International Journal of Science Education

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/tsed20

The development of a questionnaire to measure students' motivation towards science learning

Hsiao-Lin Tuan [a] , Chi-Chin Chin [b] & Shyang-Horng Shieh [c]

[a] National Changhua University of Education, Taiwan

[b] Department of Science Education, National Taichung Teachers College, Taiwan

[c] Kong-Kwang Elementary School, Taiwan

[d] Graduate Institute of Science Education, National Changhua University of Education Changhua, Taiwan 500, Taiwan E-mail:

Version of record first published: 15 Jun 2012.

International Journal of Science Education
Vol 27, No. 6, 16 May 2005, pp. 639–654

RESEARCH REPORT

The development of a questionnaire to measure students' motivation towards science learning

Hsiao-Lin Tuan[a,*], Chi-Chin Chin[b] and Shyang-Horng Shieh[c]
[a]*National Changhua University of Education, Taiwan,* [b]*Department of Science Education, National Taichung Teachers College, Taiwan,* [c]*Kong-Kwang Elementary School, Taiwan*

The purpose of this study was to develop a questionnaire that measures students' motivation toward science learning (SMTSL). Six scales were developed: self-efficacy, active learning strategies, science learning value, performance goal, achievement goal, and learning environment stimulation. In total, 1407 junior high school students from central Taiwan, varying in grades, sex, and achievements, were selected by stratified random sampling to respond to the questionnaire. The Cronbach alpha for the entire questionnaire was 0.89; for each scale, alpha ranged from 0.70 to 0.89. There were significant correlations ($p < 0.01$) of the SMTSL questionnaire with students' science attitudes ($r = 0.41$), and with the science achievement test in previous and current semesters ($r^p = 0.40$ and $r^c = 0.41$). High motivators and low motivators showed a significant difference ($p < 0.01$) on their SMTSL scores. Findings of the study confirmed the validity and reliability of the SMTSL questionnaire. Implications for using the SMTSL questionnaire in research and in class are discussed in the paper.

Introduction

The goal of science education is to enhance all students' scientific literacy; that is, to help students grasp essential science concepts, to understand the nature of science, to realize the relevance of science and technology to their lives, and to willingly continue their science study in school, or beyond school (National Research Council [NRC] 1996). Thus, research in science teaching and learning should address not only student cognition, but also the affective component to cognition. It is only recently that researchers have started to stress the importance of affective components in

*Corresponding author. Graduate Institute of Science Education, National Changhua University of Education Changhua, Taiwan 500, Taiwan. Email: suhltuan@cc.ncue.edu.tw

ISSN 0950-0693 (print)/ISSN 1464-5289 (online)/05/060639–16

DOI 10.1080/0950069042000323737

studying students' concept learning (Duit and Treagust 1998, Lee 1989, Lee and Brophy 1996, Pintrich et al. 1993, Strike and Posner 1983, 1992, West and Pines 1983).

Within the affective components, motivation is important because students' motivation plays an important role in their conceptual change processes (Lee 1989, Lee and Brophy 1996, Pintrich et al. 1993), critical thinking, learning strategies (Garcia and Pintrich 1992, Kuyper et al. 2000, Wolters 1999) and science learning achievement (Napier and Riley 1985).

A review of learning motivation studies revealed the diversity and variety of motivation factors, such as self-perceptions of ability, effort, intrinsic goal orientation, task value, self-efficacy, test anxiety, self-regulated learning, task orientation and learning strategies (Garcia 1995, Garcia and Pintrich 1995, Nolen and Haladyna 1989, Pintrich and Blumenfeld 1985). These studies, on the one hand, highlighted the diversity of the learning motivation and, on the other hand, showed how researchers' interests influenced the approach taken to aspects of motivation.

Although there are many motivation questionnaires used in the aforementioned educational psychology studies (Midgley et al. 1993; Pintrich et al. 1991; Uguroglu et al. 1981), these questionnaires were mainly developed by psychologists who were interested in pre-determined motivation domains in understanding students' general learning motivation rather than addressing, specifically, motivation for learning science. For instance, the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich et al. 1991) was designed to assess college students' motivational orientations and learning strategies, and the Multidimensional Motivation Instrument (Uguroglu et al. 1981) examined the relation between the learning environment and students' motivation, affect and behaviour. Researchers (Blumenfeld 1992, Blumenfeld and Meece 1988, Lee and Anderson 1993, Lee and Brophy 1996, Weiner 1990) have stressed the importance of investigating students' motivation when studying specific subject content areas because they may express different motivational traits in these areas. Hence, it is important to develop a questionnaire to investigate students' learning motivation in science.

The purpose of this study is to analyse existing research to identify motivation domains in science learning and to develop a questionnaire, students' motivation towards science learning (SMTSL), which addresses students' motivation in science learning.

