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Informing Brain Health Behaviour Choices: The Efficacy of a High-School Brain Awareness Pilot Study

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Authors' contributions

This work was carried out in collaboration between all authors. Authors JB, NS, SM, JMG and ST designed the study and wrote the protocol. Author NS wrote the first draft of the manuscript. Author JB complied the final draft for publication. Authors NS and JB managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Lifestyle choices such as diet and exercise significantly impact mental wellbeing and this is particularly so during the period of adolescence. The aim of the current study was to determine whether neuroscience concepts could be introduced to the classroom in a manner that improved high school student awareness of how health behaviour choices impact brain health.
Study Design: This study was a quantitative study that measured 47 assertions relating to brain health and neuroscience pre and post an interactive seminar.
Place and Duration of Study: A Victorian high school in Geelong, Australia. Participation in the seminar took approximately 100 minutes, including time to complete the questionnaires.
Methodology: The current study trialed a 'Brain Basics' educational program in a Victorian high-school. The neuro-educative interactive seminar was presented to 48female year 11 students. The level of student understanding, interest and enjoyment was assessed prior to and following an interactive seminar.
Results: Student understanding of brain health significantly improved in 31 out of 47 questionnaire items and interest and enjoyment were highly rated.

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Conclusion: This supports the notion that basic neuroscience concepts can be introduced into Victorian schools to increase brain health awareness of our youth during this critical time of brain development.

Keywords: Brain health; neuro-education; neuroscience; education.

1. INTRODUCTION

Recent advances in the field of neuroscience have enhanced our understanding of many processes that occur within the brain during health and disease. In some instances, these findings have demonstrated how our behavioural choices may augment or delay pathogenic processes [1]. This, in turn, has increased available options for treatment of brain diseases and mental illness and provided a wealth of information on preventative strategies that help to promote healthy brain function and prevent or delay the onset of disease [2].

Novel developments such as stem cell transplants and neuromodulation technologies now provide us with cutting edge treatments for debilitating neurological illnesses. We also have increased awareness of how our everyday actions can impact brain health, and while this research is in its infancy; there are some promising relationships emerging.Indeed the inherent value of preventative strategies which help to promote healthy brain function and prevent or delay the onset of disease are becoming increasingly apparent. This is partly because of our increased awareness that physical and mental health are inextricably intertwined [3]. Until recently, this concept was not appreciated by either the medical profession or the general public, yet we now have evidence demonstrating the relationship between physical health as a determinant of brain health, which in turnhas an impact onmental health and wellbeing. For example, lifestyle choices regarding diet and exercise can impact brain health. A balanced diet and regular physical activity have been associated with many outcomes including positive mood, lower levels of depression and elevated alertness and concentration [4,5,6,7,8,9,10,11].

Indeed, there is an emerging body of evidence which can enhance brain awareness by allowing us to further understand how behaviours affect our brain health. To highlight, it is now understood that diet and nutritionmay play a pivotal role in the aetiology of mood disorders [6]. For example, there is a relationship between the western diet (high in processed foods) and depressive disorders [4,6,12], whereas a diet rich in fruit, nuts and legumes is inversely related to depressive disorders [13]. It has been established that there is a correlation between poor diet and increase in the likelihood of diseases such as Alzheimer's in old age [5]. Furthermore, it has been found that exercise influences brain health. Physical activity triggers new brain cell development and increases neuronal connections, which enhance learning and memory processes [9]. This is a protective factor for the brain, reducing the likelihood of Alzheimer's and other neuro-degenerative disorders [14,15]. Physical activity has also been found to both prevent and reduce adolescent depression [16,8]. A common and empirically supported explanation for this is that exercise enhances neurotransmitters and produces endorphins to create feelings of wellbeing, which counter the effects of stress [8] and maintains synaptic integrity [9]. These changes in neuronal connections mimic those occurring with typical anti-depressant therapies such as selective serotonin reuptake inhibitors [17].

