International Journal of Science Education

ISSN: 0950-0693 (Print) 1464-5289 (Online) Journal homepage: http://www.tandfonline.com/loi/tsed20

Students' awareness of science teachers' leadership, attitudes toward science, and positive thinking

Ying-Yan Lu, Hsiang-Ting Chen, Zuway-R Hong & Larry D. Yore

INTERNATIONAL JOURNAL OF SCIENCE EDUCATION, 2016
http://dx.doi.org/10.1080/09500693.2016.1230792

Students' awareness of science teachers' leadership, attitudes toward science, and positive thinking

Ying-Yan Lu[a], Hsiang-Ting Chen[a], Zuway-R Hong[a] and Larry D. Yore[b]

[a]Institute of Education, National Sun Yat-sen University, Kaohsiung, Taiwan, ROC; [b]Curriculum and Instruction, University of Victoria, Victoria, BC, Canada

ABSTRACT
There appears to be a complex network of cognitive and affective factors that influence students' decisions to study science and motivate their choices to engage in science-oriented careers. This study explored 330 Taiwanese senior high school students' awareness of their science teacher's learning leadership and how it relates to the students' attitudes toward science and positive thinking. Initial results revealed that the *optimism* of positive thinking is highly and positively correlated with the *future participation* in *science* and *learning science in school* attitudes toward science and *self-concept in science*. Moreover, structural equation modelling (SEM) results indicated that the subscale of teachers' *leadership with idealised influence* was the most predictive of students' *attitudes toward science* ($\beta = .37$), and the leadership with *laissez-faire* was predictive of students' *positive thinking* ($\beta = .21$). In addition, the interview results were consistent with the quantitative findings. The correlation and SEM results indicate some of the associations and potential relationships amongst the motivational and affective factors studied and students' attitudes toward and intentions to study science, which will increase their likelihood of future involvement in science careers.

ARTICLE HISTORY
Received 2 April 2016
Accepted 27 August 2016

KEYWORDS
Attitudes toward science; positive thinking; senior high school students; science teachers' leadership; Taiwan

Introduction

Students' attitudes towards science have been seen as a vitally important learning outcome, which has been continuously investigated through international assessments as a key mechanism for producing educational improvement. Archer et al. (2010) found that the majority of young children have positive attitudes towards science at age 10 (Grade 4), but that their positive attitudes decline markedly by age 14 (Grade 8). Hong, Lin, and Lawrenz (2012) found that increases in a negative attitude may be brought about by students' undesirable experiences in previous science courses and their lack of positive perceptions about science in Taiwan.

This study assumed a positive psychology view of human endeavours, which involves factors that make life worth living—personal well-being, contentment, satisfaction, hope, optimism, happiness, etc. (Czikszentmihalyi, 2014). Thereby, science teachers are believed

CONTACT Zuway-R Hong a3803429@gmail.com Institute of Education, National Sun Yat-sen University, 18-1 F No.5, Cheng Hsin Road, San Ming District, Kaohsiung 80702, Taiwan, ROC

to be a central influence and intrinsic motivation on students' perceptions about and successful learning in science. Teachers have the capacity to make science learning enjoyable and to encourage students to have higher levels of engagement and performance. The specific attributes of a science teacher that account for these positive effects, motivation and perceptions, are not fully agreed upon. However, a teacher's image as a learning leader might be central to students' perceptions of school science and positive thinking.

Taiwan is undergoing a rapid sociopolitical transition with major changes in social and economic structures, traditional values, family structure, and the educational system. Lee, Tsai, and Chai (2012) reported that science teaching in Taiwan has traditionally focused on science content—the bedrock of the curriculum and school science examinations, which might relate to students' negative attitudes towards and underdeveloped thinking in science. Currently, there were limited studies that investigate the associations of Taiwanese science teachers' leadership, students' attitudes towards science, and positive thinking. Therefore, we hypothesised that students' perceptions of their science teachers' leaderships styles might be intrinsic motivators that influence their attitudes towards science and positive thinking.

Secondary schools worldwide involve a complex sociopolitical network of people, things, and expectations responding to various sources of leadership, cultural values, and tensions. Tu (2006) found that Taiwanese secondary school students facing pressure at school or home reported the highest pressure was academic overload (30% of respondents). Science classroom learning environments are assumed to involve a number of features (school organisation, teachers, students, learning tasks, peers, time demands, etc.) and to influence student performance and engagement (Fraser, 2015). Traditional examination-oriented approaches to science instruction can lead to boredom, frustration, and a negative perception of science in Taiwanese school settings (Hong et al., 2012).

These results seemingly point out that the teaching approach and learning environment of science might be problematic in Taiwan today. Eisenberg, Hofer, and Vaughan (2007) asserted that positive thinking can (a) produce more favourable perceptions of negative events and (b) actively produce individual well-being and growth. Fairman and Mackenzie (2015) provided a new lens on the important relationships amongst informal collaboration, trust, and collegiality in supporting teachers' leadership and school improvement. Chen, Wang, Lin, Lawrenz, and Hong (2014) indicated that positive attitudes towards science are correlated with students' positive commitment to science and might influence their life-long interest and learning in science. The current study explored students' awareness of their science teachers' leadership and how it relates to their attitudes towards science and to their positive thinking.

Leadership theory

Considerations of characteristics of transformational, charismatic, and visionary leadership have received considerable theoretical and empirical work over the last three decades (Antonakis, Avolio, & Sivasubramaniam, 2003; Bass & Avolio, 1995; Bryman, 1999; Tejeda, Scandura, & Pillai, 2001). Bass and Avolio (1995) asserted that the multifactor leadership theory, which includes transformational, transactional, and laissez-faire approaches, is an essential framework. Koh, Steers, and Terborg (1995) suggested that transformational leaders frequently raise the perceived importance and value of designated follower outcomes. Furthermore, they asserted that transformational leaders usually display behaviours associated with four characteristics: (a) idealised influence—a leader who is a role model for followers and encourages them to share common visions and goals by providing a clear vision and a strong sense of purpose; (b) inspirational motivation—a leader who motivates and encourages followers to reach desired goals and do meaningful and challenging works; (c) intellectual stimulation—a leader who challenges followers' ideas and values for solving problems; and (d) individual consideration—a leader who is typically willing to delegate projects in order to stimulate and create learning experiences, and willing to spend more time teaching and coaching followers with respect as unique individuals.