Science learning and motivation

Based on constructivist theory (Mintzes et al. 1998, von Glasersfeld 1998), students take an active role in constructing new knowledge. When students perceive valuable and meaningful learning tasks, they will actively engage in the learning tasks, using active learning strategies to integrate their existing knowledge with new experience. When students do not perceive the value of learning tasks, they use surface learning strategies (such as memorization) to learn (Pintrich and Schunk 1996). von Glasersfeld (1998) also illustrated the importance of the students' learning goal in motivating students to construct their scientific knowledge based on the learning value and learning strategies. Pintrich and Schunk stated that 'motivation is the process whereby goal-directed activity is instigated and sustained' (1996: 5), while Pintrich et al. (1993) stressed that students' learning goals, values of science learning, and self-efficacy take important roles in influencing students in constructing and reconstructing their science conceptions. In other words, when students perceived that they are capable, and they think the conceptual change tasks are worthwhile to participate in, and their learning goal is to gain competence, then students will be willing to make a sustained effort and be engaged in making conceptual change. Here, Pintrich et al. add students' self-efficacy and their intention toward learning tasks into a previous constructivist view toward science learning.

Research on motivational theories and studies of students' learning (Brophy 1998, Pintrich and Schunk 1996) reveals that self-efficacy, the individual's goals toward tasks, task value and the learning environment dominate students' learning motivation. Combining the constructivist learning and motivation theories we find that students' self-efficacy, science learning value (or task values), students' learning strategies, the individual's learning goal, and the learning environment are important motivational factors that constitute students' science learning motivation. In the following we discuss each motivational factor in more detail.

Self-efficacy refers to the individual's perception of his/her ability in accomplishing learning tasks (Bandura 1981, 1982, 1997, Pajares 1996). When students have high self-efficacy, they believe they are capable of accomplishing learning tasks, whether tasks are difficult or easy. Science learning value refers to whether or not students can perceive the value of science learning they engage. In science class, there are many unique features highlighting the value of science learning, such as problem-solving, science inquiry, thinking, and the relevance of science knowledge in students' daily lives (American Association for the Advancement of Science 1993, NRC 1996). In constructivist learning, students take an active role in interacting with the environment; they use active learning strategies to retrieve existing knowledge to interpret new experiences in order to construct new understanding. They try to find resources to help them understand concepts. These active learning strategies are also matched with MSLQ (Pintrich et al. 1991) learning strategies; that is, students' learning strategies depend on the nature of motivation and learning goals. An individual's goal toward tasks refers to students' attending the learning tasks for performance goal or achievement goal (Brophy 1998). When students have an achievement goal, they are intrinsically motivated, they intend to accomplish something to satisfy their innate needs for improving their own competence (Deci and Ryan 1991), and they believe this kind of participation will help them achieve valuable goals (Atkinson and Birch 1978). If the students' goal towards tasks is for performance, they will be concerned more with performing better than their peers and impressing their teachers (Brophy 1998; Pintrich and Schunk 1996). The learning environment comprises teachers' teaching strategies, class activities, and student–teacher and student–student interactions that would influence an individual's motivation in learning (Brophy 1998, Pintrich and Schunk 1996). Huang and Waxman (1995) found students with different motivation would have different perceptions of the learning environment. Hanrahan (1998) also pointed out that teachers' teaching, and student-teacher relationships would influence students' motivation.

These thoughts concerning science learning and motivation constitute our conceptual framework in designing a questionnaire for students' motivation toward science learning.

Students' motivation toward science learning studies

Lee and Brophy (1996) used qualitative methods to classify students' motivation patterns in science learning, which ranged from students who were intrinsically motivated to students who had disruptive behaviours. Barlia and Beeth (1999) also identified similar motivation patterns among college physics science learners. Erb (1996) found out that high school students' lack of motivation in learning science were caused by: students' lack of responsibility, students' low self-esteem, and students' family dysfunction. Other researchers (Barlia and Beeth 1999, Hynd et al. 2000, Lee 1989, Lee and Brophy 1996, Nolen and Haladyna 1989) identified factors influencing students' motivation toward science learning, which included: students' own interests toward the subjects and the grades they received in class; students' interpretations of the nature of the task; students' success or failure to make progress in scientific understanding; and students' general goal and affective orientations in science class and achievement of scientific understanding. Besides students' own reasons, other factors influencing students' motivation were teachers' expectation of students' learning, types of teachers' feedback, and curriculum and social goals (Lee 1989, Nolen and Haladyna 1989, Pintrich and Blumenfeld 1985, Urdan and Maehr 1995).

Based on these findings, students' learning goals, self-efficacy, learning strategies and perception of science learning values were identified as important domains in students' science learning motivation. These science learning motivation domains also matched with students' learning motivation addressed in the previous section. Thus, we incorporated these domains into developing a SMTSL questionnaire.

