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Education for Enhancing the Abilities of Engineers: A Survey Conducted in Japan and Its Analyses

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Abstract

While the study of science subjects at school is essential for the development of science and technology in society, it is a recognized fact that a large number of students show reluctance to study science and mathematics. Thus, it is of great significance to deliberate on ways to increase their interest in science subjects and enhance effectiveness of learning. We conducted a survey of researchers and engineers who exercise their scientific abilities in their work, asking about their experiences in science education and learning from elementary school to university. We then examined the relationship between their learning experiences and their abilities as researchers and engineers, and analysed the factors that would enhance students' interest in science subjects and motivation to study these subjects.

The results of our analysis show that "getting interested in science during the early years of elementary school," "being able to understand the science lessons," "amazing experience in science class," "association of science learning with daily life," "finding the talks in class interesting," and "approachability to science learning," have a positive effect on science learning and is crucial to improving professional capacity.

Keywords: science education, abilities of engineers, education policy, triggers for science learning, aversion for science learning

1. Introduction

The study of science and mathematics subjects in school is essential for the development of science and technology in society. Since science and mathematics are subjects that a large number of students tend to show reluctance to study, it is important to explore ways to enhance their willingness to study these subjects as well as effectiveness of learning. In this paper, we analyse the results of questionnaires completed by Japanese researchers and engineers in Japan and examine the factors that increase students' interest in and enhance their motivation to learn science subjects.

Breakwell and Beardsell (1992) conducted a survey on children aged eleven to fourteen in the U.K. to see how their learning behaviours in science subjects change by sex and by the influence of those who are close to them including their parents. Osborne et al. (2003) presented seven factors that could affect students' learning attitudes and verified their effects: (i) motivation for learning, (ii) self-efficacy in learning science (Note 1), (iii) fear of science, (iv) awareness of science, (v) opinions of science teachers about science learning, (vi) participation in science-related extracurricular activities, and (vii) interest in science-related occupations. Tytler (2014) reviewed existing studies to explore the teaching methods in science that increase motivation to study science subjects and enhance learning achievements.

Eccles (1968) applied the expectation-value theory (EVT) to education and argued that students' achievements in school are determined by the balance between the value of the goal they seek to achieve and their expectations for attainability (see also Wigfield & Eccles, 2000). Wan (2019), in the meantime, carried out a survey on ten-year-old children in Hong Kong to examine the impact of the motivation for learning science and self-efficacy on their willingness to learn science on the basis of EVT.

Locke and Latham (2002) summarise the findings of various empirical studies in the past 35 years on goal setting theory (Note 2) which analyses the impact of the way goals are set on motivations. According to their research, as long as learners accept their own goals, they achieve more with clearer and higher goals than with lower or vague goals such as "doing their best." In the studies of science subjects, where it is possible to grasp the learning conditions to some extent and to control the learning behaviour, students would be expected to produce excellent results by setting higher goals.

For this study, we conducted a questionnaire on Japanese engineers and science researchers about learning behaviour in science subjects. Based on the collected data, we clarify the characteristic features of science studies that could develop the abilities of engineers and researchers and then explain which factors are important in changing learning motivations. We also analyse the relationship between the education and learning experiences of researchers and engineers from elementary school to university and their abilities as professionals at work, and verify the impact the educational reform policies have had on science education.

In Section 2 below, we outline the survey methods and the data. In Section 3, we clarify the factors crucial to the professional capabilities of engineers and researchers. Section 4 refers to the factors that could determine the degree of strength in science during high school. Section 5 elucidates the factors that could inspire students' interest in science. Finally, in Section 6 we summarize the results of our paper.

2. Outline of Survey Methods and the Data

We obtained the data from the Internet survey "Questionnaire on the Attitudes of Engineers and Researchers" conducted on engineers and researchers or the so-called R&D engineers by NTT Com Research, the research service section of NTT Com Online Marketing Solutions Corporation, in March 2016 (the first survey). 153,272 questionnaires were distributed; 17,440 responses were collected in the pre-survey and then 5,241 in the main survey. The response rate is 3.4%. Since we screened for engineers and researchers, the final number of valid responses turned out to be 4,129. Afterwards, we conducted the second survey, the "Follow-up Questionnaire on the Attitudes of Engineers and Researchers," on the respondents to the first survey. The questions were mainly about preferences for science. The final sample size we used out of the first and the second surveys was 2,065. We conducted the third survey, the "Questionnaire on the Learning Attitudes toward Science in Student Days," on the respondents to the second survey. The sample size we used out of the first, the second, and the third surveys was 1,152.

The respondents consisted of 92.1% males and 7.9% females, indicating that males are the overwhelming majority. 75.4% are university graduates or have higher degrees and the average age of the respondents was 33.22 (standard deviation is 9.20). 78.9% with university or higher degrees have studied science, 19.1% humanities, and 2.0% integrated fields of humanities and science. The average annual income before tax of all the samples was 6,697,519 yen, with a standard deviation of 3,600,000 yen.