Koh et al. (1995) examined the transformational leadership in 89 schools in Singapore and found an indirect effect on student academic achievement. Transactional leaders, in contrast to transformational leaders, tend to focus on the short-term physical and security needs of their followers (Bass & Avolio, 1993; Koh et al., 1995) and are often seen as reactive rather than proactive (Bass, 1985). Bass (1985) suggested that transactional leadership is composed of three components:

- *Contingent reward leader* refers to behaviours that reinforce followers for task accomplishment and meeting a task goal, where rewards are provided in exchange for compliance with the leader's demands.
- *Management-by-exception (passive) leader* refers to a group that does not meet the standards.
- *Management-by-exception (active) leader* refers to active monitors who make mistakes.

Furthermore, the *laissez-faire leader* exhibits leadership that avoids clarifying expectations, does not address conflicts, and avoids making a decision.

Empirical research addressing followers' reactions to different leadership types found that their motivation, satisfaction, and performance for laissez-faire leadership were significantly different from that for transformation and transactional leaderships (e.g. Bass & Avolio, 1990; Hater & Bass, 1988). Therefore, Bass and Avolio (1993) conceptualised leadership within behavioural domains as non-leadership (i.e. laissez-faire), leadership based upon rewards and punishment (i.e. transactional), and leadership based upon attributed and behavioural charisma (i.e. transformational).

Teachers' learning leadership and students' learning outcomes

Historically, students' perceptions of their teachers and experiences with their teachers served as intrinsic motivation for their learning. Students who perceived of their teachers as authentic disciplinary representatives (perception that their music and art teachers were practising musicians and artists, physical education teachers were performing athletes, etc.) were intrinsically motivated to engage in the learning experiences and achieve the outcomes (Czikszentmihalyi, 1982, 2014). Recently, leadership theory has been applied to teachers because they are expected to be learning leaders who plan, enact, and facilitate optimal and pleasurable opportunities that meet students' learning needs and achieve desired learning outcomes. Empirical studies have explored teachers' leadership approaches and their relation to student performance (e.g. Angelle & Schmid, 2007;

Fairman & Mackenzie, 2015; Harris & Muijs, 2004; Lambert, 2003; Silva, Gimbert, & Nolan, 2000; York-Barr & Duke, 2004). Silva et al. (2000) described the development of teacher leadership as coming in three waves: teacher leaders took on managerial roles; teacher leaders used instructional expertise in tasks, such as curriculum development or coordination of improvement efforts; and teachers' leadership was applied to emerging learning environments. The last wave of leadership studies was based on the suggestion that leadership is an emerging organisation quality, which was seen everywhere (Ogawa & Bossert, 1995). York-Barr and Duke (2004) reviewed 140 studies of teacher leadership and provided a model that depicted the characteristics and supporting conditions of teacher leaders; they successfully clarified how the teachers lead through relationships of improving students' learning outcomes. In the current study, we considered what types of leadership approaches utilised by science teachers might relate and predict their students' attitudes towards science and positive thinking.

Gender differences in attitudes towards science

Osborne, Simon, and Collins (2003) suggested that attitudes are the feelings, beliefs, and values held about an object, which in terms of science may include enthusiasm about science, perceptions of school science, and contributions of science to society or of scientists themselves. Thus, attitudes allow people to judge things related to science along emotional dimensions, such as good or bad, harmful or beneficial, pleasant or unpleasant, and important or unimportant. These evaluative judgements are always towards something (Crano & Prislin, 2006). Kind, Jones, and Barmby (2007) suggested that attitudes towards science provide measures as a way of mapping students' cognitive and emotional opinions about various aspects of science. However, it was found that the more years that students are involved in science learning, the more negative their attitudes towards science becomes (Barmby, Kind, & Jones, 2008; George, 2006; Lloyd, Neilson, King, & Dyball, 2012; Hong et al., 2012). Furthermore, Hong et al. (2012) revealed that increases in negative attitudes may be brought about by children's undesirable experiences in previous science courses and their lack of positive perceptions. Lloyd et al. (2012) found that a cause of students' negative attitudes towards science was derived from the students' perception of science as a difficult or boring subject.

International studies completed in the last three decades have shown that male students have significantly higher interest and attitudes towards science and different perceptions of scientists and science careers than female students from elementary to secondary schools (Jones, Howe, & Rua, 2000; Sullins, Hernandez, Fuller, & Tashiro, 1995). Furthermore, males and females reported having different science experiences both in and out of school. Although more females than males enrol in post-secondary institutions and earn higher grades in science and engineering courses, significantly more males than females major in the natural sciences or engineering (National Science Board, 1998; National Science Foundation, 1996).

Distinctions are commonly made between science at school, real science, and science in society; each of which may be split into more detailed objects (e.g. science teachers, classroom, and content) that again may be characterised with a range of attributes. Each of these objects has attributes that may be judged along various emotions towards science. Science teachers, for example, may be characterised by their way of teaching or of relating to students that the students think of as good or bad, pleasant or unpleasant, and interesting or uninteresting (Kind et al., 2007). However, there have been only a few empirical studies on the add-on effects of teachers' leadership in explaining students' motivation, satisfaction, and academic performance (e.g. Bass, 1985; Bass & Avolio, 1990; Hater & Bass, 1988; Koh et al., 1995). These studies found that teachers with transformational leadership have indirect effects on student academic achievement, thereby confirming the positive contributions of leadership in public schools.

