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REGULAR ARTICLE

Science Motivation Across Asian Countries: Links among Future-Oriented Motivation, Self-Efficacy, Task Values, and Achievement Outcomes

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Abstract The relationships among future-oriented motivation, self-efficacy, task values of science, and achievement outcomes were investigated among 15-year-olds across four Asian nations who participated in the Program for International Student Assessment (PISA) of the Organization for Economic Cooperation and Development (OECD). The factor structure of theoretical constructs as well as the causal structure of the expectancy-value model is found to be invariant across the four countries. The future goals influence the perceptions of value among the variety of tasks individuals face. Students' subjective task values predict their science-related activities more strongly than did their self-efficacy. Self-efficacy is more strongly linked to competence than is task values in terms of total effects. The results extend the expectancy-value theory into Eastern Asian cultures.

Keywords Expectancy-value theory · Future-oriented motivation · Science motivation · Self-efficacy · Task value

Introduction

As science literacy has become increasingly important nowadays, science knowledge and skills are considered essential requirements for full participation in today's technological society. Moreover, economy relies on the sufficient supply of scientific practitioners. Therefore, evaluating students' science performance has attracted increasing attention over recent decades. The Trends in International Mathematics and Science Study (TIMSS) and Programme for International Student Assessment (PISA) are two known worldwide evaluation of students' performance in mathematics and science.

Results from several assessment cycles showed that most top performing countries/economies are from Asia. For example, the top five countries for PISA 2006 results in science are Finland, Hong Kong, Canada, Taiwan, Estonia, and Japan with Estonia and Japan having the same score. Similar to the PISA assessment, Asian countries topped the list at both fourth and eighth grades for the TIMSS 2011 results in science. At the fourth grade, Singapore, Korea, Hong Kong, Taiwan, and Japan were the top performing countries. At the eighth grade, the top five countries were Korea, Singapore, Taiwan, Hong Kong and Japan. Many studies have shown that students with higher average achievement in mathematics and science have more positive attitudes toward mathematics and science. (Bong 2001; Durik et al. 2006; Eccles(Parsons) et al. 1983; Meece et al. 1990; Mettas et al. 2006; Singh et al. 2002; Watt 2004). In a meta-analysis study on student attitudes toward school, Hattie (2009) found a positive relationship between attitudes toward science and science achievement across 288 studies. Based on the previous findings, one might expect that students in these Asian countries would tend to have higher science self-concept, interest, and enjoyment. On the contrary, students in these Asian countries were found to have lower scores in the affective variables (Kifer 2002; Martin et al. 2012; Organization for Economic Co-operation and Development 2007; Shen 2002; Wilkins 2004). The findings suggest that cultural factors may play a role in affecting the relations between affective factors and science achievement.

There have been a number of motivation constructs such as self-efficacy, interest, goal orientation, utility value, and

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enjoyment. It is important to explore these constructs together because the phenomenon of motivation is complex. For example, students' motivation can be affected by whether they find the subject interesting and place value on the subject. In addition, students' motivation can be affected by their self-efficacy in learning the subject and long-term goals. Expectancy-value theory has been one of the most important models for achievement motivation, which integrates competence-related beliefs and purposes individuals have for doing activities as ways of explaining individuals' achievement (Eccles (Parsons) et al. 1983; Wigfield & Eccles 1992, 2000, 2002). Findings from a variety of studies have indicated that individuals' success expectancy and subjective task values are strong predictors of achievement-related outcomes (Bong 2001; Durik et al. 2006; Eccles (Parsons) et al. 1983; Meece et al. 1990; Watt 2004). However, few studies explored the effects of long-term goals on task value, expectancy, and achievement-related outcomes.

In this study, Taiwan, Japan, Korea, and Hong Kong were chosen because of their top performance. In addition, they are characterized as "Confucian" societies with fierce competition in the public examination (Yang 1998). In general, the Confucian heritage sets high value on education. Success in education is the most important means of social mobility (Organization for Economic Co-operation and Development 2012). It is believed that motivation for student achievement in these societies is largely extrinsic. It would follow that students in Asian countries may have different components of task values. Many studies have investigated relations of expectancy-related belief to science competence from various countries (Kaya & Rice 2010; Valentine et al. 2004). There are fewer cross-cultural studies of task value and less is known about the relations of task value to science achievement-related outcomes.

