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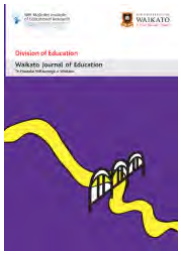

Attitudes towards science among senior secondary students in Fiji

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Abstract

In order to investigate gender and ethnicity-based differences in scientific attitudes among Fijian students, the widely studied Test of Scientific Related Attitudes (TOSRA) was administered to 1401 senior secondary Fijian students (Years 11–13; approximately 15–18 years of age). Students generally had a positive attitude towards science overall in Years 11–13, with females showing a more positive attitude than males. By Year 13, the attitudes of females towards science had become more negative. The attitude of iTaukei students towards science started out lower than other ethnicities in Year 11 and increased during Year 12, before falling to below the starting attitude levels in Year 13. Fijian students of Indian descent generally had a positive attitude towards science that remained consistent throughout Years 11–13, with an increase in leisure and career interest in science in Year 13. A strong correlation was found between the ethnicity of a student and their first language. Continued science outreach programmes, particularly in Year 12, are important to achieve and retain scientific interest and attitudes among Fijian secondary students.

Keywords

Test of Scientific Related Attitudes (TOSRA); ethnicity; gender; senior secondary students, Fiji Islands.

Introduction

The world-wide status of science education

There is a general trend worldwide of a decline in the uptake of science in schools (De Broucker, 2001; Dekkers & De Laeter, 2001; Dobson, 2006; Kennedy et al., 2014), which continues through the secondary system into the tertiary education sector (Sharma et al., 2018). Given the importance of science as an innovative, problem-solving, inquiry/investigative-based discipline that forms increasingly essential daily applications, this suggests that there are some significant challenges in the area of science education that need to be addressed globally. The Pacific Island countries also show this trend and clearly demonstrate low student achievement in junior and senior levels (Dakuidreketi, 2014; Sharma et al., 2018). This is particularly evident in Fiji, which is striving to improve its standing in the scientific community primarily in the oceanic region and globally in general. However, this goal remains

hindered by the relatively low numbers of, and private-sector positions available for, its scientists and workers in related disciplines.

The study population: Secondary education in the Fijian context

Education has gone through massive developments in order to meet the changing needs of Pacific societies. Particularly over the last few decades, notable change in the education sector has taken place in the Pacific Island nations, forcing those in the Pacific Island communities to make continual adjustments (Jones et al., 1991; Lingam, 2012). As pointed out by Renagai Lohia, the Ambassador of Papua New Guinea to the United Nations, the people "have had to run in order to remain on the same spot" (Baba, 1985). It must be added that changes have come slowly and at different paces for the Pacific Island nations (Dakuidreketi et al., 2016; Sharma et al., 2018).

The progression of the secondary school system in Fiji has been extensively reviewed (Baba, 1985; Tavola, 1991); hence only a brief outline is presented here. The earliest formal education systems were established by Christian missions in the late 1800s, with the aim of proselytising students and their families and steering the society as a whole towards the more "civilised" Western way of life (Dakuidreketi et al., 2016; Tavola, 1991). Although locally trained teachers were often utilised, in general the education system was established without regard to the content, orientation or form of delivery best suited to and/or required by its "consumers".

Following the handover of many Methodist schools to their communities in the 1920s–30s (Tavola, 1991), the government was left struggling to consolidate a fragmented education sector together into a functional system. Some of the remaining missionary schools were annexed by the government in the following decades, while a growing influence on the content and delivery of independent schools was exerted (Baba, 1985). Regardless of their origin, Fijian schools have generally had to make do with limited infrastructure and a lack of external support. Change is required to meet the rising pressures of the future, including a lack of employment positions for the ever-increasing number of secondary school graduates (Baba, 1985).

Amongst recent changes in government policy and the education sector, emphasis has been placed on universal access to education, with initiatives including supply of free textbooks, assistance in student transport and meals, zoning policy for intakes, and a focus on early childhood education (Fijian Government, 2013). Other changes have included the restructure of the school system and alteration of external examinations to "non-elimination" and "non-certification" status, with the aim to move away from the historical focus of solely passing examinations and turn it towards holistic learning. The introduction of the Fiji National Curriculum Framework, National Toppers Scheme, low interest tertiary education loans, e-learning and distance education comprise other notable initiatives taken by the Fijian Government to improve accessibility while maintaining quality control (Dakuidreketi et al., 2016).

