

Scientific Method and Advent of Literacy: towards Understanding Itaukei and Indo-Fijian School Students' Differential Achievement in Science

Mesake Rawaikela Dakuidreketi

The University of the South Pacific, School of Education ,Faculty of Arts, Law & Education ,Laucala Campus, Private Mail Bag, Suva,Fiji Islands

*Corresponding Author: rawaikela_m@usp.ac.fj

Copyright © 2014 Horizon Research Publishing All rights reserved.

Abstract In general, people believe that if we want our children to be good in and relate well to science, or to enable at least a few of them eventually to become scientists themselves, we may need to be clear about what science is and the nature of its method. Individuals can then wield the method of science, making them scientists. This way of thinking is firmly committed to the view that science is what a scientist does, times the number of scientists that there are. Thus we might hope to foster in children certain behaviours that are conformable to 'the method of science'. If this is the case, then we would expect every student who takes science to understand and be good in science. However, this is not the case. A contention of the paper is that the main enabling conditions for the ignition of science are in fact writing and literacy. The implication is that a culture that is well used to literacy from past generations will have an advantage vis-à-vis school science learning as compared to a culture that remains significantly oral, and has had very few generations to adjust to the range of possible uses that writing opens. This could possibly be a causal explanation of differences in science achievement levels between iTaukei (Indigenous Fijian) and Indo-Fijian students at school.

Keywords Philosophy of Science, Literacy, Orality

1. Introduction

This position paper grows out of my earlier PhD research to find out why iTaukei (Ethnic Fijian) students are not doing well in science at school as compared to their Indo-Fijian student counterparts. In the discussion I will first describe the problem and provide some figures to show the ethnic difference in performance between the two ethnic groups at school. In addition, I will also present various philosophical theories and views, attending mostly to the literature in contemporary philosophy of science. Parts of the philosophical discussion stem from my conversation with

my co-supervisor for my PhD research - Dr Philip Catton, of the Philosophy Department at the University of Canterbury. parts (as will be indicated) stem from my attendance at a particularly clear and helpful series of lectures given by the Australian philosopher of science and University of Canterbury Erskine Fellow, Dr Alan Chalmers. In addition, part of my discussion comes from what I found in my previous research (Dakuidreketi, 2006).

My argument takes as its starting point a non-technical, lay person's definition of what science is. This is important because if, as a sizeable number of people tend to think, we want our children to be 'good in science' and if we want to enable at least a few of them eventually to become scientists, it might seem necessary to be clear from the start about what science is. I will engage with what some well-known philosophers of science say about the 'method of science'. The philosophy of science might seem especially pertinent for analysing what might promote better and more effective teaching and learning of science in the schools of Fiji, since explaining what science is has been a major part of the philosophy of science endeavour. But I will argue that the philosophers' accounts of how science itself supposedly 'works' offer less than we might have expected for understanding effective school science teaching and learning. At the end, after discussing the relationship between orality, literacy and science, I will draw my conclusion and recommendations.

2. What is the Problem?

The realisation that iTaukei students are not achieving well academically is not new since there have been many reports on this lag (Baba, 1979, 1985; Hopkin, 1978; Kishore 1981; Sherlock, et al. 1969; Whitehead, 1986; Otsuka, 2006; Fiji Education For All Mid-Decade Assessment Report 2008;) and specifically in science related subjects (Dakuidreketi, 1995, 2006; Kenchington, 1988; Nabuka, 1984; Narsey 1994; Taylor 1990). No aspect of education in

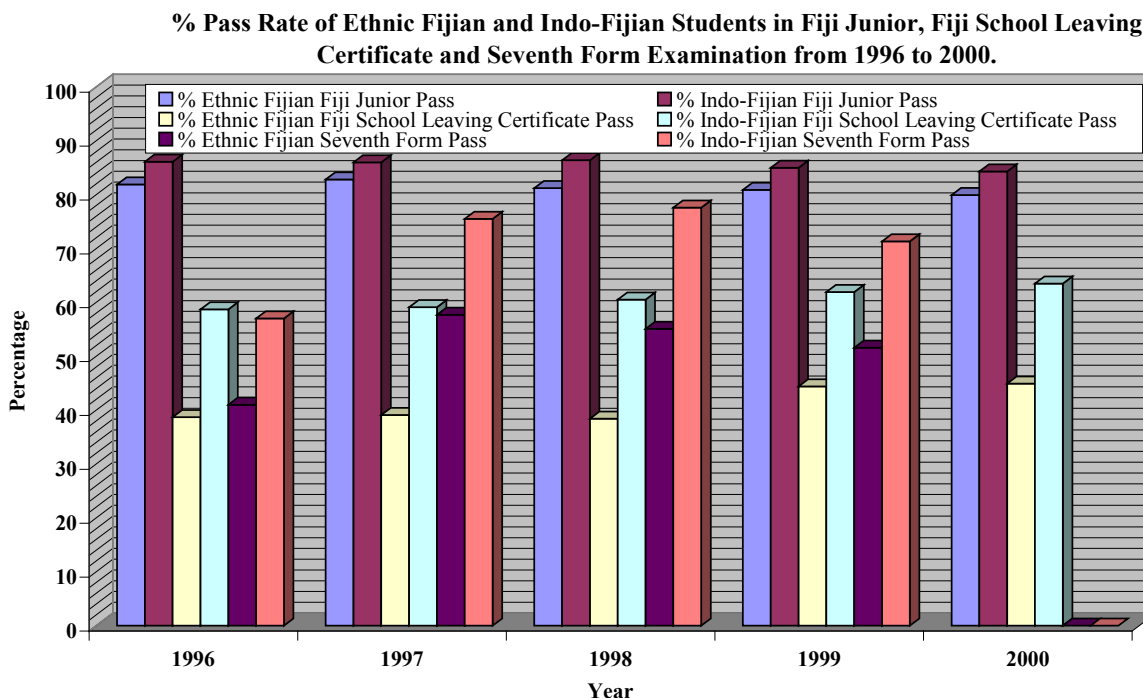
Fiji has been so consistently written and talked about as that of the 'iTaukei Education Problem' or the failure to get enough iTaukei to the top.