3. Factors that Determine the Professional Capabilities of Engineers and Researchers

This section analyses the characteristic features of science learning that had an impact on the abilities of the respondents to perform their duties as professional engineers and researchers. In this survey, the question "Do you think that you have enough professional capabilities to be recognized as experts in your field?" is answered by choosing one of the following: 1) Not at all, 2) Not very much, 3) Rather no, 4) Rather yes, 5) Yes to some extent, and 6) Yes. The answers to this question are interpreted as "confidence in their professional capabilities (Note 3)."

We have also examined the number of patent applications, which is generally regarded as an index of professional abilities. Many of the respondents, however, have an occupation or post irrelevant to patent applications, and the ratio of respondents who have applied for a patent more than once was as low as 28.2%. Therefore, we did not use the number of patent applications as a variable to indicate professional capabilities. In the following analysis, we do not restrict the samples to the respondents whose number of patent application is more than 1.

However, when the number of patent applications is regressed by the "confidence in professional capabilities" of the respondents who have applied for a patent more than once, the critical p-value is significant at below the 1% level, showing that the "confidence in professional capabilities" is consistent with the number of patent applications. Thus, we employ the "confidence in professional capabilities" as a variable to measure the professional capabilities. We henceforth call it "professional capabilities."

In this survey, we asked 56 questions related to science learning from elementary school to high school in order to analyse the characteristics of science learning in detail (Note 4). The results of a search-type factor analysis performed on the survey data are shown in the attachment. We opted for a principal component analysis as a factor sampling method, adopting the rotation by the Equamax method with Kaiser normalisation. The variables sampled from the factor analysis were: 1) positive attitude toward science learning from junior high school days onward; 2) feeling that science is one's favourite subject from junior high school days onward; 3) feeling that science is one's favourite subject during elementary school; 4) studying science with friends; 5) association of science learning with daily life; 6) approachability to the content of science subjects; 7) positive attitude toward science learning during elementary school; 8) patience in learning science during elementary school; and 9) feeling that science is one's weakest subject from elementary school to university. It has been confirmed that the correlation coefficient between these samples is 0 by orthogonalization. These factors are used in the analyses in Appendix A.

The impact of the learning experience in science subjects on professional capabilities was analysed by using these 9 factors and the degrees of strength felt in learning physics and chemistry during high school (Note 5). Figure 1 compares the impact of the respective factors by sampling only the elements that have a statistically significant impact on professional capabilities at the 5% significance level from the characteristics of science learning during the elementary and secondary school levels and comparing the standardized coefficient values.

As Figure 1 shows, the following factors that account for present professional capabilities have a statistically significant positive impact at the 5% significance level: 1) the degree of strength in physics in high school; 2) positive attitude toward science learning from junior high school days onward; and 3) association of science learning with daily life. It should be noted that, while the degree of strength in physics in high school has a strong impact on professional capabilities, the degree of strength in chemistry in high school does not. Since the p-value of the degree of strength in chemistry is below 5% significance level, it is dropped from Figure 1. This suggests that physics learning could contribute more effectively to developing essential abilities than chemistry learning. Accordingly, in the next section, we analyse how science learning during elementary school and junior high school helps build up the strength in physics in high school.