We (Huang and Tuan 2001, Tuan and Chin 1999, 2000, Wu and Tuan 2000) have conducted case studies to explore eighth-grade and ninth-grade students' motivation in science learning in order to confirm the motivation domains. These studies were conducted using 1-year intensive classroom observations, interviews with students and teachers. Our findings showed that students constantly mentioned that their motivation toward science learning was related to themselves, the teacher's performance, and the abstractness and relevance of science content related to their daily lives, which matched previous research (Lee 1989, Nolen and Haladyna 1989, Pintrich and Blumenfeld 1985). Students also mentioned their goals of learning science to be both extrinsic (e.g. competition, getting award from teachers) and intrinsic (e.g. satisfying with their own curiosity). These goals addressed were identified by motivation theories as performance goal and achievement goal (Brophy 1998).

Tuan and Chin (2000) asked 315 students in four ninth-grade science classes two questions: Why are you motivated to learn physical science? and Why are you not motivated to learn science? The data were analysed using an open-ended coding system. Findings indicated that teacher's teaching strategies and the science content such as concrete, relevant and perceptual science concepts presented in the class stimulated students' motivation toward science learning. These findings matched those from previous studies (Brophy 1998, Lee 1989, Nolen and Haladyna 1989, Pintrich and Blumenfeld 1985, Urdan and Maehr 1995), addressing the importance of a supportive learning environment created for students. Therefore, we incorporated this part of the findings into designing the questionnaire and named it 'learning environment stimulation' in the SMTSL questionnaire.

Methodology

We used six factors of motivation into designing our scales in the new questionnaire. In the following, we define each factor in the questionnaire.

1. *Self-efficacy*. Students believe in their own ability to perform well in science learning tasks.
2. *Active learning strategies*. Students take an active role in using a variety of strategies to construct new knowledge based on their previous understanding.
3. *Science learning value*. The value of science learning is to let students acquire problem-solving competency, experience the inquiry activity, stimulate their own thinking, and find the relevance of science with daily life. If they can perceive these important values, they will be motivated to learn science.
4. *Performance goal*. The student's goals in science learning are to compete with other students and get attention from the teacher.
5. *Achievement goal*. Students feel satisfaction as they increase their competence and achievement during science learning.
6. *Learning environment stimulation*. In the class, learning environment surrounding students, such as curriculum, teachers' teaching, and pupil interaction influenced students' motivation in science learning.

After establishing these six scales, we also adjusted the items from some relevant motivation questionnaires — such as the MSLQ (Pintrich et al. 1991), the Patterns of Adaptive Learning Survey (Midgley et al. 1993), and the Multidimensional Motivational Instrument (Uguroglu, Schiller and Walberg, 1981) — into developing self-efficacy, performance goal, and achievement goal scales. There are two reasons for not directly applying existing scales from other questionnaires: many items from the previous questionnaires were not designed primarily for junior high school students, and the statements in many items of the previous questionnaires did not address science learning. Therefore, we also incorporated our previous qualitative findings (Huang and Tuan 2001, Tuan and Chin 1999, 2000, Wu and Tuan 2000) and the feature of science learning into designing scales and items. For instance, in the science learning value, we integrated the inquiry and problem-solving features of science learning (American Association for the Advancement of Science 1993, NRC 1996) in designing items. An example of the scale is: 'In science, I think it is important to learn to solve problems'. In active learning strategies scale, we incorporated both constructivist learning with Patterns of Adaptive Learning Survey surface and deep learning strategies. A sample item related to this domain is 'During the learning process, I attempt to make connections between the concepts that I learn'. Finally, in learning environment stimulation, we incorporated previous research finding such as 'teachers pay attention to me' and 'teachers use a variety of teaching methods' (Tuan and Chin 2000) in designing items. An examplar item is 'I am willing to participate in this science course because the teacher pays attention to me'.

The items were constituted using five-point Likert-type scales. Items on the scales are anchored at 1 = strongly disagree, 2 = disagree, 3 = no opinion, 4 = agree and 5 = strongly agree. The entire questionnaire is listed in appendix 1.

Stratified random sampling was used to identify 15 senior high schools allocated in central Taiwan. One class of seventh, eighth and ninth graders was randomly selected from each school to fill out the SMTSL questionnaire. We also collected students' responses to a science attitude test (Fraser 1981); science achievement scores were collected from the previous and current semesters to conduct external validity tests for SMTSL. The final effective sample size was 1407.

In order to examine whether the SMTSL questionnaire could identify students with different levels of learning motivation, we asked five science teachers to identify students with high, moderate, and low motivation from their classes. One-way analysis of variance was used to analyse whether students with high, moderate and low motivation showed significant difference on SMTSL scores.

Results

Messick (1989) identified that three types of validity need to be addressed in developing a questionnaire. These were content validity, construct validity and criterion-related validity. We used previous case studies from different settings and different students' learning motivation and also used existing questionnaires to design the questionnaire items. Six experienced science teachers, three educational psychologists and five science educators reviewed all the test items. Construct validity was verified by factor analysis. In addition, how students with high, moderate and low motivation would show differences in responding to the SMTSL questionnaire was also identified. A science attitude test (Fraser 1981) and students' science achievement scores from the previous semester and the current semester were used to assess the criterion-related validity of the SMTSL questionnaire.

