Science Subjects Studied and Relation to Income after University Graduation —An Empirical Analysis in Japan*

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This paper examines the effect of science education during the high school education how science graduates of universities are evaluated in the labor market. We conducted two online research projects and studied the subjects they were good, the size of companies where initially employed, employment status, and current income. The results show that among science graduates, workers adept at physics tend to have higher incomes compared to workers good at other subjects. Generational analysis based on the curriculum guideline amendments shows that the generational gap is small among science majors who are good at physics.

INTRODUCTION

This paper studies how science education during the high school periods affects performance at work of the science graduates of universities. Previous studies on educational returns include research on college credits completed and annual income by Kane and Rouse (1995). Tostel, Walker, and Wooley (2002) as well as Brunello and Comi (2004) performed an international comparison on educational returns. Willis (1986) and Card (1999) researched even broader returns of college education. On the other hand, O'Leary and Sloane (2005) collected data in the United Kingdom on college graduates and analyzed the rate of return according to the departments they graduated from. Previously, we identified the impact of mathematics in Japanese high schools on income (Hirata et al. 2006). In addition, we conducted two independent surveys in 2011, and collected the data on the employment status after college, the size of companies where initially employed, employment status, and current income, and we also checked the robustness of the survey results.

In our study (Nishimura et al. 2006), we found that math learning positively impacts the income of workers who graduated from humanities departments (social science) at private universities. In addition, Hirata et al. (2013a) conducted a web survey[1] targeting a broader sample, including science major students. Their study revealed that employees who majored in science tend to have higher incomes than those who majored in humanities regardless of the difficulty level of the university/department admission.

Science graduates show some disproportionate emphasis on certain subjects. This paper focuses on physics, chemistry, biology, and earth science to employ a generational analysis using questions (e.g., Which subject strongly impacts employment status and income earning capacity? Which subjects are (are not) useful?). A web survey was conducted to examine the impact of studying scientific subjects on the income of science graduates as well as various private and public university graduates from different perspectives.

This paper consists of five sections. The second section overviews the web survey and characteristics of the data used for the analysis. The third section discusses about subjects respondents think useful and they want future generations to study. The fourth section highlights the size of the company that the respondents initially worked for, current employment status, and current income level to elucidate the gap induced by different levels of science and math learning. The fifth section sums up the observations made in this research and discusses future challenges.

DATA

Research Overview

We conducted two online surveys: Survey N and Survey G. Both survey inquired about the name of the university and the department that the respondents graduated from. Then respondents were divided into science graduates and humanities graduates. Humanities majors mainly hold degrees in liberal arts and social science, while science majors include science, engineering, medicine, agriculture, and biology. The information fields were sorted comprehensively based on the university and department. Then information business fields were categorized humanities, while information technology was categorized into as science and engineering. Art, home economics, and food were classified as humanities. Because this study focuses on science graduates, any ambiguous majors were categorized as humanities.

They are briefly reviewed below. Survey N was conducted via Nikkei Research in February 2011 as part of a project by the Research Institute of Economy, Trade and Industry (REITI) titled, "Fundamental Research for the Construction of a Vibrant Economy and Society in Japan." 100,000 people were randomly selected to answer the survey from a population of 169,536 monitors registered with Nikkei Research. We eventually extracted people with at least a university degree, and received 11,399 responses. The following analysis is based on these 11,399 answers.

Using the Survey N data we discussed the average income of science graduates based on the scientific subjects they are good at in Hirata et al. (2013b) and Nishimura et al. (2013). In Section 3 of the present paper we will discuss which subjects respondents think useful and which subjects they want future generations to study based on the Survey N.

Survey G was a web survey titled, "Survey on School Education and Working Style" conducted through Goo Research in February 2011. From 6.6 million monitors registered with Goo Research, the survey extracted ones with at least an undergraduate degree. There were 13,059 respondents, who were used in the analysis. The response rate of Survey G was very high. Based on this categorization, 3,456 were science graduates (average age: 43.7) or nearly 30%, while 7,879 or 70% (average age: 42.5) were humanities graduates. In section 4 below we study the size of the company of initial employment, the initial employment status and the current income of the science graduates using the Survey G data. Science and humanities majors were differentiated in the same manner as Survey N. According to this categorization, there were 4,083 science graduates (average age: 44.4) or 31.3% of the sample population, and 8,976 people (average age: 42.5) humanities graduates or 68.7% of the sample population.

Data Characteristics

When evaluating the age and income distributions in Survey N, the average age was 42.9 years with a standard deviation of 9.98 years. The age distribution mostly follows a normal curve. The gender breakdown was 59.7% male and 40.3% female. The average annual income was 4,833,000 yen with a standard deviation of 4,064,829 yen.

In terms of major variables in the Survey G data characteristics, 68.0% of the respondents were male and 32.0% were female. The age ranged widely from 24 to 74 years with an average age of 43.1 years and a standard deviation of 11.0 years. Of the respondents, 62 (0.5%) graduated from overseas universities. The annual income was 4,721,000 yen on average with a standard deviation of 3,822,000 yen. The largest frequency was found in the 4,000,000 to 5,990,000 yen range, and the distribution is right-skewed. In the analysis, the samples were divided into three generations: Generation A (born before March 1966), Generation B (born between April 1966 and March 1978), and Generation C (born after April 1978).

USEFUL AND USELESS SUBJECTS AS WELL AS TOPIC THAT SHOULD BE STUDIED MORE

The disproportionate emphasis on particular scientific subjects was examined using the data from Survey N. Figures 1 and 2 depict subjects the humanities and science graduates considered useful, respectively. Figure 3 shows the subjects that the respondents considered useless, while Figure 4 shows topics that the respondents wished they had studied more. Figures 5 and 6 show the subjects that humanities graduates and science graduates want future generations (their children and grandchildren) to study, respectively. The results are compared by the three generations (A, B, and C).

Humanities graduates indicated that English followed by Japanese, math, and social studies **have** been the most useful. Around 15% of Generations A and B said math is most important, while only 12.4% of Generation C think so. (See Figure 1). This reflects the fact that the percentage of math learners is decreasing.

