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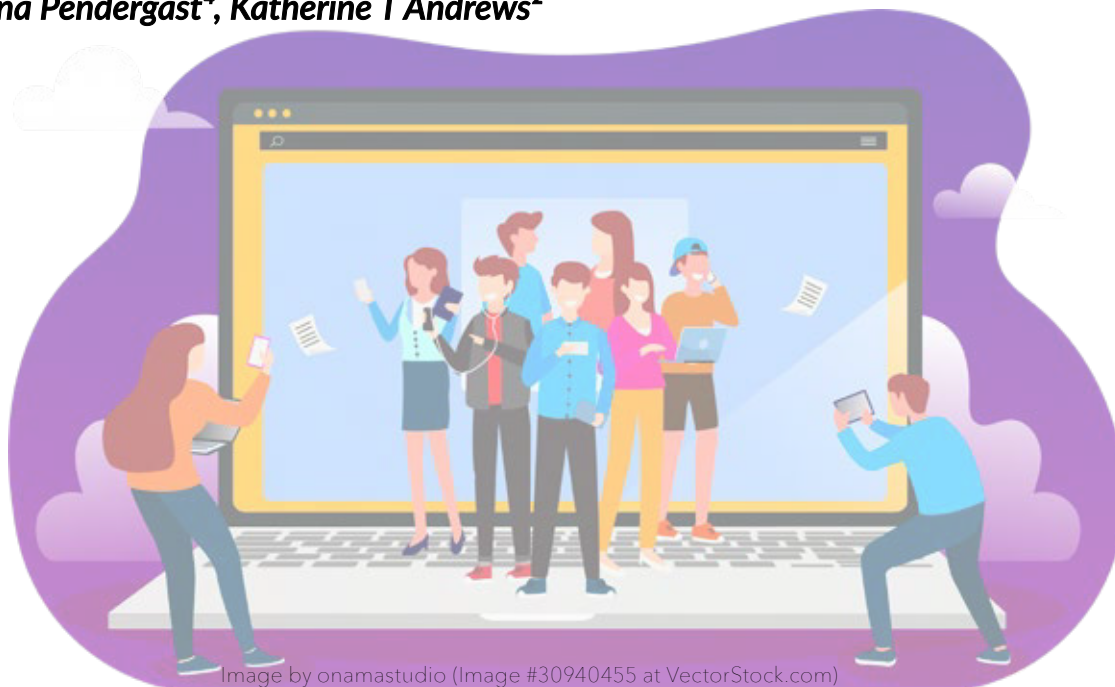
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# THAT'S RAD! Science STEM books: Survey results on adult perceptions of benefits and impacts

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## Abstract

The need for early engagement in science, technology, engineering, and mathematics (STEM), and representation of role models in STEM careers is of national and international importance. The That's RAD! Science project aims to address these needs through a series of engaging picture books for younger children that feature women in STEM as role models. The goal of this research project was to use a survey tool to gain feedback from adults on their impression of the impacts and benefits on children of the That's RAD! Science books, as well as their perceptions of the benefits of STEM engagement and use of identifiable women in STEM as role models. Participants were sent a set of four That's RAD! Science books for children to engage with and the adult participant then completed an online survey. A total of 83 participants were recruited, with a 61% completion rate for the online survey. Of these, 98% identified as parents/carers. Survey data showed the That's RAD! Science books engaged children and the books are also beneficial to informal hands-on learning processes.

In addition, survey results revealed that the books are useful in exploring STEM topics and encouraging children to think about career pathways in STEM by using identifiable female role models in STEM careers. More broadly, survey data reinforced previous findings that an understanding of STEM is important for young children; children are highly engaged by informal learning processes; and exposure to identifiable, relatable, female role models in STEM careers is perceived as being valuable to long-term engagement.