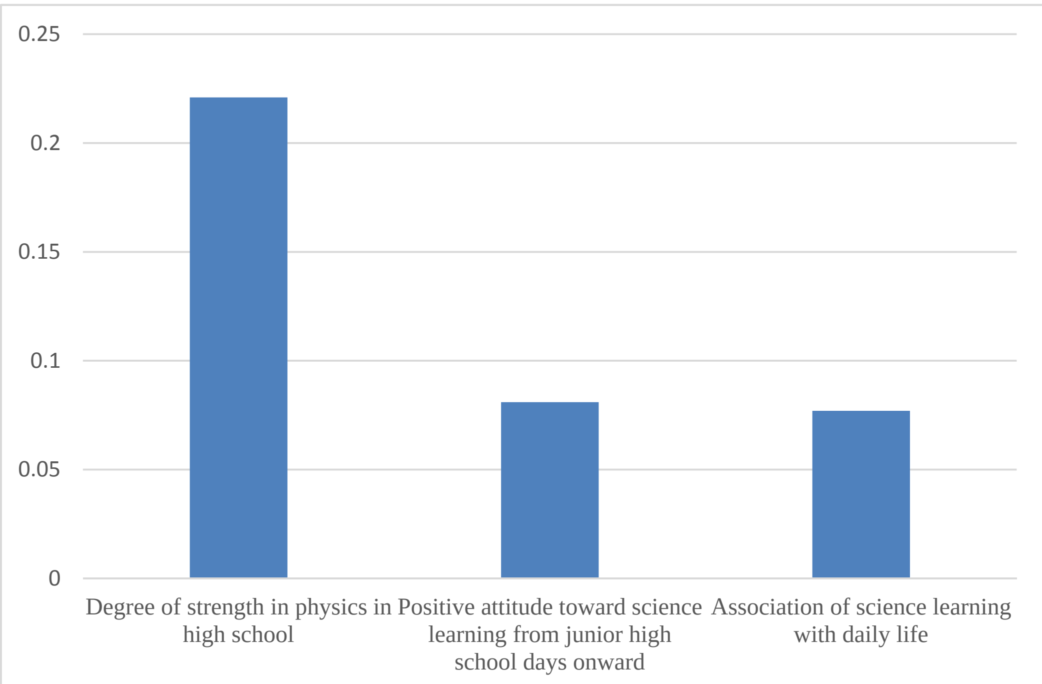

Figure 1. The characteristic features of science learning in elementary school, junior high school, and high school and professional capabilities

4. Factors that Determine the Degree of Strength in Physics in High School

Figure 2 clarifies the factors that determine the degree of strength in physics in high school by multiple regression analysis. In conducting the multiple regression analysis, we included the responses to the question: "Did you ever have any amazing experiences or experiments in science class?" named as "amazing experience in class", and also the reasons for getting interested in science or having an aversion to science, in addition to the factors sampled by the factor analysis.

Each column in the graph shows the standardised coefficient value of the element that has a statistically significant impact on the degree of strength at the 5% significance level. By comparing the standardised coefficient values, we can compare the strength of the impact of each factor. A negative value indicates a negative impact on the degree of strength.

The factors that have a strong positive impact on the degree of strength in physics in high school are: "getting interested in science during the early years of elementary school," named as "dummy of the early years of elementary school," "being able to understand the science lessons," "amazing experience in science class," "association of science learning with daily life," "finding the talks in class interesting," and "approachability to science learning."

Among the factors that did not have an impact on the degree of strength in science, "experiments in science class" should be noted. Theoretical understanding of experiments is considered essential so that experiments in class could lead to the development of abilities in science. Meanwhile, getting interested in science during the early years of elementary school has a positive impact on the degree of strength.

If students get interested in science during the early years of elementary school and maintain the appropriate learning methods, it would be possible for them to enhance their understanding of science classes and develop their abilities on a long-term basis. Another important point to note is that the association of science learning with daily life can not only enhance the degree of strength in physics but also have a strong impact on the development of professional capabilities as engineers and researchers as they understand that individual scientific facts are interrelated in a complex manner in real life.