On the other hand, science graduates found math to be most useful followed by science and then English. However, 41.1% of Generation A, 38.0% of Generation B, and only 30.1% of Generation C indicated that math is most important. (See Figure 2). The younger the generation is, the higher the percentages of English and science become. On the other hand, 19.4% of Generation A found science to be useful, while 22.9% of Generation B and 24.2% of Generation C found science to be useful.

FIGURE 1
SUBJECTS THAT HUMANITIES GRADUATES FOUND USEFUL
(Employed Respondents, Survey N)

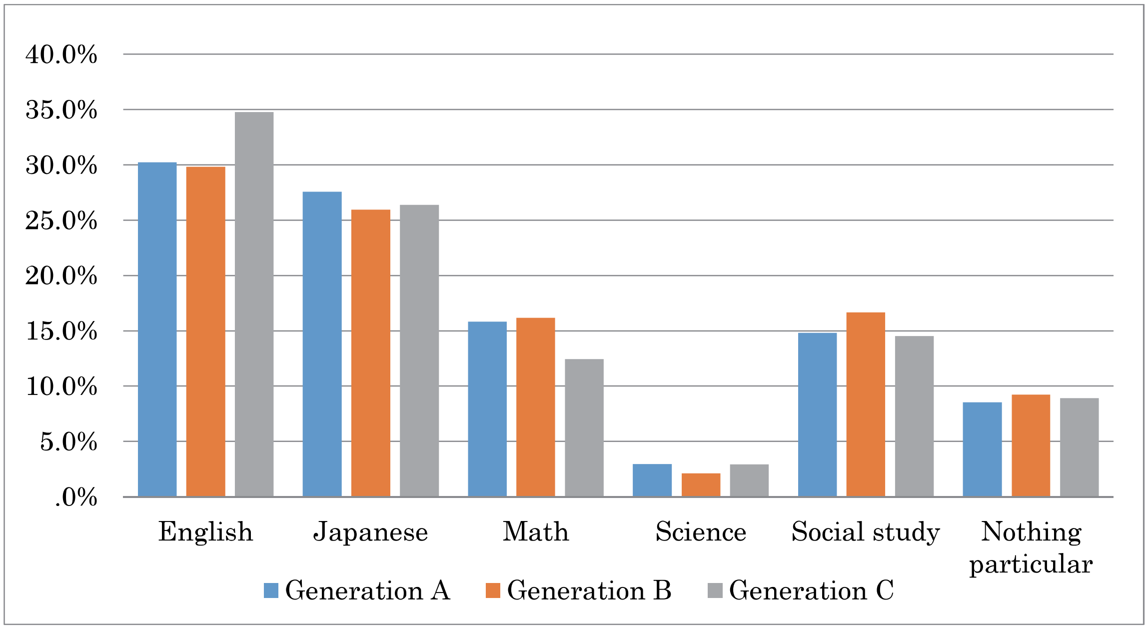
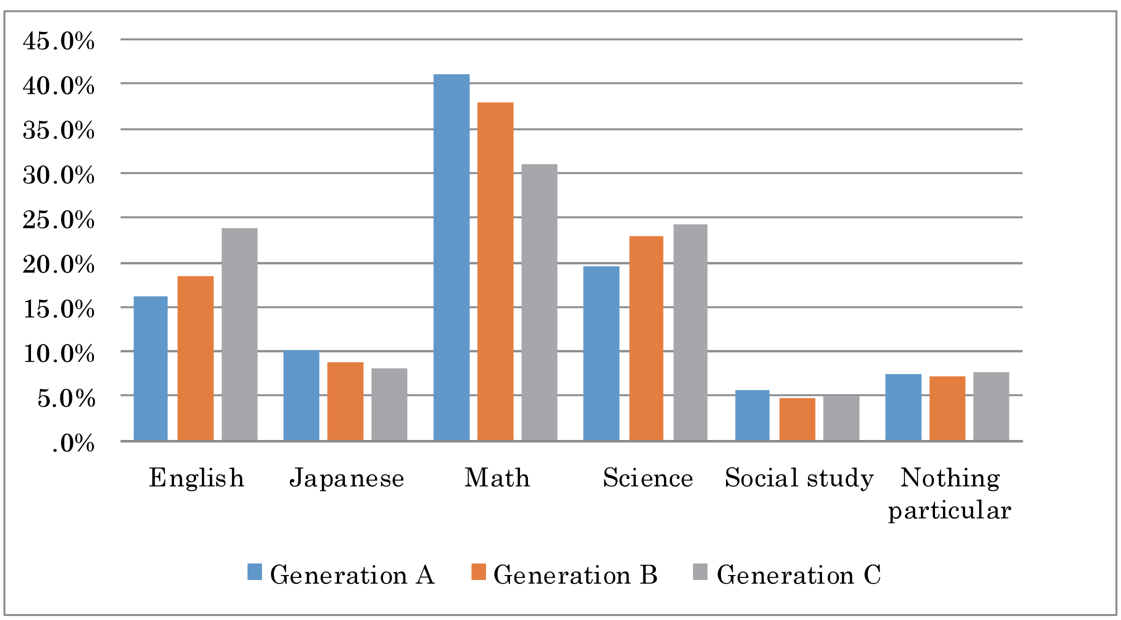
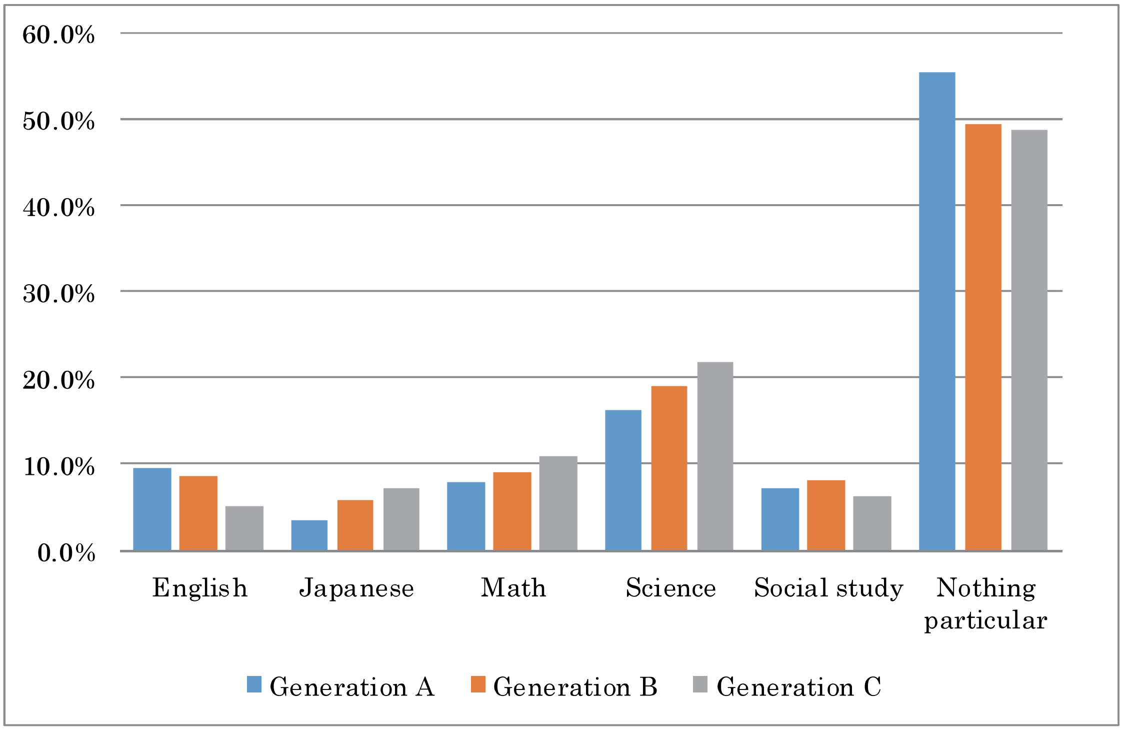