However, if scientific advances are not successfully conveyed to the public, their potential to positively impact human health is restricted. This is particularly important when research relates to how health behaviour choices, which are under an individual's control, have the potential to positively impact brain health. Herculano-Houzel [18] investigated which neuroscience themes the general public were informed about and found that participants correctly understood only 48.4% of the issues presented. Adding to this lack of understanding, it has also been found that people do not have a thorough (or only adequate) concept of what brain health is, what factors contribute to brain health, or the basic neuroscience principles behind this [19,20,21,22]. In contrast, greater brain health awareness is positively related to engagement in good health practices [20], and can also foster improvements in life quality [23,24,25,26]. Despite this, current levels of brain education in schools do not reflect its importance.

Studies in the U.S. have found that neuroscience can be taught at both primary school and high-school levels with positive results [27,28,29,30]. MacNabb et al. [28] and Zardetto-Smith et al. [29] found that students are interested in learning about the brain and perceive it to be both interesting and relevant. Enjoyment is likely to result in positive and meaningful learning experiences, and these programs, along with Foy et al. [27] and Miller et al.'s [29] studies were able to enhance student knowledge of topics such as those relating to perception and the senses, the impact of drugs and alcohol, hormones, movement and brain structure and function.It is important to note however, that enjoyment, interest and understanding of health issues does not guarantee participation in health related behaviour [31].

No such studies have been conducted in an Australian setting. Moreover, a program which integrates the emerging research regarding how our everyday behaviours such as diet and exercise affect our brain health, with the basic neuroscience principles required to understand this, has yet to be evaluated. This pilot study aimed to explore the effect of a school based, neuro-educative interactive seminaron the understanding of health information.The seminar was designed to enhance student perceptions about basic neuroscience principles such as brain structure and function, neurons and neurotransmission. It also aimed to explore students' understanding of 'brain health', what it meant to have a healthy brain and how behaviours such as diet, exercise and sleep influence these factors. This approach provides students with the scientific basis for concerns regarding brain health and provides students with the information necessary to make decisions regarding their own personal health choices. It was predicted that students would increase their knowledge of brain health, while finding the seminar relevant and enjoyable.

2. MATERIALS AND METHODS

2.1 Participants

Participants were 48 female Year 11 students aged 16 -17 years who attend a private girls' school in Geelong, Victoria. Participants were enrolled in psychology classes.

2.2 Materials

The Pre-test Questionnairecomprised 47 assertions relating to brain health and neuroscience that participants answered on a 5-point likert scale of 'strongly agree' to 'strongly disagree'. Fifteen statements were derived from Herculano-Houzel's (2006) study [18] and the remaining statements were developed by the authors, and were based on the four key concepts given below. Sample items:

- Stress releases cortisol and adrenaline in the brain.
- Brain cells communicate via electrical messages.

The Post-test Questionnaires consisted of the pre-test questionnaire supplemented by 3 extra statements evaluating the enjoyment, relevance and usefulness of the neuro-educative interactive seminar on a 5-point likert scale.

2.2.1 Theinteractive seminar

The interactive seminar designed by the authors covered four key concepts (with objectives):

(1) The structure and functions of the brain.

   a. Understand particular functions are localized to specific areas of the brain

(2) Neurons and neurotransmission.

   a. Understand the hierarchical organization of the brain, neuron, and synapse;
   b. Understand the basic structure and function of the neuron;
   c. Understand the sequence of events involved in communication at the synapse.

(3) How diet nourishes the brain.

   a. Understand how neurons are made up of various vitamins and minerals which we get from food;
   b. Understand our feelings and behaviours can be due to a lack, or over-abundance, of various vitamins and minerals in the brain.

(4) How to protect your brain and minimize harm through diet, exercise, managing stress, sleep, etc.

   a. Understand what we put into our bodies has direct implications on brain function;
   b. Understand our brain health is influenced by our behaviour;
   c. Understand we can optimize our brain health by undertaking various healthy activities, such as eating well, exercising, minimizing stress, sleeping well and by minimizing harmful activities.

2.2.2 Mode of delivery

PowerPoint was used to aid the presentation. It delivered images, animations and key messages to backup the information provided by the presenter. Booklets were provided to each student that had a number of activities relevant for each key-learning objective, and provided space for students to jot down notes as they pleased. Group and individual activities were planned at various time points in the presentation to help students consolidate the information just learned. There were also many opportunities for discussion either with peers or as a class.