The main focus of PISA 2006 was science with more than half of the assessment time devoted to science. Additionally, the PISA 2006 survey sought detailed information on students' motivation and attitudes to science, including an individual's general and personal values of science, interest and enjoyment of science, one's self-concept of science, sense of self-efficacy, and motivation orientation (Organization for Economic Co-operation and Development 2006). However, there are few studies that investigated the relations between affective factors and achievement outcome based on the PISA 2006. Özel et al. (2012) examined the relation between affective factors and science achievement based on the PISA 2006 Turkish data set, while Lin et al. (2012) using the PISA 2006 Taiwanese data set. Özel et al. reported that self-concept had a negative effect on science achievement (−.11), while Lin et al. found that self-concept was unrelated to science competence. Since the results are inconsistent and very few studies explored science motivation based on the PISA 2006, this paper attempts to apply expectancy-value theory linking motivation constructs with science achievement-related outcomes based on the PISA 2006 data from four Asian countries. Many key constructs in expectancy-value theory were measured reliably and validly in the PISA 2006 survey. Therefore, the data set thus obtained is valuable in answering the research questions. In particular, each sample well represents the corresponding national population. The results of this study will have high external validity and help elucidate the similarities and differences in motivation constructs across cultures as well as their relations to science competence, in particular, as to how science-related career goals affect task value, expectancy, and achievement-related outcomes. Also, the study will offer several implications for curriculum development.

Expectancy-Value Theory

Based on Atkinson's work, Eccles and her colleagues developed expectancy-value theory. The theory proposes that success expectancies and task values are the most direct predictors of academic performance and choices. Expectancies and values themselves are influenced by task-specific beliefs such as self-concept of one's abilities, short-term and long-term goals, perceptions of task demands, and self-schemata, and along with their affective memories for different achievement-related events (Eccles (Parsons) et al. 1983; Wigfield & Eccles 1992, 2000, 2002). In this study, I am especially interested in the following motivation constructs: expectancy (self-efficacy), task values (importance, utility, interest, and enjoyment), and future-oriented motivation, because they are connected directly to achievement outcomes, including science competence and science-related activities.

Expectancy refers to an individual's belief concerning how well he will do in an impending task. Some researchers have pointed out that expectancy and self-efficacy in the achievement domain are conceptually and empirically similar (Bong 2001; Meece et al. 1990; Schunk 1984; Wigfield & Eccles 2000). In investigating the relation between self-efficacy and achievement, the specificity of measurement of self-efficacy remains crucial. Researchers have argued that the relation between self-efficacy and achievement is moderated by measurement specificity (Bandura 1997; Bong 2001; Pajares & Miller 1995). Bandura (1986) contended that the level of specificity at which self-efficacy should be measured depends on the performance one intends to predict. For the present study, the measure of self-efficacy is more task-specific than that adopted by Wigfield and Eccles. Specifically, in PISA 2006, the self-efficacy was assessed by asking students to rate the ease with which they believed they could perform eight specified scientific tasks.

Values have been defined as an individual's perceptions of interest, importance, usefulness of the task and cost (Eccles (Parsons) et al. 1983; Wigfield & Eccles 1992). Interest or intrinsic value is the enjoyment one derives from performing a task; usefulness or utility value refers to the usefulness of a task in contributing one's future goals; importance value refers to whether doing well in the task is consistent with one's identity, and cost is what one must be sacrificed to complete a task. Most studies have been done with reference to the first three components of task values (Wigfield & Cambria 2010a, b), but, the measures of task value vary throughout the literature. Some research has separately assessed three components of task value (Cole et al. 2008; Eccles & Wigfield 1995; Xiang et al. 2004). Other research has utilized two subscales. The utility and importance items are combined to yield a scale (Durik et al. 2006; Simpkins et al. 2006; Updegraff et al. 1996. Other research has combined three components to form a composite (Bong 2001; Eccles et al. 1993). Although in most investigation, task value scales/subscales are constructed based on factor analyses, the resulting scales vary. Possible causes of variation are variation in numbers of items associated with components, age of subjects, and composition of item pools to be factorized (referring to whether factor analysis is conducted using items of task value alone, or using items of task value and other related constructs in expectancy-value theory). In the factor analysis literature, three indicators per construct are recommended (Marsh et al. 1999). Given only one or two items associated with each component of task value, obtaining a distinct factor for each component is difficult. In this study, each construct is measured using four to eight items. Using more items for each component of task value may give us a clearer picture of the measurement structure of task values.

Future-Oriented Motivation to Learn Science

Goals are regarded as a major influence on the motivation and achievement of individuals. In expectancy-value theory, goals affect expectancies for success and subjective task value (Eccles 2005). Tasks that help to attain valued short- and long -terms goals will have higher task values. Similarly, in Miller and Brickman's model of future–oriented motivation and self-regulation, they posited that future goals influence the development of subgoals, which are in turn related to the perceived instrumentality of the tasks that individuals undertake. Perception of the instrumentality of the current task relates to task choice, engagement, and performance (Miller & Brickman 2004).

