and its history, and the methodology of science, Oldroyd (1986) says:

"It was Comte who consciously 'invented' the new science of society and gave it the name to which we are accustomed.... For social phenomena were to be viewed in the light of physiological (or biological) laws and theories and investigated empirically, just like physical phenomena."
(Oldroyd 1986)

Comte was in a position to lead the general belief of positivism to hold that all genuine knowledge is based on the experiences sensed and that advancements can only be made through observations and experiments, (Cohen, Manion and Morrison, 2007). One meaning of the term is that of the methodological procedures of natural science can be directly applied to the social sciences. The second begins with the end product of an investigation by social scientists can be collected and formulated in terms parallel to those of natural science. The meaning being that the analysis would be presented in the form of laws or law-like generalizations much like the kind that have been established relating to natural phenomena.

Inference

Using what was said by Cohen, Manion and Morrison, (2007), One such method of allowing learners the ability to understand what is being asked is inference. Teaching inference has its challenges and perhaps this could be one reason as to why learner's scientific literacy skills are underdeveloped. The use of inference is used in every subject that involve the reading of large texts, from languages to history, art. The idea that inference is an idea that learners find hard to grasp is hard to imagine however this appeared to be the case when questioned as prior knowledge indicator, to the participants involved in the research.

One tool that was suggested was the use of inference squares. Inference squares use a simple idea of three questions laid out in the form of a square as seen in Figure 2. The three questions are in essence what a curious, scientifically literate mind would do naturally when asked a question. This layout is an aid to allow the participants to visualize the process of tackling higher order questions. With this in mind, the delivery of this aid and the explanation of what inference is must be extremely explicit to cater for any misconceptions that may occur. The majority of approaches to developing the skills involved with inferring questions is primarily the same with a minor change of the delivery or the visualization. Some practitioners use simple questions in list form, or some teach through a storyboard style however all convey the same idea that inference is a simple process of applying a set of ideas as below;

1. What information is given?
2. What do I already know?
3. What conclusion can I now make? Or What can I now say?

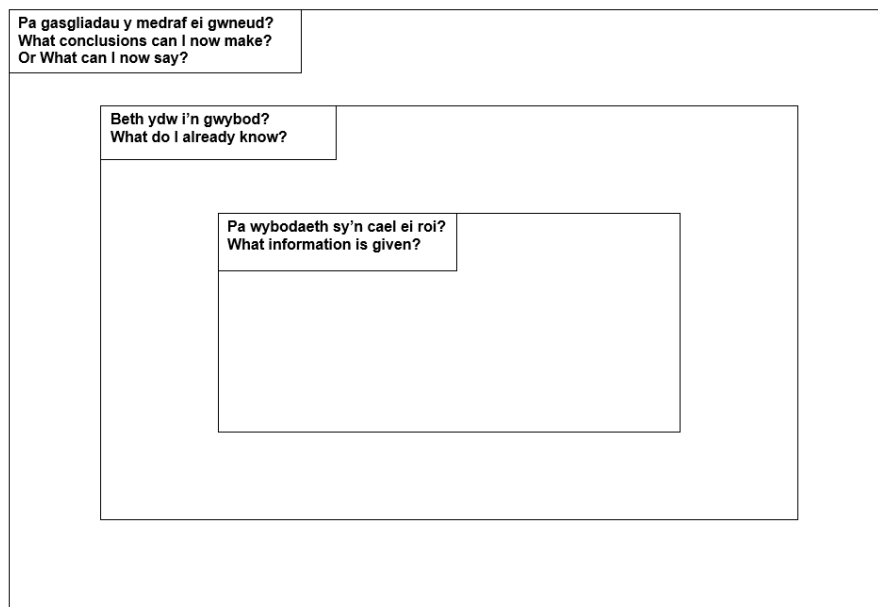


Figure 2 - An example of the visual aid used to aid with inference, 'Inference Squares'

The collection of data

During the course of the research the aim to capture and record the results of willing participants with the aim to see if the above mentioned intervention had an impact in the way the participants view questions asked of them. This will be done and explained further in the evaluation section using a single diagnostic test being given to the participants on two occasions once prior to the intervention and one post. The question used in the diagnostic test was an example from the 'Take the Test Sample Questions from OECD's PISA Assessments', along with an additional question on the same topic.

Evaluation

Overview

Here in this section, the data that was generated from the discussed pre and post diagnostic tests will be evaluated and how the methodology mentioned prior has affected the participant's ability to answer PISA style scientific literacy questions.

