A cross-cultural comparison of the relationship between motivation and performance in math and science

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Abstract

Prior research suggests that motivation, including intrinsic and extrinsic motivation, is the key to effective math and science learning. In this study international assessment data, including 2011 Trends for International Study of Math and Science (TIMSS) and 2015 Programme for International Student Assessment (PISA), were utilized to examine the relationship between motivation-related variables and test performance in math and science. Asian countries/regions (Taiwan, Hong Kong, Singapore, Japan, and South Korea) and USA were selected for cross-cultural comparison. Because the sample size of these international assessments is very large, data visualization and data mining, which are based on pattern recognition, instead of hypothesis testing, were employed as the primary tools for this study. The data reveal that extrinsic motivation does not necessarily predict performance, especially in USA. According to 2011 TIMSS, whether US Grade 8 students agreed that math can help in their daily life, whether they need math to learn other subjects, and whether they need math to get the job they want have no impact on their math performance. Similarly, 2015 PISA does not show a significant association between instrumental motivation and math/science test scores among US students. Rather, interest in broad science topics and enjoyment of science are powerful predictors of PISA math and science test performance. Cultural differences between Asians and Americans in motivation for math and science are discussed in this presentation.

Introduction

Traditionally, motivation is classified into two major categories, namely, intrinsic motivation and extrinsic motivation (Sansone & Harackiewicz, 2000). Intrinsic motivation is said to be the drive for action arising from internal factors whereas extrinsic motivation is believed to be driven by external factors, such as utility value. Specifically, in the former students might be enthusiastic to learn math and science because knowing the information can bring personal satisfaction, such as appreciating the beauty of nature and appeasing the curiosity by understanding the deeper structure of the universe. On the other hand, students who are externally motivated might focus on the practical values of math and science. A typical example is that engineers and programmers are well-paid professions and thus it is worth the pain to take these challenging majors. This classification is also applicable to many other domains. For example, an artist insisting upon "art for art's sake" is considered intrinsically motivated while a commercial artist displays his work in a for-profit gallery is regarded as extrinsically motivated. Prior research indicates that there is a seesaw relationship between intrinsic motivation and extrinsic motivation. If people care more about materialistic and monetary rewards, they care less about intrinsic values of social wellbeing (Music, 2014). By the same token, some educators refuse to give too many awards or incentives to students because they believe that students who get used to be extrinsically motivated would deplete their intrinsic motivation (Sansone & Harackiewicz, 2000).

Intrinsic motivation is often tied to interest (Eccles, Wigfield, & Schiefele, 1998; Pintrich & Schunk, 2002). Hence, triggering and maintaining interest is said to be the key to effective science and math education (Renninger, Nieswandt, & Hidi, 2015). However, prior research on the motivation mode of Asian students does not appear to be straight-forward. Utilizing TIMSS data, Leung (2002) found that while Hong Kong, Singapore, South Korean, and Japanese students outperformed their Western peers in math performance, they held a negative attitudes towards the subject. Another study shows that while Whites invest more efforts into the subject matter that they like, Chinese student spent equal efforts on all task, no matter whether they are interested in the subject matter or not (d'Ailly, 2004). More importantly, among Chinese students intrinsic and extrinsic motivation tend to co-exist rather than being in opposition (Salili, Chiu, & Lai, 2001).

Method

International assessment data, such as TIMISS and PISA, were utilized. Because the sample size is extremely large, conventional statistical procedures are inappropriate. i.e. given a large sample size, any trivial effect would be mis-identified as significant. Hence, in this study data visualization tools will be utilized to unveil the data patterns.

Results

2011 TIMSS data (Table 1-3) reveal that Asian students who agree a lot to the statements regarding the utility value of math tend to have much better performance than those who agree only a little. However, this difference is not observed among American students. No matter whether they agree a lot or a little, the average scores remain flat. In other words, US students seem to be immune to extrinsic motivation.