FIGURE 2
SUBJECTS THAT SCIENCE GRADUATES FOUND USEFUL
(Employed Respondents, Survey N)



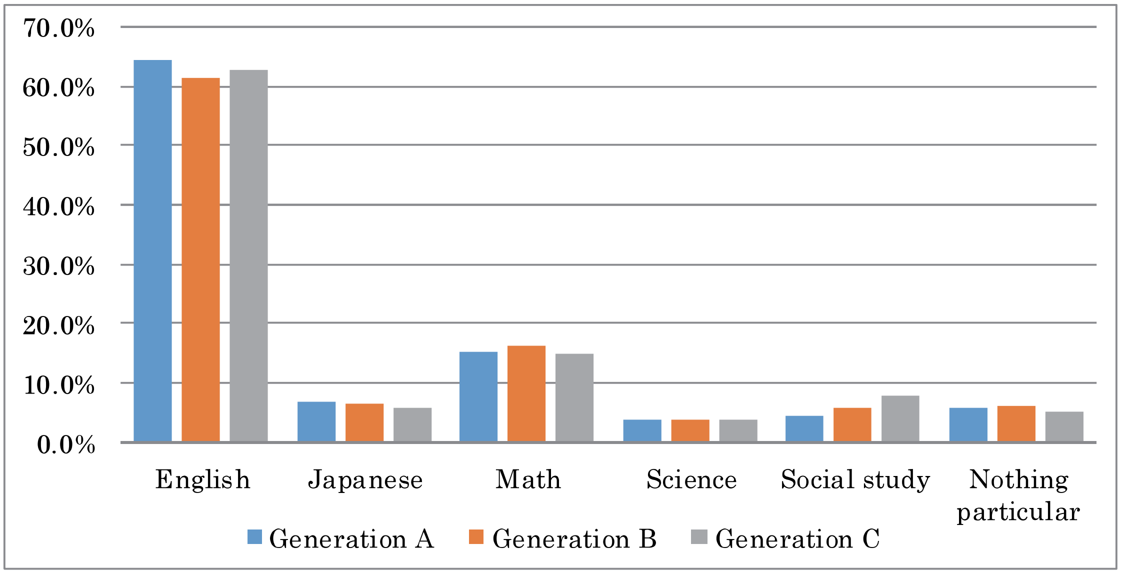
On the contrary, the subjects that respondents found useless show the same tendency regardless of major. (See Figure 3). Almost 60% of the respondents said "nothing in particular." Because all five subjects are basic and provide a foundation for something, it was unlikely that respondents are certain about a particular subject being useless. However, 20% of the respondents found science to be useless; this tendency is stronger among the younger generation, which may be a reflection of the fact that fewer people are studying science.

FIGURE 3
SUBJECTS THAT RESPONDENTS FOUND USELESS
(Employed Respondents, Survey N)