Science education in Fijian secondary schools

In general, exciting developments brought to fruition by science-related disciplines have raised the profile of science and similar subjects among the general Pacific Island communities (Anwer et al., 2012; Mokoro et al., 2014). This is especially true in the developing country of Fiji, where studying more academic disciplines often produces better employment outcomes (Baba, 1985). However, in part due to the low wages of the teaching profession (Puamau, 2007), many schools lack suitably qualified or motivated teachers (Prasad, 1996; Sharma et al., 2018). This is compounded by the ongoing lack of basic equipment used for practical work and demonstrations, particularly for schools in rural areas (Dakuidreketi et al., 2016; Prasad, 1996). In part, this may be due to the incorrect perception by administrators that science can be taught through theory alone (Prasad, 1996). However, more recently there has been a huge push towards IT-driven initiatives and innovations which has seen a growth of e-learning, m-learning and cohort-based programmes benefitting science disciplines in the Pacific region including Fiji (Sharma et al., 2015; Sharma et al., 2018; Sharma et al., 2019).

When considered across the 12 member nations that have campuses and centres of The University of the South Pacific (USP) (Chandra & Sharma, 2018), the total number of science students admitted to the USP continues to grow; however, the ratio of science to non-science remains as low as 1:3 (Dakuidreketi et al., 2016; Sharma et al., 2018). Figure 1 also shows that the number of Fijian entrants has increased only marginally in recent years. Given that the Fijian population has grown steadily over this period, this could indicate a possible decline in interest of science among Fijian students, failure to meet the requirements of undergraduate programmes in science, or that Fiji's scientifically minded students are opting to pursue tertiary education in other countries such as Australia and New Zealand. In all instances, this equates to a potentially preventable loss of scientific talent for Fiji.

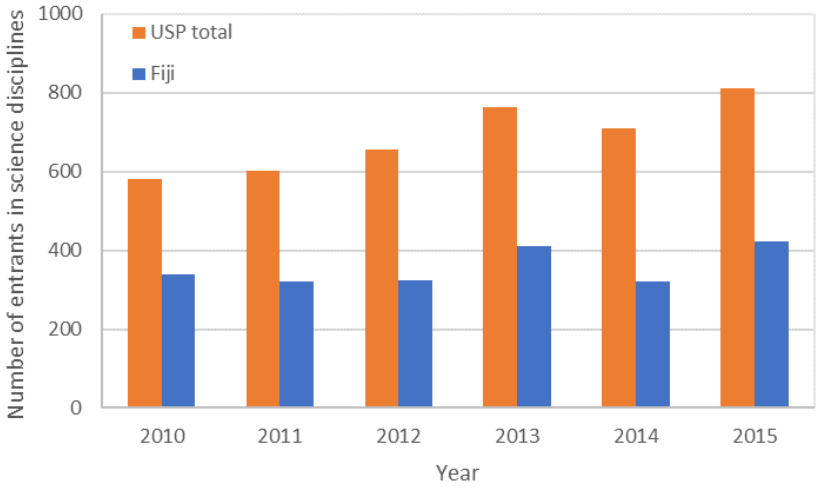

Figure 1. Number of students admitted to a science programme at USP between 2010 and 2015.

In an attempt to promote science education in Fiji schools, ongoing awareness programmes, such as titration competitions, Science Circus Pacific, FIRST Global Challenge, STEM Camp for Girls, maths quizzes, school visits and showcases, are run by organisations and partnerships including the USP, Australian National University, Graduate Women Fiji, CSSP (Chemical Society of the South Pacific), PSSP (Physics Society of the South Pacific), Fiji National University and University of Fiji (The University of the South Pacific, 2015, 2019). Providing secondary schools with access to high-quality research equipment and resources forms another outreach programme of the USP (Prasad, 1996). However, the general attitude of secondary students towards science has been poorly studied in the Fijian context. A number of studies from last century reported student attitudes (Brown et al., 2014; Dakuidreketi et al., 2016; Dunne & Rennie, 1990; Giddings & Waldrip, 1993; Rennie & Dunne, 1994) but contemporary data remains scarce, especially on the attitude towards science studies of high school students. This information is crucial to developing appropriately aligned curriculums, innovative tools and outreach programmes to encourage the brightest minds of Fiji to pursue science as a further education culminating into a scientific based career and contribute to the growth of Fijian scientific capabilities.

Measuring students' attitude towards science

Despite showing a general interest in science at a young age (Barmby et al., 2008; George, 2006), by secondary school many students believe science to be difficult, boring and irrelevant (Anwar & Bhutta, 2014; Bennett, 2001; Kind et al., 2007). To fully evaluate the effectiveness of secondary education in meeting students' needs in preparation for higher education, it is necessary to account for not only the experiences of students in school but also their attitude towards their field of study. This is especially the case in the science domain where every person has past experiences that impact their view of science

either positively or negatively, with the present general trend being more negative, as evidenced by the declining enrolments in university science courses (Dobson, 2012).