Table 1
Averages for math scores of Grade 8 by agreement to "I need math to learn other subjects" [BS4MAOSS]

	Agree a lot		Agree a little		Disagree a little		Disagree a lot	
Country/region	Average	Standard Error	Average	Standard Error	Average	Standard Error	Average	Standard Error
Taiwan	645	(5.3)	620	(3.5)	609	(3.7)	544	(5.3)
Hong Kong	611	(4.9)	590	(3.8)	570	(4.6)	536	(7.8)
Japan	581	(5.2)	575	(2.8)	562	(3.4)	520	(6.7)
S. Korea	650	(4.5)	618	(3.3)	592	(3.3)	563	(6.2)
Singapore	617	(4.2)	611	(3.9)	609	(4.4)	575	(9.5)
USA	**515**	(3.1)	**514**	(2.6)	500	(4.6)	476	(4.1)

Table 2
Averages for math scores of Grade 8 by agreement to "math will help in my daily life" [BS4MAHDL]

	Agree a lot		Agree a little		Disagree a little		Disagree a lot	
Country/region	Average	Standard Error	Average	Standard Error	Average	Standard Error	Average	Standard Error
Taiwan	638	(4.2)	608	(3.3)	597	(4.9)	522	(6.9)
Hong Kong	604	(4.2)	581	(3.9)	561	(5.9)	540	(10.3)
Japan	581	(4.1)	571	(2.7)	564	(4.2)	520	(7.3)
S. Korea	639	(5.0)	612	(3.0)	610	(3.8)	591	(5.5)
Singapore	615	(4.1)	607	(4.1)	613	(4.9)	585	(8.3)
USA	**512**	(2.9)	**512**	(2.8)	508	(3.5)	485	(4.7)

Table 3
Averages for math scores of Grade 8 by agreement to "I need math to get the job I want" [BS4MAGET]

	Agree a lot		Agree a little		Disagree a little		Disagree a lot	
Country/region	Average	Standard Error	Average	Standard Error	Average	Standard Error	Average	Standard Error
Taiwan	642	(4.8)	622	(4.3)	609	(3.4)	547	(4.9)
Hong Kong	604	(4.2)	586	(3.6)	577	(5.3)	515	(8.8)
Japan	585	(5.0)	572	(2.9)	564	(2.9)	528	(5.7)
S. Korea	650	(3.6)	611	(3.2)	586	(3.5)	550	(5.9)
Singapore	609	(4.3)	612	(3.7)	627	(5.0)	575	(9.7)
USA	**514**	(2.8)	**512**	(3.2)	501	(5.1)	486	(4.7)

Results (continued)

2015 PISA data indicate that while there is a positive relationship between test performance in math and science and instrumental motivation in Asia, the regression line of USA students is almost flat (Figure 1 & 2).