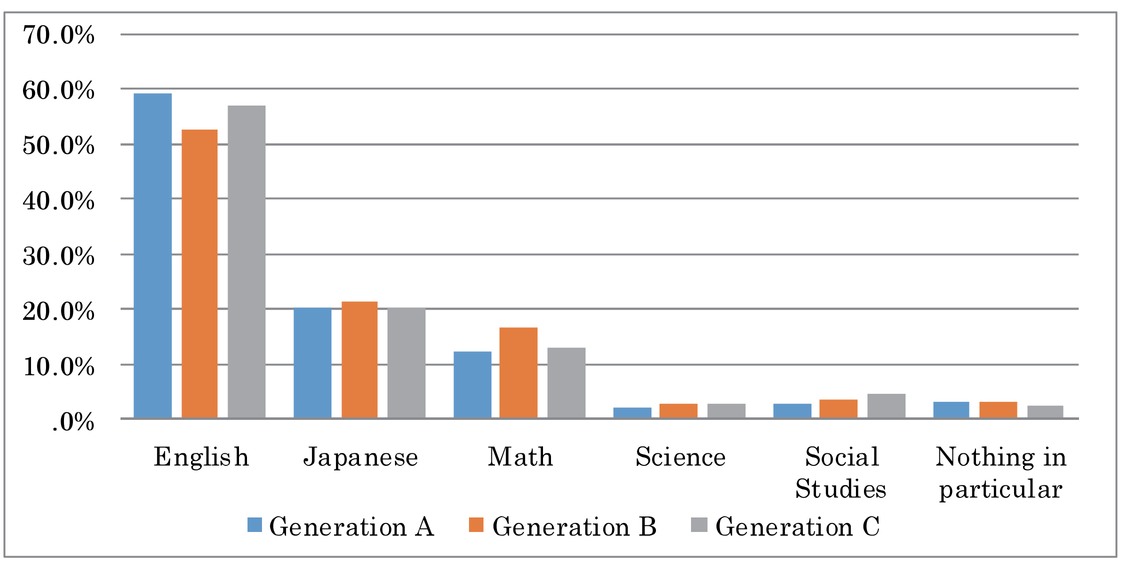
Among the subjects that respondents think they should have studied harder, English is the most prominent (over 60%) followed by math. There is not a remarkable generational gap in any subject. (See Figure 4). The subjects that they should have studied harder reflect the importance of the subject as perceived through employment opportunities in their adult lives. Although the subjects that the respondents are good/bad at or found to be useful/useless significantly differ between humanities and science graduates, the subjects that they wished they studied more are similar (English followed by math). It is noteworthy that humanities graduates also identified the importance of math.

FIGURE 4
SUBJECT THAT RESPONDENTS WISHED THAT THEY HAD STUDEIED MORE
(Employed Respondents, Survey N)



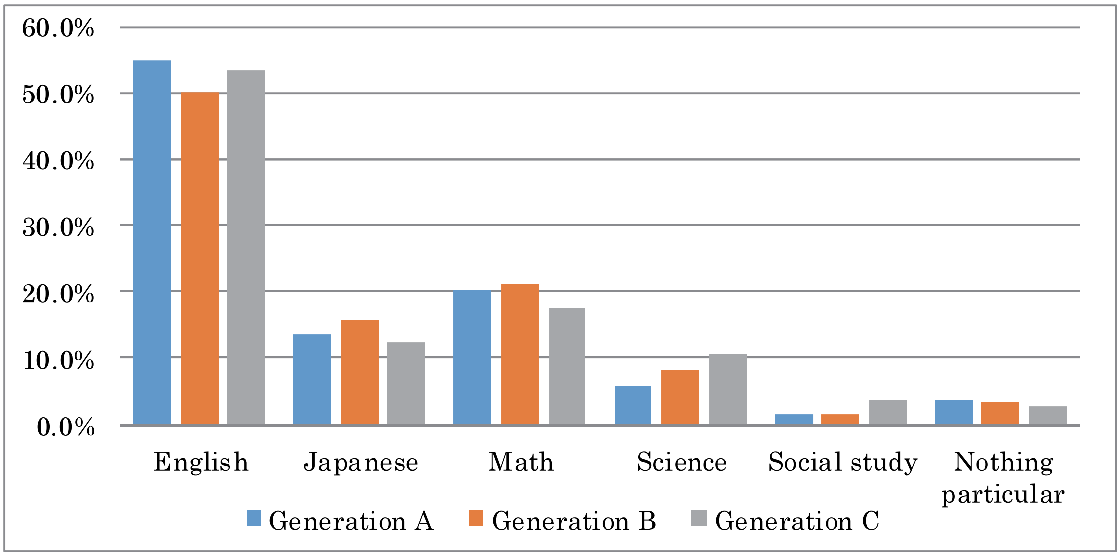
The subjects that people want future generations to study more can be interpreted as the ones that are important in society regardless of specialty or preference. (See Figure 5 and 6). Given the fact that English is foremost on the list and based on the trend of other subjects, these subjects are mostly the same as those that people regret not personally studying more. The only difference is that Japanese outnumbers math among humanities graduates.

FIGURE 5
SUBJECTS THAT HUMANITIES GRADUATES WANT FUTURE GENERATIONS TO STUDY
(Employed Respondents, Survey N)



Among humanities graduates, all generations showed identical preferences. It is noteworthy that humanities graduates also think math is important. However, more science majors noted math. Science is less likely to be chosen by humanities graduates regardless of their generation. However, it is noteworthy that the younger the generation is, the more science graduates want future generations to study science.

FIGURE 6
SUBJECT THAT SICENCE GRADUATES WANT FUTURE GENERATIONS TO STUDY
(Employed Respondents, Survey N)



EVALUATION IN THE LABOR MARKET BASED ON THE SCIENTIFIC SUBJECTS THAT SCIENCE GRADUATES ARE GOOD AT

Next we looked at how science graduates are evaluated in the labor market based on the scientific subject they were good at using the data obtained in Survey G. Figures 7 and 8 show the scientific subjects the respondents are good and bad at by generation, respectively. The percentage of people adept at physics decreases significantly for the younger generation, whereas those good at biology shows the opposite trend (Fig. 7). Figure 8 shows that the percentage of people who are inept at physics is quite high; nearly 50% of the entire sample is bad at physics in Generations B and C.