The Indo-Fijians have consistently done better than the iTaukei students in standardised external school examinations (refer to Figure 1) and particularly in science and science related subjects as shown in Tables 1 and 2.

From Figure 1, it can be seen clearly that in all the National Examinations namely the Fiji Junior Examination

(Form 4); the Fiji School Leaving Certificate (Form 6) and the Fiji Seventh Form examination, Indo-Fijian students tend to do better than their Ethnic Fijian (iTaukei) counterparts.

In considering the National Examination at Form 6 level where students begin to concentrate on learning pure science, it is clearly seen that the percentage of iTaukei students who sat the subject and their percentage pass rate in those subjects are below that of Indo-Fijian students. The bar graphs on Figure 2 clearly illustrate this.



Source: 'Ministry of Education Annual Reports', 1997, 1998, 1999; and statistics of the Ministry of Education.

Note: For Fiji Seventh Form Examination, numbers passed are those that score 200 and above for English (at least 35%) and best 3 subjects. The figure does not represent the quality of subject passed. Figures for Fiji Seventh Form result in 2000 for both Ethnic groups were not available.

Figure 1. % Pass Rate of Ethnic Fijian and Indo-Fijian Students in Fujian Junior, Fiji School Leaving Certificate and Seventh Form Examination from 1996 to 2000

Table 1. Form 6 Fiji School Living Certificate % Sat and Pass Rate per Science Subject by Race – 1999.

Science Subject	Ethnic Fijian		Indo Fijian	
	% Sat	% Pass Rate	% Sat	% Pass Rate
Maths	46.9	22.4	53.1	40.1
Biology	47.8	33.8	52.2	51.5
Chemistry	43.4	36.0	56.6	56.8
Physics	44.1	25.3	55.9	58.7
Agricultural Science	55.5	58.4	44.5	65.3

Note. Data personally collected and derived from 'Ministry of Education Examination Office', 2001.

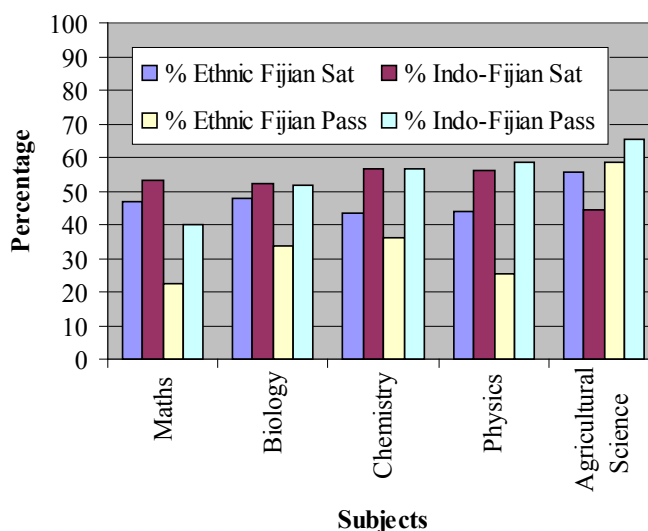
Table 2. % Pass and Enrolment of iTaukei and Indo-Fijian First Year Science Students at the University of the South Pacific from 1983 – 1993 and from 1997 to 2002

Years	Ethnic Fijian		Indo Fijian	
	% Enrolment	% Pass Rate	% Enrolment	% Pass Rate
1983	23	50	58	82
1984	21	45	45	80
1985	24	58	56	83
1986	39	71	44	91
1987	43	76	44	92
1988	33	76	41	86
1989	26	60	43	91
1990	24	52	70	83
1991	21	48	72	80
1992	16	45	74	76
1993	12	42	77	73
1997	67.4	38.7	32.6	46.7
1998	59.4	43.9	40.6	64.3
1999	54.2	82	45.8	76.3
2000	63.3	40.4	36.7	57.6
2001	63.8	60	36.2	79.4
2002	58.7	71.8	41.3	75.6

Source: Derived from ‘The University of the South Pacific, and Fiji Centre’, 2003.

Note: From 1983 to 1993, this first year University Programme was administered at The University of the South Pacific. It was phased out by the government in 1994 and was re-introduced by the Ministry of Fijian Affairs (now called Ministry of iTaukei Affairs) in 1997 through the Fiji Centre of the University of the South Pacific. That is why there is no data available between 1994 and 1996 in this table.

Form 6 Fiji School Leaving Certificate % Sat and Pass Rate per Science subject by Race in 1999



Note. Derived from ‘The Report of the Fiji Islands Education Commission’, 2000. Recent figures were not available.

Figure 2. Form 6 Fiji School Leaving Certificate % Sat and Pass Rate per Science by Race in 1999

The trend seen from this figure is that in 1999 Indo-Fijian students both sat science subject examinations in the form 6 Fiji School Leaving Certificate examination in greater numbers than iTaukei students (the exception being Agricultural Science) and were (without exception) more likely to pass those examinations than Ethnic Fijians.

The data shown in Table 3 clarify a further dimension of difference, namely that the exam passes by iTaukei students are more heavily weighted into the C category (with very few A and B grade passes) as compared to Indo-Fijian students in

science subjects, in the Seventh Form Examination results for the years 1998, 1999 and 2001.