Attitude both affects and is affected by student learning behaviours (Bauer, 2008; Mensah et al., 2013), highlighting the relevance of evaluating students' attitudes as well as experiences during their studies. To ensure valid and comparable data is obtained, a high quality, validated survey instrument is needed for implementation. Various survey instruments have been developed and validated to assess, measure and evaluate secondary school students' attitudes, views, and perception towards learning science (Adams et al., 2006; Chen, 2006; Guzey et al., 2014). Many of these instruments have previously been reviewed by Blalock et al. (2008). Instruments typically compromise of a range of questions or statements (items) grouped into various categories (scales), with each statement or question assessed using a Likert scale.

One of the most widely used and validated instruments is the Test of Science Related Attitude (TOSRA), developed in Australia in the late 1970s (Fisher et al., 1995; Fraser, 1978, 1981). TOSRA has previously been used in numerous research studies in Australia (Fraser, 1981; Fraser & Butts, 1982; Fraser & Fisher, 1983; Lucas & Tulip, 1980; Rickards & Fisher, 1996), the United States of America (Elam et al., 2012; Fraser & Butts, 1982; Giddings & Waldrip, 1996; Joyce & Farenga, 1999, 2000; Martin-Dunlop & Fraser, 2008; Welch, 2010), Borneo (Dhindsa & Chung, 2003), Indonesia (Fraser, et al., 2010), Taiwan (Lin & Crawley III, 1987), Singapore (Wong & Fraser, 1996), Korea (Fraser & Lee, 2015; Uk, 2001), Turkey (Telli et al., 2006) and Pakistan (Ali & Awan, 2013; Ali et al., 2013; Anwer et al., 2012; Rana, 2002), amongst others. Furthermore, TOSRA has been translated into a number of other languages, including Chinese (Sivan & Chan, 2013), Korean (Fraser & Lee, 2015), Indonesian (Fraser et al., 2010) and Urdu (Rana, 2002). TOSRA-inspired instruments for assessing attitudes towards other disciplines have also been reported (Afari, 2013; Biggs, 2008; Tran & Clewett, 2003; Walker, 2006). Across a number of research studies, the reliability coefficient value for TOSRA has been found to range from 0.83 to 0.96 (Anwar et al., 2012), indicating that the results obtained are valid and reasonably reliable (Fraser et al., 2010).

In this study, we aimed to profile the scientific attitudes of senior secondary Fijian students using TOSRA and investigate any differences based on the gender, ethnicity and/or first languages of the students.

Materials and methods

TOSRA instrument and scoring

The Test of Science Related Attitude (TOSRA), as outlined in Fraser (1981), was used in this study. The instrument comprises 70 items across seven attitude scales, with each scale assessed by 10 equally weighted items. The seven scales are: Social Implications of Science (S); Normality of Scientists (N); Attitude to Science Inquiry (I); Adoption of Scientific Attitudes (A); Enjoyment of Science Lessons (E); Leisure Interest in Science (L); and Career Interest in Science (C) (Fraser, 1981). Each item possessed five possible responses: strongly agree, agree, not sure, disagree and strongly disagree. For items associated with a positive attitude towards science, answers were ranked from 5 (strongly agree) to 1 (strongly disagree), while rankings were reversed for negative items. For each respondent, scores from all 10 items were summed to provide the score for that scale. In this way, the highest sum of the scores (50) would indicate the most positive attitude towards science possible, while the lowest sum of the scores (10) would indicate the poorest attitude toward science possible. Invalid or absent responses were scored as 3.

Additionally, each respondent was asked to nominate their gender (male or female), ethnic identity (iTaukei, Fijian of Indian descent or other) and their first language (iTaukei, Hindi, English or other).

Study population and administration of the instrument

Official approval to conduct this research in Fiji schools was obtained from the Fijian Ministry of Education (Reference: RA 43/13), and from the Federation University Australia Human Research Ethics Committee (Project Number: B12-134). Eight secondary schools in the Suva and Nausori areas of Fiji were included in this study. Within these schools, all students in Years 11–13 (approximately 15–18 years of age) were invited to participate. Students could decline participation or withdraw at any point. All data were collected anonymously, and no identifiable data were collected. In total, the sample size comprised 1401 students (803 females and 598 males). Of these, 641 were in Year 11, 458 in Year 12, and 302 in Year 13. Hardcopy versions of TOSRA were administered during the 2014 school year.