Past studies have focused on the effects of goal orientations on achievement-related outcomes (as in Hulleman et al. 2008). Much less is known about how an individual's commitment to a science-related career affects three components of task value. In this investigation, the role of a future goal in expectancy-value theory will be explored. It is proposed that if an individual has a greater desire to pursue a science-related career, then learning science may have higher perceived instrumentality for achieving a personally valued goal. Therefore, the utility and attainment value of task will be enhanced. Positive relationships also exist between future goals and interest values. Ryan et al. (1992) maintained that making a commitment to future goals, which is a highly autonomous act, will experience enjoyment and satisfaction.

Relations to Achievement Outcomes

In expectancy-value theory, achievement-related performance and choice are major indicators of achievement outcome (Eccles (Parsons) et al. 1983; Wigfield & Eccles 1992, 2000, 2002). Studies have established that both self-efficacy and task values predict achievement-related outcomes (Bong 2001; Durik et al. 2006; Eccles et al. 1993; Lin et al. 2012; Simpkins et al. 2006; Updegraff et al. 1996; Xiang et al. 2004). Notably, some studies have examined the relationships of self-efficacy and task values to achievement outcome focusing primarily on school grades and test scores(Denissen et al. 2007; Marsh et al. 2005). Others investigated the effects of motivation constructs on academic choice behaviors (such as course enrollment, leisure activities) (Durik et al. 2006; Simpkins et al. 2006; Updegraff et al. 1996). Some studies explored the effects of self-efficacy and task values on both actual achievement and choice behaviors utilizing structural equation modeling (Bong 2001; Lin et al. 2012; Meece et al. 1990). In summary, self-efficacy predicts academic performance better than task value, whereas task value is a stronger predictor of activity choices (Simpkins et al. 2006; Updegraff et al. 1996). However, some studies yielded inconsistent results. Bong (2001) found that task value was a stronger predictor of students' midterm scores and intention to enroll. Simpkins et al. (2006) found that youths' self-concept more importantly determines their enrollment in high school math courses. Based on previous findings that within-country data, there is positive relationship between student's achievement and academic self-perception, while at country level, the direction is just opposite. Yang (1998) pointed out the four societies have different education and public examination systems. The educational competition is more drastic in Hong Kong and Taiwan than in Japan and Korea. It is expected that these four nations will be similar in terms of relationships between constructs in the expectancy-value model and maybe differ at mean level of motivation scores. In other word, it is proposed that there may be a general motivational process that affect student learning.

Current Research

Based on PISA 2006 science data, this study examine the relevance of expectancy-value theory cross-culturally in four aspects. First, the factor structure that underlies the key constructs of expectancy-value theory will be examined. Specifically, the dimensionality of items measuring the three components of task value, self-efficacy, and future goals will be assessed. Second, the effect of future goal on task values will be evaluated. Third, the role of task values and self-efficacy in predicting achievement outcomes will be explored. Finally, the generalizability of the findings across four Asian countries will be evaluated.

Method

Sample

Data are taken from PISA 2006. The PISA study assessed reading, mathematical, and scientific literacy of 15-year-olds in a three-yearly cycle. Nationally representative samples were drawn by a two-stage stratified sample design. In the first stage, schools were sampled by the systematic probability proportional to size sampling technique. At least 35 students were then randomly sampled from the sampled schools. The sample sizes for Hong Kong, Japan, Korea, and Taiwan, are 3654, 5757, 5072, and 8564, respectively.

Measures

Self-Efficacy in Science

Eight items were used to measure students' science self-efficacy. Students were asked to indicate how easily they think they can perform the following tasks on their own: (1) Explain why earthquakes occur more frequently in some areas than in others; (2) Recognize the science question that underlies a newspaper report on a health issue; (3) Interpret the scientific information provided on the labelling of food items; (4) Predict how changes to an environment will affect the survival of certain species; (5) Identify the science question associated with the disposal of garbage; (6) Describe the role of antibiotics in the treatment of disease; (7) Identify the better of two explanations for the formation of acid rain; (8) Discuss how new evidence can lead you to change your understanding about the possibility of life on Mars.

Future-Oriented Motivation

Four items were used to measure students' motivation to pursue a science-related career. Students were asked to rate how much they agreed with the four statements. (1) I would like to work in a career involving science. (2) I would like to study science after high school. (3) I would like to spend my life doing advanced science. (4) I would like to work on science projects as an adult.