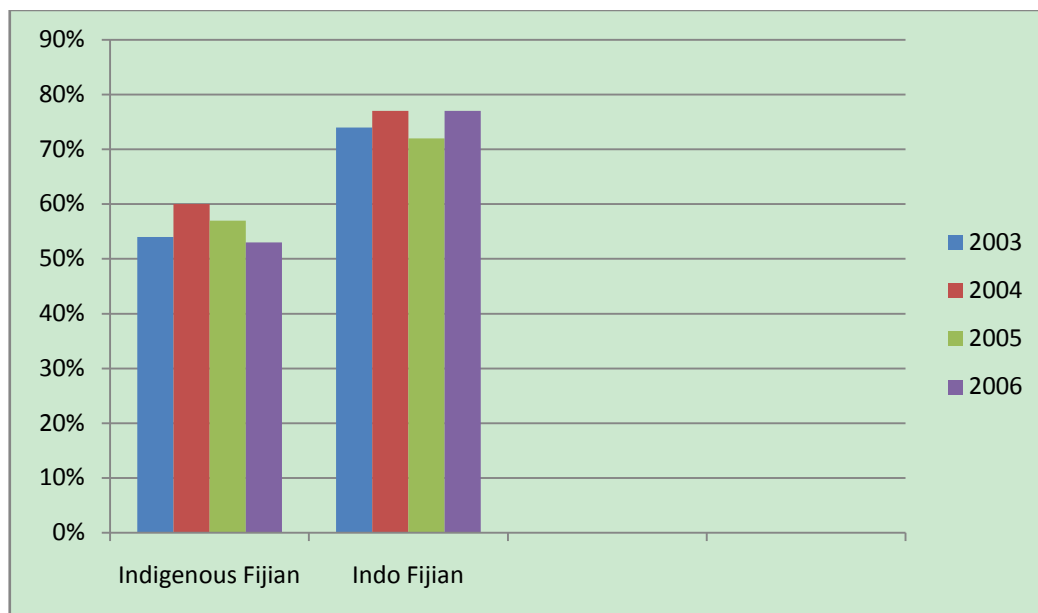
Table 3. Seventh Form Grades of Pass per Science Subject by Race from 1998, 1999 and 2001

	Pass Grades	Mathematics	Chemistry	Biology	Physics	
1998	A	2	0	0	0	
	Fijian	B	72	17	15	10
	C	322	132	164	97	
	Indian	A	68	0	2	10
		B	680	277	170	254
		C	749	460	494	315
1999	A	8	2	1	3	
	Fijian	B	100	50	53	30
	C	350	180	134	113	
	Indian	A	156	82	73	72
		B	528	305	241	253
		C	924	432	329	318
2001	A	3	1	4	-	
	Fijian	B	121	34	30	27
	C	427	159	158	134	
	Indian	A	138	68	59	74
		B	650	312	238	250
		C	904	437	367	324

Note. Adapted from 'Ministry of Education Annual Report for the Year 1998, 1999, & 2001'. The year 2000 figures and the more recent ones were not available.

The figures presented were taken when I conducted my PhD research in 2005. People might think that the trend in academic performance between the two main Ethnic races no longer exists now. However, looking at the recent result available on the performance of the two Ethnic groups in Form 6 Fiji School Leaving Certificate Examination from 2003 to 2006, in Table 4, it clearly indicates that the same trend still exist.

Table 4. Percentage pass rate in Fiji School Leaving Certificate by ethnicity: 2003 - 2006



Source: Derived from 'Fiji Education For All Mid – Decade Assessment Report 2007

This trend creates feelings and thoughts amongst people that the iTaukei are not academically as able as other races in Fiji. The questions which may direct most people to ask are: Why are the iTaukei students not doing so well in science and other science related subjects when compared to other races at school? Do they tend to find the subject difficult or do they tend simply not to find it pertinent or interesting? Either way, what are the reasons? Is their underachievement related to the teaching of the subject at school? Could it be that what iTaukei students learn at school is not viable within the context of their cultural and traditional upbringing, or that what the students learn at school does not form a meaningful part of their life especially in their homes and villages? Do they have negative or positive perceptions of the value of schooling, and why do they have the perceptions they do? Is it related to literacy? This is what I will discuss at the end of this paper.

3. What is Science?

An ever-popular (and rather simplistic) conception that people have about science is encapsulated in the aphorism, 'Science is what a scientist does, times the number of scientists that there are'. According to this way of looking at it, what a scientist does, as a scientist, is to follow the method of science: in other words, the whole nature of science can be identified by describing the kind of method that individual scientists have and use.

When it comes to science education, people often betray the influence of the popular conception. If we want our children to relate to science, and if we want to enable at least a few of them eventually to become scientists themselves, it might indeed seem necessary to be clear about what science is. That might seem to require saying what the method of science is, on the supposition that that method can be wielded by each individual scientist, making them scientists. This way of thinking is surely committed to the view that science is what a scientist does, times the number of scientists that there are. Thus we might hope to foster in children certain behaviours that are conformable to 'the method of science'. In this way we would help those children to become scientists. This at least is a view towards which one is led by the popular conception discussed above.

Science, though, is not so simple to define. According to the University of California Museum of Paleontology (2013) it is difficult to define science accurately since it is complex but they define science as 'a body of knowledge of all that is in the universe' and is a reliable process by which we are able to learn about everything in the universe; how it operates; and how it has come to being. In addition, science is different from other ways of learning because of how it is conducted. It depends on testing of ideas and gathering of evidence so that an idea can be accepted. Without thorough testing and substantial evidence, a conclusion cannot be reached and/or accepted. Therefore, science focuses on the natural world and is a way of learning about what is in the natural world. In

addition, it relies on thorough testing of ideas. Hence, outcomes of science is reliable since the evidence produced have been through thorough examination, observation and testing to be able to be accepted. So, science affects our daily living and can be used in our everyday life to increase our understanding of our universe. All in all, science does not just happen in a laboratory it can happen anywhere in the natural world.

Helmenstine (2013), highlights that the method of science is a way of 'conducting an objective investigation'. It entails asking questions, making observations and testing hypothesis. First, there has to be a problem or issue or question and then observations are carried out to try and address the problem or issue or questions asked. In addition, background research should also be made so that a hypothesis can be put forward to be tested using an appropriate method. After the hypothesis has been tested the outcome will determine if the hypothesis can be accepted or not. If the hypothesis is accepted, conclusions can be drawn from it; however, if it is rejected then the hypothesis can be revised and retested.

Therefore, to understand science and the method of science requires certain skills; research, critical thinking and observational skills are not the least but some vital skills that are needed. To be able to find out background information for any scientific research one must have basic reading, writing, comprehension and counting skills. Therefore, any form of literacy (reading, writing, counting using whether linguistics or non-linguistics features) is vital in science and science methods.