FIGURE 7
GOOD AT SCIENCE SUBJECT BY GENERATION
(Survey G)

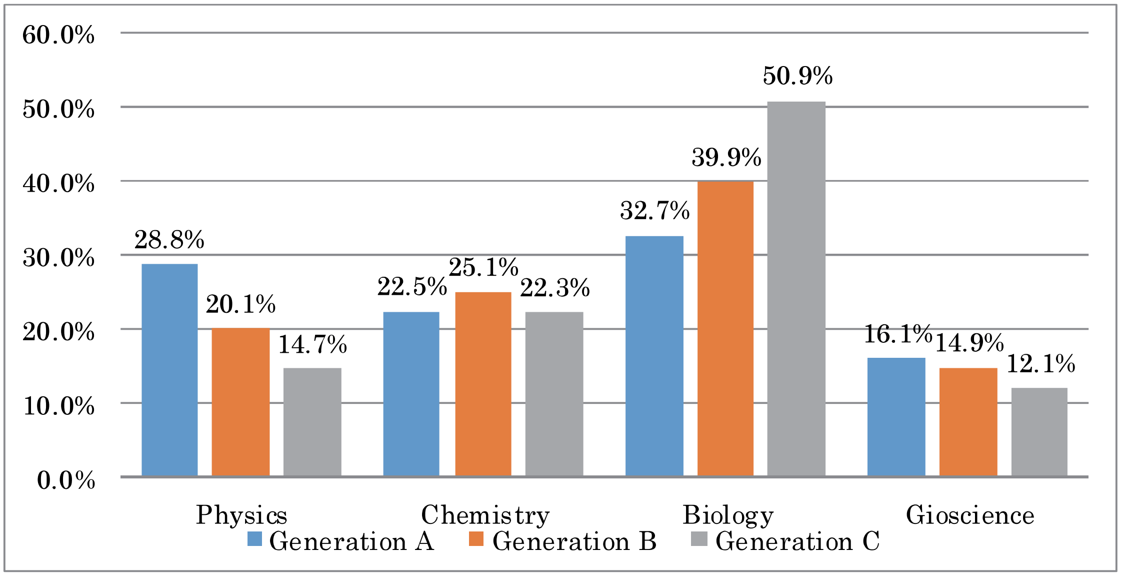
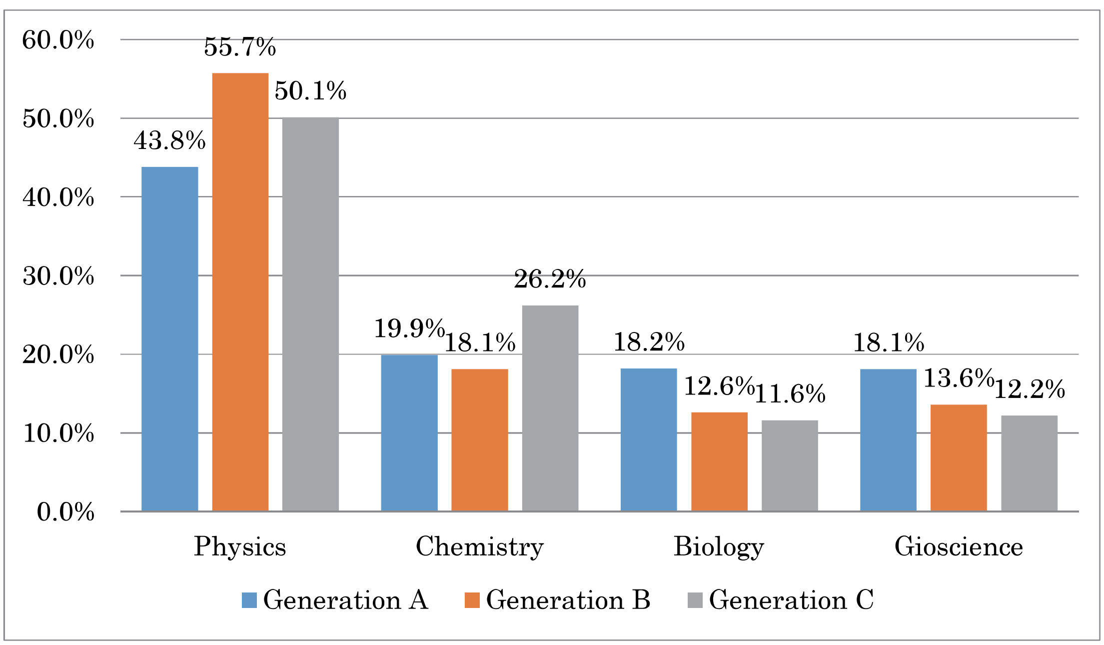


FIGURE 8
BAD AT SCIENCE SUBJECT BY GENERATION
(Survey G)



Size of the Company of Initial Employment

First, we looked at the size of the companies where the respondents were initially employed, and compared the companies based on the scientific subjects the respondents are good at. Since the income gap among graduates should be very small at their first jobs, the size of the companies may reflect how new graduates are evaluated in the labor market.

FIGURE 9
SIZE OF THE COMPANY WHERE THE SCIENCE GRADUATES WERE INITIALLY EMPLOYED BASED ON THE SUBJECTS THAT THEY WERE GOOD AT
(Survey G)