## Introduction

Increasing community understanding of the value of science, technology, engineering and mathematics (STEM) and improving workforce capabilities in STEM areas is important both nationally and internationally. The Youth in STEM Research 2019–20 report from the Australian Government Department of Industry, Science, Energy and Resources states that skills in STEM “are at the forefront of driving innovation and meeting future job requirements” (YouthInsight, 2020, p.2). In addition, data from the Australian

Government Department of Education, Skills and Employment shows a significant growth in STEM-related occupations, that STEM-related occupations are growing at a rate faster than others, and that this trend is predicted to continue (Australian Government Department of Education Skills and Employment, 2019). Likewise, an international study found that 75% of the fastest growing occupations will require STEM skills and knowledge (Barcelona, 2014) and employment in STEM occupations is also predicted to grow at up to double the rate of other occupations (Australian Academy of Science, 2019; Australian Industry Group, 2017; Craig, Thomas, Hou & Mathur, 2011). Data indicate that there are unacceptably low levels of participation by secondary school students in STEM-related areas of knowledge and skills, and that students must be made aware of career opportunities in STEM prior to Years 11 and 12 (Australian Industry Group, 2017; Universities Australia, 2012). The Australian Defence Industry Skilling and STEM Strategy highlights the crucial role STEM skills play in our workforce, defence systems and in the development of our nation as a whole (Australian Government Department of Defence, 2019).

Increased diversity in the Australian STEM workforce is also recognised as a critical need, including: increased representation of women and First Peoples of Australia (Australian Academy of Science, 2019; Australian Industry Group, 2017). Women currently represent only 16% of Australia's skilled STEM workforce (Australian Academy of Science, 2019). First Nations of Australia people also continue to be underrepresented in tertiary STEM courses and gaps in STEM achievement have not improved over the past two decades (Australian Government Department of Education Skills and Employment, 2020).

The need to ensure a robust and diverse STEM workforce in the 21st century raises a number of questions, including how to effectively prepare children for everyday life in the increasingly complex technologically driven world (Australian Industry Group, 2017) and what strategies will best encourage girls and First Peoples to participate and engage in STEM. It is well recognised that, as part of any strategy to increase STEM engagement, it is important that children be engaged in STEM from a young age. Early engagement with, exposure to, and participation in, STEM studies and activities has been shown to be key to developing STEM skills and fostering long-term involvement in STEM (McClure, 2019; McClure et al., 2017; Simoncini & Lasen, 2018; YouthInsight, 2020). The development of attitudes towards, and aspirations around, STEM careers begin at an early age (DeWitt & Archer, 2015). Furthermore, the Australian National STEM Education Resources Toolkit found that gender

biases are formed by the age of four and some students lose interest in STEM subjects by age six (Australian Government Department of Education Skills and Employment, 2020).

There are a range of factors that impact student's choices in relation to STEM. Research has found the most influential and direct factors fit into four categories: Student, Teacher, Parent and Other (Panizzon, Ward & Westwell, 2013). Student-related factors focus on "identity", which is interlinked with attitudes and motivation. How students perceive themselves directly influences their future decisions. Parents are also major influencers of student engagement and participation, however their not knowing the relevance of STEM in primary school education can be detrimental. Data indicates there are incorrect perceptions that primary children are too young to form career aspirations, however, research shows that students are likely to make decisions about career aspirations by the time they reach 14 years of age (Australian Government Department of Education Skills and Employment, 2020; Bonnette, Crowley & Schunn, 2019). Teachers' and parents' attitudes towards STEM engagement directly influence children's perception of, and attitude towards, STEM studies. There is often a transfer of attitudes and beliefs from significant adults in children's lives to the children themselves. Therefore, when adults downplay the relevance and importance of STEM exposure early in children's lives, they could be diminishing young children's current and future potential (McClure et al., 2017).

Informal learning experiences have been found to be essential in supporting children's interest in, and motivation for, science (Bonnette, Crowley & Schunn, 2019). Informal learning experiences such as, storytelling, reading books, experimenting at home, and exposure to career professionals are positive predictors of fascination (Bonnette et al., 2019). There is also great importance placed on the use of engaging books with primary school-aged children (Strouse, Nyhout & Ganea, 2018). However, it has been found that women are underrepresented as adult characters in children's STEM books, despite female children being represented as equally as male children in such books (Caldwell & Wilbraham, 2018). This may lead to messaging that learning about and doing science is for everyone but that pursuing a career in science is for males. This gap between "doing" and "being" has been critically analysed by the ASPIRES Project (DeWitt & Archer, 2015). Additionally, a 50-year study on how children draw scientists found that male scientists are depicted three times as often as female scientists in children's science books (Caldwell & Wilbraham, 2018). Further, the study also found that when girls do not see female role models as scientists, they are unlikely to see their

future selves as scientists. This supports the need to promote science books that highlight girls and women in STEM roles (Caldwell & Wilbraham, 2018).