Pre-Diagnostic Test

To evaluate the participant's responses prior to the intervention, the responses for the entirety of the test will be examined. The test provided a baseline to show the participants the ability to tackle questions of a PISA style of nature before any intervention was done.

For the context of the question being asked to the participants, the topic revolved around the natural occurrence of the transit of Venus. The text is given as can be seen in appendix 1, present information about the key ideas of the topic, so what is a transit, the time and date of the transit, some history on the occurrence along with some text explaining an image of the event.

So to begin, the first question required the participants to use the knowledge that they unknowingly use every day. The question required the participants to use this minor realization of a piece of information that we consider to be an everyday common fact to answer the simple question on,

'Why was the transit of Venus observed by projecting the image onto a white card, rather than by looking directly through the telescope

- A. The Sun's light was too bright for Venus to show up.*
- B. The Sun is big enough to see without magnification.*
- C. Viewing the Sun through a telescope may damage eyes.*
- D. The image needed to be made smaller by projecting it onto a card.'*

The answers given by the participants here were varied in response with a total of 13 pupils obtaining the correct answer giving a percentage of 41.94% of the available marks. The learners here show that the general understanding of the question was misguided as can be seen in the possible answers, some could be correct if the perception of the question was misunderstood.

Continuing with the second part the question where the learners were asked to answer the following;

'When viewed from Earth, which one of the following planets can be seen in transit across the face of the Sun at certain times?

- A. Mercury
- B. Mars
- C. Jupiter
- D. Saturn '

With the answer to this question, the learners were required to have a very minimal understanding of the solar system and the order in which the planets orbit at. So, the question here was assessing the element of scientific literacy involve with the science content knowledge as described by Gräber et al, (2001), Rychen & Salganik, (2003), Holbrook & Rannikmae, (2009), etc.

Here the answers given by the participants were again varied in response, with a total of 12 pupils obtaining the correct answer, meaning 38.71% of the available marks were achieved.

With the responses for the third question of,

'For the transit of Venus, explain where the orbits of Earth and Venus must be in order for us to view this event from the Earth's surface.

Things to include in your answer;

- *A diagram of the Sun, Earth, and Venus at the time of transit*
- *An explanation of the position of the planets and the Sun*
- *The movement of the planets '*

Here the question itself had some level of scaffolding in place for the learners with a list of key features to include in the responses. While this aid was in place still, the answers given by the participants were ranged from some achieving zero despite the aid and some being awarded the maximum with some responses including knowledge above the intended year group. In any case, the responses awarded the total number of marks obtained of 14 full marks. Meaning a percentage of 45.16% of the available marks being correct.

For the last of the four questions in the test. The learner in this section were required to use logic to simplify the statement in order to determine the key words involved with the topic.

'Several words have been underlined in the following statement.

Astronomers predict that, as seen from Neptune, there will be a transit of Saturn across the Sun's face later this century.

Which three of the bold, underlined words would be most useful in an internet or library search to find when this transit might occur? '

The learner in this question were required to use the knowledge given to them in the entirety of the question while also using there subject content knowledge, (Holbrook & Rannikmae, 2009), along with their skills in digital competence. The question required the learner to remove the words that are important to the subject but not in the location within a

search of a database. The responses here were more than expected with 51.61% correct marks being taken. Meaning the total marks obtained were 16 full marks for the pupils. All the questions analyzed here are available to see in full in Appendix 1. To further the raw data collected can also be seen in appendix 2, also showing the varied response from each participant.