Relationships amongst students' attitudes towards science, positive thinking, and teachers' leadership

Positive psychology is a relatively new field of research that grew out of a need to rebalance the focus of psychological studies from the negative attributes of human nature to more positive aspects (Buck, Carr, & Robertson, 2008). Sasson (2010) claimed that positive thinking was a disposition that opens the mind to thoughts, words, images, and behaviours that are conducive to growth, expansion, and success. Seligman, Steen, Park, and Peterson (2005) recommended positive psychology approaches that include three essential domains: (a) the subjective level that considers a person who is full of well-being and satisfaction in the past, flow (narrow band of enjoyable and important endeavours between anxiety and boredom in the work-play space) and happiness in the present, and hope and optimism into the future; (b) the individual level that considers a person who is full of love, courage, aesthetic sensibility, perseverance, forgiveness, spirituality, high talent, and wisdom; and (c) the institutional level that considers a person who is full of responsibility, altruistic, polite, moderate, tolerant, and has a strong work ethic. Positive thinking can produce a more favourable view of a negative event, which actively produces personal growth. Adolescents are encountering both psychological and physical problems due to reaching the period of puberty (Hong, 2010); therefore, secondary school is a critical time and place to encourage students to build more positive thinking, to develop positive dispositions towards learning and others, and to learn essential workplace skills. How best to promote these goals is still a matter for debate. Previous studies indicated that individual health-promoting efforts should be addressed in a developmentally appropriate manner (Eisenberg et al., 2007).

Positive psychology has great promise for the field of education since many students face classrooms that do not provide learning experiences focusing on their strengths, their need for appropriate challenge, and the importance of developing initiative in the youth. Teachers drawn to positions of leadership are potential influences on students' positive thinking because they are viewed as achievement and learning oriented and as willing to take risks and assume responsibility (Wilson, 1993; Yager & Lee, 1994).

York-Barr and Duke (2004) believed that teachers' leadership could provide a productive intrinsic motivation lens to explain student behaviour. They examined various paths of teachers' leadership that influence students' learning, behaviours, and emotions. Thus, in the current study, we designed a survey with follow-up interviews to examine the relationship of teachers' leadership and students' attitudes towards science and their positive thinking models. This study's research questions (RQ) were as follows:

1. Are there any differences between male and female students on their attitudes towards science, positive thinking, and awareness of teachers' leadership?

2. Do any relationships exist amongst students' attitudes towards science, positive thinking, and awareness of their science teachers' leadership?
3. How might students' awareness of their science teachers' leadership be predictive of their attitudes towards science and positive thinking?

Methods

This mixed-method design involved a survey with follow-up interviews to provide data that could be interpreted by quantitative and qualitative means. High school students' attitudes and perceptions were analysed using statistical methods; the interview responses were interpreted using appropriate qualitative approaches.

Participants and setting

A total of 350 senior high school students were randomly selected from two typical urban senior high schools in southern Taiwan (Kaohsiung) to participate in the study during the spring of 2015–2016. These schools, like Taiwan generally, have a history of high participation and performance in science, and many of their graduates are accepted into some of the highest ranked Taiwanese and international universities. These schools have approximately 15 teachers involved with Grade 9–12 science courses. The faculties at these schools are rather stable, with little annual turnover or new teachers. The students come from diverse socio-economic status families and have similar psychological and physical educational environments. Informed consent for teachers, parents, and students to participate in the study (a survey and a potential interview), which was approved by the university's research ethics committee, explained the purpose of the study and that all participants could withdraw at any time without negative effects; completing the questionnaire and its responses were anonymous, the data were confidential, and the results were not to be compared or identified personally. A random subsample of 10 students (5 males and 5 females) was recruited to be interviewed after they completed the survey.

The authors personally conducted the survey, so the response rate was very high (100%). After checking incomplete data on each questionnaire, we identified a total of 330 valid surveys (147 males and 183 females, 124 Grade 10 and 206 Grade 11 students). The students' mean ages were 16.68 years ($SD = 0.47$) for the males and 16.65 years ($SD = 0.48$) for the females. The male students' mean performance percentage in their current science course was 66% ($SD = 10.95$); the female students' mean performance percentage was 65% ($SD = 9.12$). The *t*-test comparisons of male and female participants' ages and mean percentage scores in science revealed non-significant ($p > 0.05$) gender differences.

Development and validation of instruments

The high school science questionnaire (HSSQ), a 78-item survey, was developed to document students' perceptions and attitudes about their teachers, the discipline, and positive thinking. The HSSQ includes four sections: demographic items, Science Teachers' Leadership Scale (STLS), Attitudes towards Science Scale (ATSS), and Positive Thinking Scale (PTS).

Students' demographic information

The first section of the HSSQ elicited all respondent demographics (i.e. gender, age, and average percentage score in the current science course).

Science teachers' leadership scale

The 21-item Chinese version of the STLS has been well validated through a cross-cultural translation process from the original English version of the Multifactor Leadership Questionnaire (MLQ) Form 6S (Bass & Avolio, 1995). All participants are asked to rate each item using a 4-point Likert scale (4 = strongly agree … 1 = strongly disagree), where a higher total score indicates more positive awareness towards science teachers' leadership. The total STLS score ranged from 21 to 84, with an internal consistency of .89. Appendix 1 provides descriptive statistics on all items. An exploratory factor analysis (EFA) was conducted to examine the structural validity of the subscales. A Kaiser-Meyer-Olkin (KMO) and Bartlett's test of sphericity revealed a high KMO (.91) and significant differences for all items (approximate $\chi^2 = 2332.68$, $p < 0.001$) (Tabachnick & Fidell, 2001). The EFA revealed that the final version contained seven factors, which together accounted for 66% of the variance.

The first subscale, idealised influence, included 3 items, with an internal consistency of .88 and a total score range of 3–12, and accounted for 18% of the variance; a sample item is *My science teacher is my learning model*. The second subscale, inspirational motivation, included 3 items, with an internal consistency of .83 and a total score range of 3–12, and accounted for 16% of the variance; a sample item is *My science teacher is passionate in teaching science*. The third subscale, intellectual stimulation, included 3 items, with an internal consistency of .91 and a total score range of 3–12, and accounted for 8% of the variance; a sample item is *My science teacher asks students questions very often*. The fourth subscale, individual consideration, included 3 items, with an internal consistency of .91 and a total score range of 3–12, and accounted for 7% of the variance; a sample item is *My science teacher is concerned for each student's needs*. The fifth subscale, contingent reward, included 3 items, with an internal consistency of .80 and a total score range of 3–12, and accounted for 6% of the variance; a sample item is *If I complete assignments, I can obtain praises from my science teacher*. The sixth subscale, management-by-exception, included 3 items, with an internal consistency of .81 and a total score range of 3–12, and accounted for 6% of the variance; a sample item is *My science teacher points out my misconceptions in science*. The seventh subscale, laissez-faire leadership, included 3 items, with an internal consistency of .74 and a total score range of 3–12, and accounted for 5% of the variance; a sample item is *My science teacher never sets his/her teaching plan ahead of the start of class*. These results indicated that the STLS has appropriate validity and reliability.