The That's RAD! Science project focuses on the engagement of young children in STEM through books targeted to primary school-aged children (~4–9 years old). The project is a non-profit Griffith University initiative started in 2017 with the aim to inspire in young children a love of STEM and to use female role models currently working in STEM areas to do this. To date, four books (Figure 1) have been produced with over 6,000 copies distributed to children, schools, and libraries around Australia, most in the state of Queensland and predominantly at STEM engagement events.



**Figure 1: That's RAD! Science books.**

Each book features an authentic role model and her career, these being: parasite scientist, forensic scientist, nanotech scientist and protein crystal scientist. The books are intentionally titled to identify the scientist as a female recognisable to children — “My Mum is...”, “Our Mum is ...” and “My aunt is ...”. The books are presented in a highly visual manner with a combination of cartoon and photographic images. A storyline is woven through each book, which also includes quizzes, activities, and text designed for early-to-mid primary readers. There is also a page for the guiding educators and parents identifying connections to the Australian Curriculum.

For this project, a survey tool was designed and implemented to gain feedback from adults on their impressions of the impacts and/or benefits of the That's RAD! Science books. General perceptions around the benefits of STEM engagement with primary school children, including the value of featuring identifiable, relatable, female role models in a range of STEM careers was also assessed.

## Methods

**Ethics:** Ethics approval was obtained from the Griffith University Human Research Ethics Committee (HREC Ref no. 2020/039).

**Survey Design:** A 16-question survey was designed using the LimeSurvey online survey tool and included both multiple choice and optional open-ended questions. Questions focussed on participant information (Questions 1 and 2), importance of STEM engagement with primary school aged children (Questions 3 and 4, a Likert scale from Strongly Agree to Strongly Disagree), children's engagement with That's RAD! Science books (Questions 5–8), significance of featuring real-life female role models (Questions 9 and 10, a Likert scale from Strongly Agree to Strongly Disagree), promotion of careers in STEM (Questions 11 and 12, “Yes” or “No” with optional comments), benefits to learning outcomes (Question 13, a “Yes” or “No” with optional comments) as well as suggestions for improvements, future topics, and complementary resources (Questions 14–16).

**Recruitment:** Recruitment commenced in March 2020 for a period of ten days. Recruitment was carried out by Facebook posts to two community groups (Wilston Grange 4051 [>900 members] and Corinda Sherwood 4075 [>5,000 members]). Following agreement to participate in the research project, a set of four That's RAD! Science books and an information letter with a scannable barcode and a link to the online survey were sent to participants. The four books are titled: *My mum is a parasite scientist. That's RAD!*; *Our mum is a nanotech scientist. That's RAD!*; *Our mum is a forensic scientist. That's RAD!*; and *My aunt is a protein crystal scientist. That's RAD!* (Figure 1). The initial target was 100 participants, however, due to the evolving COVID-19 virus pandemic, recruitment needed to be closed earlier than expected. Follow-up emails to remind participants to complete the online survey were sent at two, four and five weeks after distribution of book packages. The survey remained open for 42 days.

**Data Analysis:** Analysis of the data was performed by the LimeSurvey inbuilt analysis function, which calculated statistics for responses to each survey question.