2.3 Procedure

Ethics approval for the study was obtained from the university ethics committee. Students filled out the pre-test questionnaire immediately prior to the brain awareness interactive seminar, which was conducted by a member of the research team. At the completion of the interactive seminar, the participants were asked to fill out the post-test questionnaire. Participation in the seminar took approximately 100 minutes, including time to complete the questionnaires. Consent was received from both the participant and each participant's parent.

3. RESULTS

3.1 Data Cleaning

Prior to the main analysis, data were checked for missing values, outliers, and departures from normality. There were no missing data, outliers, and all variables conformed to assumption of normality [32]. The alpha level for significance was set at $P < 0.01$ for all analyses, in order to reduce the Type 1 error inflation that would otherwise result from the many comparisons conducted in this paper.

3.2 Descriptive Statistics

Assessing Student Knowledge before the Interactive Seminar. The pre-test was used to determine student knowledge of brain health prior to the interactive seminar. Several topics were well understood by the students at the outset Table 1. These included Q21. 'Performance in activities such as playing the piano improves more as we practice' (M = 4.81, SD = .44); Q8.'Sleep is important for optimal brain function' (M = 4.75, SD = .56) and Q7. 'We use our brain 24 hours a day' (M = 4.58, SD = .74); Correspondingly, some topics were less well understood by the participants Table 1, such as: Q10. 'The brain is the body organ that consumes the most oxygen". (M = 2.88, SD = .86), Q46.'The cells in our brain are made up of what we consume in our diet' (M = 2.60, SD = 1.00), Q30.'We usually utilise only 10% of our brain' (M = 2.73, SD = 1.11), and Q23. 'If it were possible to transplant our brain into another body we would still be ourselves' (M = 2.85, SD = 1.13).

Table 1. Mean Scores, Standard Deviations, F Values and Eta Squared Values of all 47 assertions as they appeared in Questionnaire

Question	Pre-test		Post-test			
	M	SD	M	SD	F	η^2
1. People are either born with or without good mental health - you can't control it.	3.15	1.05	4.06	1.06	28.01***	.37
2. Brain cells are called neurosomes.	3.21	.74	4.00	1.40	17.26***	.27
3. I can help keep my brain healthy.	4.46	.74	4.90	.31	16.73***	.26
4. Good nutrition helps brain cells communicate.	4.40	.73	4.90	.31	20.14***	.30
5. Communication between neurons is the foundation of brain function	3.37	.84	4.63	.64	47.05***	.50
6. Exercise and physical activity affect my body, but not my brain.	4.23	.86	4.69	.85	6.08**	.11
7. We use our brain 24 hours a day.	4.58	.74	4.67	.72	.35	.01
8. Sleep is important for optimal brain function.	4.75	.56	4.83	.63	.42	.01
9. Things I do everyday do not have any effect on my brain.	4.44	.74	4.48	1.13	.04	.00
10. The brain is the body organ that consumes the most oxygen.	2.88	.86	3.29	1.51	2.76*	.06
11. Brain cells communicate via electrical messages.	4.08	.71	4.44	1.16	4.10***	.08
12. Braincells communicate via chemical messages.	3.31	1.07	4.13	1.35	14.42***	.23
13. Happiness, anger, or fear are experienced in the brain.	4.04	.74	4.63	.64	22.80***	.32
14. How I learn is related to nutrition.	3.27	.84	4.54	.71	87.84***	.65
15. Stress releases cortisol and adrenaline in the brain.	3.56	.77	4.35	.98	20.82***	.31
16. The mind is a product of the brain.	3.75	8.38	4.08	.89	6.16*	.12
17. Our mood can be affected if the chemicals in our brain get out of balance.	4.08	.85	4.71	.68	18.65***	.28
18. Memory is stored in the brain much like in a computer, that is, each memory goes in a tiny piece of the brain.	3.96	.94	4.19	1.16	2.55	.05
19. Stimulants such as energy drinks release cortisol and adrenaline in the brain.	3.81	.82	4.69	.62	51.95***	.52
20. There are different parts of the brain which relate to different functions.	4.48	.85	4.90	.39	11.63**	.20
21. Performance in activities such as playing the piano improves more as we practice.	4.81	.44	4.88	.33	1.00	.02
22. Knowing our brain we can understand better how our thoughts, our reasoning and our memories work.	4.35	.76	4.79	.41	14.84***	.24
23. If it were possible to transplant our brain to another body we would still be ourselves.	2.85	1.13	2.98	1.2	.43	.01
24. "State of Mind" is a reflection of the state of your brain.	3.37	.84	3.94	.91	14.33***	.23
25. Dreaming is important for learning.	3.52	.85	4.69	.55	88.58***	.65