All the findings to confirm the aforementioned validity are listed in the following. The results presented in table 1 indicate that six factors constitute the construct of the SMTSL questionnaire, and these factors confirmed the six scales designed in the SMTSL questionnaire.

The internal consistency of the six scales of the SMTSL questionnaire were estimated by the Cronbach alpha coefficient to be generally satisfactory (table 2). The

Table 1. Factor loading of items in the SMTSL questionnaire (n = 1407).

		Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
Self-efficacy	Q1	0.57					
	Q2	0.74					
	Q3	0.66					
	Q4	0.68					
	Q5	0.59					
	Q6	0.55					
	Q7	0.63					
Active learning strategies	Q8		0.65				
	Q9		0.68				
	Q10		0.63				
	Q11		0.67				
	Q12		0.69				
	Q13		0.62				
	Q14		0.63				
	Q15		0.60				
Science learning value	Q16			0.57			
	Q17			0.63			
	Q18			0.50			
	Q19			0.58			
	Q20			0.64			
Performance goal	Q21				0.72		
	Q22				0.83		
	Q23				0.84		
	Q24				0.77		
Achievement goal	Q25					0.71	
	Q26					0.64	
	Q27					0.68	
	Q28					0.76	
	Q29					0.72	
Learning environment stimulation	Q30						0.65
	Q31						0.75
	Q32						0.67
	Q33						0.67
	Q34						0.42
	Q35						0.43

Note: All loadings smaller than 0.4 have been omitted.

Table 2. Internal consistency (Cronbach alpha coefficient) and discriminate validity (mean correlation with other scales), and ability to differentiate between classrooms for the SMTSL questionnaire ($n = 1407$).

Scale	Item number	Mean	Standard deviation	Cronbach alpha		Analysis of variance results (η^2)	Mean correlations with other scales
				Individual	Class mean		
SMTSL	35	120.01	15.57	0.91	0.89	0.17**	
Self-efficacy	7	23.37	5.25	0.82	0.78	0.16**	0.31
Active learning strategies	8	29.62	5.22	0.87	0.84	0.11**	0.39
Science learning value	5	18.76	3.05	0.70	0.66	0.09**	0.51
Performance goal	4	9.06	3.02	0.81	0.79	0.08**	0.09
Achievement goal	5	19.39	3.41	0.80	0.78	0.08**	0.30
Learning environment stimulation	6	19.48	4.05	0.75	0.69	0.21**	0.32

Note: ** $p < 0.01$.

Cronbach alpha reliability coefficient for each scale, using an individual student as the unit of analysis, ranged between 0.87 and 0.70. The discriminative validity referred to the extension to which each scale measured a dimension different from that measured by any other scale. In the SMTSL the discriminative validity ranged from 0.09 to 0.51, showing the independence of each scale and also somewhat overlapping with other scales.

The ability of the questionnaire to differentiate between classes is also important. Students within a class usually have different motivation from students in other classes. The ability of the questionnaire to differentiate this aspect was measured using analysis of variance with class membership as the main effect. The results in table 2 show that each scale in the SMTSL questionnaire differentiated significantly between classes ($p < 0.01$). The amount of variance explained by class membership is reflected in the η^2 scores, which ranged from 0.08 to 0.21.

The results of the correlation ($r = 0.41$, $p < 0.01$) between the SMTSL questionnaire with the science attitude scores and science achievement are presented in table 3. All scales have significant correlation with science attitude ($p < 0.01$). Among the scales, learning environment stimulation has the highest correlation ($r = 0.48$) with students' science attitude, while performance goal has the least correlation ($r = 0.07$) with students' science attitude.

The SMTSL questionnaire has significant correlation with students' science achievement scores in the previous and the current semesters ($r^p = 0.40$ and $r^c = 0.41$, $p < 0.01$). Except for learning environment stimulation, the other five scales

Table 3. Pearson correlation analysis of the SMTSL questionnaire with science attitude and science achievement.

Pearson correlation (significance two-tailed)	SMTSL	Self-efficacy	Active learning strategies	Science learning value	Performance goal	Achievement goal	Learning environment stimulation
Science attitude	0.41**	0.22**	0.30**	0.35**	0.07**	0.17**	0.48**
Science achievement^{P}	0.40**	0.46**	0.37**	0.18**	0.13**	0.27**	0.06*
Science achievement^{C}	0.41**	0.44**	0.37**	0.20**	0.14**	0.29**	0.10**

Notes: Science achievement^{P}, students' science achievement scores in the previous semester; science achievement^{C}, students' science achievement scores in the current semester. * $p < 0.05$, ** $p < 0.01$.

have significant correlation with students' science achievement in the previous semester ($p < 0.01$). All the scales have significant correlation with students' science achievement in the current semester ($p < 0.01$).