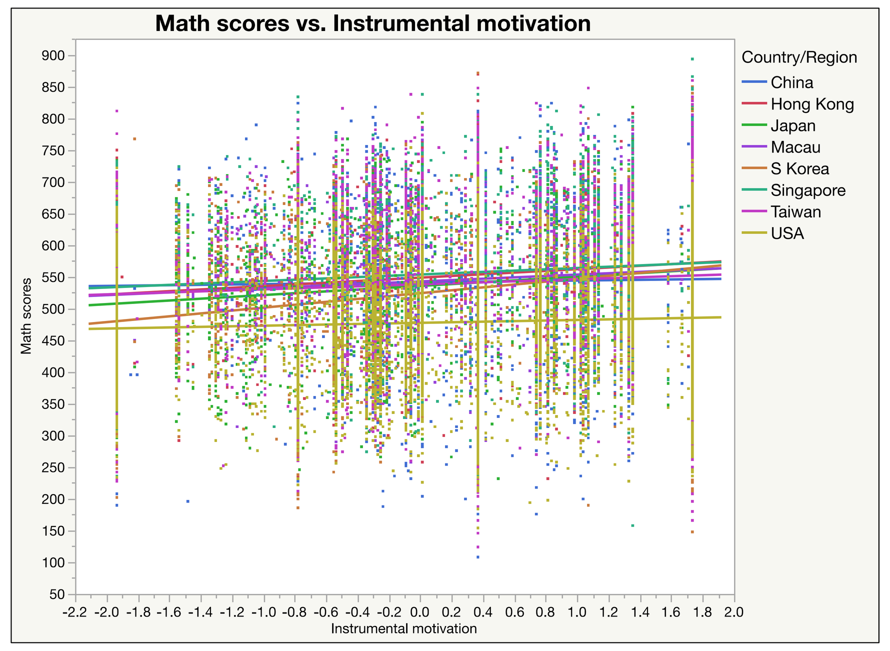

Figure 1

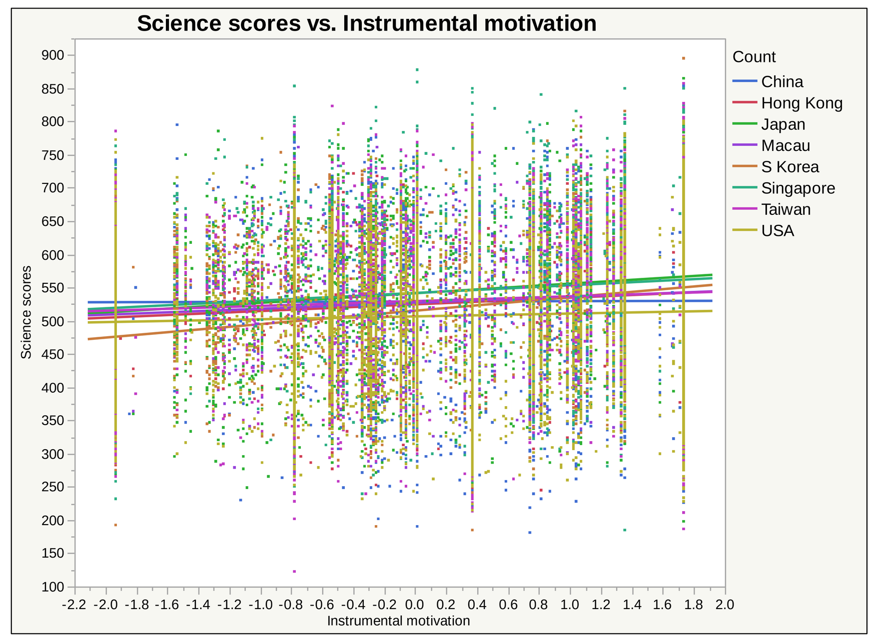

Figure 2

PISA data also show that there is no seesaw association between intrinsic motivation and extrinsic motivation. Figure 3 shows only the scatterplot matrix of enjoyment of science (intrinsic), interest in broad science topics (intrinsic), and instrumental variable using observations of USA and East Asian students (n = 54,978). It is apparent that the data cloud shows no pattern between instrument motivation and the two variables related to intrinsic motivation.

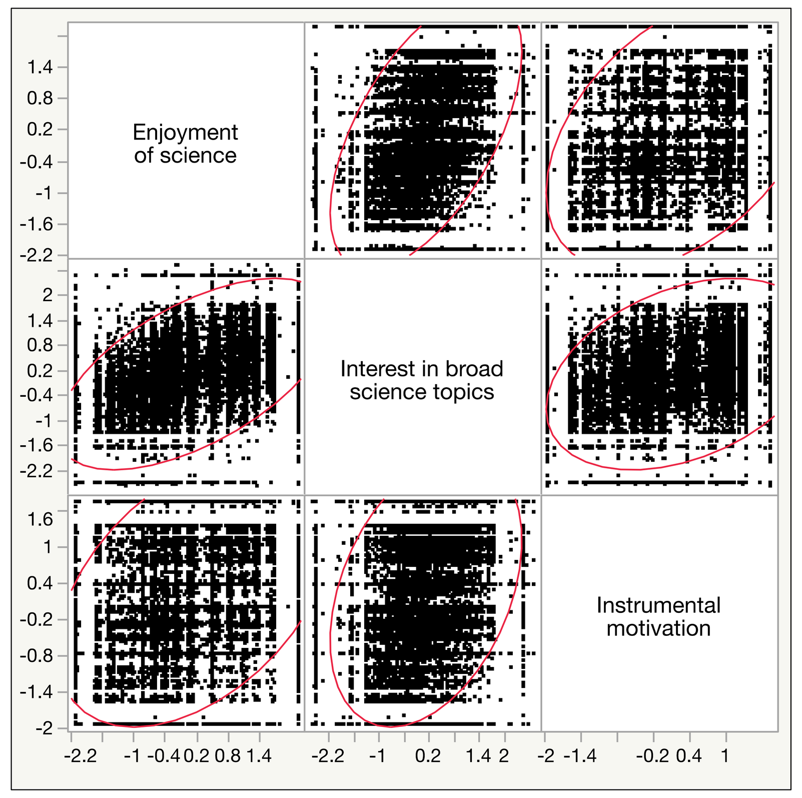

Figure 3

Table 4 shows the descriptive statistics of test performance and intrinsic motivation. Interestingly, the mean scores of enjoyment of science and interest in science of Hong Kong students are both higher than that of US students.