Statistical analysis

As previously outlined, each respondent's score for a particular scale was calculated by summing the number of points awarded for each answer. In this way, possible scale scores ranged from 10 (very negative attitude towards science) to 50 (very positive attitude towards science), with a score of 30 indicating an ambivalent attitude (i.e., no preference). For each year level, the mean and standard deviation of the results were calculated.

The reliability of the results was estimated through calculating the Cronbach α coefficient, as previously described (Cronbach, 1951; Fraser, 1978). Additionally, the Cronbach α coefficient was calculated if each entire scale was not included (i.e., dropped), in order to determine if any one scale was causing reduced reliability of the results. Independent samples *t*-testing was used to investigate gender differences in the responses, while a one-way ANOVA was used to examine ethnicity and language differences. If a response failed to include certain demographic data (e.g., ethnicity), all responses from that student were excluded from analyses pertaining to that demographic information only. All statistics were performed using IBM SPSS.

Results and discussion

Means and standard deviations

The mean score for each scale was approximately similar at all three-year levels (Table 1). Compared to the results from Year 11 students, the mean scores for all scales were slightly higher for Year 12 students; all scales except I (attitude towards science inquiry) and A (adoption of scientific attitudes) were slightly reduced for Year 13 students.

Table 1. Mean, Standard Deviation, Reliability and Discriminant Validity of Each TOSRA Scale for Fijian Secondary School Students

Scale	**Year 11** (n=641)			**Year 12** (n=458)			**Year 13** (n=302)		
	Mean (SD)	*Cronbach α, if scale dropped*	*Correlation with other scales*	*Mean (SD)*	*Cronbach α, if scale dropped*	*Correlation with other scales*	*Mean (SD)*	*Cronbach α, if scale dropped*	*Correlation with other scales*
S (social implications of science)	34.39 (5.43)	0.69	0.51	34.86 (5.15)	0.67	0.47	30.07 (5.41)	0.69	0.50
N (normality of scientists)	30.71 (4.34)	0.39	0.31	30.91 (4.96)	0.32	0.25	30.01 (4.96)	0.47	0.36
I (attitude towards scientific inquiry)	34.97 (5.90)	0.48	0.38	35.83 (5.77)	0.41	0.32	37.17 (6.02)	0.44	0.34
A (adoption of scientific attitudes)	36.11 (5.18)	0.58	0.44	36.76 (5.17)	0.57	0.41	37.44 (5.06)	0.50	0.38
E (enjoyment of science lessons)	36.53 (8.20)	0.85	0.60	37.33 (7.59)	0.82	0.56	35.39 (9.49)	0.85	0.59
L (leisure interest in science)	34.80 (7.71)	0.82	0.59	35.57 (7.32)	0.79	0.54	33.44 (8.47)	0.81	0.57
C (career interest in science)	33.94 (7.63)	0.77	0.55	34.09 (7.15)	0.72	0.50	33.55 (8.34)	0.77	0.55
Mean Cronbach α	**0.87**			**0.84**			**0.86**		

Scores for each scale ranged from 30.01 for normality of scientists to a high of 37.44 for attitude towards scientific inquiry (both in Year 13). The range of means was similar to that previously reported for Year 7–10 Australian students (Fraser, 1978). Notably, leisure and career interest in science was found to be much higher in Fijian students compared to Australian students, corroborating previously documented observations of increased interest in science among Fijians (Baba, 1985). Enjoyment of science lessons was typically higher, while somewhat paradoxically, the normality of scientists score was lower than that of Australian students. The standard deviations were similar to those of Australian Year 7–10 students (Fraser, 1978), indicating a similar level of variation in the scientific attitudes of students across both cohorts. Higher standard deviations were found for enjoyment of science, and leisure and career interest in science, indicating a broader spectrum of attitudes that students presented towards these areas.

A two-step cluster analysis (Euclidean distance measure using Schwarz's Bayesian Criterion) revealed no significant clusters of students in Year 11 or Year 13. However, two clusters were identified in Year 12; the first containing students with an average attitude towards science (n=406) and a second cluster of students showing a better scientific attitude (n=52 or around 11% of the class). The average subscale score was greater for these students across all scale measurements (Figure 2).