Table 4 indicates that students' motivation labelled by teachers as high, moderate and low does show a significant difference in their total SMTSL scores ($p < 0.01$). In addition, students with high, moderate and low motivation showed significant differences in self-efficacy and active learning strategies ($p < 0.01$). Students with high

Table 4. One-way analysis of variance of high-motivation, moderate-motivation and low-motivation students' responses on the SMTSL questionnaire.

Motivation	Self-efficacy	Active learning strategies	Science learning value	Performance goal	Achievement goal	Learning environment stimulation	Total
High motivation ($n = 55$)	25.93/4.43	31.40/ 4.32	19.76/ 3.20	14.95/3.76	18.82/3.91	31.31/4.01	132.16/ 15.21
Moderate motivation ($n = 101$)	23.05/4.82	28.83/ 5.14	18.28/ 3.27	15.02/3.31	18.00/3.65	20.12/4.18	123.30/ 16.53
Low motivation ($n = 54$)	21.20/3.81	26.28/ 5.38	17.59/ 3.42	13.11/3.12	13.37/2.99	19.41/2.81	113.96/ 13.42
F	15.51**	14.27**	6.35**	6.20**	6.74**	3.47*	18.93**
Scheffe	A, B, C	A, B, C	A, BC	BA, C	AB, C	AB, BC	A, B, C

Notes. Data presented as mean/standard deviation. A, high motivation; B, moderate motivation; C, low motivation. $p < 0.05$, ** $p < 0.01$.

motivation showed a significant difference to moderate and low motivation students in the science learning value ($p < 0.01$). Students with high and moderate motivation showed a significant difference to low-motivation students in the performance goal and achievement goal. Students with high motivation showed a significant difference to low-motivation students in learning environment stimulation ($p < 0.05$).

Discussion

According to the literature review, the questionnaire survey and data analysis presented in tables 1–4, we have found that among various motivation factors in exploring students' motivation, students' self-efficacy, active learning strategies, science learning value, performance goal, achievement goal, and learning environment stimulation do contribute to students' science learning motivation. The SMTSL questionnaire has good construct validity and also criterion-related validity. In addition, the SMTSL questionnaire has significant correlations with science attitude and achievement scores.

Students' motivation has moderate and significant correlation ($r = 0.41$) with their science attitude. Researchers (Reynolds and Walberg 1992, Singh et al. 2002) reported that students' attitude and motivation are two of the most important factors to predict students' science achievement, while students' motivation is the most important factor in predicting students' science attitude. Among motivation factors, this research revealed that learning environment stimulation had the highest correlation with students' science attitude ($r = 0.48$), followed by science learning value ($r = 0.35$). Learning environment stimulation has a highest correlation with science attitude, but its correlation with student achievement appears the lowest ($r = 0.10$). In addition, high-motivation and low-motivation students showed significant differences in this scale ($p < 0.05$). Examining items in this scale, this study revealed that these items illustrated students' perception of whether or not the teacher created a comfortable and interesting science learning environment for them. But these items did not examine students' science learning. Therefore, this scale correlates highly with science attitude instead of science achievement. Scales having high correlation with attitude toward science tend to have low correlation with science achievement. The research suggests that, in the SMTSL questionnaire, scales such as learning environment stimulation and science learning value contribute more on attitude towards science than to students' motivation toward science learning.

Students' motivation has moderate and significant correlation with students' science achievement ($r^p = 0.40$ and $r^c = 0.41$). Previous research (Uguroglu and Walberg 1979) indicated that motivation contributed 11.4% of the variance of achievement. Napier and Riley (1985) also reported that motivation has highest correlation ($r = 0.26$) with science achievement. In this study, the questionnaire has higher correlation with science achievement than the aforementioned studies. Among motivation scales, self-efficacy has the highest correlation with students' science achievement ($r^p = 0.46$ and $r^c = 0.44$). For the MSLQ, Pintrich et al. (1991) also found that self-efficacy has the highest correlation with achievement ($r = 0.41$)

among motivational scales. In fact, Schunk (1991) summarized studies related to self-efficacy and found that self-efficacy has significant and positive correlation with students' achievement and cognition engagement. Followed by self-efficacy, the active learning strategies scale has the second highest correlation with students' achievement scores ($r^p = 0.37$ and $r^c = 0.37$). These correlations are higher than cognitive learning strategies in MSLQ (0.15–0.30) (Pintrich et al. 1991). Students with active learning strategies are likely to learn more effectively and gain better score on the tests than those who do not use these strategies. Table 4 also shows that students with high, moderate and low motivation showed significant differences ($p < 0.01$) in these two scales.

The fact that students' motivation was significantly correlated with both their previous and current science achievement scores indicates the stability of motivation in relation to students' achievement. Thus, science achievement is often used as indirect evidence of students' motivation (Pintrich and Schunk 1996).