Importance Value

Five items were used to measure importance value of science. Students were asked to indicate the extent to which they agreed with the following questions: (1) Some concepts in science help me see how I relate to other people; (2) I will use science in many ways when I am an adult; (3) Science is very relevant to me; (4) I find that science helps me to understand the things around me; (5) When I leave school there will be many opportunities for me to use science.

Utility Value

The utility component of task value was assessed by the following five items: (1) Making an effort in my science subjects is worth it because this will help me in the work I want to do later on; (2) What I learn in my science subjects is important for me because I need this for what I want to study later on; (3) I study science because I know it is useful for me; (4) Studying my science subjects is worthwhile for me because what I learn will improve my career prospects; (5) I will learn many things in my science subject that will help me get a job.

Enjoyment Value

The enjoyment of science was derived from students' level of agreement with the following statements: (1) I generally have fun when I am learning science; (2) I like reading about science; (3) I am happy doing science problems; (4) I enjoy acquiring new knowledge in science; and (5) I am interested in learning about science.

Interest Value

In PISA 2006, two measures are related to interest value of science. One is general interest in science. The other is enjoyment of science. General interest was measured by asking students to specify their level of interest in eight subjects, physics, chemistry, the biology of plants, human biology, astronomy, geology, experimental design, and scientific explanations. Enjoyment of science assessed the feelings-related valences associated with engagement in science learning. The following five statements are used to measure enjoyment of science: (1) I generally have fun when I am learning science topics; (2) I like reading about science; (3) I am happy doing science problems; (4) I enjoy acquiring new knowledge in science; (5) I am interested in learning about science.

Science-Related Activities

Students' activities related to science were evaluated using four items. Students were asked to specify how often they did the following things: (1) Watch TV programmes about science; (2) Borrow or buy books on science topics; (3) Visit web sites about science topics; (4) Read science magazines or science articles in newspapers.

Students responded to all questionnaire items on a scale from 1 (I could do this easily, strongly agree, very often) to 4 (I couldn't do this, strongly disagree, never or hardly ever). All questionnaire items were reverse scored. Thus, higher scores indicated higher degrees of the measured constructs.

Science Competence

Science competence was assessed in terms of three kinds of scientific tasks that require students to identify scientific issues, explain phenomena scientifically and use scientific evidence. In this study, the achievement of students was measured using a latent construct that was estimated from the three science competencies: identifying scientific issues, explaining phenomena scientifically and using scientific evidence. The science scale was constructed to have a mean score among OECD countries of 500 points and a standard deviation of 100.

Statistical Analysis

Goodness of Fit

The adequacy of the models tested in the present study was assessed by SEM with the LISREL 8.54 (Jöreskog & Sörbom 2003). The assessment of model fit was based on the Chi square index, the root mean square of approximation (RMSEA), the nonnormed fit index (NNFI), the comparative fit index (CFI), and the root mean squared residuals (SRMR). Values of the NNFI and CFI greater than .90 and .95 are typically taken to reflect acceptable and excellent fits to the data. The RMSEA assesses closeness of fit, with values approximating .08, .05, and 0 indicating reasonable, close, and exact fits, respectively. Values for the SRMR range from zero to 1.0 with well-fitting models obtaining values less than .05, however values as high as .08 are deemed acceptable (Hu & Bentler 1999).

Tests of Invariance

Multiple-group SEM tests of invariance were used to test the generalizability of the results based on analyses of separate covariance matrices for the four countries. Test of invariance involves comparing a series of nested models in which aspects of the factor structure are systematically held invariant across countries, and assessing fit indexes when elements of these structures are constrained. Little or no change in goodness of fit supports the invariance of structure. Separate tests were conducted to test the configural invariance, the invariance of the factor loadings, and the invariance of path coefficients across four countries.

Results

Distinctiveness of Self-Efficacy, Future-Oriented Motivation, Interest, Utility, Enjoyment, and Importance Value

Confirmatory factor analyses (CFAs) were conducted to establish distinction among theoretical constructs separately for each country. Items were specified as indicators only for the construct for which they were measured. No error covariances were assumed, and correlations between constructs were set to be free. CFAs were estimated using maximum likelihood (ML) method based on polychoric correlations matrix and the estimated asymptotic covariance matrix.

Table 1 presents the results of the four confirmatory factor analyses. The six-factor model—with distinct self-efficacy, future-oriented motivation, interest, utility, enjoyment, and importance value factors—fits the data very well. RMSEAs and SRMRs are below .05, and CFIs and NNFIs exceed .95. Items associated with each of the key constructs load separately on six latent factors.