Attitudes towards science scale

The 26-item Chinese version of the ATSS was adapted from the 45-item Attitudes towards Science Measures Scale (Kind et al., 2007) with six subscales (i.e. learning science in school, self-concept in science, practical work in school, science outside school, future participation in science, and importance of science). Preparing the ATSS involved selecting items, translating the instrument to Chinese, and back-translating to English to validate the translated version (Brislin, 1986). Any discrepancies were discussed and resolved through translation by another science educator. This iterative process was repeated until no error in translation was found (Chen et al., 2014).

Participants were asked to rate each ATSS item using a 4-point Likert scale (4 = strongly agree … 1 = strongly disagree). A panel of science educators examined these items to explore construct validity. An EFA to explore structural validity was conducted; results revealed five factors, which, when taken together, accounted for 64% of the variance. Appendix 2 presents means, standard deviations, correlations, factor loadings, and Cronbach's α results on the 26 items. It can be seen that all items fit within the three indices recommended by Cohen (1988; i.e. standard deviation higher than 0.60, factor loading bigger than 0.40, and correlation with total score greater than 0.25). The total ATSS scores ranged from 26 to 104, with a high internal consistency of .95; and the internal consistencies of the five subscales (i.e. learning science in school, self-concept in science, future participation in science, science outside of school, and importance of science) were .86, .82, .87, .78, and .76, respectively. These results indicate that the ATSS has adequate construct/structural validity and reliability.

Positive thinking scale

A Chinese version of the PTS with a 4-point Likert-type scale (1 = strongly disagree … 4 = strongly agree) was derived from Hong et al.'s (2012) PTS. The original version of the PTS included four factors, which taken together accounted for 60% of the variance. The PTS for the current study involved 28 items randomly selected from the original PTS items. The data from the modified PTS used with senior high school students indicated the total score ranged from 28 to 112 and had an internal consistency of .96. A higher total score indicates more positive thinking. An EFA of this data set to explore its structural validity revealed the anticipated four subscales, which, when taken together, accounted for 54% of the variance. The first subscale, self-confidence, included 8 items, with a total score range of 8–40 and an internal consistency of .86; a sample item is *I will do my best to complete the work*. The second subscale, self-satisfaction, included 8 items with a total score range of 8–40 and an internal consistency of .89; a sample item is *I feel that my life is full of fun*. The third subscale, optimism, included 6 items, with a total score range of 6–30 and an internal consistency of .83; a sample item is *I think the future is very hopeful*. The fourth subscale, appreciation, included 6 items, with a total score range of 6–30 and an internal consistency of .80; a sample item is *I appreciate the advantages of others*. It can be seen that all items fit within the three indices recommended by Cohen (1988) and detailed earlier. Appendix 3 presents means, standard deviations, correlations, factor loadings, and Cronbach's α results on the 28 items. These results indicate that the PTS has an adequate construct validity and internal reliability.

Interview protocols

A semi-structured interview protocol was developed to further elicit information for deeper insights into survey responses from 10 students. Three interview questions and potential follow-up questions for each question, which were based on the students' preliminary data analyses of the 330 participants' awareness of science teachers' leadership, positive thinking, and their attitudes towards science, were used to probe and clarify survey question responses. The interview questions were: (1) *Please describe your* *science teacher's leadership and teaching strategies in your science class?* (2) *Did you find any relationships between your thinking style and attitude towards science?* (3) *Did you find any relationships between your science teacher's leadership and your attitude towards science and thinking style?* These respondents were individually interviewed for about 20–30 minutes by the first author. All interviews were video-taped and transcribed into searchable text files.

Data analysis

The mixed data sources required the use of both quantitative and qualitative interpretation methods to address the research questions. First, we performed EFAs and internal consistency to examine the instruments' and subscales' reliabilities and construct/structural validities reported earlier. Second, students' responses to all scales and subscales were analysed using independent t-tests, Pearson correlations, and structural equation modelling (SEM) to compare differences and document relationships amongst students' attitudes towards science, positive thinking, and awareness towards their teachers' leadership. Finally, a theme analysis (Patton, 2002) was conducted to analyse the students' interview results.

Results

This section is organised by the specific issue in each research question to illustrate the logical development of the study. Quantitative results are reported for the research question followed by the qualitative assertions to provide insights into the numerical outcomes.

Male and female students' attitudes towards science, positive thinking, and awareness of teachers' leadership

Quantitative results

Table 1 summarises the descriptive statistics and t-tests for leadership, attitudes, and positive thinking. These results revealed that the males reported significantly ($p < 0.05$) higher perceptions than the females on four of the seven subscales of awareness of science teachers' leadership: idealised influence, inspirational motivation, intellectual stimulation, and individual consideration. Furthermore, the males' mean scores of attitudes towards science were significantly ($p < 0.05$) higher than those of the females on all subscales. However, the results on positive thinking were mixed, with the males significantly ($p < 0.05$) outperforming the females on the optimism subscale and the females significantly ($p < 0.05$) outperforming the males on the self-satisfaction subscale. Non-significant differences favouring the females were found for the other two PTS subscales.

Qualitative results

The following assertions (**boldface**) and student responses (*italics*) revealed the interviewees' awareness of their science teachers' leadership, attitudes towards science, and their positive thinking perspective. The interview responses to the question below indicated that the **males have positive awareness of their science teachers' leadership and more positive thinking and attitudes towards science than the females.**

Table 1. Results of t-tests of students' awareness of science teachers' leadership, attitudes towards science, and positive thinking by gender.