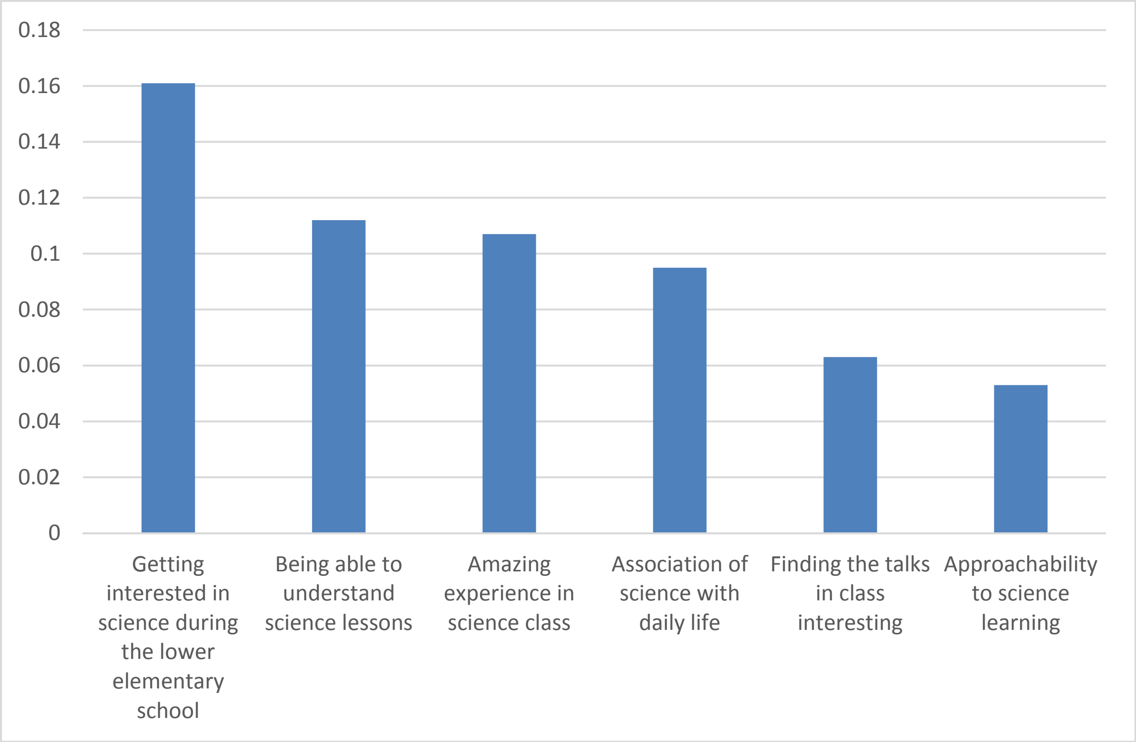

Figure 2. Factors that determine the degree of strength in physics in high school

5. Timing of Getting Interested in Science

The previous section demonstrated that getting interested in science during the early years of elementary school has the strongest impact on the degree of strength in physics in high school. This section analyses the triggers for getting interested in science.

In our survey, we asked the respondents whether they liked science subjects at their university. The respondents were engineers and science researchers so it is expected that they are interested in science subjects. However, the results show that 72.3% of the respondents answered "yes," while 27.7% said "no." Of those who answered "yes," 33.4% responded that they became interested in science during the early years of elementary school, 23.0%

during the later years of elementary school, 10.8% during junior high school, and 5.1% during high school or in higher education. On the other hand, of those who did not like science, 30.8% became averse to science during junior high school and 29.4% during high school.

In the survey, we also asked about the triggers for getting interested in science with the following answer options: “experiments in class,” “finding the talks in class interesting,” “being able to understand the lessons,” “books,” “experiments in clubs or other extracurricular activities,” “lectures by scientists or researchers or other events of that sort,” “astronomic observations,” “TV programmes,” “occupations of parents or influence of family members,” and “others.” (Note 6)

Figure 3 shows the triggers for getting interested in science according to timing. The most common trigger that respondents chose was “experiments in class” for getting interested in science during elementary school. “Experiments in class” also showed high proportions for all of the time periods. As discussed in the previous section, however, learning the theoretical grounds is considered important to effectively link the experiments in class to the development of scientific abilities.

The second most important triggers for getting interested in science were “finding the talks in class interesting” and “being able to understand the lessons.” It should be noted that the proportion of “being able to understand the lessons” increases especially as the respondents advanced from junior high school to high school. “Books” also have a significant impact. Thus, the results show that lessons and books are the major triggers for getting interested in science.