This is partly why I resist the trail of reasoning I have outlined: that positioning our children to relate to science, or eventually to become scientists themselves, requires us to be clear about what science is. For (it is suggested) we will surely want to use that knowledge in order to figure out how to invite students into the practice of science, and thus shape them into scientists. The problem with this apparently laudable reasoning is that, try as they might, philosophers of science have not yet succeeded in distilling a clear simple understanding of what science is. And this is probably because science is not one simple thing (based, say, on some simple but monolithic and ahistorical method) of which a single clear understanding can be had. Over against the claims of some philosophers of science, it does not seem that we can capture the essence of what science is by the simple means of defining the 'method of science'. In particular, pinpointing what science is turns out to be far from being a simple matter of defining some sort of method that could be wielded by an individual, turning that individual into a scientist.

Science is often conceived as though it is a cultural universal and thus knows no boundaries between cultures. On this view the state of scientific development has been lower or higher in different societies at different times, but we can expect the word 'science' to refer univocally to something at some level of development or sophistication in any society. I believe that this viewpoint is false, in ways that

betray the unhelpfulness of the philosophers' presuppositions. It is not that I can offer to define science, in some way that would exclude from that status the forms of inquiry in, say, traditional iTaukei culture. Not even in the 350-year tradition of western science that started in Europe can philosophers of science discern a single monolithic ahistorical methodological form for the whole of that enterprise. That this is so shows clearly that there is no easy definition of science. It seems that 'science' connotes a 'family-resemblance' concept (in the sense due to Ludwig Wittgenstein). Despite the looseness of the word 'science', however, there seem to be many good reasons for withholding its application to cultures significantly different from that in which the so-called 'Scientific Revolution' occurred. Indeed one does better justice to those other cultures by withholding the word 'science', than by seeking to apply it to the kinds of inquiry and knowledge that they sustain. Whether the way that, say, iTaukei in their traditional context garnered understandings of the world around them sufficiently resembles the inquiries we receive today as sciences itself to be thought of as science, I very much doubt. I believe that we do better justice to iTaukei's traditional modes of inquiry and forms of understanding by considering them not as attempts at science but rather on their own terms.

Given my overall interest in the question why iTaukei are under-performing in school science as compared to Indo-Fijians, I find that for my purposes the philosophers of science are looking in the wrong place. It is that iTaukei students, as compared to their Indo-Fijian counterparts, are, on average, relatively ill prepared by their cultural experiences to assimilate themselves well into science at school. But the factors that are most likely to be significant seem to me not to lie within the (controversial) descriptions that philosophers of science provide of what it is to 'do science'. Notably, philosophers of science simply take for granted some aspects of their own general culture, for example literal mindedness, or more particularly the preoccupation (that is necessary for the practice of philosophy itself) with literal, objective, truth. What they say about science illuminates not at all how these aspects of culture are set in place. Yet in all likelihood the aspects of culture that the philosophers of science simply take for granted (rather than seeking to illuminate) are keys to my area of research. The differences that exist between iTaukei and Indo-Fijian children in their experience of science at school is more to do with the category of literal, objective, truth, and with how weakly or firmly in the possession of students that category is, than it has to do with some (controversial) characterisation of 'the method of science'.

In the next section, I will present some philosophical views on the nature of scientific enquiry due to Bacon, (1855, first published in 1620); Popper, (1972); Lakatos, (1970); Kuhn, (1970, 1977) and Feyerabend, (1975). I will in fact argue that there is not nearly as much to take from these philosophies of science into an analysis of the situation in science education in Fiji as might have been hoped, or as

some would expect. I will explain why I believe that the standard conceptions in philosophy of science such as those by Bacon, Popper, Lakatos, Kuhn and Feyerabend prove to have relatively little to offer to me. Of course this is not to distance my argument from philosophical considerations altogether; it is just to say that the stock conceptions and debates in recent academic philosophy of science are for interesting reasons well to one side of my main concerns.

An Evaluation of the Philosophy of Science for its Relevance to my Arguments

It is true that some philosophers of science, such as Bacon and Popper, have tacitly endorsed the popular conception. They have articulated a method for science of a sort that an individual researcher could wield. They suppose that the wielding of this method is the defining factor to whether the researcher counts or not as a scientist. They seem committed to the view that science is what a scientist does, times the number of scientists that there are. But notably, neither Bacon's inductivist method nor Popper's falsificationist one stands as a philosophically successful reckoning of science. Both Bacon and Popper are roundly criticised by other philosophers for the unworkableness of their proposals. In both cases it is arguable that the proffered prescription for science is not even fully coherent, let alone accurate to the way science is actually done.

Some other philosophies of science do not suppose that science is what a scientist does times the number of scientists that there are. For example, both Kuhn and Lakatos adopt an understanding according to which there are significant social aspects to the functioning of science. According to Lakatos, (1970), the key question is not always what is rational for an individual to do. A significant separate question concerns what is rational for the community to do. According to Kuhn, (1970), the key question is not always what is rational. Science can work forward effectively by non-rational means, simply by means of the overall social form that science takes.

The popular conception discussed above is quite mistaken. If doing science were simply a matter of implementing some method that it is relatively easy to describe, then we would have to expect that just about every people would have stumbled onto doing science. On the contrary, almost all the peoples there have ever been have not 'done science'. So there must be more to what it is to 'do science' than simply to stumble upon and implement an easily describable method.

Likewise, if doing science was simply a matter of implementing some method that is relatively easy to describe, then getting children to see what science is all about and why it is worthwhile would be quite easy. But getting children to see what science is all about and why it is worthwhile is typically not at all easy. So the perspective according to which science is simply a matter of implementing some method that it is relatively easy to describe is therefore pernicious. Science is not monolithic, not unified in its form. This is a worthwhile discovery to make because it arms one against adopting an oversimplified conception of science. To learn this lesson is a salutary antidote to the widely received understanding of science, according to which science

apparently gains its distinction and authority from a single, monolithic, overarching, a historical, context-independent method that defines what it is and ensures that it is special.