As several researchers (Haladyna and Shaughnessy 1982, Napier and Riley 1985, Simpson and Troost 1982, Thompson and Mintzes 2002) mentioned, motivation has a significant correlation with cognition and attitude. The SMTSL questionnaire has proved such a theoretical position and also revealed that, among six scales, self-efficacy and active learning strategies have higher correlation with achievement scores, while learning environment stimulation has a higher correlation with science attitude.

Acknowledgements

The authors express their thanks to the National Science Council in Taiwan for their support of this work (NSC 90-2511-S-018-030; NSC 89-2511-S-018-030), and to reviewers for comments and help.

References

American Association for the Advancement of Science (1993). *Benchmarks for Science Literacy.* New York: Oxford University Press.

Atkinson, J.W., & Birch, D. (1978). *An Introduction to Motivation* (2nd ed.). New York: Van Nostrand.

Bandura, A. (1981). Self-referent thought: A developmental analysis of self-efficacy. In J.H. Flavell and L. Ross (Eds) *Social Cognitive Development: Frontiers and Possible Futures.* New York: Cambridge University Press.

Bandura, A. (1982). Self-efficacy mechanism in human agency. *American Psychologist, 37,* 122–147.

Bandura, A. (1997). *Self-efficacy: The exercise of control.* New York: W.H. Freeman.

Barlia, L., & Beeth, M.E. (1999). High school students' motivation to engage in conceptual change learning in science. Paper presented at the annual meeting of the National Association for Research in Science Teaching, Boston, MA, March.

Blumenfeld, P.C. (1992). Classroom learning and motivation. Clarity and expanding goal theory. *Journal of Educational Psychology, 84,* 272–281.

Blumenfeld, P.C., & Meece, J.L. (1988). Task factors, teacher behaviour, and students' involvement and use of learning strategies in science. *The Elementary School Journal, 88,* 235–250.

Brophy, J. (1998). *Motivating students to learn.* Madison, WI: McGraw Hill.

Deci, E., & Ryan, R. (1991). A motivational approach to self: Integration in personality. In R. Dienstbier (Ed.) *Nebraska Symposium on Motivation, Volume 38, Perspectives on Motivation* (pp. 237–288). Lincoln, NE: University of Nebraska Press.

Duit, R., & Treagust, D. (1998). Learning in science — From behaviourism towards social constructivism and beyond. In B. Fraser and K. Tobin (Eds) *International Handbook of Science Education* (pp. 3–26). Dordrecht: Kluwer Academic.

Erb, M. (1996). Increasing students' responsibility for their learning through multiple intelligence activities and cooperative learning. Unpublished master's thesis, Saint Xavier University, IL.

Fraser, B.J. (1981). *Test of Science-Related Attitude (TOSRA).* Melbourne: Australian Council for Educational Research.

Garcia, T. (1995). The role of motivational strategies in self-regulated learning. *New Directions for Teaching and Learning, 63,* 29–42.

Garcia, T., & Pintrich, P.R. (1992). Critical thinking and its relationship to motivation, learning strategies, and classroom experience. Paper presented at the Annual Meeting of the American Psychological Association, Washington, DC, August.

Garcia, T., & Pintrich, P.R. (1995). The role of possible selves in adolescents' perceived competence and self-regulation. Paper presented at the annual meeting of the American Educational Research Association, San Francisco, CA, April.

Haladyna, T., & Shaughnessy, J. (1982). Attitudes toward science: A quantitative synthesis. *Science Education, 66,* 547–563.

Hanrahan, M. (1998). The effect of learning environment factors on students' motivation and learning. *International Journal of Science Education, 20*(6), 737–757.

Huang, S.C., & Tuan, H.L. (2001). Students with different motivation patterns their perceptions toward science teachers' teaching strategies. *Science Education, 11,* 122–143 (in Chinese).

Huang, S.Y., & Waxman, H.C. (1995). Motivation and learning environment differences between Asian-American and white middle school students in mathematics. *Journal of Research and Development in Education, 28*(4), 208–219.

Hynd, C., Holschuh, J., & Nist, S. (2000). Learning complex scientific information: Motivation theory and its relation to student perceptions. *Reading and Writing Quarterly, 16*(1), 23–57.

Kuyper, H., van der Werf, M.P.C., & Lubbers, M.J. (2000). Motivation, meta-cognition and self-regulation as predictors of long term educational attainment. *Educational Research and Evaluation, 6*(3), 181–201.

Lee, O. (1989). Motivation to learning science in middle school classrooms. University Microfilms International. Unpublished doctoral dissertation, Michigan State University, East Lansing.

Lee, O., & Anderson, C.W. (1993). Task engagement and conceptual change in middle school science classrooms. *American Educational Research Journal, 30*(3), 585–610.

Lee, O., & Brophy, J. (1996). Motivational patterns observed in sixth-grade science classrooms. *Journal of Research in Science Teaching, 33*(3), 585–610.

Messick, S. (1989). Validity. In R.J. Linn (Ed.) *Educational measurement.* (pp. 13–103). New York: American Council on Education/Macmillan.