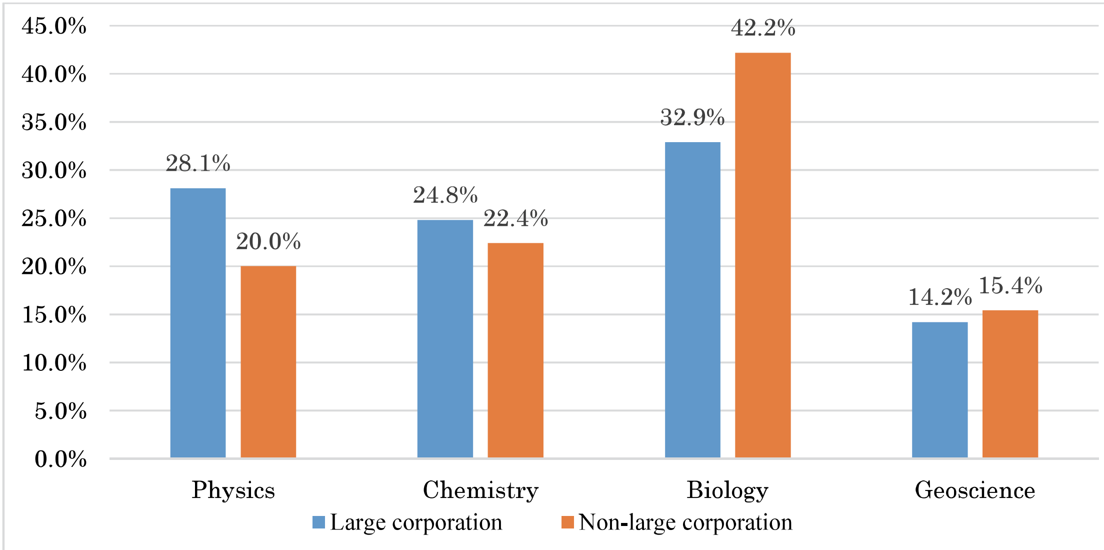


Figure 9 shows the percentage of large corporations and non-large corporations based on the subjects that science graduates are good at. Here a large corporation means a company with over 1,000 employees or a public institution. All other companies are defined as non-large corporations. According to the figure, the percentage of large corporations is higher among people who are good at physics, while the percentage of non-large corporations is higher among people who are good at subjects other than physics. The percentage of non-large corporations is much higher (42.2%) for those good at biology.

Next, we performed a logit analysis with an explained variable, which is a dummy that takes a value of 1 for a large corporation and 0 for a non-large corporation. Table 1 shows the results. Here, people who are good at earth science are introduced as a reference group. The analysis found that a dummy variable for being good at physics has a significant positive impact on the explained variable, indicating that learning physics leads to a relatively stronger competitive edge in the labor market for new graduates.

In Table 1, the dummies for Generation A and Generation B take values of 1 when the person is in Generation A and B, respectively. The reference group is the younger Generation C. The sample size of the three generations (percentage of the 4046 science graduates who provided information about their first job) are 1955 (48.3%), 1541 (38.1%), and 550 (13.6%), respectively.

TABLE 1
COMPANY SIZE DETERMINANTS FOR SCIENCE GRADUATES' FIRST JOB
(Survey G)

	B	Standard	Wald	Degree	Significance	Exp (B)
Dummy for being good at physics	0.448	0.148	9.178	1	0.002	1.565
Dummy for being good at chemistry	0.147	0.151	0.936	1	0.333	1.158
Dummy for being good at biology	−0.213	0.169	1.600	1	0.206	0.808
Dummy for Generation A	0.123	0.101	1.459	1	0.227	1.130
Dummy for Generation B	0.084	0.102	0.681	1	0.409	1.088
Dummy for male	0.309	0.099	9.664	1	0.002	1.361
constant	−0.637	0.182	12.286	1	0.000	0.529
-2 log-likelihood: 5434.442, Cox & Snell R Square: 0.020, Nagelkerke R Square: 0.026						

Initial Employment Status

Next we examined the impact of learning math and science subjects on whether a person is employed as a regular worker. According to a Labor Force Survey by the Statistics Bureau of Japan, the percentage of irregular workers was around 20% in 1990 and increased to 34.4% by 2010, showing that irregularization of workers has persisted for a long time. It is not uncommon for new graduates to have no choice but to work as irregular workers. Thus, we can assume that finding regular work at one's first job also reflects how the worker is evaluated in the labor market.

Regarding their initial employment status based on the department the worker studied, regular workers represent 93.7% of the science graduates, but only 85% of humanities graduates. On the other hand, irregular workers comprise 4.8% of science graduates, but 12.1% of humanities graduates.

These results were analyzed by science major. Table 2 shows initial employment statuses of Generations A, B, and C science graduates by subject. The percentage of regular workers decreases for the younger generation except science graduates who are good at earth science. However the total numbers are 59 and 14, respectively. Because this is regarded as an exception, earth science is excluded from the following discussion.

TABLE 2
INITIAL EMPLOYMENT STATUSES OF SCIENCE GRADUATES BASED ON THE SUBJECTS THEY WERE GOOD AT BY GENERATION
(Survey G)

		Sample Size	Initial employment status				
			Regular worker	Irregular worker	Self-employed/Entrepreneur	Family business	Other
Generation A	Physics	1010	96.2%	2.3%	0.4%	0.6%	0.5%
	Chemistry	586	94.4%	3.1%	0.9%	1.2%	0.5%
	Biology	221	92.8%	4.5%	0.0%	0.9%	1.8%
	Earth Science	138	94.2%	4.3%	0.0%	0.7%	0.7%
Generation B	Physics	677	95.6%	3.8%	0.1%	0.1%	0.3%
	Chemistry	595	92.9%	5.9%	0.3%	0.3%	0.5%
	Biology	210	89.5%	8.6%	0.5%	0.5%	1.0%
	Earth Science	59	91.5%	5.1%	0.0%	3.4%	0.0%
Generation C	Physics	203	92.1%	7.9%	0.0%	0.0%	0.0%
	Chemistry	214	87.9%	10.3%	0.5%	0.9%	0.5%
	Biology	119	84.0%	15.1%	0.8%	0.0%	0.0%
	Earth Science	14	92.9%	7.1%	0.0%	0.0%	0.0%

It should be noted that the gap between scientific subjects they are good at is increasing by generation. People who are good at physics have the highest percentage of regular workers (and the lowest percentage of irregular workers), and the decrease in the regular worker ratio from Generation A to C is low (4.1% among physics majors). On the other hand, the decrease is 6.5% for chemistry and as high as 8.8% for biology. People who are good at biology have the lowest percentage of regular workers and the highest percentage of irregular workers, which is the opposite trend of those good at physics. This observation suggests that similar to company size, the capacity built by learning physics is evaluated relatively high in the labor market for new graduates.

Current Income

The income of workers is the simplest metric to evaluate the labor in a market. First, wage is determined at the point where demand and supply match in the labor market. The demand for engineers depends on their contribution to labor productivity, and the worker demand originating from the supply–demand conditions in the goods market. The latter means that when development of biotechnology causes biotechnology market growth, the demand for engineers who can produce biotechnological products increases, driving the wage level upward. In addition, when the demand for semiconductor-related products increases, workers with a physics background are in demand, causing their wage level to rise.

On the other hand, the supply of engineers depends on the difficulty of mastering technical expertise and skills. For example, if physics is quite difficult to master, fewer workers have expertise in this area.