Table 4

	Math scores		Science scores		Enjoyment of science		Interest in science	
Country/Region	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Hong Kong	550.55	88.48	525.60	79.58	0.27	1.06	0.25	1.02
USA	474.35	87.92	502.60	98.04	0.24	1.07	0.04	0.97

Conclusion

In summary, large-scale international assessment data, including TIMSS and PISA, suggest that Hong Kong and other Asian students are motivated by so-called extrinsic factors while US students, to some extent, are immune to this type of motivation. Further, PISA data show that there is no seesaw relationship between intrinsic and extrinsic motivation. Specifically, Hong Kong students who are extrinsically motivated also show a higher mean score in "interest in broad science topic" and "enjoyment of science" than their American peers.

What is the implication for education reform in the US? In the US it is very common for teachers, professors, and parents to give this type of advice to children and youths: "Follow your heart. Don't do something that you don't have a passion for." In this sense intrinsic motivation seems to be the primary motivator. As mentioned before, many US researchers believe that triggering and keeping interest is crucial to successful math and science education. In order to make the content interesting, education becomes "edutainment" and usually technology is employed to make learning fun and exciting (Svencer, 2012). Paradoxically, the approach of triggering interest and making things fun turns out to be an extrinsic motivator. Specifically, students will not be motivated to learn math and science, which are inherently difficult and dry, and inevitably cause confusion and frustration. By contrast, Hong Kong educators do not tell students to follow their passion or to do something that they enjoy. The implicit assumption is that usually young children and youths do not know what they like to do in the future. Nonetheless, as Hau and Ho (2010) pointed out, students might start from extrinsic motivation regardless of enjoyment and interest, but as they are maturing, they can internalize the values of the discipline and become both intrinsically and extrinsically motivated.

Selected References

d' Ailly, H. (2004). The Role of Choice in Children's Learning: A Distinctive Cultural and Gender Difference in Efficacy, Interest, and Effort. *Canadian Journal of Behavioural Science / Revue canadienne des sciences du comportement, 36*(1), 17-29. http://dx.doi.org/10.1037/h0087212

Eccles, J. S., Wigfield, A., & Schiefele, U. (1998). Motivation to Succeed. In W. Damon (Series Ed.) & N. Eisenberg (Vol. Ed.), *Handbook of child psychology: Vol. 3. Social, Emotional, and Personality Development* (5th ed., pp. 1017-1095). New York, NY: Wiley.

Hau, K. T., & Ho. I. (2010). Chinese students' motivation and achievement. In M. H. Bond (ed), *Oxford handbook of Chinese psychology* (pp. 188-204). Oxford, UK: Oxford University Press. DOI: 10.1093/oxfordhb/9780199541850.013.0014

Leung, K. S. (2002). Behind the high achievement of East Asian students. *Educational Research and Evaluation, 8*, 87-108.

Music, G. (2014). *The good life: Wellbeing and the new science of altruism, selfishness and immorality*. New York, NY: Routledge.

Pintrich, P. R., & Schunk, D. H. (2002). *Motivation in education: Theory, research, and applications*. Upper Saddle River, NJ: Pearson/Merrill Prentice Hall.

Renninger, K. A., & Nieswadt, M., & Hidi, S. (ed.). (2015). *Interest in mathematics and science Learning*. Washington DC: American Educational Research Association

Sansone, C. & Harackiewicz, J. M. (2000). *Intrinsic and extrinsic motivation: The search for optimal motivation and performance*. Cambridge, MA: Academic Press.

Salili F., Chiu, C., & Lai, S. (2001). The Influence of Culture and Context on Students' Motivational Orientation and Performance. In Salili F., Chiu C.Y., Hong Y.Y. (eds), *Student motivation: The culture and context of learning* (pp. 221-247). Springer, Boston, MA.

Svencer, B. (2012). *EDUtainment: Entertainment in the K-12 classroom*. Seattle, WA: Amazon Digital Services.