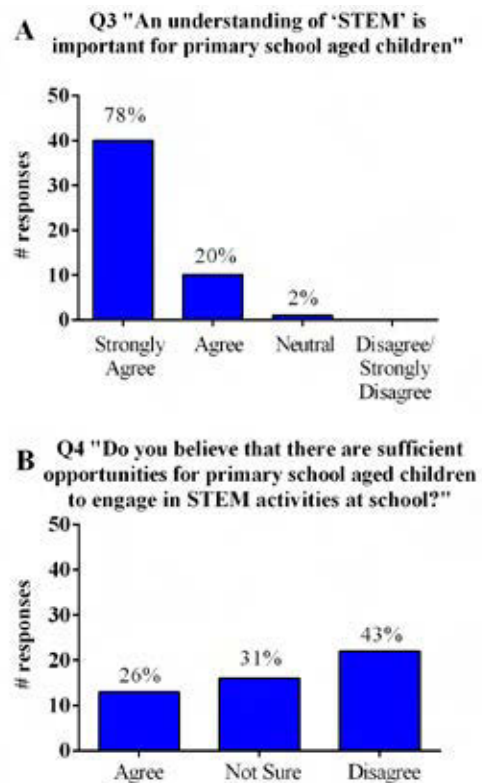
## Results

**Survey Participant Data:** A pool of 83 respondents registered to take part in the survey and were each sent a set of four *That's RAD! Science* books. The main postcodes represented were Queensland 4051 (39% of respondents), 4075 (18% of respondents) and 4031 (5% of respondents). Out of the 83 recruited participants, 51 (61%) completed the online survey. Of these, 50 out of 51 participants (98%) responded that they were parents/carers, with one survey participant identifying as a STEM professional only (Participant #21) and two participants identifying as both a parent/carer and a STEM professional (Participants #15 & #47). Two of the participants who identified as parents/carers also responded that they were either a student (Participant #24) or "home school family" (Participant #25). Of the 51 survey participants, 18% stated that they had a high level of STEM knowledge and/or were working in a STEM area, 60% stated that they had a medium level/general knowledge of STEM and 22% stated that they had low or little knowledge of STEM.

### **Perceptions on the importance of understanding STEM and opportunities for STEM engagement at school:**

As shown in Figure 2A, a combined 98% of survey participants strongly agreed or agreed that an understanding of STEM is important for primary school aged children, with 2% responding as neutral. Only 26% of survey participants believe that there are sufficient opportunities for primary school aged children to engage in STEM activities at school, with 43% responding that there are not enough opportunities and 31% of participants indicating they are not sure. A total of 22 survey participants left optional comments on the question of whether there are sufficient opportunities for primary school aged children to engage in STEM activities at school. An example of a common response was that opportunities to engage depended on what school system the child/children were enrolled in (public vs private). As one respondent explained: "I think it depends on the school the particular child attends. Initially, our children attended a private school in Sydney and were heavily exposed to STEM in the younger primary years. Now they are in a public Queensland school, there is very limited exposure to STEM" (Participant #13). Another respondent argued that there are not enough hands-on learning activities, commenting: "[T]here needs to be more hands-on STEM involvement during all terms of school, and not just select weeks throughout the year" (Participant #20). Other respondents pointed out that while there are extracurricular opportunities, there is a lack of opportunities within the curriculum itself (e.g., "There are many extra-curricular opportunities, but I don't believe there are enough opportunities

within the curriculum or provided as extension." — Participant #6). Respondents also pointed out the need for a more holistic approach to education as "science is limited to one short lesson a week" (Participant #12) and finally, there were comments around being unsure of what the current curriculum was for their children and hence being unable to provide a clear response.



**Figure 2: Survey responses focused on STEM understanding and STEM engagement opportunities.** Responses from a total of 51 participants. Number of respondents is shown, with % of total responses indicated above each bar.

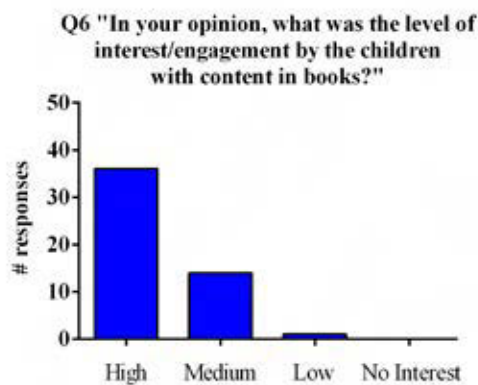
### **Perceptions of child engagement with *That's RAD! Science* books:**

Participants used a variety of processes in order to share one or more of the *That's RAD! Science* books with children. Of those respondents who answered the question, 42% used one-on-one reading of the books to children or carried out the hands-on science activities presented in the books (26%). Furthermore, all survey participants (100%) agreed that the *That's RAD! Science* books were useful in exploring STEM topics with children, with 31 participants making comments. The major themes of these comments included: the value of using experiments (e.g., "The kids loved the examples and experiments" — Participant #7); showing science in action (e.g., the books "put science in simple terms and made them relevant and hands on" — Participant #15); and that the books were colourful, engaging and presented in an easy-to-understand way.