Thus, the higher the demand for this type of worker, the more their wage increases. Therefore, if workers' average age and the age distribution are at the same level when comparing incomes based on their attributes, income can be an evaluation index that reflects various conditions in the labor market.

Figure 10 shows the average income (unit; 10,000 yen annually) of science graduates based on the scientific subjects they are good at. Table 3 shows the base data for Figure 10 by generation. The average income is highest (6,609,000 yen) for physics followed by 6,406,000 yen for earth science.[2] When looking at the data based on generation, physics remains the highest, but is followed by biology and chemistry for Generation A and Generation C, respectively.

However, there is a significant difference in the standard error values between physics and earth science. The standard error was calculated by dividing the standard deviation by the square root of sample size, representing the dispersion of sample means. In other words, it is an index that represents the reliability of the sample means. The larger the standard error is, the lower the reliability is. The standard error for earth science is large (27.9) whereas that for physics is small (8.79), demonstrating the difference in reliability.

FIGURE 10
AVERAGE INCOME BASED ON THE SCIENTIFIC SUBJECT THAT SCIENCE GRADUATES ARE GOOD AT (10,000YEN) BY GENERATION
(Survey G)

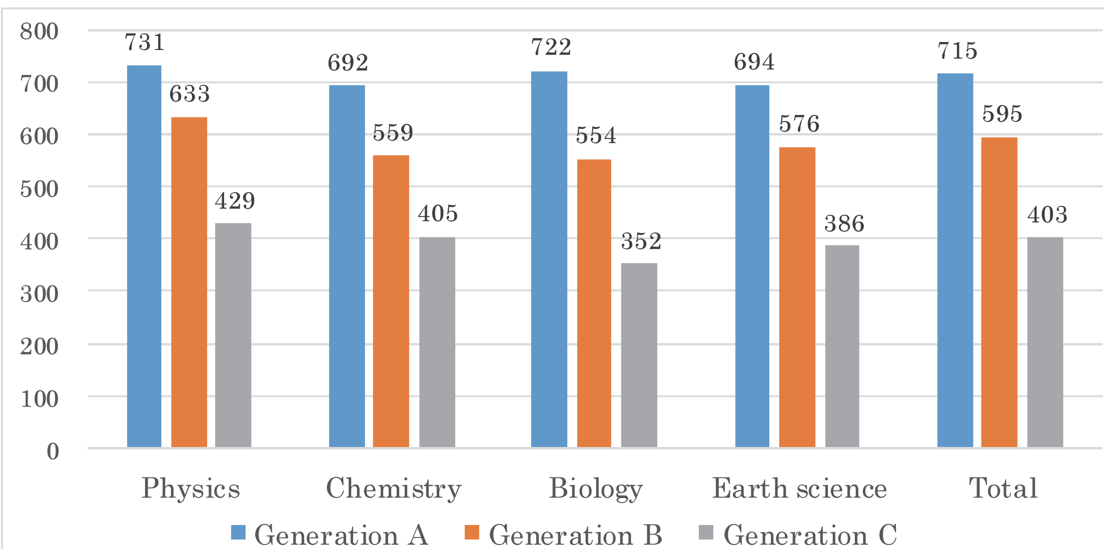


TABLE 3
AVERAGE INCOME (UNIT:10,000YEN) BASED ON THE SCIENTIFIC SUBJECT THAT SCIENCE GRADUATES ARE GOOD AT BY GENERATION
(Survey G)

The scientific subject they are good at	All samples			Generation A			Generation B			Generation C		
	Frequency	Ave. Income	Ave. Age	Frequency	Ave. Income	Ave. Age	Frequency	Ave. Income	Ave. Age	Frequency	Ave. Income	Ave. Age
Physics	1792	660.9	45.4	938	730.7	53.4	652	632.5	38.8	202	428.7	29.0
Chemistry	1295	589.9	43.1	542	691.9	53.3	544	559.2	38.3	209	405.3	29.0
Biology	501	576.6	41.6	201	721.9	52.2	189	554.0	38.0	111	352.3	28.4
Earth Science	202	640.6	47.5	133	694.0	52.9	55	576.4	39.1	14	385.7	29.3
Total	3790	624.4	44.2	1814	715.4	53.2	1440	592.4	38.5	536	402.6	28.9

When looking at the average annual income in Survey N (unit: 10,000 yen) based on the scientific subject that science graduates are good at (Fig. 11 and Table 4), the income is highest for physics followed by chemistry, earth science, and biology. This tendency is relatively consistent among the three generations. Age is a major determinant of income level. Table 4 considers the average age, but the difference between subjects is insignificant.

FIGURE 11
AVERAGE INCOME BASED ON THE SCIENTIFIC SUBJECT THAT SCIENCE GRADUATES ARE GOOD AT (10,000 YEN) BY GENARATION
(Survey N)