26.	Sleep helps the body and brain repair itself.	4.50	.71	4.87	.61	7.33*	.13
27.	When we sleep, the brain enters into rest.	3.21	1.30	2.60	1.70	5.74*	.11
28.	Depression can be caused by a lack of certain chemical substances in the brain.	3.85	.99	4.92	.28	52.17***	.53
29.	The bigger the brain, the more intelligent the animal.	4.00	1.05	4.13	1.14	.52*	.01
30.	We usually utilise only 10% of our brain.	2.73	1.11	3.21	1.40	10.36*	.18
31.	When imagining an object, we use the same brain areas as when we are seeing it.	2.85	.74	3.21	1.40	3.88	.08
32.	Brain activity is completely dependent on the external environment: when our senses are not stimulated, we don't see, hear, or feel anything.	3.19	1.02	3.31	1.07	.39	.01
33.	Diseases such as Parkinson's or Alzheimer's are due to cell death in some brain areas.	3.69	.85	3.83	1.14	1.04	.02
34.	With more knowledge about our brain, we can improve our health and well-being.	4.29	.74	4.87	.49	21.52***	.31
35.	Learning occurs through changes in the way brain cells communicate.	3.69	.72	4.29	.97	18.11***	.28
36.	What I do today can affect the health of my brain when I am older.	4.54	.617	4.94	.24	22.84***	.33
37.	I know a lot about the brain.	2.31	1.15	3.44	1.15	51.68***	.52
38.	I would like to learn more about the brain.	4.13	.94	4.40	.84	3.81	.07
39.	Stress damages the brain.	3.58	.68	4.15	.90	15.58***	.25
40.	Exercise causes stress on the brain.	3.98	.70	4.42	.99	8.02**	.15
41.	Exercise is a stress relief.	4.04	.77	4.62	.87	16.10***	.25
42.	I can improve the health of my brain through healthy behaviours.	4.44	.62	4.83	.38	22.84***	.32
43.	I am likely to consider my brain health in day to day life.	2.98	1.28	4.27	.87	47.10***	.50
44.	Knowing about the brain allows me to carry out healthy behaviours to support it.	4.04	.88	4.73	.50	29.36***	.38
45.	Our diet relates to how well neurons can communicate.	3.48	.68	4.42	.94	46.31***	.50
46.	The cells in our brain are made up of what we consume in our diet.	2.60	1.00	4.02	1.24	55.44***	.54
47.	Interruption of neural communication causes changes in cognition and behavior.	3.52	.71	4.40	.82	49.00***	.51

**=P<.05, **=P<.01, ***=P<.00*

Comparison of Number of Correct Answers from Pre-test to Post-test.Fig. 1 details the percentage of correct answers across pretest and post-test for each individual item on the questionnaire. All items exhibited an increase in correct answers from pre to post-test, with one exception. Item 27 had significantly fewer correct scores at post-test than at pretest. It can also be seen there were 8 questions which obtained 100% 'correct' scores at post-test. These were items3, 4, 20, 21, 22, 28, 36, and 42, Fig. 1.