The CFA results confirm the stability of measurement for each construct in four national contexts. The underlying structure among these constructs is further examined by item parceling (combining items into small groups of items within scales). Research has indicated that item parceling can yield more stable parameter estimates and proper solutions of model fit (Little et al. 2002). Further, Likert-type items are nonnormal and discontinuous, item parceling enhanced estimate of model fit. Items for each construct were scaled using the IRT scaling methodology. In PISA 2006, the partial credit model (Masters & Wright 1997) was used to estimate questionnaire item parameters and weighted likelihood estimation was used to obtain individual student scores. Detailed information about scaling methodology can be found in the PISA 2006

Table 1 Confirmatory factor analysis results

Country	χ^2 (df)	CFI	NNFI	SRMR	RMSEA
Hong Kong	4361.95** (545)	.97	.97	.049	.044
Japan	6746.52** (545)	.98	.97	.045	.045
Korea	6259.38** (545)	.97	.97	.045	.046
Taiwan	10173.64** (545)	.97	.97	.045	.046

CFI comparative fit index, *NNFI* non-normal fit index, *SRMR* root mean squared residuals, *RMSEA* root mean square error of approximation

** $P < .01$

Table 2 Means, standard deviations, and reliabilities for the variables

Variable	1	2	3	4	5	6	7	8
Japan								
Mean	−.24	−.53	−.26	−.13	−.43	−.23	−.62	531
SD	.99	.98	1.04	1.02	1.05	.93	.95	100
Reliability	.94	.85	.93	.86	.94	.76	.80	.91
Hong Kong								
Mean	.29	.06	.38	.19	.16	.52	.26	542
SD	.91	.95	.90	.98	.93	.89	.99	92
Reliability	.93	.83	.91	.83	.94	.79	.84	.92
Korea								
Mean	−.25	−.21	−.17	−.24	−.26	−.06	−.19	522
SD	.94	.89	1.00	.96	.94	.87	.98	90
Reliability	.92	.83	.91	.81	.93	.75	.80	.91
Taiwan								
Mean	.14	.18	.17	.09	.27	.60	.40	532
SD	.91	1.01	.92	1.01	.86	.94	.90	94
Reliability	.94	.85	.91	.87	.92	.82	.84	.92

Note. 1. Future-oriented motivation; 2. self-efficacy; 3. enjoyment of science; 4. general interest; 5. utility value; 6. importance value; 7. science-related activities; 8. science competence

technical report (Organization for Economic Co-operation and Development 2009). Means, standard deviations, and scale reliabilities for the variables in this study are presented in Table 2. Measures were sufficiently reliable. The reliabilities for all other measures other than importance value, exceeded .80. All scale scores except for achievement scores were scaled with an international average of zero and a standard deviation of one.

Descriptive and Correlation Analyses

All students in Japan and Korea responded more negatively to motivation-related measures than did students on average across OECD countries. Students in Hong Kong and Taiwan responded more positively than the average in the OECD area. The relationships among self-efficacy, future-oriented motivation, interest, utility, enjoyment, and importance value, competence, and science-related activities are similar across the four countries. All motivation-related measures are positively related to two achievement outcomes.

Correlations among constructs of expected-value theory are presented in Table 3. Correlations between components of task value and engagement in science-related activities range from .38 to .60. Correlations between components of task value and competence are from .13 to .41. Notably, future-oriented motivation is moderately related to activity (rs = .46–.50). The magnitude of the correlation is similar to that between utility/importance value and engaging in science-related activities. Self-efficacy is correlated more strongly with engagement in science-related activities than with competence in all countries.

All task values are positively correlated with future-oriented motivation. As predicted, the utility value is correlated most highly with future-oriented motivation (r = .61–.68), followed by that between enjoyment and future-oriented motivation and between interest and future-oriented motivation. Surprisingly, the importance value is not correlated with future-oriented motivation more highly than is enjoyment/interest.

Modeling Future-Oriented Motivation, Self-Efficacy, Task Values and Outcomes

Structure Equating Modeling was utilized to assess the relative contributions of task values and self-efficacy to both achievement outcomes separately for each country. The structural model tested is presented in Fig. 1. Note that the path coefficients in Fig. 1 were estimated based on the constrained model, in which the coefficients were specified to be equal across countries. The constrained model will be explained later in more detail.

Fit indices for the four datasets are presented in Table 4. As noted in the table, CFIs, NNFIs, and SRMRs suggest that the model provides a satisfactory fit to the data from the four countries (Hu & Bentler 1999). RMSEAs indicate a close fit of the model for Taiwan and Hong Kong, and an adequate fit for Japan and Korea (Browne & Cudeck 1993; MacCallum et al. 1996). A comprehensive assessment reveals the data for each country fit the model sufficiently well.