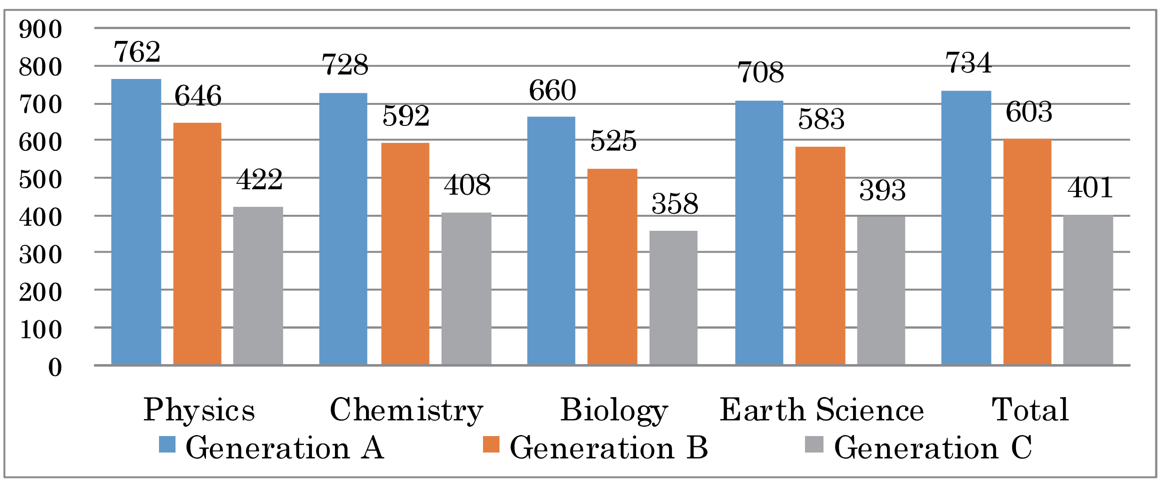


TABLE 4
AVERAGE INCOME (UNIT: 10,000YEN) BASED ON THE SCIENTIFIC SUBJECT THAT SCIENCE GRADUATES ARE GOOD AT BY GENERATION
(Survey N)

The scientific subject they are good at	All samples			Generation A			Generation B			Generation C		
	Frequency	Ave. Income	Ave. Age	Frequency	Ave. Income	Ave. Age	Frequency	Ave. Income	Ave. Age	Frequency	Ave. Income	Ave. Age
Physics	1397	681.4	44.9	768	762.2	52.4	452	645.6	38.3	177	422.0	29.1
Chemistry	1148	620.0	43.0	497	728.2	52.7	458	591.7	38.4	193	407.8	29.1
Biology	499	548.5	41.9	222	660.4	51.5	167	525.1	38.0	110	358.2	28.4
Earth Science	162	646.9	47.0	106	707.5	53.1	41	582.9	38.0	15	393.3	28.9
Total	3206	636.9	43.8	1593	733.9	52.3	1118	603.2	38.3	495	401.4	29.0

The above observations suggest that those who are good at science and math, especially physics, have a relatively stronger competitiveness in the labor market. However, it also indicates that the amendments made to the guidelines by the ministry of education in Japan in the last 30 years have not promoted students majoring or even studying these subjects. Viewed from another perspective, the amendments forced many to study certain subjects disproportionately, creating a situation where students avoid studying science/math subjects, particularly physics. As a result, those who master these subjects increase their logical thinking capacity and are evaluated highly in the labor market.

CONCLUSION

This paper examines the results of two online surveys and evaluates the effect of the science learning on the performance at work (the size of the company and their initial employment status) as well as the current income while considering the influence of the Japanese national curriculum guidelines. Among science graduates, those who are good at physics are likely to earn more compared to those good at other subjects. Also, generational analysis based on the curriculum guidelines amendments shows that, for science major workers who are good at physics, the generational gap is small and the impact of the amendments on the curriculum guidelines has been minimal.

From these observations, it is obvious that building capacity by studying physics leads to a higher evaluation in the labor market and reinforces workers' competitiveness. The findings suggest that studying scientific subjects, especially a foundational subject like physics, broadens employment opportunities and eventually enhances average income.

ENDNOTES

* This study was conducted as part of the "Fundamental Research for Sustainable Economic Growth in Japan" project of the Research Institute of Economy, Trade, and Industry, Tokyo, Japan. We acknowledge the financial support of the Grant-in-Aid for Scientific Research (Nos. 15H05729 and 16H03598).

1. Survey on human resource development (2008, Goo Research)
2. It might be possible that the income gap between physics and biology is due to a gender difference as male respondents are more likely to be good at physics while female respondents are more likely good at biology. Hence, the study compared data among employed male science graduates only, and found that those who are good at physics make 6,732,000 yen on average, 6,324,000 yen for chemistry, 6,540,000 yen for biology, and 6,536,000 yen for earth science. Thus, the study confirms that the relatively higher income among those who are good at physics is not solely a gender difference.

REFERENCES

Brunello, G. and S. Comi. (2004). Education and Earnings Growth: Evidence from 11 European countries, *Economics of Education Review,* 23, 75-83.

Card, D. (1999). The Causal Effect of Education on Earnings, in *Handbook of Labor Economics,* Vol. 3A, 1801-1863, edited by O. Ashenfelter and R. Layard, Elsevier Science Publishers B. V.

Kane, T. J. and C. E. Rouse (1993). Labor Market Returns to Two- and Four-Year Colleges: Is a Credit a Credit and Do Degrees Matter?, NBER working paper, No.4268, Cambridge, MA.

Hirata, J., Nishimura K., Urasaka J. and Yagi T. (2013a). Mathematics & Science Education and Income: An Empirical Study, *Journal of Reviews on Global Economics*, 2, 1-8.

Hirata, J., Nishimura K., Urasaka J. and Yagi T. (2013b). Annual Incomes of University Graduates and their Science Studies during High School Periods, in *Recent Advances in Modern Educational Technologies* edited by Hamido Fujita and Jun Sasaki, 42-45, WSEAS Press.

Hirata, J., Nishimura, K., Urasaka, J., & Yagi, T. (2006). Parents' Educational Background, Subjects "Good-At" in School and Income: An Empirical Study, *The Japanese Economic Review*, 57 (5), 533-546.

Nishimura Kazuo, Hirata Junichi, Urasaka Junko and Yagi Tadashi (2013). Impacts of High School Science Studies on Incomes of Japanese University Graduates, *US-China Education Review* B, Vol.3, (9), 651-662.

O'Leary, N. O. and P. J. Sloane (2005). The Return to a University Education in Great Britain, *National Institute Economic Review* 193 (1): 75-89.

Tostel, P. (2005). Nonlinearity in the Return to Education, *Journal of Applied Economics* 53,(1),191-202.

Tostel, P., I. Walker and P. Woolley (2002). Estimates of the Economic Return to Schooling for 28 Countries, *Labour Economics* 9,1-16.

Wills, R. J. (1986). Wage Determinants: A Survey and Reinterpretation of Human Capital Earnings Functions, in *Handbook of Labor Economics.* Vol. 1. 525-602, edited by O. Ashenfelter and R. Layard. Elsevier Science Publishers B. V.