There may be dispositions that interfere with a child's engaging in science let alone becoming a scientist. In addition, there may also be dispositions that can help a child engage in science or even eventually to become a scientist. Yet my point remains: we have little reason to expect that philosophers' accounts of science will help us to pinpoint which dispositions matter one way or the other and why. The best dispositions for young people to have if any of them are eventually to become scientists are quite different from the dispositions Bacon calls our attention to, or Popper, or for that matter Lakatos or Kuhn.

In other words, the best dispositions for young people to be equipped with if any of them are eventually to become scientists is indeed not those that are needed in adult scientists themselves. For example, a willingness to have a vast amount of received knowledge packed into oneself through very dogmatic education may be a significantly helpful disposition for a young person to have in order eventually to become scientifically creative. (To say this is contrary to the wisdom of many educationalists, but I will sketch an example shortly that supports my present point.) It is true that a creative, adult scientist would need to have very different dispositions from this. It may seem anathema for me to suggest that willingness to learn by doctrinaire education is consistent with eventually being creative. In fact I do not propose that this is a way forward for Fiji. But I think that what happened in Germany after its educational reforms in the late nineteenth century in fact does show that in some contexts this is possible. New, science-intensive schools were created there, to cater to a technically able elite, and to teach mathematics and science with the same intensity as the *Gymnasias* had traditionally taught classical subjects. Students at these schools were forced to learn vast reaches of established science. Some who endured this education, such as Albert Einstein, confirm that it was very doctrinaire. (For a discussion, see Pyenson, 1985.) Yet the consequence was that a fleet of young geniuses emerged who worked a creative effect on the fields of mathematics, physics, chemistry, geology and life science.

The experience in German-speaking lands at the end of the nineteenth century seems to show that (perhaps under special conditions) creativity can arise precisely as a result of thoroughgoing indoctrination. One reason why, say, Einstein proved to be very creative after learning a vast amount of received knowledge is that he was able to detect that the sum total of what he had been taught was not fully coherent. Einstein shows us that a person into whom a lot of received knowledge has been packed may encounter difficulties with it. If that person is, say, charged with the task of teaching others, or of using received knowledge in novel applications, that person may be forced to face the incoherencies in received knowledge for what they are. If in this situation that person takes the steps necessary to transcend or eliminate the incoherencies, then that will be creative. Yet the condition

for becoming creative in this way seems to me to be the willingness as a young person to sustain a style of learning that little allows creativity to breathe let alone grow.

Of course all those German-speaking children who went to the elite schools were probably there under a self-conception that they might one day be scientists. So even as children they might already have had an image of themselves as one day being scientifically creative. I am not suggesting that a doctrinaire style of science education is necessarily the best thing for all children, and I suspect that in many contexts it might be disastrous for everybody. Even in Germany at the end of the nineteenth century it is likely that many who were taught this way were put off or fell behind and found the experience totally negative. My overall point from this is just that we cannot learn what dispositions will best help children to acquire an ability for science at school by considering the dispositions that adult, creative scientists ideally should have.

The implication of this for science education in Fiji is that the classroom behaviours that a science teacher can most beneficially nurture or elicit may not be the same as are to be found in practicing scientists. In any case there is no set of behaviours in practicing scientists that define what science is. To suppose otherwise is to adopt the popular conception discussed above, and that is an error. I do not mean to suggest that science teachers can in no way beneficially nurture or elicit behavioural or cognitive dispositions in children. There may well be reason, for example, for teachers to encourage iTaukei children to think more for themselves, to come to appreciate the importance of evidence as opposed to personal authority, and in these ways to begin to acquire more firmly the category of literal, objective, truth. It may well be that Indo-Fijian children are less in need of such help at school, while perhaps there are other kinds of help that they ideally should have. My point is just that the philosophies of science seem to point away from rather than at the dispositions that it will be most important for a school science teacher to consider and aim to instil.

So the question that most would like to ask is: What could be the possible explanation for one group of people to do well in science and other related subjects at school as compared to the other? In the next section, I will try to answer this question by discussing the relationship between orality, literacy and science.

Relationship between Orality, Literacy and Science

Writing and literacy are thought by some people to have been the key enabling conditions for the very ignition of science. According to Olson (1994), writing and literacy are necessary conditions for the rise of distinctively modern modes of thought as epitomised by philosophy, science, justice and clinical medicine. This of course supports the view that in literate cultures, people's consciousness of language itself is very much structured by their writing system. The importance of writing to the advancement of philosophy and science has in recent times been examined and defended in a series of major works by such writers as McLuhan (1962), Goody and Watt (1968), Goody (1978),

Ong (1976); works that trace a new orientation to language, the world and the mind, to changes in the technology of communication.

Wellington and Osborne (2001) highlight that for students to be actively involved in science and understand it fully, they need to learn its language. Students should be able to understand scientific words and non-linguistics features of science such as pictures, diagrams, images, animations, graphs, equations, tables and charts. Hence, it is vital that students learn the language of science. Furthermore, Essential Information for Education Policy (2009) highlights that to be successful in any subject in school, literacy skills such as comprehension, writing and oral language is vital. In this regard therefore, schools should establish policies to ensure the efficient teaching of these literacy skills so that students can do well in all the subjects they do in school, for instance, Mathematics and Science. Hence, not only teachers and schools should ensure the language development of students, communities should also establish programs to assist students develop their literacy skills so that they can perform well in subjects such as Science, Mathematics and Social Sciences.

Shelly and Yildirim (2013) in their research amongst Turkish students found that reading plays a role in students' scores in Science and Mathematics. Having literacy skills such as reading and writing fosters knowledge transfer and cognition therefore assists in the successful performance in Science and Mathematics. Consequently, it is vital that students have literacy skills for improved performance in Science and Mathematics.

Webb (2009) highlights that students' literacy skills both in their vernacular and the language of instructions in their school are vital for students' performance in science. When students have literacy skills, it allows them to be able to argue science issues meaningfully. In addition, students who are literate in their vernacular have an added advantage since they understand science topics they are learning better when they read and speak in their vernacular than if they were to read and or speak in a foreign or unfamiliar language like English. When unfamiliar languages are used for teaching science, students are bound to learn through rote learning hence become passive learners and not active learners of science; when this happens students do not fully understand the concepts they are learning therefore cannot apply them or even see their relevance for their use or for their survival.