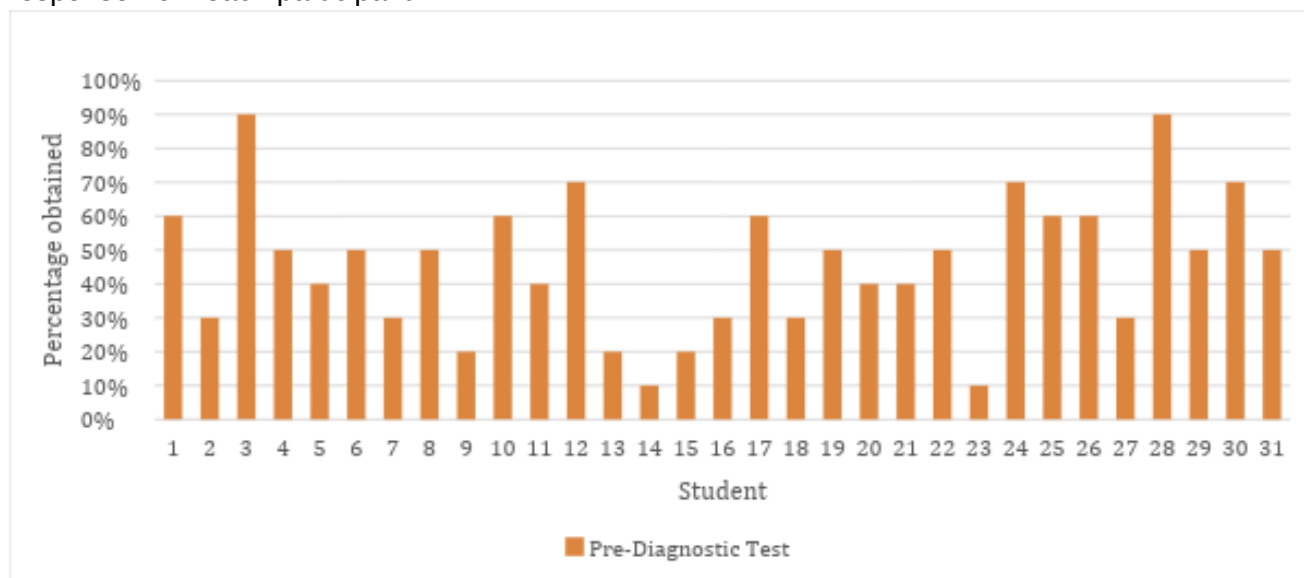


Figure 3 - The percentage of marks obtained by each participant in the pre-diagnostic test

Tasks, Resources, approaches and methods

To evaluate the tasks and resources used to allow for the opportunity for the participants to use the method given to them. The main area of there use of this technique was to tackle a question from the PISA sample questions as a class. This group activity allowed the whole class to see how an example of the use of this method could be used prior to themselves attempting to use the method. From the results of the first test, however, some participants naturally work through the problem by using the steps unknowingly however to challenge these participants questions on how they came to a conclusion were asked rather than the step by step process of the inference squares.

Post-Diagnostic Test

Upon the completion of the intervention of introduction the use of inference square to the participants. The post-diagnostic test could be completed to provide a level of effectiveness of the intervention.

For the first question, participants here achieved a total of 18 correct answers, meaning a percentage of 58.06% of the total available marks being awarded. Continuing with the second question, the number of correct answers given by the participants here was 21 correct answers providing a percentage of 67.74% of the total available marks. The third part to the test yielded in the total correct number of responses of 15.4 full marks in the awarded, 49.68% of the total available marks. This along with the fourth question show the marks awarded rather than the number of correct answer due to there being more than one mark for the question. Finally, the

answers given by the participants gave a total number of marks equaling 17.33 full marks being given, i.e. 55.91% of the available marks.

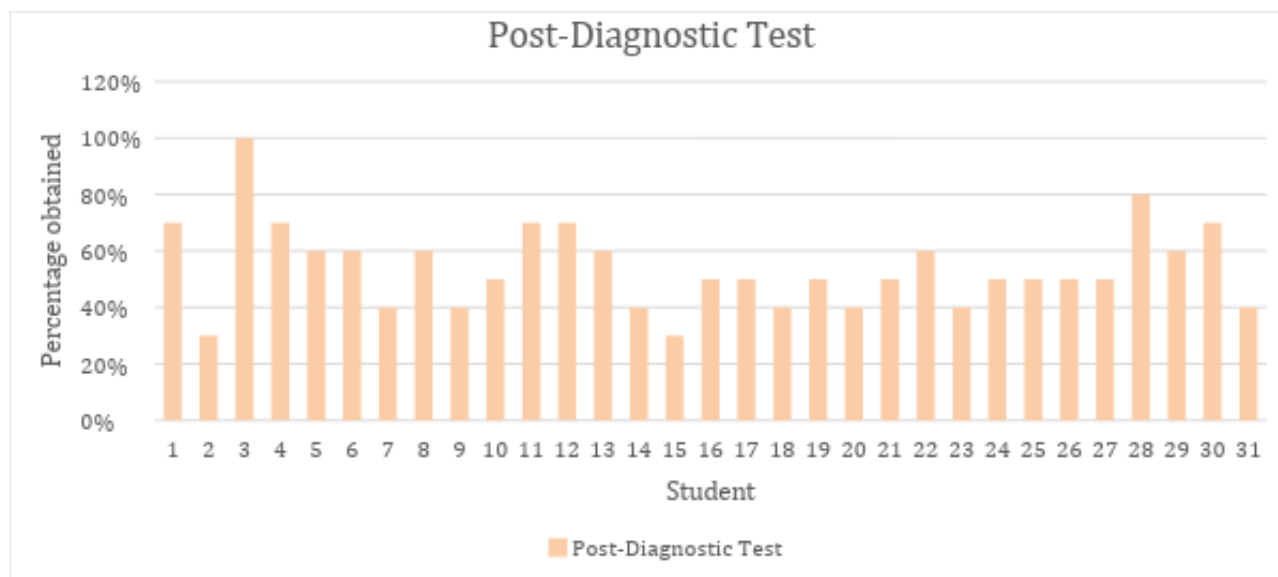


Figure 4 - The percentage of marks obtained by each participant in the post-diagnostic test