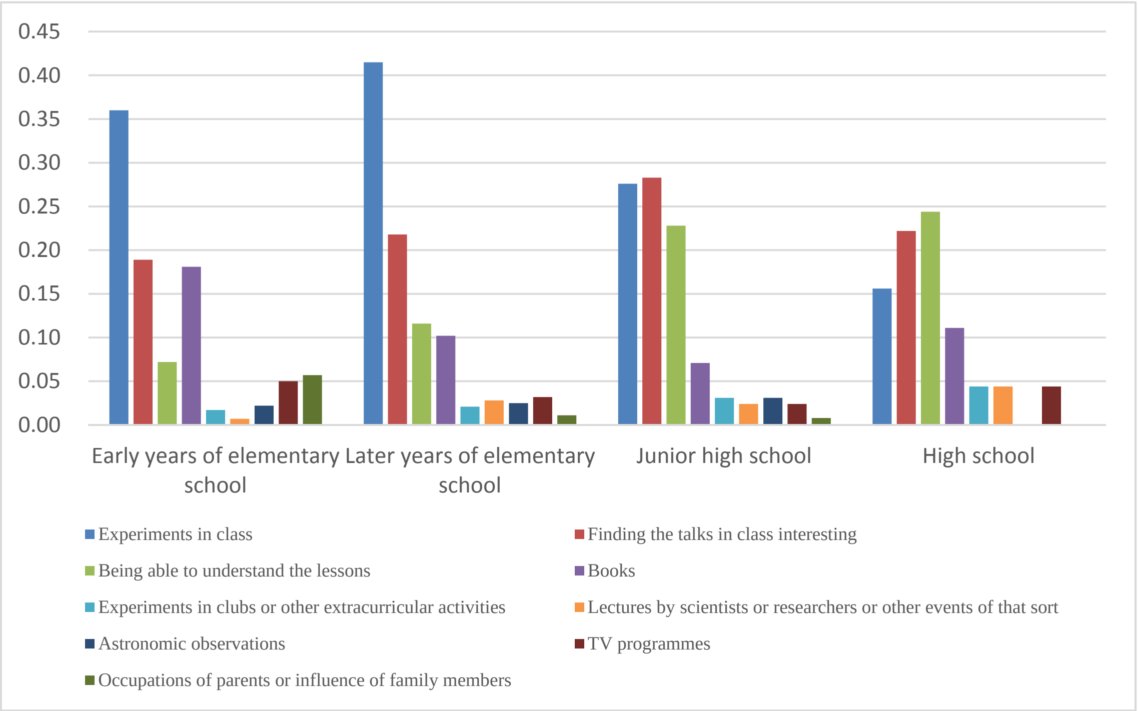

Figure 3. Timing of and triggers for getting interested in science

In the survey, we also asked about the reasons for becoming averse to science with the following answer options: “the lessons were too difficult to understand,” “the lessons were boring,” “was averse to insects and other living creatures,” “the experiments were boring,” and “the experiments were too difficult to understand.” Figure 4 shows the timing of and reasons for becoming averse to science. The reason most chosen for all of the time periods was “the lessons were too difficult to understand,” followed by “the lessons were boring,” which proves that lessons are the most important.

Figures 3 and 4 both indicate that school lessons have a great impact on whether students become interested in or averse to science learning.

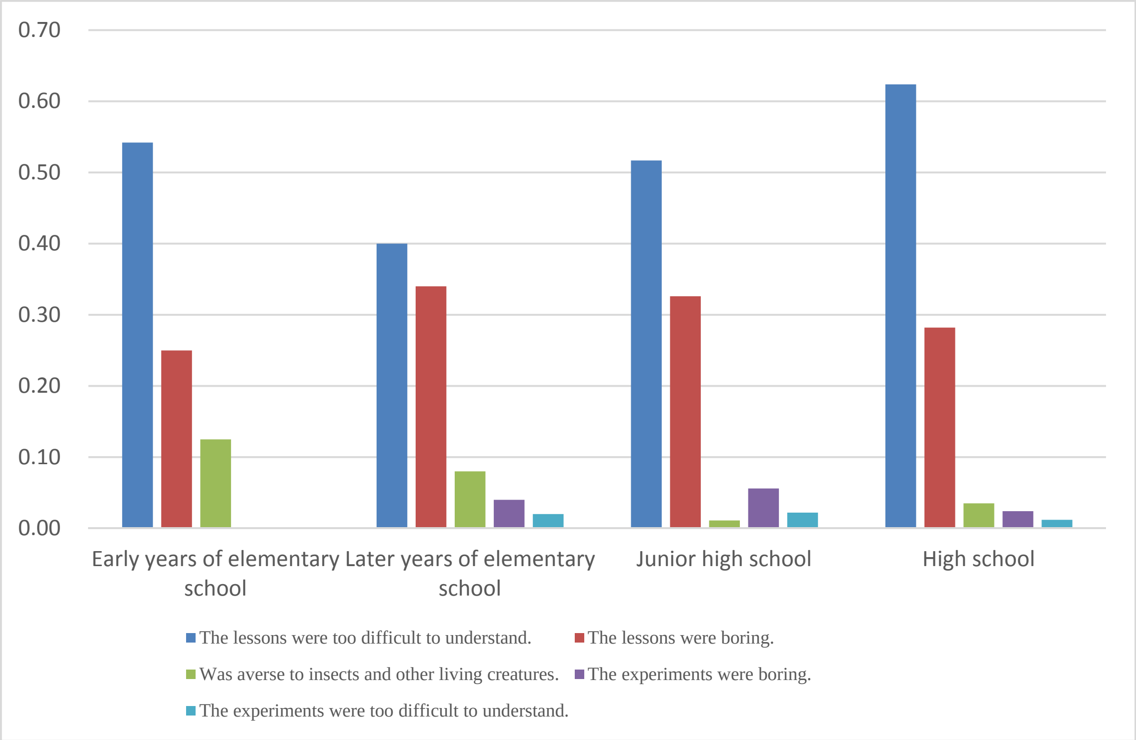

Figure 4. Timing of and reasons for becoming averse to science

6. Conclusion

This paper analysed the relationship between the development of engineers' capabilities and learning behaviour and the factors that cause changes in learning behaviour. It also clarified the changes that the revision of the education policy caused in engineers' scientific abilities. Our analyses revealed the following.

First, while the degree of strength in physics in high school had a strong impact on the professional abilities of R&D engineers, the degree of strength in chemistry did not.

Second, the degree of strength in physics, which has an important effect, was enhanced by the following factors: "getting interested in science during the early years of elementary school," "being able to understand the lessons," "finding the talks in class interesting," "amazing experience in science class," "association of science learning with daily life," and "approachability to science learning." Furthermore, "association of science learning with daily life" not only enhanced the degree of strength in physics but also developed the professional capabilities as engineers and researchers.

The findings of this research suggest that increasing interest in science during the early stages of school education, developing positive attitudes toward science learning, and associating science learning with daily life are important ways to enhance scientific abilities. Further research will be required to discover what sorts of methods are effective in enhancing interest in science during the early stages of school education.