Variable/subscale	Male ($n = 147$)		Female ($n = 183$)				
	M	SD	*M*	SD	*t*	*P*	*d*
Science teachers' leadership							
Idealised influence	8.28	1.46	7.87	1.41	2.59	.010	.28
Inspirational motivation	8.11	1.59	7.74	1.57	2.09	.037	.23
Intellectual stimulation	7.98	1.75	7.51	1.64	2.52	.012	.28
Individual consideration	7.99	1.67	7.45	1.57	3.01	.003	.33
Contingent reward	8.37	1.16	8.19	1.17	1.46	.146	.15
Management-by-exception	8.52	1.19	8.35	1.35	1.23	.220	.13
Laissez-faire leadership	8.09	1.31	7.85	1.23	1.69	.092	.19
Attitudes towards science							
Learning science in school	22.12	3.90	18.78	4.36	7.27	≤.001	.81
Self-concept in science	15.39	3.29	12.51	2.95	8.39	≤.001	.92
Future participation in science	13.49	2.83	10.89	3.01	8.02	≤.001	.89
Science outside of school	11.12	2.27	9.76	2.43	5.18	≤.001	.58
Importance of science	9.07	1.59	8.56	1.99	2.60	.010	.28
Total	71.19	11.85	60.50	12.30	7.99	≤.001	.89
Positive thinking							
Self-confidence	25.00	2.88	25.66	3.32	−1.93	.054	.21
Self-satisfaction	24.31	3.67	25.60	3.92	−3.06	.002	.34
Optimism	16.00	3.08	13.44	3.00	7.63	≤.001	.84
Appreciation	17.56	2.87	17.79	2.78	−.71	.478	.08
Total	82.87	10.17	82.49	9.64	.36	.717	.04

Notes: Effect sizes (ES): small ES of $d = 0.2$; medium ES of $d = 0.5$; large ES of $d = 0.8$.

Interviewer (I): Please describe your science teachers' leadership and teaching strategies in your science class.

Wang (male [M]): *My physics teacher is a humorous instructor; he used life-oriented and hands-on teaching strategies, which help students learning more practical knowledge, not only focus on the textbooks. Moreover, my teacher is responsible to the students, especially for the male students. … However, I find that he asks the boys questions more often than the girls.*

Lin (female [F]): *My physics teacher pays more attention to the male students, so I always can't keep up with his steps during the class. Frankly speaking, I am really frustrated about learning physics in physics class.*

Li (M): *My physics teacher always encourages me to think positively. Although I have a lot of pressure on schoolwork, I still face difficulties optimistically and accept the challenges courageously.*

Relationships amongst students' awareness of science teachers' leadership, attitudes towards science and their positive thinking

Quantitative results

Table 2 demonstrates the results of the Pearson correlations that indicated the optimism subscale of positive thinking is highly and positively associated with four subscales of attitudes towards science: future participation in science ($r = .91$), learning science in school ($r = .85$), self-concept in science ($r = .83$), and science outside of school ($r = .79$). Furthermore, several other subscales of the STLS, ATSS, and PTS are significantly correlated. These results suggest that there may be meaningful associations amongst the constructs measured by these instruments.

Table 2. Relationships of students' awareness of science teachers' leadership, attitudes towards science, and positive thinking.

	STL1	STL2	STL3	STL4	STL5	STL6	STL7	ATS1	ATS2	ATS3	ATS4	ATS5	PT1	PT2	PT3	PT4
STL1	1.00															
STL2	.67**	1.00														
STL3	.58**	.68**	1.00													
STL4	.53**	.72**	.69**	1.00												
STL5	.43**	.51**	.55**	.66**	1.00											
STL6	.40**	.51**	.48**	.59**	.48**	1.00										
STL7	.41**	.41**	.26**	.36**	.31**	.33**	1.00									
ATS1	.53**	.38**	.40**	.31**	.21**	.23**	.31**	1.00								
ATS2	.46**	.32**	.36**	.30**	.25**	.16**	.28**	.79**	1.00							
ATS3	.33**	.18**	.22**	.17**	.07	.12*	.18**	.77**	.73**	1.00						
ATS4	.42**	.20**	.23**	.14*	.03	.16**	.19**	.73**	.60**	.75**	1.00					
ATS5	.35**	.12*	.15**	.02	.06	.15**	.15**	.50**	.35**	.47**	.51**	1.00				
PT1	.14*	.07	.08	.06	.01	.21**	.19**	.15**	.09	.13*	.22**	.23**	1.00			
PT2	.13*	.15**	.06	.14**	.09	.23**	.17**	.04	.06	.01	.10	.08	.70**	1.00		
PT3	.43**	.25**	.30**	.23**	.14*	.18**	.23**	.85**	.83**	.91**	.79**	.48**	.16**	.06	1.00	
PT4	.15**	.14**	.11*	.15**	.13*	.23**	.20**	.13*	.18**	.08	.14*	.06	.74**	.77**	.13*	1.00

Notes: * < *.05*; ** < .01; STL1 = idealised influence; STL2 = inspirational motivation; STL3 = intellectual stimulation; STL4 = individual consideration; STL5 = contingent reward; STL6 = management-by-exception; STL7 = laissez-faire leadership; ATS1 = learning science in school; ATS2 = self-concept in science; ATS3 = future participation in science; ATS4 = science outside of school; ATS5 = importance of science; PT1 = self-confidence; PT2 = self-satisfaction; PT3 = optimism; PT4= appreciation.

Qualitative results

The interview responses to the question below indicated that students who demonstrated ***optimistic*** thinking appeared to have high interest in participating in science activities/ experiments, had high scientific self-concept/self-efficacy, and were willing to pursue science majors in college/university.

I: Did you find any relationship between your thinking style and attitudes toward science?

Lin (M): *I like to learn challenging things since I was an elementary school child. I was full of curiosity toward science. I always think positively and try to find out solutions while meeting troubles. I prefer to read scientific books and visit science museums after school. My dream is to be an inventor and invent a lot of interesting and useful stuff, which can make our life more convenient.*

Hu (M): *I'm looking forward to experimental-oriented courses very much, because I think hands-on experiments is full of fun. While I fail to do the experiments occasionally, I am still enthusiastic about the experiments. Every time I do experiments successfully, I can find interesting scientific theory from the experiments, which makes me feel a sense of accomplishment.*

Hsu (F): *Although chemistry is very difficult, I still take a lot of time to understand these complex formulas and theories. When encountering problems, I would like to ask teacher and my classmates modestly. I believe that if I study hard, I will get good grade in exams.*

Prediction of students' attitudes towards science and positive thinking

Quantitative results

The SEM of the students' attitudes towards science, positive thinking, and their awareness of their science teachers' leadership produced a model with significant path coefficients (Figure 1). All of the standardised coefficients indicated significant relationships. The goodness-of-fit index (GFI = 1.00, which is >.90), the comparative fit index (CFI = 1.00, which is > .90), the standardised root mean square residual (SRMR = .01, which is < .08), and the root mean square error of approximation (RMSEA = .07, which is < .08) support the quality of the model for the data from the participating students (Bagozzi & Yi, 1988; Browne & Cudeck, 1993; Hu & Bentler, 1999).