Morgan (2012) defines Science literacy as having the abilities and habits to be able to understand scientific knowledge and skills that are put in different modes and genres and be able to apply them successfully to address relevant scientific problems and issues. Students and teachers need to have science literacy to be able to be successful in learning and teaching science.

Carrejo and Reinhartz (2010) highlight that there is a synergy between science and language learning; as learning occurs in science so does it occur in language and vice versa. They define science literacy as a person having the ability to collect and measure information through observation and be

able to construct graphs using information they have collected and be able to make conclusions from them, constructing models and identifying patterns. Learning science through practice provides a context for language learning and vice versa. Language literacy is students using their experience are able to understand words and texts and be able to analyze cause and effects and represent knowledge they have learnt in different forms and make conclusions and analyze different characters of different objects. Therefore, science literacy and language literacy complement each other in students' learning so should be co-taught to assist in students' academic performance.

Worth (n.d) highlights that to have a deep understanding of science, one must have the ability to be able 'to use language to form ideas, theorize, reflect, share and debate with others, and ultimately, communicate clearly to different audiences.' In addition, to develop their language skills, students should contextualize them or use or practice them in real life situations. Therefore, to understand science, literacy skills are vital.

Guzzetti and Bang (2011), highlight that literacy is a catalyst for learning science. It is essential for the understanding of instructions whether it be verbal or written. In addition, literacy is an important tool for learning science and a vital instrument for students becoming scientists.

In a society that has thoroughly assimilated the technology of writing, knowledge tends to be identified with what is learned in school or from books. Literacy skills in fact provide the route of access to that knowledge. People who cannot read and write are thus cut off from knowledge, both current knowledge and the long tradition of accumulated knowledge on which a literate society is continuously building.. This reduced condition, the condition of the illiterate person in a modern society, is pathetic. For this reason 'illiterate' becomes a highly negatively charged word. Of course, the non-literate condition of people in oral societies is for this reason best distinguished sharply from the condition of illiterate people in any modern society.

According to Olson (1980), literacy imparts a degree of abstraction to thought, which is absent from oral discourse. This view is also supported by Baker, Barzun and Richards (1971) who think that literacy is of the highest importance to abstract, theoretical thought. Havelock (1982) provides evidence that the Greeks evolved a philosophical disposition only as they gradually pressed the Greek language into uses it would not have had in an entirely oral culture.

Some cultural historians and anthropologists over the past two or three decades have a different viewpoint to this. For example, Harris (1989), over against Havelock, contends that the degree of literacy in classical Greece, far from being universal, was quite limited. He argues that probably no more than 10% of the Greeks in the era of Plato were literate. Others like Carruthers (1990) argue that writing something down cannot change in any significant way our mental representation of it. Thomas (1989) and Anderson (1989) insist that classical Greek culture was primarily an oral culture favouring dialectic (that is to say, discussion and

argument) for the development of knowledge, and that writing played a small and relatively insignificant part. Consequently it is unlikely that we can simply attribute the intellectual achievements of the Greeks just to their literacy. Lloyd (1990, p. 37, cited in Olson, 1994) found that the discourse that gave rise to the distinctively Greek modes of thought 'was mediated mainly in the spoken register'.

People who study oral cultures with a view to showing how much can be achieved in them remark for example how Polynesian navigators sailed many-thousand-mile voyages without the aid of a compass or chart (Gladwin, 1970; Hutchins, 1983; Oatley, 1977). How are such accomplishments possible? Anthropological studies of oral culture by Bloch (1980) and Fieldman (1991) have revealed both complex forms of conversation and memorisation as the answer. Consequently, these authors claim, contrary to Olson, that no direct causal links have been established between literacy and the development of sophisticated systematic modes of cognition.

I personally think that the truth is somewhere between these opposing views. The counterarguments that I have just discussed do underline neither that literacy is not a sufficient condition for the emergence of science and philosophy; nor is it a necessary condition for the advancement of technology and quite sophisticated systematic thinking. Yet they all fall short of undermining the picture that Olson presents, of literacy as an important enabling condition for mathematics, science and philosophy. To understand how literacy helps enable a people to undertake mathematics, science and philosophy, there is a need to look closely at how cognitive change (change related to the mind) is caused by social change. I will first endeavour to illustrate what some other writers think about this before I present my own view.

In a classical work (Durkheim, 1948) Emile Durkheim argues that cognitive structures are first social in nature and that social change had brought about a shift from religious to scientific concepts. Scientific concepts, he argues, are an effect of the progress of social relations and concomitant changes in modes of thinking. This theory could explain the rise of early modern science. Cognition according to him was born out of coping with and rationalising new social roles and relations.

Merton (1970), in trying to explain the relationship between religious and scientific thought, offers a much narrower but still sociological conception. He focuses on why so many early modern scientists were also Puritans. He offers the view that Puritan communities are hardworking people with each man being his own interpreter of scripture and nature. This, he contends, was conducive to the development of experimental science.

However, Thomas Kuhn (1977) criticises Merton's standpoint for being far too narrow and insufficiently explanatory. Kuhn urges that the critical factor in the scientific revolution was the development of exemplars of successful scientific activity. What Kuhn calls 'paradigmatic' or 'normal' science is the social effect of the community of researchers receiving certain individuals' work as exemplary,

or thus as setting the standards for what a worthy further contribution to the field could be thought to be.

There is one thing that I think each of these sociological theories misses in trying to explain the connection between social change and cognitive development. That is, they all fail to recognise the significant role of literacy. Literacy encourages thinking of a sort that enables a person to acquire a quite different variety of skills and knowledge from those that people come by in an oral society.

Vygotsky (1978) adopts the view that the 'higher mental processes' always involve the use of socially invented signs. Such signs are, of course, culturally diverse, and they also always have a history. Although Vygotsky does not himself draw much attention to the differences of oral from literate cultures, his theories nonetheless potentially help to explain how writing and literacy could influence cognitive operations and activities and thus also potentially help to explain the development from primitive to modern forms of thinking. Vygotsky contends that cognition and consciousness are the products of human activities rather than the cause. This tends to suggest, furthermore, that human memory takes alternative forms depending upon cultural resources.