Relations of Self-Efficacy and Task Value to Achievement Outcomes

The path coefficients and factor loadings in the model were estimated for the four countries. All of the path coefficients and factor loadings are statistically significant at $p < .001$. The patterns of path coefficients are similar across the

Table 3 Correlations among the constructed variables

	Hong Kong				Japan			
	1	2	3	4	5	6	7	8
1. Future-oriented	–	.32	.59	.52	.68	.52	.47	.28
2. Self-efficacy	.33	–	.45	.50	.31	.43	.42	.32
3. Enjoyment	.63	.45	–	.65	.53	.57	.60	.35
4. Interest	.54	.47	.69	–	.50	.51	.51	.35
5. Utility	.68	.31	.58	.52	–	.50	.41	.30
6. Importance	.44	.38	.50	.46	.50	–	.46	.24
7. Activities	.50	.43	.60	.56	.44	.44	–	.21
8. Competence	.23	.37	.35	.31	.20	.21	.25	–
	Taiwan				Korea			
	1	2	3	4	5	6	7	8
1. Future-oriented	–	.32	.65	.51	.67	.49	.46	.25
2. Self-efficacy	.30	–	.43	.47	.29	.41	.41	.38
3. Enjoyment	.61	.42	–	.66	.59	.53	.57	.41
4. Interest	.53	.45	.64	–	.50	.47	.52	.36
5. Utility	.61	.31	.56	.49	–	.54	.42	.25
6. Importance	.39	.33	.44	.35	.51	–	.43	.28
7. Activities	.48	.42	.58	.52	.43	.38	–	.27
8. Competence	.19	.38	.28	.31	.16	.13	.18	–

Note. Correlations computed on Japan's and Korea's data are above the diagonal; correlations computed on Hong Kong's and Taiwan's data are below the diagonal

All correlations are statistically significant at $p < .01$

countries. Self-efficacy has a stronger direct effect on competence (γs around .20s) than on participation in science-related activity (γs around .10s). The results are consistent with previous studies (Meece et al. 1990, Xiang et al. 2004).

Task value predicts participation in science-related activities (βs around .70s) much better than does competence (βs around .19–.32) across all countries. Engaging in science-related activities are more strongly related to task value than to self-efficacy. The results are consistent with previous findings that task values are more highly correlated with engaging in science-related activities than with competence (Bong 2001; Meece et al. 1990; Xiang et al. 2004). Also, task value has stronger direct effect than self-efficacy on competence.

Table 5 presents the total effects of self-efficacy and task value on competence. When the indirect effects of self-efficacy on competence are taken into account, the total effect of self-efficacy on competence is as strong or stronger than the effect of task value on competence.

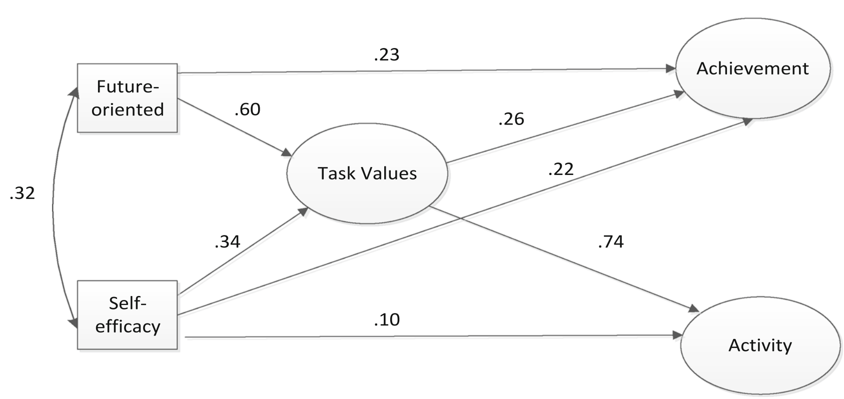

Fig. 1 The causal paths of the invariant model across 4 countries

Table 4 Fit indices for the structural equation models

Country	χ^2 (df)	CFI	NNFI	SRMR	RMSEA
Hong Kong	643.87** (58)	.99	.99	.027	.052
Japan	1636.40** (58)	.98	.98	.040	.068
Korea	1278.46** (58)	.98	.98	.039	.064
Taiwan	1231.19** (58)	.99	.99	.030	.048

CFI comparative fit index, *NNFI* non-normal fit index, *SRMR* standardized root mean squared residual, *RMSEA* root mean square error of approximation

** $P < .01$

Table 5 Total effects of self-efficacy, task value, future goal on competence and activities

	Hong Kong	Japan	Korea	Taiwan
Competence				
Self efficacy	.31	.25	.31	.34
Task value	.26	.30	.32	.19
Future goals	.15	.19	.20	.12
Science-related activities				
Self efficacy	.36	.35	.34	.35
Task value	.72	.78	.72	.73
Future goals	.44	.44	.43	.46

In sum, it is clear that task value predicts the tendency of students to participate in science-related activities much better than does their competence. Task value has a stronger direct effect on the competence of students than does self-efficacy in three of the four countries. However, the total effect of self-efficacy on the competence of students is as strong or stronger than that of task value.