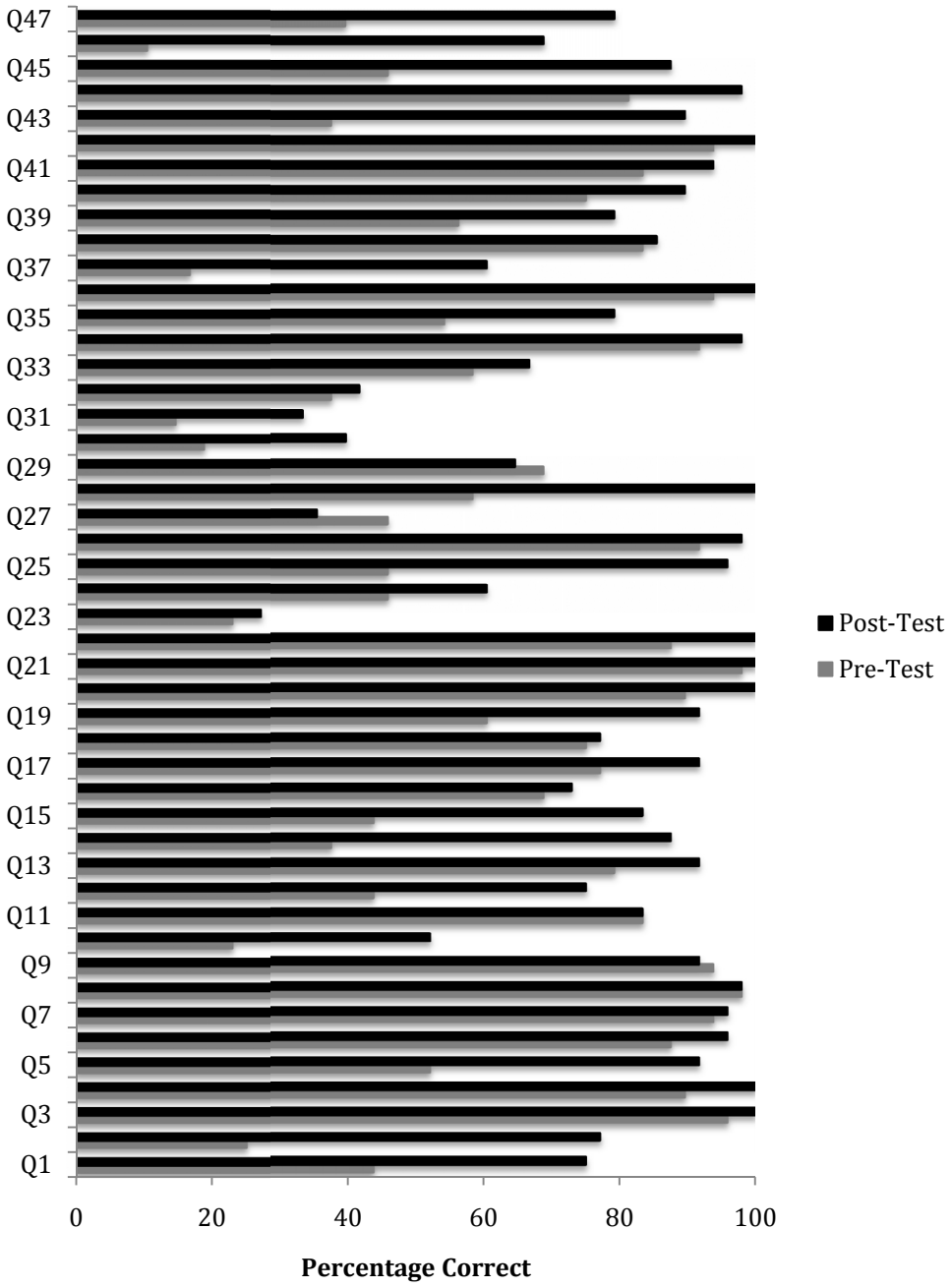

Fig. 1. Percentage of Total Correct Scores (Scores of 4 and 5 Combined) at Pretest and Post-test

3.3 Interactive Seminar Effect on Item Scores

A repeated- measures MANOVA was conducted with student scores to the 47 questionnaire items as the dependent variables, and time as the independent variable. Multivariate statistics found scores changed significantly from time one to time two: F (47, 1) = 52969.41, p <.05, η^2 = 1. In support of the study predictions that knowledge would improve, univariate effects for each item show 31 out of 47 items significantly improved. Of the remaining items, 15 out of 16 showed a trend in the direction of improvement, which further supports the predictions.