There were many comments that affirmed this view, including this comment: “[T]here is a good balance between information and experiments and I especially like the scattered test question throughout the books to reaffirm to the child what they have learnt. I also think the illustrations, colours and fonts are bold and attractive for children” (Participant #2). The overall effect reportedly led to deep engagement.

As one respondent affirmed: “[M]y 5 year old was so engaged with these books and pleaded with me for us to keep reading the other books (I was only going to read two today but we read all four). After he said he wished we had 10 of those books” (Participant #9).

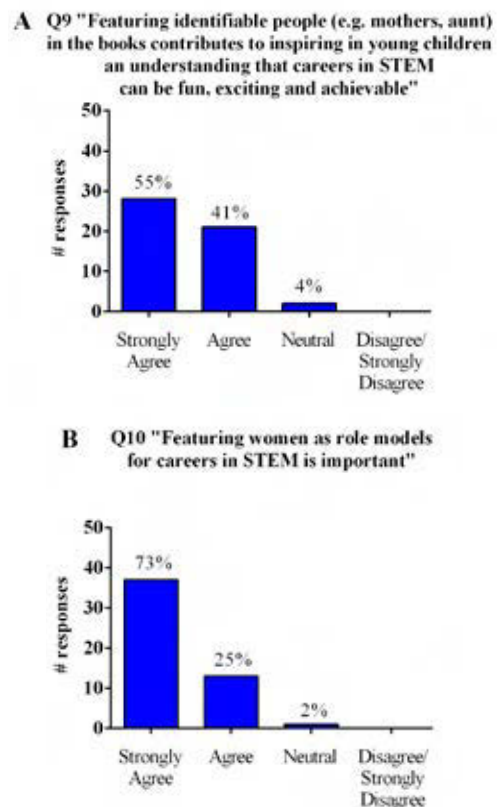
When asked about the perceived level of engagement of children with the That's RAD! Science books, the majority (71%) of responses were that children had high levels of interest/engagement, such as asking questions and pointing things out (Figure 3). A further 27% of responses indicated medium interest/engagement and only 2% stated that there were low levels of interest. None of the survey responses stated that there was no interest at all (Figure 3). Specific parts of the That's RAD! Science books that were perceived to engage and interest children the most were the fast/fun facts (23%) and hands-on science experiments (23%). Furthermore, 18% of participants stated that children were interested in all of the listed parts of the books. Additional comments noted that children also engaged with quizzes and real-life pictures.



**Figure 3: Survey responses on children’s level of engagement and interest in the That’s RAD! Science books.** Responses from a total of 51 participants. Number of respondents is shown, with % of total responses indicated above each bar.

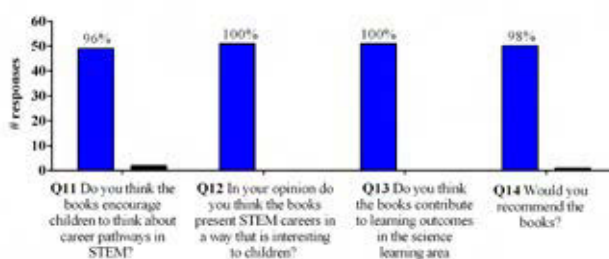
**Importance of featuring women role models in STEM careers:** As shown in Figure 4A, 96% of survey participants agreed, or strongly agreed, that featuring identifiable women in STEM careers contributes to promoting an understanding that careers in STEM can be fun, exciting

and achievable. No survey participants disagreed or strongly disagreed with this statement. Additionally, 98% of survey participants either strongly agreed or agreed that featuring women as role models in STEM careers is important, the majority (73%) strongly agreeing. No participants disagreed or disagreed strongly with this statement. A total of 20 participants left comments in response to this statement. The themes of the responses included noting that, historically, females have been under-represented in STEM, which is exemplified in this comment: “[N]early all role models/important figures in history are male. It’s important to have female role models too” (Participant #14). Furthermore, comments pointed to the importance of children seeing science as accessible to everyone by normalising women in STEM occupations, such as with this response: “[C]hildren do not see enough women working in STEM. Featuring them as role models will help make boys see that women can make valuable contributions in this area as well, and should be listened to, included, encouraged and respected” (Participant #23). And finally, the comments indicated that featuring women in STEM as role models inspires young girls and demonstrates that women can enjoy a variety of careers, as evident in this comment: “[I]t gives girls role models and encourages more children to see science as accessible by everyone” (Participant #19).