Future-Oriented Motivation as a Predictor of Task Value, and its Indirect Effect on Competence and Participation in Science-Related Activities

As expected, future-oriented motivation has a highly significant influence on task value. The path coefficients from future-oriented motivation to task value range from .57 to .62. Indirect effects of future-oriented motivation on engagement in science-related activities are .40 s across countries, higher than those of self-efficacy. Future-orientation motivation affects competence, although the effect is weaker as indicated in Table 6.

Invariance of Causal Structure Across Countries

Since the pattern of path coefficients in the model is similar across countries, the structural invariance across countries is tested. First, the configural invariance is tested. This test assesses whether students from four countries conceptualize task value, science-related activities, and competence in the same ways (Riodan & Vandenberg 1994). The model specified by Fig. 1 with the same items associated with each latent construct across the four countries was fitted to data. The fit indices indicate that the model has a satisfactory fit. ($\chi^2 = 4789.92, df = 232, p < .01, \text{CFI} = .99, \text{NNFI} = .98$, RMSEA = .058). This result shows factor structure is the same in all four countries.

The second test examines metric invariance (which is the equality of all factor loading parameters across countries). The proposed model demonstrated a satisfactory fit to the data ($\chi^2 = 6896.92$ with $df = 256$, CFI = .98, NNFI = .98, RMSEA = .067). Chi square difference between unconstrained and constrained model is statistically significant. However, the Chi square statistic is sensitive to sample size. Owing to this fact, Cheung and Rensvold (2002) recommended using changes in the GFI, CFI, or McDonald's NCI instead of the Chi square difference test to evaluate measurement invariance. Since the change in CFI is −.01, the metric invariance hypothesis should not be rejected. Constructs are manifested in the same way across the four countries.

Since the measurement model appeared to be invariant across countries, the hypotheses concerning the equivalence of specified causal paths were tested. The results yielded $\chi^2 = 8694.56$ with $df = 283$, CFI = .98, NNFI = .98, and RMSEA = .071. The model-fit indices except χ^2, were close to those of the metric invariant model, indicating that imposing an additional constraint (i.e. the equivalence of structural coefficients) did not have an impact on the overall model data fit. The invariance of the causal structure across countries could therefore not be rejected. Self-efficacy has the same effects on task value, competence, and science-related activities across the four countries. Furthermore, the effects of task value on competence and science-related activities are the same across the four countries as are the coefficients leading from future-orientated motivation to task value. Figure 1 shows the causal paths of the invariance model. The results not only demonstrated that the expectancy—value model can be applied to Asian contexts, but also the relations among theoretical constructs are stable across the four countries.

Discussion

The results of this study provide clear evidence that expectancy-value theory can be used to explain motivational process in science achievement and engagement across Asian cultures. The factor structure of theoretical constructs as well as the causal structure of the expectancy-value model is found to be invariant across cultures. The results of confirmatory factor analyses demonstrate self-

Table 6 Test for invariant causal structure across three countries

Hypothesis	χ^2	df	CFI	NNFI	RMSEA
Configural invariance	4789.92	232	.99	.98	.058
Metric invariance	6896.92	256	.98	.98	.067
Invariant causal structure	8694.56	283	.98	.98	.071

efficacy, future-oriented motivation, interest, utility value, enjoyment value, and importance value are clearly distinguishable from one another. In addition, the distinctions among different aspects of task value are both theoretically and empirically meaningful in Asian cultures. These findings provide evidence of similarities in these motivation-related constructs in non-Western cultures. As Walker (2010) suggests, "motivation, conceptualized as social in nature, is internalized to become an individual process." It implies that there may be a general motivational process that affect student learning.

The strong effects of future-oriented motivation on task value revealed the important influences of future goals on the perceptions of task values. Also, the relations between future-oriented motivation and components of task value are consistent across countries. The total effects of future-oriented motivation on science-related activities are around .44, indicating that the future goals had a large effect on science engagement. Lin et al. (2012) roposed that science engagement predicted future-oriented motivation and the path coefficient was only .07. The results of this study suggest the opposite direction that future-oriented motivation predicts science engagement, however, it should be understood that the study is based on cross-sectional data. To address the causal relation between future-oriented motivation and science engagement, longitudinal study should be conducted.