Moreover, the SEM results indicated that teachers' leadership with idealised influence was the most predictive of students' attitudes towards science ($\beta = .37$), while leadership with intellectual stimulation was also predictive of students' attitudes towards science ($\beta = .21$). Furthermore, the leadership with laissez-faire was significantly predictive of students' positive thinking ($\beta = .21$).

Qualitative results

The students' awareness of their science teachers' leadership, attitudes towards science, and positive thinking indicated in their interview responses were supportive of the SEM results. **Teachers' personal and interpersonal attributes appear to be important influences on students' affective dispositions towards and positive outlooks on science.**

I: Did you find any relationships between your science teachers' leadership and your attitudes toward science and thinking style?

Chen (M): *My physics teacher is very cute and funny, so I'm looking forward to attending his class. He always explains difficult theoretical concepts in a funny way, and he*

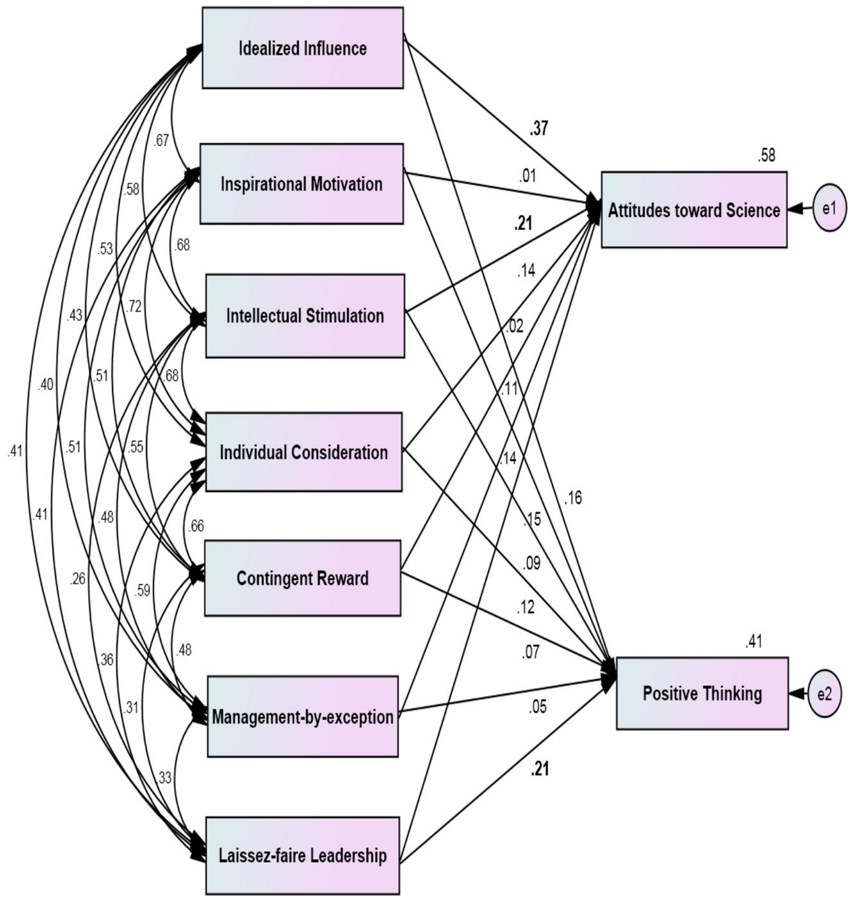

Figure 1. Path analysis models between students' attitudes towards science, positive thinking, and their awareness of science teachers' leadership.

combines textbook knowledge with life experience. I feel that his teaching uses practical and life-oriented strategies.

Wang (F): *I was a low achiever in biology in junior high school, so I dislike biology very much. Fortunately, I met a great biology teacher in this course. She is knowledgeable in biology; she teaches us with a lovely and life-orientated teaching strategy; I always was encouraged by my biology teacher. Now, I really like science (biology), and I am a teaching assistant in biology class.*

Hsu (F): *My physics teacher treats students kindly; actually, he provides a kind of free learning environment for his students; therefore, all the students in his class are very joyous, and there is no pressure in his class.*

Discussion

We found that the males' mean scores for the attitudes towards science subscales were significantly higher than the females' mean score. These findings were consistent with previous studies reporting gender differences favouring males over females. Part of the reason might come from a stern perspective that still exists within secondary school learners (Hong, McCarthy Veach, & Lawrenz, 2003) and from gender stereotyping that may decrease females' achievement motivation and encourage them to set lower school aspirations (Eagly, 1995). International studies completed in the last three decades have shown that male students have significantly higher interest and attitudes towards science and more positive perceptions of scientists and science careers, especially in the physical and mathematical sciences, than female students from elementary to secondary school ages (Jones et al., 2000; Sullins et al., 1995). Moreover, large effect sizes for gender differences on students' attitudes towards science in Taiwan might relate to insufficient encouragement, low focused interactions with the females, and lack of role models in science classrooms, which might hinder young female students' identity with and decrease their interest and self-confidence in Science-Technology-Engineering-Mathematics (STEM) careers (Wan's and Lin's interview results). Students' images of scientists play a special role in promoting their interest in learning science, attitudes towards science, and engagement in science-related careers in the future (Osborne et al., 2003). Czikszentmihalyi (1982, 2014) promoted the idea of 'flow' as a factor related to students' intrinsic motivation. This study found that more male than female students viewed their science teachers as the 'real deal' or authentic examples of the discipline in action, not just transfers knowledge to the learners. These positive perceptions appear to provide intrinsic motivation to enhance the male students' learning attitudes and thinking to be more positive and optimistic than the female counterparts. It has been found that males are encouraged to select science-related subjects and majors, while females are encouraged to select social and human liberal arts majors by parents, school teachers, and students themselves in Taiwan (Hong et al., 2003). Females seem to have insufficient self-confidence and self-efficacy necessary to risk experiencing challenges in science-related future careers (OECD, 2007). Furthermore, females who have difficulty understanding science ideas appear to be ignored by their science teachers (Lin's interview result).