Performance on all questions which pertained to 'brain health' or 'health and wellbeing' significantly improved. Furthermore, in support of the hypothesis that students would find the seminar relevant, item 43, *'I am likely to consider the health of my brain in day to day life',* experienced a mean score increase from 2.98 to 4.27: F (1, 47) = 47.10, P <.001. Effect sizes for all significant individual effects show a range of η^2= .08 to.65. Twenty-four of the 31 significant items show eta squared values of .25 or above, which are classified as large effects according to Cohen (1988). Item 27, '*when we sleep, the brain enters into rest',* was the only assertion with a significant F value to show a decline in mean score, from 3.21 to 2.60, F (47, 1) = 5.739, P <.05.

3.4 Student Feedback

Fig. 2 illustrates that 85.5% of students rated the interactive seminar an enjoyable experience, 97.9% agreed the information talk was relevant, 98% believed there was a lot of useful information contained in the neuro-educative interactive seminar, indicating the interactive seminar was both practical and valuable.

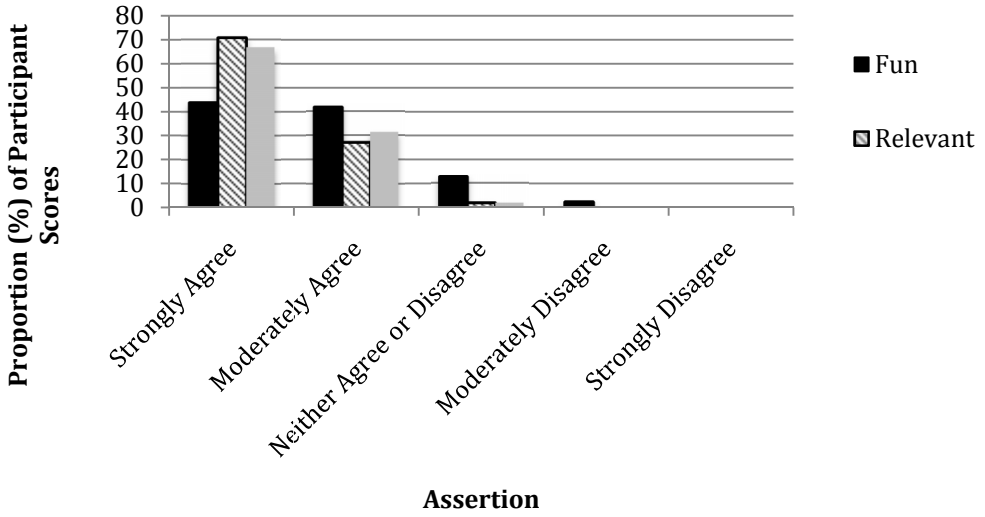

Fig. 2. Percentage Weighting of Student Answers to questions relating to whether the neuro-educative interactive seminar was '*Fun', 'Relevant'* and helped the student *'learn a lot'*

4. DISCUSSION

The present study evaluated whether knowledge about the brain and the factors involved in brain health could be improved among high-school students through a school based, interactive seminar. The study also examined students' beliefs regarding how brain health influences mental health and well-being and students' desires to learn more about the brain. Prior to the interactive seminar, some of the topics tested were already well known by the students i.e. '*Performance in activities improves more as we practice'*. It is possible that these items constituted information that is likely to be picked up anecdotally, and more likely to be 'guessed correctly' than the other items that relate more specifically to neuroscience content. Other topics were less well understood, such as the misperception '*We only use 10% of our brain'*, with 81.3% of students answering this question incorrectly. Herculano-Houzel's [18] also found this common myth widespread.