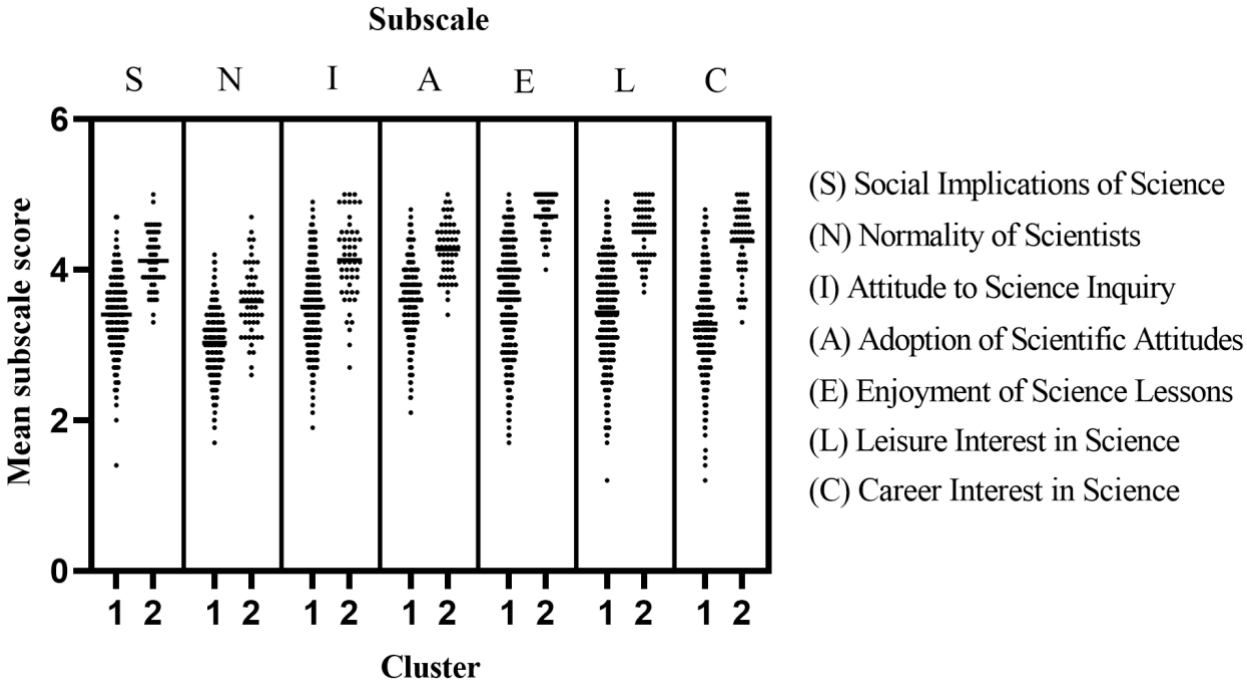

Figure 2. Results of the cluster analysis across all Year 12 students, demonstrating a small cluster (n=52) of students with a much more positive attitude towards science.

Reliability analysis of each TOSRA scale

As a measure of internal consistency (reliability), the Cronbach α coefficient was calculated for each year level (Table 1). The Cronbach α quantifies how much items within the same scale are measuring the same (desired) attitude. A value of 0.7 or above for Cronbach's α is generally considered to indicate acceptable reliability (Cortina, 1993). The results (α = 0.84-0.87) indicated good internal reliability and consistency between year levels. Closer examination of the Cronbach α coefficients through excluding one entire scale at a time from the analysis suggested that if any particular scale is dropped, the overall reliability of the results would not improve (Table 1). This indicated that all scales comprised reasonably reliable data.

Discriminant validity

In order to quantify the degree to which a particular scale is targeting a unique attitude, the mean correlation between the scale and each of the six remaining scales was calculated (Table 1). The mean correlation values were moderate, ranging from 0.25 for normality of scientists (in Year 12) to 0.60 for enjoyment of science lessons (in Year 11). Overall, this suggested that the scales were measuring distinct and unique attitudes; hence each scale provided valuable information about the scientific attitudes of Fijian students and should not be dispensed with.

It is noteworthy that the highest scale intercorrelations (values of approximately 0.5 or more) occurred between the four scales of social implications of science, enjoyment of science lessons, leisure interest in science and career interest in science. Although these attitudes are distinct in a conceptual sense, it is a logical extension that students who enjoy science lessons would have a greater tendency to be interested in science for leisure or career purposes. The mean correlations found here were 15–50 percent higher than the corresponding correlations reported by Fraser (1978), apart from the attitude towards scientific inquiry scale, which had a correlation almost three times higher.

Analysis of scientific attitude by gender

In order to assist stakeholders in improving equality in the education system, gender and ethnicity-based differences for each scale were determined. As can be seen from Table 2, most responses were similar between males and females. For Year 11 and 12 students, female attitudes were more positive than male attitudes across all scales. However, independent samples *t*-testing indicated that in most cases, the average attitude did not significantly vary with gender (P>0.05). One notable exception was the attitude towards scientific inquiry (A), which was found to be significantly higher (P<0.001) for female Year 11 and 12 students. Surprisingly, in Year 13 no significant difference between male and female responses was found for scientific inquiry (scale A) (P=0.65). Females also showed a significantly more positive attitude towards scientific inquiry (P<0.05; both Year 11 and 12) and a greater leisure interest in science (P<0.05; Year 12 only) than male students.