**Figure 4: Survey responses focussed on importance of featuring female role models in STEM.** Responses from a total of 51 participants. Number of respondents is shown, with % of total responses indicated above each bar.

**Perceptions on benefits and impacts of That's RAD! Science books:** Figure 5 shows the online survey responses to survey questions 11–14, all of which were “Yes”/“No” answer questions. Most (96%) survey participants responded “Yes” to the question “Do you think the That's RAD! Science books encourage children to think about career pathways in science, technology, engineering and mathematics (STEM)?” (Survey Question 11; Figure 5). Comments left regarding the “No” response were that the children engaged were too young to consider this. All participants (100%) responded “Yes” to the question “In your opinion, do you think That's RAD! Science books present STEM (science, technology, engineering and mathematics) careers in a way that is interesting to children?” and the question “Do you think That's RAD! Science books contribute to learning outcomes in the science learning area?” (Survey Questions 12 and 13, respectively; Figure 5). A total of 98% of survey responses were “Yes” in response to the question “Would you recommend the That's RAD! Science books?” (Survey Question 14; Figure 5). Options to leave comments for each response were provided. Some of the key themes were: that children were exposed to new jobs and careers that parents themselves did not know existed; that content was relatable and on point; interesting real-life examples were given; that the books are colourful, interesting and have an engaging presentation; that a high level of knowledge was imparted in easy-to-understand ways; and that helpful easy experiments were included. Optional comments also included requests for the production of more editions in the That's RAD! Science book collection. The comments were all affirming, and some indicated a keenness for the books to be used in their schools, with recommendations such as: “I would love to see our school use them” (Participant #30); “[T]hey would be great in a classroom setting” (Participant #9); and “I'll donate them to our school library” (Participant #35).



**Figure 5: Survey responses focussed on benefits and impacts of That's RAD! Science books.** Responses from a total of 51 participants. Number of respondents is shown, with % of total responses indicated above each bar.

**Suggestions for improvements to future That's RAD! Science book editions:** The final two survey questions (Questions 15 and 16) were optional. A total of 20 survey participants (39%) chose to leave comments in response to Question 15, which asked for suggestions for STEM topics for future editions of the That's RAD! Science books. The main topics suggested for future editions of the series were: mathematics/code breaking; virologist and/or the immune system; engineering and/or mechanical science; geologist/ecology; zoology; chemistry; and genetics/DNA. Additionally, 12 survey participants (24%) chose to leave comments in response to Question 16, which focussed on improvement to future books in the series. The majority of responses regarding improvements for future editions were suggestions to increase the number of pages and add more quizzes, puzzles or interactive games. Several participants stated that they would like more editions added to the That's RAD! Science book series. The most common comment (4/12 comments) on improvements to future editions of books were that fewer cartoons and graphics be used, as they blurred fact and fiction, this along with suggestions that more real-life photos be used instead.

## Discussion

The overall aim of this project was to gain feedback from adults on their impression of the impacts and benefits of the That's RAD! Science books as well as their general perceptions around the benefits of STEM engagement and use of identifiable women as role models. It was found that the majority (98%) of survey participants agreed/strongly agreed that an understanding of STEM is important for primary school aged children (Figure 2A). This corroborates previous observations in the literature of the importance of an understanding of STEM (Bonnette et al., 2019; Simoncini & Lasen, 2018; YouthInsight, 2020). Strategies suggested by Holmes, Gore, Smith and Lloyd (2018) to improve STEM participation in schools are all addressed in the design of the That's RAD! Science books: expanding knowledge of STEM careers, showcasing more female role models in STEM careers and increased awareness of the range of STEM careers from a young age. Furthermore, the That's RAD! Science books address the need for awareness of career opportunities in STEM at an earlier age than Years 11 and 12, the age by which children are reported to have made decisions about career choices (Australian Industry Group, 2017; Bonnette et al., 2019). The majority of survey participants agreed that the That's RAD! Science books encourage children to think about career pathways in STEM (96%) and present STEM careers in a way that is interesting to primary school aged children (100%) (Figure 5, Question 11 and 12).