References

Breakwell, G. M., & Beardsell, S. (1992). Gender, parental and peer influences upon science attitudes and activities. *Public Understanding of Science*, *1*(2), 183–197. https://doi.org/10.1088/0963-6625/1/2/003

Eccles, J. S. (1983). Expectancies, Values, and Academic Behaviors. In J. T. Spence (Ed.), *Advances in Motivation and Achievement* (pp. 75–146). W.H. Freeman and Company, San Francisco, CA.

Ito, T., & Shinto, T. (2003). An Examination of the Causal Model for the Relationships among Self-efficacy, Anxiety, Self-Regulated Learning Strategies, and Persistence in Learning: Focused on Cognitive and Motivational Aspects of Self-Regulated Learning Strategies. *Japan Society for Educational Technology Journal / Japan Society for Educational Technology Magazine*, *27*(4), 377–385.

Locke, E. A. (1968). Toward a theory of task motivation and incentives. *Organizational Behavior and Human Performance*, *3*(2), 157–189. https://doi.org/10.1016/0030-5073(68)90004-4

Locke, E. A., & Latham, G. P. (2002). Building a practically useful theory of goal setting and task motivation: A 35-year odyssey. *American Psychologist*, *57*(9), 705‒717. https://doi.org/10.1037/0003-066X.57.9.705

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: a review of the literature and its implications. *International Journal of Science Education*, *25*(9), 1049–1079. https://doi.org/10.1080/0950069032000032199

Tytler, R. (2014). Attitudes, identity, and aspirations toward science. In N. G. Lederman & S. K. Abell (Eds.), *Handbook of research on science education* (vol. 2, pp. 82–103). Routledge.

Wan, Z. H. (2019). Exploring the Effects of Intrinsic Motive, Utilitarian Motive, and Self-Efficacy on Students' Science Learning in the Classroom Using the Expectancy-Value Theory. *Research in Science Education* (online journal). https://doi.org/10.1007/s11165-018-9811-y

Wigfield, A., & Eccles, J. S. (2000). Expectancy-value theory of achievement motivation. *Contemporary Educational Psychology*, *25*, 68–81. https://doi.org/10.1006/ceps.1999.1015

Notes

Note 1. Self-efficacy in this context means students' confidence that they can expect some achievements.

Note 2. Ref. Locke, 1968.

Note 3. We have also examined the number of patent applications, which is generally regarded as an index of professional abilities. Many of the respondents, however, have an occupation or post irrelevant to patent applications, and the ratio of respondents who have applied for a patent more than once was as low as 28.2%. Therefore, we did not use the number of patent applications as a variable to indicate professional capabilities. In the following analysis, we do not restrict the samples to the respondents whose number of patent application is more than 1. However, when the number of patent applications is regressed by the "confidence in professional capabilities" of the respondents who have applied for a patent more than once, the critical p-value is significant at below the 1% level, showing that the "confidence in professional capabilities" is consistent with the number of patent applications. Thus, we employ the "confidence in professional capabilities" as a variable to measure the professional capabilities. We henceforth call it "professional capabilities."

Note 4. We employed the questions used in Ito and Shinto (2003).

Note 5. We asked about the degree of strength in physics and chemistry in high school on six scales: 1) very poor, 2) poor, 3) rather poor, 4) rather strong, 5) strong and 6) very strong.

Note 6. Note that physics, chemistry, biology, and earth and planetary science are taught in a single subject called science, not in isolated subjects, in elementary and junior high schools in Japan. Astronomy is one of the most important parts in earth and planetary science.

Appendix A (The detail questions are listed below the table)