Table 2. Gender Differences in the Responses of Fijian Secondary School Students to Each TOSRA Scale

Scale	Year 11 (n=641)			Year 12 (n=458)			Year 13 (n=302)		
	Male (n=309)	*Female* (n=332)	*T-test*	*Male* (n=172)	*Female* (n=286)	*T-test*	*Male* (n=117)	*Female* (n=185)	*T-test*
S (social implications of science)	34.2 (5.7)	34.6 (5.2)	NS	34.4 (5.2)	35.2 (5.1)	NS	30.9 (5.8)	29.6 (5.1)	*
N (normality of scientists)	30.6 (4.3)	30.8 (4.3)	NS	30.8 (4.7)	31.0 (4.5)	NS	30.5 (5.1)	29.7 (4.9)	NS
I (attitude towards scientific inquiry)	34.4 (5.5)	35.5 (6.2)	*	35.0 (5.7)	36.3 (5.8)	*	37.9 (5.6)	36.7 (6.2)	NS
A (adoption of scientific attitudes)	35.2 (5.1)	37.0 (5.1)	***	35.5 (5.2)	37.5 (5.0)	***	37.3 (5.2)	37.5 (5.0)	NS
E (enjoyment of science lessons)	36.2 (8.1)	36.9 (8.3)	NS	36.5 (6.9)	37.8 (7.9)	NS	37.1 (8.5)	34.3 (10.0)	*
L (leisure interest in science)	34.8 (7.7)	34.8 (7.7)	NS	34.7 (6.9)	36.1 (7.5)	*	34.9 (7.5)	32.5 (9.0)	*
C (career interest in science)	33.9 (7.6)	34.0 (7.7)	NS	33.2 (6.3)	34.6 (7.6)	NS	34.5 (7.5)	32.9 (8.8)	NS

Results are given as the mean aggregate score for each scale with the standard deviation presented in brackets. The t-test column gives the statistical significance of an independent samples t-test between the genders within each scale and year level.

In a notable reversal, by Year 13 male students showed higher average results on each scale, except for their attitude towards scientific inquiry. Although further investigations are warranted, evidently, some significant changes in students' scientific attitudes take place between Year 12 and 13. In this instance, the reversal of gender-based scientific attitudes appeared to be largely derived from a decrease in the attitudes of female students towards science (average score change of -2.2), with only a slight positive shift in male students' attitudes (average score change of +0.4).

Analysis of scientific attitude by ethnicity

Student ethnicity can also play a major role in determining and/or influencing students' perceptions about science (Catsambis, 1995; Dunne & Rennie, 1990; Rennie & Dunne, 1994). Hence ethnicity-based differences are explored here. The possible responses to ethnicity included on the TOSRA

instrument were iTaukei (i.e., indigenous Fijian), Fijian of Indian descent (abbreviated here as 'Indian') and 'other'. Across all levels, most students (58%) identified as iTaukei, with 37 percent identifying as Fijian of Indian descent and 5 percent as being of another ethnicity.

For Year 11 students, Fijians of Indian descent typically showed a higher average attitude across all scales than those of iTaukei descent (Table 3). However, the difference was only significant ($P<0.05$) for the scales S (social implications of science), N (normality of scientists), I (attitude towards scientific inquiry) and A (adoption of scientific attitudes). The attitudes of students of 'other' descent were generally more similar to those of Indian descent. In some instances, post-hoc testing was unable to determine which groups were significantly different to each other despite there being a statistically significant difference determined through the ANOVA ($P<0.05$). This is due to the reduced power associated with post-hoc tests such as the Tukey test (McKillup, 2011).