My own belief coincides with what Olson contends about writing as our dominant model for thinking about nature and mind. Olson argues that our understanding of the world (our science) and our psychology are produced from our ways of creating and interpreting written texts. Olson believes that writing makes it possible for the first time to set two pieces of text side by side in order to check them for identity or to look for relationships between them. Writing preserves statements and thereby opens them up to critical inquiry. Thus while writing is used to preserve information much as oral memory arts also do, it introduces an altogether higher set of standards concerning the identity of items of information and for the critical question whether or not they should be retained and if so in what systematic relation to other items of information. In fact, writing tends to relax the constraints on memorability. That is, being equipped with a writing system makes a culture capable of preserving an unlimited number of statements or facts. The question of how to order facts rationally (rather than merely preserving selected important facts mnemonically) becomes paramount. Thus, thinking can take on an orientation to an *all-things-considered, rationally best-systematised, ideal way of thinking*. Another name for this ideal is 'literal truth'. A statement is literally true if it is conformable with *all-things-considered, rationally best-systematised thought*. If it is not so conformable, it is false, literally speaking. The very categories of literal truth and literal falsity arise for the first time in the cultural condition of literacy.

Naturally every society marks out in some way the distinction between having spoken or thought well and having spoken or thought ill. And the distinction will often map directly onto that between having spoken or thought what is literally true and having spoken or thought what is literally false. But it would be wrong to conclude from this

that every people possess the categories of literal truth and literal falsity. On the contrary, in an oral culture having said or thought well often ties tightly with the memorability of what is said or thought, or the functioning of what is said or thought for the memorability of other, important, thoughts. Because memorability can be such a crucial concern, oral societies have no real truck with the ideal of an all-things-considered, rationally best-systematised way to think. For that way to think cannot really be approached by humans, let alone memorised. Memorability depends on playful associations of ideas often in the form of myths. It is aided by rhyme and metre, and by oral practices of recounting, retelling, embellishing, and selectively eliding and adapting. The ideal of an all-things-considered, *rationally* best-systematised way to think is a luxury that can be afforded in a literate society whereas in an oral society people not only do not need to be literal-minded but they actually need not to be; for what they need most is for their memories to be vast and powerful.

With particular reference to Fiji, Indo-Fijians could be significantly advantaged in school learning over iTaukei. Of course not all Indo-Fijians were literate during their time of arrival in Fiji. However, they had long lived in cultural circumstances powerfully different because some in their society could read and write. They were long used to thinking of those who read and write as the more elevated because they can do this. They were used to the institution of the law, money-based commerce, political institutions in many ways centred on the written word (e.g. the passing of laws), and religion based at least in part in scripture. It is easy to imagine that the mind-set even of illiterate Indians was significantly different from that of non-literate iTaukei, because their overall culture depended deeply on uses of writing and reading. It is true that oral culture is very strong in India and these traditional forms of culture were clearly brought to Fiji by the arriving Indo-Fijians. Yet at the same time India has a two-thousand year history of literacy and of the pursuit of systematic theoretical knowledge (e.g. logic, mathematics, physics, cosmology). There was to this extent a very great difference culturally between the arriving Indo-Fijians and the iTaukei with their traditional culture. These differences are liable to have been compounded by other related differences concerning attitudes to formal education, to literacy and book learning, and to the question of the separateness of epistemic from political authority.

4. Conclusion and Recommendation

Literacy is having the ability to read, write, count, comprehend and form of genre whether it be linguistic or non linguistic and being able to apply knowledge and ideas acquired from reading, writing and counting appropriately to make sense of one's environment and create new knowledge. Literacy is vital in the understanding of science and the application of science method so that a clearer understanding of the natural world can be achieved.

In considering all my above arguments on the philosophical ideas about the method of science together with the relationship between orality, literacy and science and what Olson (1994) suggested about writing in providing our dominant model for thinking about nature and the mind, it can be said that the type of culture that is well used to literacy from many generations back will confer an advantage within school learning, as opposed to the type of culture that remains significantly oral, and has had very few generations to adjust to the possible uses of writing. The echoes of such differences in the present generation contribute to the differences in academic performance of the two Ethnic groups in science and other theoretically oriented subjects such as mathematics, economics, and even social studies, at school.

However, while my argument here points to literacy as one of the factor affecting the differential achievement in science for the two ethnic groups at school, it should not be forgotten that there are other factors that needs to be considered, which include peer pressure, cultural values, beliefs and practices of students, assessment methods and students traditional ways of knowing. Hence, it is recommended that in future, a repeat study should be conducted and the factors highlighted above should also be considered and studied as to how they may or may not contribute to students' academic achievement. Furthermore, since national external examination has been abolished for Class 8 and Form 4 and new forms of assessments; FILNA, LANA, & Classroom Based Assessment has recently being introduced in Fiji schools, it may be interesting to conduct another study to find out how Indo Fijian students and iTaukei students perform in using the new national assessment strategies. In addition, due to urbanization and globalization, values of iTaukei may have changed, so this may affect iTaukei students' academic achievements. Moreover, due to technological advancement literacy rates of iTaukei and Indo Fijian students may have been affected, hence it warrants another study.

REFERENCES

- [1] Anderson, O. (1989). The significance of writing in early Greece. In K. Schousboe & M. T Larsen (Eds.), *Literacy and society*. Copenhagen: Centre for research and humanities.
- [2] Baker, S., Barzun, J., & Richards, I. A. (1971). *The written word*. Rowley, MA: Newbury House.
- [3] Bacon, F. (1855 (1620)). *The Novum Organon: A true guide to the interpretation of nature*. Oxford: The University Press.
- [4] Bloch, M. (1980). Literacy and enlightenment. In K. Schousboe & M. T. Larsen (Eds.) *Literacy and society*. Copenhagen: Centre for research in humanities. (In press).
- [5] Carrejo, D.J. and Reinhartz, J. (2010). *Exploring the Synergy Between Science Literacy and Language Literacy with English Language Learners: Lessons Learned within a Sustained Professional Development Program*, University of

Texas, El Paso.