The current study found that the females' mean score on the self-satisfaction subscale was significantly higher than the males'. This might relate to gender stereotypic thinking and lower academic expectations and future career aspirations than their male counterparts (Hong et al., 2003). Hu's interview results suggested that he was more enthusiastic about the experiments than his female counterparts.

Previous studies demonstrated that people regard self-worth as one of the most important needs for life satisfaction (Sheldon, Elliot, Kim, & Kasser, 2001). Students with high self-worth were more likely to be academically successful (Marsh, 1990), had more favourable attitudes towards school, displayed more positive classroom behaviour, and were more popular with other students (Cauley & Tyler, 1989). These findings were consistent from interview results, which suggested that science teachers pay more attention to male students, especially in physics class (Wang's and Li's interview results). In addition, Taiwan's culture is highly influenced by the Confucian Heritage Culture, which cultivates and encourages males working harder on their academic studies to reflect positively on their families. Within such male-dominant society, most of the school teachers, parents, and students themselves prefer to focus on academic performances than other subjects (Hong, Lin, & McCarthy Veach, 2008). Generally, male students performed better in academic domains (especially science) than their female counterparts in Taiwan, thereby the success results in more optimistic attitudes to learn and face challenges. According to the Programme for International Student Assessment 2012 (OECD, 2013), significant risk factors of low performance of 15-year-old students relate to low attitudes in learning behaviours, low expectations, unsupportive teachers, and low teacher morale. This study seemly contributed empirical evidence to address these risks of low performances in learning science and mathematics. For example, we found that male students' awareness of their science teachers' leadership was significantly higher on the idealised influence, inspirational motivation, intellectual stimulation, and individual consideration subscales than female students'. These findings might indicate that male students have higher awareness of obtaining more encouragement, positive stimulation, and individual consideration from their teachers during science class, while female students were aware that their science teachers pay less attention to and have less concern for their learning in science. Previous studies indicated that male teachers have been found to interact two-thirds of the time with male students and only one-third of the time with female students in school science classes (Bellamy, 1994). Therefore, the unbalanced gender ratios of science teachers and science students (recent statistics indicate that ∼66% of science teachers are male in Taiwan) may have led to gender differences in science learning. Fairman and Mackenzie (2015) provided a new lens on the important relationships of informal collaboration, trust, and collegiality in supporting teachers' leadership development and school improvement. Our model (Figure 1) of teachers' leadership approaches, students' learning attitudes, and students' positive thinking appears to support their hypothesis. The most significant predictor of students' attitudes towards science is students' awareness of science teachers with an idealised influence approach; the second significant predictor of students' attitudes towards science is science teachers with intellectual stimulus; and the third significant predictor of students' positive thinking is science teachers with a laissez-faire leadership approach. Furthermore, we found that these optimistic students have the highest significant relationship to their future participation in science, learning science in school, and self-concept in school (Lin's interview result). This study provides evidence that science teachers focused on practising idealised influence, intellectual stimulation, and laissez-faire leadership approaches seemingly benefit their students' attitudes towards science and positive thinking. We suggest that senior high school science teachers place more emphasis on fostering students' positive thinking, especially for the female students on promoting their optimism, which seemingly increases students' positive attitudes towards science and positive thinking.

Conclusion and suggestions

This paper contributes to the literature by illustrating how a science teachers' leadership model predicts students' attitudes towards science and positive thinking. Collectively the mixed-methods (t-tests, interviews, and SEM) results suggest interesting potential cause–effects relationships within the intrinsic motivation and science achievement/performance framework, but the directionality of the relationships is uncertain—awareness causes performance or performance causes awareness. The males' positive perceptions of learning leadership and science could be natural outcomes for (1) students who were valued and engaged by their science teachers in relevant practical tasks, or (2) the perceptions could be the results of successful students who enjoy and identify with science and thereby view their teachers and instruction in positive terms. This effect could result from science teachers who are learning leaders who seek to engage and encourage their students in and with optimal experiences—relevant skilful challenges within the narrow band of enjoyable and important activities between anxiety and boredom in the work-play space (Czikszentmihalyi, 1982, 2014).

However, the results for positive thinking were mixed with the females outperforming the males on three subscales (self-confidence, appreciation, and self-satisfaction), while the males outperformed on the optimism subscale. The males' higher optimism could again be an expected outcome of the supportive, engaging, and enjoyable science classroom environments reported in the interviews. The reasons for the females' self-confidence, appreciation, and self-satisfaction are much less obvious in the male-oriented classrooms reported for Taiwan. The females may be assuming survival-coping approaches in the unsupportive climate and pressure by setting lower personal, achievement, and identity expectations that they can easily achieve without considering the limitations placed on their future STEM career choices.

The average SEM path strengths between learning leadership and positive thinking (∼.09) illustrate that these potential relationships are weaker than the average relationships (∼.16) between learning leadership and attitudes towards science. The correlation results indicate that optimism could be the positive psychology linchpin amongst learning leadership, positive thinking, and attitudes towards science, with strong associations with four attitudes towards science subscales ($r = .79–.91$) and moderate associations ($p = .18–.43$) with learning leadership modes, while a similar association for self-confidence, self-satisfaction, and appreciation is much less convincing (all $p < .23$). The interviews indicated that these high school students' current attitudes and positive thinking could well be persistent and may have been initiated in elementary school and inquiry-oriented laboratory experiences and extended into informal learning environment choices and future career aspirations.

The SEM results indicate insights into instructional effects—idealised influence and intellectual stimulation were highly predictive of students' attitudes towards science, while laissez-faire leadership was predictive of students' positive thinking. The interview responses suggested that teachers who were knowledgeable, provided a safe and supportive environment, encouraged and respected their students, and used life-oriented and enjoyable strategies in student-oriented approach had a lasting impact on students. These results suggest that effective science instruction and pedagogical content knowledge may be as much about intrinsic motivation as much as about science content and pedagogical strategies.