Midgley, C., Maehr, M.L., & Urdan, T.C. (1993). *Patterns of adaptive learning survey.* Ann Arbor, MI: University of Michigan Press.

Mintzes, J., Wandersee, J.H., & Novak, J.D. (1998). *Teaching for understanding — A human constructivist view.* San Diego, CA: Academic Press.

Napier, J.D., & Riley, J.P. (1985). Relationship between affective determinants and achievement in science for seventeen-year-olds. *Journal of Research in Science Teaching, 22*(4), 365–383.

National Research Council (1996). *National Science Education Standards.* Washington, DC: National Academy Press.

Nolen, S.B., & Haladyna, T.M. (1989). Psyching out the science teacher: Students' motivation, perceived teacher goals and study strategies. Paper presented at the annual meeting of the American Educational Research Association, San Francisco, CA, March.

Pajares, F. (1996). Self-efficacy beliefs in academic settings. *Review of Educational Research, 66,* 543–578.

Pintrich, P.R., & Blumenfeld, P.C. (1985). Classroom experience and children's self-perceptions of ability, effort, and conduct. *Journal of Educational Psychology, 77*(6), 646–657.

Pintrich, P.R., & Schunk, D.H. (1996). *Motivation in education: Theory, research and applications* (2nd ed.). Englewood Cliffs, NJ: Merrill Company.

Pintrich, P.R., Smith, D.A.F., Garcia, T., & McKeachie, W.J. (1991). *A Manual for the use of the Motivated Strategies for Learning Questionnaire (MSLQ),* Report Number NCRIPTAL-91-B-004. Ann Arbor, MI: National Center for Research to Improve Postsecondary Teaching and Learning. (ERIC Document Reproduction Service No. ED 338 122).

Pintrich, P.R., Marx, R.W., & Boyle, R.A. (1993). Beyond cold conceptual change: The role of motivational beliefs and classroom contextual factors in the process of conceptual change. *Review of Educational Research, 63*(2), 167–199.

Reynolds, A.J., & Walberg, H.J. (1992). A structural model of science achievement and attitude: An extension to high school. *Journal of Educational Psychology, 84*(3), 371–382.

Schunk, D.H. (1991). Self-efficacy and academic motivation. *Educational Psychologist, 26*(3&4), 207–231.

Simpson, R.D., & Troost, K.M. (1982). Influences on commitment to and learning of science among adolescent students. *Science Education, 66*(5), 763–781.

Singh, K., Graville, M., & Dika, S. (2002). Mathematics and science achievement: Effects of motivation, interests and academic engagement. *Journal of Educational Research, 95*(6), 323–332.

Strike, K.A., & Posner, P.J. (1983). On rationality and learning: A reply to West and Pines. *Science Education, 67,* 41–43.

Strike, K.A., & Posner, P.J. (1992). A revisionist theory of conceptual change. In R.A. Duschl and R.J. Hamilton (Eds) *Philosophy of Science, Cognitive Psychology, and Educational Theory and Practise* (pp. 147–176). Albany, NY: State University of New York Press.

Thompson, T.L., & Mintzes, F.F. (2002). Cognitive structure and the affective domain on knowing and feeling in biology. *International Journal of Science Education, 24*(6), 645–660.

Tuan, H.L., & Chin, C.C. (1999). Promoting junior high school students' motivation toward physical science learning (I). Report for Taiwan National Research Council (NSC 88-2511-S018-013).

Tuan, H.L., & Chin, C.C. (2000). Promoting junior high school students' motivation toward physical science learning (III). Report for Taiwan National Research Council (NSC 89-2511-S018-030).

Uguroglu, M.E., & Walberg, H.J. (1979). Motivation and achievement: A quantitative analysis. *American Educational Research Journal, 16*(4), 375–389.

Uguroglu, M.E., Schiller, D.P., & Walberg, H.J. (1981). A multidimensional motivational instrument. *Psychology in the Schools, 18,* 279–285.

Urdan, T.C., & Maehr, M.L. (1995). Beyond a two-goal theory of motivation and achievement: A case for social goals. *Review of Educational Research, 65*(3), 213–243.

Von Glasersfeld, E. (1998). Cognition, construction of knowledge and teaching. In M.R. Matthews (Ed.) *Constructivism in Science Education* (11–30). Dordrecht: Kluwer Academic.

Weiner, B. (1990). History of motivational research in education. *Journal of Educational Psychology, 82*(4), 616–622.

West, L.H.T., & Pines, A.L. (1983). How 'rational' is rationality? *Science Education, 67,* 37–39.

Wolters, C.A. (1999). The relation between high school students' motivational regulation and their use of learning strategies, effort, and classroom performance. *Learning and Individual Differences, 11*(3), 281–300.