Results of Factor Analysis of the Survey Data on Attitudes toward Science Study

Question No.	Positiveness toward science from junior high onward	Feeling of strength in science from junior high onward	Feeling of strength in science during elementary school	Studying science with friends	Association of science learning with daily life	Approach ability to content of science learning	Positiveness toward science learning during elementary school	Patience in learning science during elementary school	Feeling of inferiority in science subjects
1.	0.732	0.185	0.002	0.157	0.079	0.092	0.157	0.279	-0.047
2.	0.731	0.139	0.020	0.198	0.103	0.105	0.313	0.137	-0.065
3.	0.694	0.057	0.033	0.218	0.019	0.071	0.404	0.093	0.011
4.	0.668	0.199	0.097	0.143	0.170	0.019	0.220	-0.005	-0.130
5.	0.627	0.213	0.034	0.109	0.063	0.070	0.125	0.307	-0.067
6.	0.603	0.296	0.090	0.092	0.277	0.135	0.128	0.212	-0.217
7.	0.593	0.191	0.049	0.177	0.134	0.011	0.223	0.286	0.002
8.	0.584	0.152	0.017	0.114	0.142	0.090	0.009	0.459	-0.012
9.	0.574	0.156	0.071	0.119	0.085	0.088	0.028	0.558	-0.053
10.	0.513	0.146	0.118	0.044	0.116	0.135	-0.089	0.501	-0.130
11.	0.167	0.806	0.307	0.072	0.119	0.205	0.026	0.008	-0.234
12.	0.145	0.804	0.351	0.063	0.139	0.206	0.038	0.018	-0.213
13.	0.162	0.799	0.363	0.057	0.163	0.204	0.022	0.016	-0.215
14.	0.186	0.766	0.395	0.049	0.138	0.214	0.021	0.032	-0.183
15.	0.019	0.243	0.836	0.032	0.147	0.249	0.109	0.139	-0.190
16.	0.034	0.224	0.832	0.034	0.133	0.239	0.113	0.162	-0.162
17.	0.025	0.272	0.813	0.028	0.127	0.264	0.080	0.116	-0.210
18.	-0.015	0.277	0.808	0.035	0.138	0.257	0.098	0.109	-0.216
19.	0.199	0.079	0.027	0.850	0.133	0.008	0.035	0.113	0.005
20.	0.247	0.103	0.006	0.807	0.189	0.025	0.058	0.084	-0.071
21.	0.164	0.054	0.030	0.782	0.087	-0.105	0.098	0.085	0.173
22.	-0.040	-0.045	0.051	0.694	0.249	0.005	0.354	0.188	0.048
23.	-0.076	0.022	-0.004	0.658	0.155	-0.108	0.388	0.087	0.256
24.	-0.018	-0.031	0.115	0.610	0.357	0.036	0.384	0.179	0.015
25.	0.371	0.075	-0.053	0.490	0.392	0.061	0.165	0.013	-0.052
26.	-0.067	0.005	0.167	0.191	0.771	0.105	0.260	0.184	-0.059
27.	-0.062	0.037	0.206	0.079	0.770	0.133	0.242	0.161	-0.085
28.	0.271	0.264	0.094	0.235	0.710	0.110	-0.065	0.101	-0.190
29.	-0.051	0.070	0.191	0.137	0.684	0.064	0.326	0.093	0.007
30.	0.263	0.250	0.026	0.345	0.679	0.080	-0.050	0.084	-0.121
31.	0.288	0.305	0.140	0.190	0.658	0.098	-0.062	0.029	-0.137
32.	0.364	0.149	0.104	0.247	0.447	0.072	0.001	-0.013	0.045
33.	0.057	-0.077	0.036	0.442	0.396	0.074	0.473	0.074	0.019
34.	0.017	0.043	0.381	-0.019	0.078	0.832	0.001	0.082	-0.173
35.	0.020	0.042	0.382	-0.059	0.075	0.830	-0.009	0.098	-0.158
36.	0.023	0.061	0.424	-0.003	0.095	0.786	0.014	0.077	-0.163
37.	0.102	0.517	0.019	-0.021	0.074	0.731	-0.009	0.052	-0.211
38.	0.120	0.545	0.044	0.005	0.081	0.705	0.029	0.020	-0.219
39.	0.080	0.575	0.012	0.003	0.054	0.698	0.039	0.017	-0.228
40.	0.246	0.008	0.053	0.179	0.102	0.030	0.739	0.337	-0.043
41.	0.205	-0.001	0.035	0.184	0.010	-0.001	0.712	0.317	0.017
42.	0.194	0.081	0.195	0.152	0.140	-0.037	0.681	0.185	-0.040
43.	0.265	-0.012	0.050	0.188	0.069	0.021	0.640	0.462	-0.009
44.	0.149	0.069	0.182	0.086	0.241	0.130	0.510	0.442	-0.157
45.	-0.060	0.060	0.091	0.225	0.312	-0.019	0.471	-0.035	0.271
46.	0.108	0.018	0.124	0.141	0.074	0.087	0.259	0.764	-0.028
47.	0.136	-0.011	0.128	0.078	0.101	0.064	0.193	0.744	-0.020
48.	0.026	-0.010	0.123	0.080	0.083	0.109	0.212	0.707	-0.013
49.	0.218	-0.031	0.173	0.078	0.040	0.042	0.347	0.519	-0.054
50.	0.053	0.073	0.096	0.166	0.132	-0.004	0.459	0.510	0.003
51.	-0.141	-0.381	-0.075	0.026	-0.095	-0.125	-0.007	0.028	0.792
52.	-0.119	-0.394	-0.049	0.039	-0.075	-0.118	-0.031	0.037	0.781
53.	0.000	0.008	-0.416	0.033	-0.034	-0.180	-0.055	-0.038	0.772
54.	-0.003	0.020	-0.423	0.037	-0.050	-0.185	-0.041	-0.056	0.767
55.	0.061	-0.041	-0.360	0.117	-0.037	-0.310	0.120	-0.083	0.528
56.	0.104	-0.368	0.094	0.085	-0.027	-0.252	0.074	-0.047	0.509

List of questions

1. (From junior high school days to university graduation), when studying for the exams, I reviewed the lessons, remembering the important things again and again.