- [6] Carruthers, M. J. (1990). *The book of memory: A study of memory in medieval culture*. Cambridge: Cambridge University Press.
- [7] Dakuidreketi, M.R. (1995). *Factors Contributing to Academic Under-achievement of First-year Native-Fijian Students in Science Courses at the University of the South Pacific*. MSc Thesis, University of Waikato, New Zealand.
- [8] Dakuidreketi, M.R. (2006). *Context of Science Teaching and Learning in Fiji Primary Schools: A Comparative Study of Ethnic Fijian and Indo-Fijian Communities*. The University of the South Pacific, Lautoka Campus, Fiji.
- [9] Durkheim, E. (1948 (1912)). *The elementary forms of religious life*. Glencoe, IL: The Free Press.
- [10] *Essential Information for Education Policy (2009) Essential Early Literacy Success*, 6, (1).
- [11] Feyerabend, P. (1975). *Against Method: Outline of an Anarchistic Theory of Knowledge*. London: New Left Books.
- [12] Fieldman, C. F. (1991). Oral meta-language. In D. R. Olson & N. Torrance (eds.), *Literacy and orality* (pp. 47-65). Cambridge : Cambridge University Press.
- [13] Gladwin, T. (1970). *East is a big bird: Navigation and logic on a Pulawat Atoll*. Cambridge, MA: Harvard University Press.
- [14] Goody, J. & Watt, I. (1968). The consequences of literacy. In J. Goody (Eds.), *Literacy in traditional societies*. Cambridge: Cambridge University Press. Goody, J. (1986). *The logic of writing and the organisation of society*. Cambridge: Cambridge University Press.
- [15] Goody, J. (1978). *The interface between the oral and the written*. Cambridge: Cambridge University Press.
- [16] Government of Fiji, Ministry of Education, National Heritage, Culture and Arts (2008). *Fiji Education For All Mid-Decade Assessment Report 2007*,
- [17] Guzzetti, B. J., & Bang, E. (2010). The Influence of Literacy-Based Science Instruction on Adolescents' Interests, Participation and Achievement in Science. *Literacy Research and Instruction*, 50 (1), p44-67.
- [18] Harris, W. V. (1989). *Ancient literacy*. Cambridge: Cambridge University Press.
- [19] Havelock, E. (1982). *The literate revolution in Greece and its cultural consequences*. Princeton, N. J: Princeton University Press.
- [20] Helmenstine, A.M. (2013) *Scientific Method Steps*, (on line) Available, <http://chemistry.about.com/od/sciencefairprojects/a/Scientific-Methods-Steps.htm>
- [21] Hutchins, E. (1983). *Understanding micronesia navigation*. In D. Gentner & A. Stevens (eds.), *Mental models*. Hillsdale, NJ: Erlbaum.
- [22] Kuhn, T. (1970). *The Structure of Scientific Revolution*. Chicago, University of Chicago Press.
- [23] Kuhn, T. (1977). *The essential tension*. Chicago: University of Chicago Press.
- [24] Lakatos, I. (1970). Falsification and the methodology of scientific research programmes. In Lakatos, I. And Musgrave, A. (eds.) *Criticism and the growth of knowledge*. Cambridge, U. K. : Cambridge University Press.
- [25] Lloyd, G. E. R. (1990). *Magic, reason and experience*. Cambridge: Cambridge University Press.
- [26] McLuhan, M. (1962). *The Gutenberg galaxy*. Toronto: University of Toronto Press.
- [27] Merton, R. K. (1970). *Science, technology and society in seventeenth century England (1st American ed.)* New York: H. Fertig.
- [28] Morgan, A. (2012) 'Me as a Science Teacher': Responding to a Small Network Survey to Assist Teachers with Subject-Specific Literacy Demands in Middle Years of Schooling, *Australian Journal of Teacher Education*, 37 (6), p6.
- [29] Oatley, K. (1977). Inference, navigation, and cognitive maps. In P. Johnson-Laird & P. Wason (eds.), *Thinking : Readings in cognitive science* (pp . 537-547). Cambridge: Cambridge University Press.
- [30] Olson, D. R. (1980). Some social aspects of meaning in oral and written language. In D. R. Olson (ed.), *The social foundations of language and thought*. New York: W. W. Norton
- [31] Olson, D. R. (1994). *The world on paper: The conceptual and cognitive implications of writing and reading*. Cambridge; New York: Cambridge University Press.
- [32] Ong, W. (1976). *The presence of the word*. New Haven, CT: Yale University Press.
- [33] Otsuka, S. (2006) *Cultural Influences on Academic Performances in Fiji*, University of Sydney, Australia.
- [34] Popper, K. R. (1972). *The logic of scientific discovery*. London: Hutchinson.
- [35] Pyenson, L. (1985). *Young Einstein: The Advent of Relativity*. New York Adam Hilger
- [36] Shelly, M. and Yildirim, A. (2013) Transfer of Learning in mathematics, science and reading among students in Turkey: A study using 2009 PISA data. *International Journal of Education in Mathematics, Science and Technology*, 1(2), 83 – 95
- [37] The University of California Museum of Paleontology and the University of California (2013) *Understanding Science: An overview*, (on line) Available, www.understandingscience.org pp 1 – 10, 22.
- [38] Thomas, R. (1989). *Oral tradition and written record in classical Athens*. Cambridge: Cambridge University Press.
- [39] Vygotsky, L. (1978). *Mind in society: The development of higher psychological process*. In M. Cole, V. John-Steiner, S. Scribner, & E. Souberman (eds.) Cambridge: Harvard University Press.
- [40] Webb, P. (2009) *Towards an Integrated Learning Strategies Approach To Promoting Scientific Literacy in South African Context*, *International Journal of Environmental & Science Education*, 4 (3), pp.313-334.
- [41] Wellington, J. and Osborne, J. (2001) *Language and Literacy in Science Education*, Open University Press, Philadelphia
- [42] Worth, K. (n.d). *Linking Science in the K-8 Classroom*. Centre for Science Education, Education Development Centre, Inc