Wu, S.J., & Tuan, H.L. (2000). A case study of students' motivation in a ninth grader physical science class. In D. Fisher and J.H. Yang (Eds) *Proceedings of the Second Conference on Science, Mathematics and Technology Education* (341–350). Perth: Curtin University of Technology.

Appendix 1: the SMTSL questionnaire

Directions for students

This questionnaire contains statements about your willingness in participating in this science class. You will be asked to express your agreement on each statement. There are no "right " or "wrong" answers. Your opinion is what is wanted. Think about how well each statement describes your willingness in participating in this class.

Draw a circle around

1. if the statement you strong disagree
2. if the statement you disagree
3. if the statement you have no opinion
4. if the statement you agree
5. if the statement you strong agree

Be sure to give an answer for all questions. If you change your mind about an answer, just cross it out and circle another.

Some statements in this questionnaire are fairly similar to other statements. Don't worry about this. Simply give your opinion about all statements.

Your Name___________; Teacher's Name___________
School___________; Grade___________ ;Male_____ Female_____
Science Class; Biology_____ Physical Science_____

A. Self efficacy	**Strongly disagree**	**Disagree**	**No opinion**	**Agree**	**Strongly agree**
1. Whether the science content is difficult or easy, I am sure that I can understand it.	1	2	3	4	5
2. I am not confident about understanding difficult science concepts.(–)	1	2	3	4	5
3. I am sure that I can do well on science tests.	1	2	3	4	5
4. No matter how much effort I put in, I cannot learn science.(–)	1	2	3	4	5
5. When science activities are too difficult, I give up or only do the easy parts.(–)	1	2	3	4	5
6. During science activities, I prefer to ask other people for the answer rather than think for myself. (–)	1	2	3	4	5
7. When I find the science content difficult, I do not try to learn it (–)	1	2	3	4	5

B.	Active learning strategies	**Strong disagree**	**Disagree**	**No opinion**	**Agree**	**Strong agree**
8.	When learning new science concepts, I attempt to understand them.	1	2	3	4	5
9.	When learning new science concepts, I connect them to my previous experiences.	1	2	3	4	5
10.	When I do not understand a science concept, I find relevant resources that will help me.	1	2	3	4	5
11.	When I do not understand a science concept, I would discuss with the teacher or other students to clarify my understanding.	1	2	3	4	5
12.	During the learning processes, I attempt to make connections between the concepts that I learn.	1	2	3	4	5
13.	When I make a mistake, I try to find out why.	1	2	3	4	5
14.	When I meet science concepts that I do not understand, I still try to learn them.	1	2	3	4	5
15.	When new science concepts that I have learned conflict with my previous understanding, I try to understand why.	1	2	3	4	5
C.	Science Learning Value	**Strong disagree**	**Disagree**	**No opinion**	**Agree**	**Strong agree**
16.	I think that learning science is important because I can use it in my daily life.	1	2	3	4	5
17.	I think that learning science is important because it stimulates my thinking.	1	2	3	4	5
18.	In science, I think that it is important to learn to solve problems.	1	2	3	4	5
19.	In science, I think it is important to participate in inquiry activities.	1	2	3	4	5
20.	It is important to have the opportunity to satisfy my own curiosity when learning science.	1	2	3	4	5
D.	Performance Goal	**Strong disagree**	**Disagree**	**No opinion**	**Agree**	**Strong agree**
21.	I participate in science courses to get a good grade. (–)	1	2	3	4	5
22.	I participate in science courses to perform better than other students. (–)	1	2	3	4	5

23.	I participate in science courses so that other students think that I'm smart.(–)	1	2	3	4	5
24.	I participate in science courses so that the teacher pays attention to me.(–)	1	2	3	4	5
E.	Achievement Goal	**Strong disagree**	**Disagree**	**No opinion**	**Agree**	**Strong agree**
25.	During a science course, I feel most fulfilled when I attain a good score in a test.	1	2	3	4	5
26.	I feel most fulfilled when I feel confident about the content in a science course.	1	2	3	4	5
27.	During a science course, I feel most fulfilled when I am able to solve a difficult problem.	1	2	3	4	5
28.	During a science course, I feel most fulfilled when the teacher accepts my ideas.	1	2	3	4	5
29.	During a science course, I feel most fulfilled when other students accept my ideas.	1	2	3	4	5
F.	Learning Environment Stimulation	**Strong disagree**	**Disagree**	**No opinion**	**Agree**	**Strong agree**
30.	I am willing to participate in this science course because the content is exciting and changeable.	1	2	3	4	5
31.	I am willing to participate in this science course because the teacher uses a variety of teaching methods.	1	2	3	4	5
32.	I am willing to participate in this science course because the teacher does not put a lot of pressure on me.	1	2	3	4	5
33.	I am willing to participate in this science course because the teacher pays attention to me.	1	2	3	4	5
34.	I am willing to participate in this science course because it is challenging.	1	2	3	4	5
35.	I am willing to participate in this science course because the students are involved in discussions.	1	2	3	4	5

Note: (–) represent reverse items.