Table 3. Ethnic Differences in the Responses to Each TOSRA Scale by Fijian Secondary School Students, Separated by Year Level

Year 11				
Scale	*iTaukei* (n=370)	*Indian* (n=236)	*'Other'* (n=32)	*F-test*
S (social implications of science)	33.7 (4.9)[a]	35.7 (6.1)[a]	34.1 (4.7)[a]	***
N (normality of scientists)	30.3 (4.1)[a]	31.3 (4.7)[a]	31.4 (4.2)[a]	*
I (attitude towards scientific inquiry)	34.1 (5.5)[a]	36.3 (6.1)[b]	35.2 (6.8)[a,b]	***
A (adoption of scientific attitudes)	35.4 (5.1)[a]	36.9 (5.1)[a]	38.8 (5.9)[b]	***
E (enjoyment of science lessons)	36.1 (7.7)	37.1 (8.7)	38.4 (8.9)	NS
L (leisure interest in science)	34.7 (7.5)	34.9 (7.8)	35.9 (9.1)	NS
C (career interest in science)	33.8 (7.2)	34.1 (8.0)	35.5 (8.9)	NS
Average	34.0 (4.5)[a]	35.2 (5.3)[a]	35.6 (5.1)[a]	**
Year 12				
Scale	*iTaukei* (n=244)	*Indian* (n=192)	*'Other'* (n=21)	*F-test*
S (social implications of science)	34.7 (4.7)	35.3 (5.5)	33.0 (5.3)	NS
N (normality of scientists)	30.3 (4.6)[a]	31.7 (4.3)[a]	30.4 (5.5)[a]	**
I (attitude towards scientific inquiry)	36.2 (5.5)	35.4 (6.1)	35.1 (5.5)	NS
A (adoption of scientific attitudes)	37.0 (5.0)	36.7 (5.3)	34.7 (5.4)	NS
E (enjoyment of science lessons)	37.5 (7.5)	37.3 (7.8)	36.2 (7.1)	NS

L (leisure interest in science)	36.3 (7.1)	34.9 (7.5)	33.6 (7.0)	NS
C (career interest in science)	34.8 (7.1)	33.4 (7.2)	32.9 (6.3)	NS
Average	35.2 (4.2)	35.0 (4.9)	33.7 (4.4)	NS
Year 13				
Scale	*iTaukei* (n=197)	*Indian* (n=86)	*'Other'* (n=19)	*F-test*
S (social implications of science)	32.5 (5.9)[a]	35.8 (5.6)[b]	35.5 (4.8)[b]	***
N (normality of scientists)	29.0 (5.1)[a]	31.7 (4.1)[b]	32.6 (4.1)[b]	***
I (attitude towards scientific inquiry)	37.3 (6.0)	36.6 (6.3)	37.4 (4.7)	NS
A (adoption of scientific attitudes)	37.4 (4.8)	37.3 (5.6)	38.2 (5.6)	NS
E (enjoyment of science lessons)	34.3 (10.0)[a]	37.8 (7.6)[a]	35.4 (10.5)[a]	*
L (leisure interest in science)	32.7 (8.9)	34.7 (7.8)	35.4 (6.1)	NS
C (career interest in science)	32.6 (8.9)[a]	36.0 (6.8)[a]	32.6 (7.1)[a]	**
Average	**33.7 (5.4)[a]**	**35.6 (4.9)[a]**	**35.5 (4.6)[a]**	*

NS – not statistically significant (P>0.05)
** P<0.05*
*** P<0.01*
**** P<0.001*

Results are given as the mean aggregate score for each scale with the standard deviation presented in brackets. The statistical significance of a one-way ANOVA for each scale is given in the F-test column. Results designated with the same superscript letter were not significantly different to other items in the same row, according to post-hoc Tukey testing at α=0.05.

Within the Year 12 students, only scale N (normality of scientists) showed any statistical difference between students of varying ethnicities (P<0.001).

Among Year 13 students, only the differences in scales S (social implications of science; P<0.001), N (normality of scientists; P<0.001), E (enjoyment of science lessons; P<0.05) and C (career interest in science; P<0.01) were statistically significant by ethnic group. For scales S and N, iTaukei students gave significantly lower scores than both the other alternative ethnicities.

Overall, the scientific attitudes among different ethnicities and grade levels reveal a complex story. iTaukei students in early senior secondary school (Year 11) appeared to have a less positive view of the social implications of science and normality of scientists, along with lower adoption of scientific attitudes and tendency towards scientific inquiry. However, subsequent improvement in their scientific attitude across all scales (excluding normality of scientists) occur in Year 12. Subsequent declines across most scales (with the exception of scales I and A) again relegated iTaukei students to last place by Year 13. This suggests that between Years 12 and 13 would be an ideal time to target increased involvement of iTaukei students in scientific opportunities, with the goal being to prevent this decline in scientific attitude. One possible reason for the current lack of scientific interest could be a lack of duly trained teachers. For example, in some areas of the Pacific Islands, such as Samoa, teachers with a certificate in education and major in a non-science area may be responsible for teaching science at senior level (Sharma et al., 2018). During teacher shortages in Fiji, science graduates may be permitted to teach

without a qualification in education, usually in regional areas (pers. obs.). A lack of mathematical skills on the part of students can compound this issue, causing them to find science-related subjects even more difficult. All of these factors may potentially play a role in the compounding and cumulative process towards the loss of interest in science in the crucial Years 12 and 13. It is also possible that the ethnicity of senior science teachers could differentially influence the attitudes of students towards science. However, further research in this area is required to confirm if this is the case.