The major goal of this study was to elucidate the role of task values and self-efficacy in predicting science competence and participation in science-related activities. Based on zero-order correlations and path coefficients of SEM, some general observations can be made. First, students' subjective task values predicted their engagement in science-related activities more strongly than did their self-efficacy. These results are consistent with previous findings (Bong 2001; Lin et al. 2012; Meece et al. 1990; Updegraff et al. 1996). Second, the direct link from task values to competence was stronger than that from self-efficacy to competence. However, the total effect of self-efficacy on the competence of students is as strong or stronger than that of task value. The results are inconsistent with the findings of Özel et al. (2012) and Lin et al. (2012). In their studies, interest, enjoyment, utility, and importance values were treated as separated latent variables. Nevertheless, in this study, task value is treated as a latent variable composed of interest, enjoyment, importance, and utility value. Since correlations among the components of task values are around .5–.6, considering the attenuation created by measurement error, the actual level of multicollinearity may be fairly high among the latent exogenous constructs. Multicollinearity can lead to inaccurate parameter estimates and a high incidence of Type II errors (Grewal et al. 2004). The negative effect sizes of utility value, self-concept, and future-oriented motivation on science achievement in the findings of Özel et al. may be due to the type II errors. The results suggest that task values formed by multiple interrelated components can predict achievement outcomes well.

Implications for Science Education

Given the strong effect of future-oriented motivation on task value and the role of task values in predicting science performance and participation in science-related activities, helping students develop personally valued future goals that include science learning as part of their path is crucial. To initially commit to any future goal, an individual must know that such a goal exists and believe that it has some value. Thus, science teachers need to ensure that the two factors are addressed. Students need to be exposed to the knowledge about the paths people follow in pursing their future goals. Also, school policy and practice can inform students of potential career opportunities in science early in their lives (Tai et al. 2006). For example, scientists may be invited to classrooms to share their work and the experiences that led them to careers in science (Kaya & Rice 2010). Furthermore, educators can work to increase the values of learning science by highlighting the instrumental relationship between doing well in science and future economic success, by pointing out how science making a positive contribution to society and fostering greater understanding of the world, and by making science itself more engaging.

Students' self-efficacy was found to positively predict science outcomes. To improve self-efficacy, it is recommended that teacher help students acquire new skills and cognitive strategies that increase the likelihood of success. In addition, teachers may need to find ways to identify the students' perceived obstacles to learning success, and change the circumstances leading to those perceptions.

Limitations and Suggestions for Future Research

In the present investigation, students' reports of self-efficacy, future-oriented motivation, and task value are used to predict science achievement and engagement. All the measures were collected at the same time, thereby limiting inferences of causality. Nevertheless, the observed relationships are revealing even without being able to make unambiguous claims of directionality.

The data in this study were from four Asian countries, and may not be representative of people from other countries, therefore this study should be replicated using PISA data from other countries. The present study used data from 15 year-olds to elucidate how future goals, expectancy and value affect science-related outcomes, further research should also examine the relationships of the variables for more diverse groups of children and adults and in different educational contexts.

The measures of motivation-related constructs in this study have high reliability and validity. Each component of task value was measured using a scale, rather than a single item. Then, each component was treated as an indicator of task value in the SEM analysis. The construct of task value is broadly conceptualized and the hypothesized relationships between task value and science engagement were substantial in size. Moreover, future-oriented motivation and utility value are conceptually and empirically distinctive. The use of these measures in future study is recommended.

Research on students' science achievement have focused on short-term motivational issues and excluded potentially important personally valued, distant goals in their analysis. The findings indicate the important influences of personally valued future goals on science engagement. There is no question that students' career aspirations are important to the study of achievement motivation. Researchers interested in the motivation of students should consider the ways that future-oriented motivation may fit into the current models of achievement motivation.

Although the relationships among the constructs of expectancy-value theory are similar across the four countries, the mean scores of future-oriented motivation, task values, and science-related motivation varies across countries. The results do not offer an explanation for why students in these Asian countries responded less positively than student on average across OECD countries. There are a number of possibilities that could be investigated. As Shen and Pedulla (2000) have suggested, it is possible that the lower self-concept may reflect relatively demanding curricular standards in high performing countries. Additionally, American teachers gave much higher grades to students and tended to offer praise far more frequently than Japanese teachers did (Ban & Cummings 1999). Heine (2004) argued that people in individualistic societies choose downward comparisons and have higher self-concept (self-enhancement bias) while people in more collectivist societies often seek upward comparisons and have lower self-concept (modesty bias). These and other possible mechanisms responsible for the lower mean values of motivational measures warrant further exploration.

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