Previous observations in the literature highlight the importance of role models in terms of career development (DeWitt & Archer, 2015; Fluckiger, Dunn & Stinson, 2018; Holmes et al., 2018; Shin, Levy & London, 2016; Vedder-Weiss & Fortus, 2013), further regarding the lack of female STEM role models as a core reason for the continued lack of female interest in STEM (Holmes et al., 2018). Therefore, the representation of female role models in STEM careers in the That's RAD! Science books not only answers the call from previous research for more representation of women in STEM, but also widens the lens around who can "be" a scientist for children. This was reflected in the survey results from this study, with 96% of survey participants agreeing or strongly agreeing that featuring identifiable women as role models in the That's RAD! Science books contributes to inspiring in young children an understanding that careers in STEM can be fun, exciting and achievable (Figure 4A). Additionally, 98% of survey participants either agreed or strongly agreed that featuring women as role models for careers in STEM in the That's RAD! Science books is important (Figure 4B). As seen in previous studies, students' aspirations are often stymied by narrow images of who can be a scientist (DeWitt & Archer, 2015; Wilbraham & Caldwell, 2018). Findings that gender biases are formed by the age of four, consequently resulting in a loss of interest in STEM for some students by the age of six (Australian Government Department of Education Skills and Employment, 2020) underscores the value of engaging children in STEM early on in life. This was reflected in the survey results from this study, with 100% of survey participants finding the That's RAD! Science books useful in exploring STEM topics as well as encouraging children to think about career pathways in STEM (96%; Figure 5).

Data analysis found that the survey participants reported that the majority (71%; Figure 3) of children displayed a high level of interest and engagement with content in the That's RAD! Science books, with a further 27% reporting a medium level of engagement. Only one respondent reported a low level of engagement with the books and qualitative feedback from the participant in response to other questions (Survey Questions 11 and 14) notes that this was due to the young age of children engaging with the books who were said to "move on quickly" (Participant #37).

A range of informal learning processes was reported as being used to share the books with children (e.g., one-on-one reading of the books, group readings, independent reading and carrying out the hands-on science activities presented in the books). This aligns with past studies that have found that the use of informal learning processes is beneficial for engaging children and are positive predictors for future engagement (Bonnette et al., 2019; Fluckiger et al., 2018; McClure, 2019;

McClure et al., 2017). Survey respondents reported that children engaged with multiple parts of the That's RAD! Science books such as the cartoons, fast/fun facts and hands-on science experiments with 98% of participants stating that they would recommend these books to others (Figure 5). All of the participants (100%), reported that the books are beneficial in exploring STEM topics, as well as further contributing to learning outcomes in the science learning area (Figure 5; Question 13).

A limitation of this study was the number of participants able to be recruited (83 participants, 51 of whom completed survey). A larger number of participants (>100) was initially targeted to provide increased confidence in the data, however, the recruitment period was shortened due to the COVID-19 pandemic situation. It should also be noted that there is a potential bias in this data due to the majority (57%) of recruited participants residing in two dominant Queensland postcodes (4051 and 4075). Both postcodes surpass state levels for a variety of socioeconomic factors such as median weekly income, level of highest educational attainment, employment status and gross weekly household income (Australian Bureau of Statistics, 2016). Future work in this area should therefore consider a broader distribution of participants across different socioeconomic areas and also include regional locations. It would also be beneficial in the future to include a question on the year level of the child/children that the survey participants engaged with using the That's RAD! Science books to account for age-related differences. Qualitative analysis of responses to Questions 15 and 16 provided insightful feedback regarding future topics of That's RAD! Science books as well as further improvements that could be considered for future books in this series. Interestingly, some comments focused on adjustment/reduction of cartoons and graphics used in the books and increased use of real-life photos in their place.

## Conclusion

Key results of this survey included an understanding by the adults surveyed that STEM is important for primary school aged children, however, the perception is that there are not sufficient opportunities to engage in STEM activities in primary school. The survey results also indicated that the That's RAD! Science books are considered engaging, interesting and useful in exploring STEM topics with children. A consensus on the importance of featuring identifiable role models, especially women in careers in STEM, was reported. Additionally, the That's RAD! Science books were perceived to encourage children to think about career pathways in STEM and presented STEM careers in a way that were interesting to children. Furthermore, the books were perceived to contribute to learning outcomes in the science area and that the participants would recommend these books to others.



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