Fijians of Indian descent began senior secondary school with a relatively positive attitude towards science, particularly in the concepts of the social implication of science and attitude towards scientific inquiry. Remarkably little change in attitudes occurred over the subsequent two years of study. The most notable shifts in scientific attitude were an increased career interest in science developing in Year 13, and a slight decrease in attitude towards scientific inquiry in Year 12, before being restored in Year 13. Year 12 would appear to be the most appropriate time to target increased awareness and improved attitude towards science among students who are Fijians of Indian descent. There have always been continuing discussions on the various ways science subjects can be taught in the Pacific generally, and more specifically in the Fiji Islands. Some of this discussion has been around incorporating and implementing more student-centred learning (such as problem based, inquiry oriented, project based and process oriented guided inquiry learning) as has been demonstrated to be successfully implemented elsewhere (Naiker & Wakeling, 2015). However, traditional methods of rote-learning can prevail, which can result in the lack of important attributes such as critical thinking, creativity and discovery learning.

Students of 'other' ethnicities had the best initial overall attitude towards science. A notable reduction in the adoption of scientific attitudes occurred in Year 12, before increasing again in Year 13. Reductions across scales E, L and C also occurred in Year 12, with only leisure interest in science being restored in Year 13. However, small increases in attitude across the board resulted in similar average scores between Years 11 and 13. It should also be noted that results from this group should be interpreted with caution, due to the relatively small sample sizes.

Analysis of scientific attitude by first language

The first language of students is another factor that should be considered (McKinley et al., 1992), particularly as the TOSRA was only presented in English in this study. In the TOSRA instrument utilised in this study, the possible responses to first language were iTaukei (54% of all respondents), Hindi (34%), English (10%) and other (2%).

As anticipated, the correlation between the first language of a student and their ethnicity was statistically significant (Spearman's rho = 0.820, $P<0.001$). This was confirmed by the observation that 92 percent of iTaukei students reported iTaukei as their first language, while 89 percent of Fijians of Indian descent reported Hindi as their first language.

Following on from this correlation, the relationship between first language and attitude towards science was quite similar to those found for that between student ethnicity and attitude towards science. In Year 11 students, a statistical difference between first language was found for all scales ($P<0.05$ for all) except leisure interest in science. This was in contrast to results for ethnicity, where there were no significant differences for the scales of E (enjoyment of science lessons) and C (career interest in science). As with ethnicity, the only significant difference in Year 12 students was found for scale N (normality of scientists). Finally, the results for Year 13 were again similar to those found for ethnicity.

Conclusion

The attitude of Fijian secondary school students towards science varies depending on gender, year level, ethnicity and the first language learned or spoken. Most students showed a moderately positive attitude towards science, although students were typically ambivalent as to the normality of scientists. Year 11 and 12 female students showed a more positive attitude towards science than Year 13 female students. Students who are Fijians of Indian descent showed the most consistent interest in and attitude towards

science across all three-year levels. The scientific attitude of iTaukei students was lower in Year 11, increased to equal that of Indian descended students in Year 12, before falling again in Year 13 students. Students of other ethnicities showed the opposite pattern to iTaukei students. Targeted scientific outreach programmes, particularly prior to and during the crucial period of Years 12 and 13, may be of use to increase and/or maintain students' attitudes towards science. This should be of particular use in assisting Fiji to retain its young scientific talent. In addition, teacher training, upskilling and upgrading of qualification should be a priority. Trained qualified teachers with good knowledge of IT tools and pedagogies can help significantly improve the attitude of science in Fiji and the Pacific region. The research team hopes to extend this study holistically to other Pacific Island nations in the near future, while stocktaking the best practices currently taking place in isolation and highlighting to the education sector for improvements to student attitude and hence uptake and achievement of science.

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Ethics approval

Ethics approval was obtained from the Fijian Ministry of Education's Research and Ethics Council and from the Federation University Australia Research Ethics Committee (approval number B14-134). The study was explained to all participants or their parents/guardians and informed consent was obtained from all study participants.

Conflict of interest

This research did not receive any specific grants from any funding agency in the public, commercial, or not-for-profit sectors. The authors declare no conflict of interest.

Availability of data

Due to technical limitations, the full dataset is unable to be published at this time. However, it is available from the authors upon request.

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