Overall comparison of the obtained results

With the use of the data collected from the two diagnostic tests, a comparison between the two sets of data can be analyzed.

To examine the first section, an increase in the number of marks were obtained by the participants from a total of 13 which increased to 18 marks prior to the use of inference square. This increase could be caused by the use of the inference square or the fact the participant is retaking the same test. So, those that misunderstood the question prior may have read the question in greater detail thereby inferring the intended response. This could be the case for each of the sections so this will only be mentioned here in the comparison section. The total percentage change here can be seen as 16.13% with a total percentage increase in responses of 38.46%.

To compare the second sections responses, here in this section the largest change occurred. With a total percentage change of 29.03%, the number of learners achieving a correct answer rose from 12 to 21. This question yielded the largest total percentage increase of 75%.

The third question provided a minor increase however here in this question, for some participants namely students 2, 6, 10, 17, 24-26, 28 and 31 reduced their obtained mark for the question after the use of the aid. For this case, I believe that the scaffolding would be sufficient for these students and the use of the aid only complicated the matter. In this question, only ten students had no change in obtained marks. The total percentage change here was 22.58% and the total percentage increase of 10%.

Finally, for question 4, the change here resulted in only a very minor increase in marks with a total of four additional marks, meaning a total percentage change of 12.9% and a total percentage increase of 8.33%, the lowest increase for the paper.

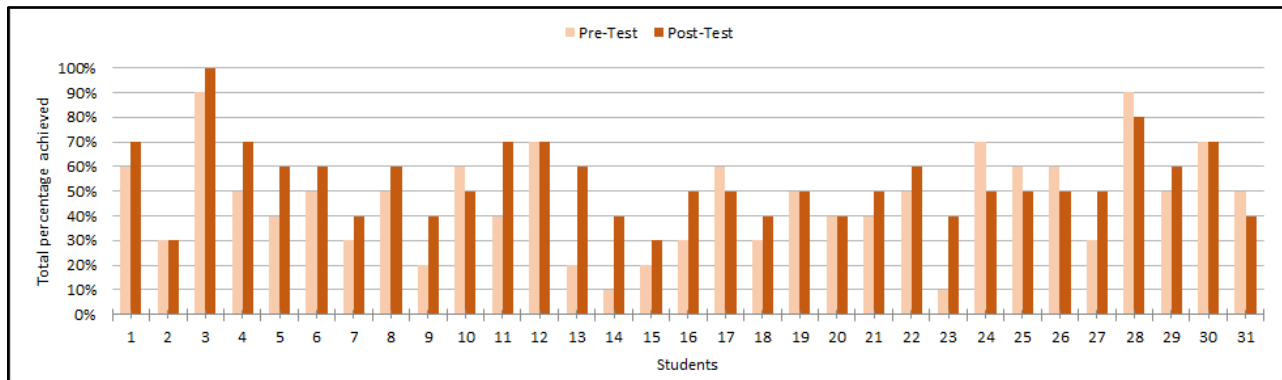


Figure 5 - A Comparison between the obtained percentage for the pre-diagnostic test and post-diagnostic test

With the total question responses compared the individual learner's change can be examined. As can be seen in Appendix 2 and a visual representation in Figure 5, the two percentages can be seen for each participant. The change per student varied, with a decrease of two marks for student 24 and a maximum increase of four marks for student 13. All the percentage changes can be seen in appendix 2 in column U on sheet 1 for further details.

With the comparison for the overall total increase in marks obtained by the participants, an increase of 0.81 marks per participant occurred meaning an increase of 8.1%. This increase was the result of the total number of the mark in the post diagnostic test being 25 above the prior.

	Marks	Question 1	Question 2	Question 3	Question 4	Additional marks	Reduced marks
Total change in marks	25	5	9	7	4	37	-14
Average total marks change	0.81	0.16	0.29	0.23	0.13	1.19	-0.47

Table 1 - The change in marks obtained by the participants for each question along with the total marks gained and lost after the intervention stage.