2. (From junior high school days to university graduation), I wrote down the points of what I learned so that I could understand better.

3. (From junior high school days to university graduation), I reorganized my notebooks so that I could remember what I learned while studying.

4. (From junior high school days to university graduation), I worked at exercises by myself in addition to my homework.

5. (From junior high school days to university graduation), I carried out my studies even though the content was boring and uninteresting.

6. (From junior high school days to university graduation), I applied what I had learned before to the new assignment (task) given.

7. (From junior high school days to university graduation), I replaced important and difficult words with my own words when studying.

8. (From junior high school days to university graduation), I always tried to understand what the teacher was saying even when it was difficult to understand.

9. (From junior high school days to university graduation), I tried to remember what the teacher said in class so that I could answer the questions correctly while doing my homework.

10. (From junior high school days to university graduation), I tried to collect hints and clues from the lessons and books when studying for the exams.

11. (From junior high school days to university graduation), I think I got good marks in science.

12. (From junior high school days to university graduation), I felt that I was strong in science study.

13. (From junior high school days to university graduation), I was confident that I could go on studying science.

14. (From junior high school days to university graduation), I think I studied for science well.

15. (In my elementary school days), I was confident that I could go on studying science.

16. (In my elementary school days), I think I studied science well.

17. (In my elementary school days), I think I got good marks in science.

18. (In my elementary school days), I thought I was strong in science study.

19. (From junior high school days to university graduation), I studied science with my friends.

20. (From junior high school days to university graduation), my friends and I taught each other and gave questions to each other in science study.

21. (From junior high school days to university graduation), I consulted with someone about the difficulties I had with studying science.

22. (In my elementary school days), I studied science together with my friends.

23. (In my elementary school days), I consulted with someone about the difficulties I had with studying science.

24. (In my elementary school days), my friends and I taught each other and gave questions to each other in science study.

25. (From junior high school days to university graduation), I drew pictures and illustrations in my notebook when studying science.

26. (In my elementary school days), I studied science associating it with my daily life.

27. (In my elementary school days), I studied science associating it with things I knew well or I was interested in.

28. (From junior high school days to university graduation), I studied science associating it with things I knew well or I was interested in.

29. (In my elementary school days), I thought that studying science would prove beneficial to me in the future.

30. (From junior high school days to university graduation), I studied science associating it with my daily life.

31. (From junior high school days to university graduation), I thought that studying science would prove beneficial to me in the future.

32. (From junior high school days to university graduation), I envisioned the time when I would be accepted to the school I wanted to attend.

33. (In my elementary school days), I drew pictures and illustrations in my notebook when studying science.

34. (In my elementary school days), I could feel at ease when studying science.

35. (In my elementary school days), I felt calm and relaxed when studying science.

36. (In my elementary school days), I could study science without anxiety.

37. (From junior high school days to university graduation), I felt calm and relaxed when studying science.

38. (From junior high school days to university graduation), I could study science without anxiety.

39. (From junior high school days to university graduation), I could feel at ease when studying science.

40. (In my elementary school days), I wrote down the points of what I learned so that I could understand better.

41. (In my elementary school days), I reorganized my notebooks so that I could remember what I learned while studying.

42. (In my elementary school days), I worked at exercises by myself in addition my homework.

43. (In my elementary school days), when studying for the exams, I reviewed the lessons, remembering the important things again and again.

44. (In my elementary school days), I applied what I had learned before to the new assignment (task) given.

45. (In my elementary school days), I envisioned the time when I would be accepted to the school I wanted to attend.

46. (In my elementary school days), I tried to remember what the teacher said in class so that I could answer the questions correctly while doing my homework.

47. (In my elementary school days), I always tried to understand what the teacher was saying even when it was difficult to understand.

48. (In my elementary school days), I tried to collect hints and clues from the lessons and books when studying for the exams.

49. (In my elementary school days), I carried out my studies even though the content was boring and uninteresting.

50. (In my elementary school days), I replaced important and difficult words with my own words when studying.

51. (From junior high school days to university graduation), I easily got tired when studying science.

52. (From junior high school days to university graduation), I often got tired easily and gave up when working out a difficult problem in science.

53. (In my elementary school days), I often got tired easily and gave up when working out a difficult problem in science.

54. (In my elementary school days), I easily got tired when studying science.

55. (In my elementary school days), I felt uneasy and nervous while studying science.

56. (From junior high school days to university graduation), I was felt uneasy and nervous while studying science.