Student knowledge was significantly improved in 31 out of 47 items post teaching. This provides strong evidence that students were engaged throughout the interactive seminar and were able to absorb and utilise the presented information at the post-test. Other studies, such as that of Miller et al. [29] which attempted to improve student information regarding the brain, also found significant improvements at post-test. However, unlike Miller et al.'s study [29], where the mean percent of correct scores was improved but still relatively low, the mean percent of correct scores in the present study at post-test indicate, in many instances, that mastery of the information was excellent, with over 70% on 36 items, and eight with 100% correct scores. The difference in the present study may be due to a number of factors; firstly, the present study allocated more time to cover the information intended, and the experiential hands-on activities and class discussion during the interactive seminar may have facilitated learning in accordance with general principles of neuro-education [33]. The results of the current study also highlight that the methods used to deliver the presentation itself were successful in doing what they intended to do. The use of various media such as PowerPoint, self-reflection, group discussions and activities, enabled students to connect with the information, put them into a receptive frame of mind, and allowed them to organise the ideas and information presented to build on and challenge their pre-existing knowledge. This finding provides strong justification to pursue a post-pilot study focusing of the impact of neuro-educative programs in Australian schools.

Performance on questions pertaining to 'brain health' and 'health and wellbeing' provide a measure of how well neuroscience and health topics were integrated to facilitate student understanding of the relationship between these concepts. The results show that the information conveyed in the interactive seminar not only demonstrated to students how health behaviours have an effect on brain health, but that this information was sufficiently motivating for them to believe they would more likely consider the health of their brain in day-to-day life at post-test. Wilcox et al.'s [20] study found participants who knew more about brain health reported higher levels of physical activity and better diets than those who expressed little knowledge of brain health. Such changes would not necessarily be expected after one 100-minute interactive seminar, so it would be ideal for future studies to implement longer-running, more in-depth programs, to understand any possible effects of behaviour change.

4.1 Areas of Understanding that did not Improve

There are possible explanations for why performance on some items on the questionnaire did not significantly improve from pretest to post-test. In the case of items 7, 8, 9, 21 and 38, these topics were already well known at pretest, causing a ceiling effect. Due to time restrictions, items 31, 32 and 33 were not specifically covered in the interactive seminar and this would account for why the students did not improve on these questions. Item 27, relating to brain activity during sleep, was the only item to experience a significant decline in mean score. This may indicate that a discussion in the interactive seminar led students to erroneously believe this item was true. There was a discussion about the importance of sleep because it is an opportunity for rest, cell rejuvenation, neuron repair, and because it is vital for nervous system functioning. Perhaps the students inferred that this also means the brain goes into rest at the same time.

4.2 Student Evaluations

While researchers believe in the value of brain education because of what it can provide students, another important indicator of program success is whether students themselves believe in the significance of this information. In line with previous studies [30,27] the current pilot study found, as predicted, that students considered the neuro-educative interactive seminar to be fun, relevant to their lives, and to contain lots of useful information. This finding provides evidence that neuroscience information can be presented in ways that are appealing and enjoyable for students [30,27]. This is an important result, as learning can be improved, with increased likelihood of success, when the learning is seen as a 'fun' activity [34].

5. CONCLUSION

This pilot study may be limited by recruiting an all-female school of upper-middle socio-economic status, and can only comment on the immediate increase in knowledge about brain health, and notabout whether this learning was transferred into action. Nevertheless the neuro-educative interactive seminar improved student knowledge of the brain and the factors involved in brain health. Initially, students demonstrated a lack of knowledge of basic brain function, and how appropriate behavioural choices either support, or detract from, healthy brain function. Following participation in the seminar, students were able to better understand specific neuroscience content, and to see how these processes are influenced by behavioural choices. Students agreed this knowledge had the potential to maximise their brain health and mental health and wellbeing, and noted they were more likely to consider their brain health in daily life than they were prior to the interactive seminar. Students found the interactive seminar fun, relevant, and useful to their lives, and it is evident high-school students are eager to know more about many areas of the brain. This study provides justification for a post-pilot study on the effects of instruction on beliefs about brain health, and the implications to improve student's engagement in good health practices [20].

ETHICAL APPROVAL

The authors have obtained all necessary ethical approval from the Deakin University Human Ethics Advisory Group

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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