To gather an idea on the number of marks that students gained and lost during the research, a total for each can be seen in table 1. Here the number of marks students gained while using the inference squares was 37 meaning an average of 1.19 marks per student while some lost marks in areas totaling 14, thereby reducing the total average mark by 0.47.

As can be seen in table 2, with the use and teaching of the use of inference squares, the total percentage increase of the results can be seen at 17.48% with a percentage change between the pre-diagnostic and post-diagnostic tests.

	Total	Q1	Q2	Q3	Q4
Total Percentage change	8.06%	16.13%	29.03%	22.58%	12.90%
Total Percentage increase	17.48%	38.46%	75.00%	10.00%	8.33%

Table 2 – The total percentage change and total percentage increase for each question and the total mark per participant

Conclusions

To provide a closing statement of the reasons and conclusions of the research that can be made from the evaluation prior. The paper has aimed to explore the meaning of what is scientific literacy and some of the methodologies that are used to aid pupils to address and answer for scientific literacy questions in School X. Firstly, to show this a range of meanings for the term 'Scientific literacy' were explored. With the majority focusing on the key idea that are involved with the term. The key areas focus on the subject content knowledge the person is able to draw upon, but this is only one element on the model as most view points seem to aim towards. The model from Gräber et al, 2001 shows that along with subject knowledge, the ability to apply said knowledge is needed but this application must be done in a certain manner taking into consideration such as how its effects will connect with others these effects could include changes in aspects of human rights, tolerance, education for peace, gender equity, and the place of indigenous technologies. This idea or view point seems to include the majority of the other readings view such as the point drawn up by Norris and Philips (2003).

So following this, the paper attempted to explore how a chosen method from educational literature, here inference squares, can be used to aid the understanding and use of participants within the school. This was arrived at using the Positivist approach introduced by Comte in 1830, to show how that establishing theories with the end goal of improving our world once these theories were clearly laid out. The approach was devised to discover the natural laws that applied to society. He viewed the natural world, science with its weird and wonderful compilation of ideas as an essential step in the development of social science. This approach involved the use of a methodology that was founded using scientific observations or experiments. So, it was a natural step in research based on the improvement of scientific literacy.

Following this, the results of the two diagnostic test concluded that outside factor could have played a part in the obtained results of such a small sample of participants. However, the results show that an increase of 8.1% between the pre-diagnostic test and post-diagnostic test, implying that the use of inference square could aid the improvement of scientific literacy responses. The awareness of the learners to the idea of their inference skills are used in these types of questions could have played a role however this would only benefit the research as the main idea was to find methods to improve the responses of students scientific literacy skills and any improvement is a step in the right direction.

With the idea of furthering the research points of interest will be mentioned in the 'Limitations and future development' section below.

Limitations and future development

In this section of the paper, the limitation that occurred during the course of the research will be discussed and what additional actions could be done prior to the completion of the research to further develop the ideas discussed.

Firstly, to begin with, the limitations that occurred over the course of the research with the sample that was chosen. With an original sample size of thirty-four participants, the range of the research undertaken was considerably small and to further this research into the matter. The research performed would need to include the data collected into a large sample size, ranging from further afield to allow for the range of catchment areas that are witnessed across the country.

Over the course of the data collection stage, a further number of three participants withdrew from the research. This was due to some participants not wishing to continue to take part in the research or the failure to complete either the pre or post diagnostic tests within the allocated data collection period.

With the conclusion of the work, it is only natural to think how the research could be used, be it further research into the use of these methodologies used here or how the techniques used here could be implemented in any classroom teaching.

One such development on the implementation of the techniques used into classroom teaching could be, the use of inference is used in a number of subject areas that involve the use of large volumes of text, such as languages and humanities. These subject areas use the above-mentioned methodologies to some extent in order to analyze the question and determine different aspects that could be considered to answer the question fully and in smaller portions. This could be used to develop the inference squares used in this research. The squares could be adjusted to include questions related to the specific question rather than the pre-set questions proposed here. This strategy would increase the scaffolding needed for classroom teaching however once the method was familiar to the pupils, the scaffold will hopefully be removed the thinking style will be present to aid pupils in answering scientific literacy questions.

Another point to consider in further development could be the situation of the pupils within the class setting. The pupils in the sample data collected were of mixed ability due to the schools banding system. The data here in the view of further development could be used to compare

the ability of pupils with their current attainment in school. This could also be used to compare the effectiveness of the methodology when given to varying class ability. This could determine effectiveness when used to aid any pupil from ALN, (additional learning needs), to MAT, (more able and talented) pupils.

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