Leadership model is a relatively new concept in science education; therefore, empirical testing of these ideas has been limited. Future research is needed to address the limitations in the present study. This study used data from senior high school students that may not be representative of the relationships amongst older or younger populations. Therefore, studies should be conducted with different groups of elementary to post-secondary science students to determine if the relationships found with these high school participants apply across a broad age-span. Furthermore, since perceived science teachers with idealised influence were the most predictive of students' attitudes towards science, and those with laissez-fair influence leadership were significantly predictive of students' positive thinking, then future studies should focus on the effects of these teacher leadership attributes. In addition, future studies should investigate or explore the effects of teachers' learning leadership within different instructional interventions on promoting students' attitudes towards science and positive thinking, which might enhance the understanding of the relationships amongst these variables and elaborate the explanatory model.

The HSSQ had reasonable reliability and validity, indicating that it can be used effectively to (a) document senior high school students' attitudes towards science, positive thinking, and awareness of their science teachers' leadership and (b) explore the relationships amongst these ideas. We believe that science teachers' leadership, especially idealised influence, intellectual stimulation, and individual consideration, plays an important role in teaching and provides insights into needed professional development of science teachers. In addition to science expertise, science teachers should provide multiple teaching approaches, support students' reflective and creative thinking abilities, address individual needs of students with empathy, and listen to students' ideas. These leadership traits not only enhance students' attitudes towards science learning, but also cultivate students' positive thinking.

Acknowledgements

Special thanks go to the editor's thoughtful suggestions, anonymous reviewers' constructive comments. We are thankful to Professor Huann-shyang Lin for his constructive suggestion, and Mrs. Shari Yore for her technical revisions of this manuscript.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

The authors are thankful for the support from the Ministry of Science and Technology, Taiwan with the grant number of MOST 104-2511-S- 110-011- MY3.

Notes on contributors

Ying-Yan Lu is a Ph. D. candidate at the Institute of Education in the National Sun Yat-sen University, Taiwan. Her research interest focuses on inquiry and moral education.

Hsiang-Ting Chen is a postdoctoral researcher at the Institute of Education in the National Sun Yat-sen University, Taiwan. Her research interest focuses on gender differences, inquiry and affective factors in learning science.

Zuway-R Hong is a Distinguished Professor at the Institute of Education, National Sun Yat-sen University, Taiwan. Her research interests focus on affective factors and inquiry teaching in learning science.

Larry, D. Yore is a Distinguished Professor Emeritus, Science Education, in University of Victoria, Canada. His current research explores the cross cultural science communication and students' learning outcomes.

References

Angelle, P. S., & Schmid, J. B. (2007). School structure and the identity of teacher leaders: Perspectives of principals and teachers. *Journal of School Leadership*, *17*, 771–799.

Antonakis, J., Avolio, B. J., & Sivasubramaniam, N. (2003). Context and leadership: An examination of the nine-factor full-range leadership theory using the multifactor leadership questionnaire. *The Leadership Quarterly*, *14*(3), 261–295. doi:10.1016/S1048-9843(03)00030-4

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2010). 'Doing' science vs 'being' a scientist: Examining 10/11-year-old schoolchildren's constructions of science through the lens of identity. *Science Education*, *94*(4), 617–639. doi:10.1002/sce.20399

Bagozzi, R. P., & Yi, Y. (1988). On the evaluation of structural equation models. *Journal of the Academy of Marketing Science*, *16*(1), 74–94. doi:10.1007/BF02723327

Barmby, P., Kind, P. M., & Jones, K. (2008). Examining changing attitudes in secondary school science. *International Journal of Science Education, 30*(8), 1075–1093. doi:10.1080/09500690701344966

Bass, B. M. (1985). *Leadership and performance beyond expectations*. New York, NY: Free Press.

Bass, B. M., & Avolio, B. J. (1990). The implications of transactional and transformational leadership for individual, team, and organizational development. In R. W. Woodman & W. A. Pasmore (Eds.), *Research in organizational change and development* (pp. 231–272). Greenwich, CT: JAI Press.

Bass, B. M., & Avolio, B. J. (1993). Transformational leadership: A response to critiques. In M. M. Chemers & R. Ayman (Eds.), *Leadership theory and research: Perspectives and directions* (pp. 49–80). San Diego, CA: Academic Press.

Bass, B. M., & Avolio, B. J. (1995). *Full range leadership development: Manual for the multifactor leadership questionnaire*. Menlo Park, CA: Mind Garden.

Bellamy, N. (1994). Bias in the classroom: Are we guilty? *Science Scope*, *17*(6), 60–63.

Brislin, R. W. (1986). The wording and translation of research instrument. In W. J. Lonner & J. W. Berry (Eds.), *Field methods in cross-cultural research* (pp. 137–164). Beverly Hills, CA: Sage.

Browne, M. W., & Cudeck, R. (1993). Alternative ways of assessing model fit. In K. A. Bollen & J. S. Long (Eds.), *Testing structural equation models* (pp. 136–162). Newbury Park, CA: Sage.

Bryman, A. (1999). Leadership in organizations. In S. R. Clegg, C. Hardy, & W. R. Nord (Eds.), *Managing organizations* (pp. 26–42). London: Sage.

Buck, B., Carr, S. R., & Robertson, J. (2008). Positive psychology and student engagement. *Journal of Cross-Disciplinary Perspectives in Education*, *1*(1), 28–35.

Cauley, K., & Tyler, B. (1989). The relationship of self-concept to prosocial behavior in children. *Early Childhood Research Quarterly*, *4*, 51–60. doi:10.1016/S0885-2006(89)90064-1

Chen, H.-T., Wang, H.-H., Lin, H. S., Lawrenz, F., & Hong, Z. R. (2014). Longitudinal study of an after-school, inquiry-based science intervention on low-achieving children's affective perceptions of learning science. *International Journal of Science Education*, *36*(13), 2133–2156. doi:10.1080/ 09500693.2014.910630

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.

Crano, W. D., & Prislin, R. (2006). Attitudes and persuasion. *Annual Review of Psychology*, *57*, 345–374. doi:10.1146/annurev.psych.57.102904.190034

Czikszentmihalyi, M. (1982). Intrinsic motivation and effective teaching: A flow analysis. *New Directions for Teaching and Learning*, *1982*(10), 15–26. doi:10.1002/tl.37219821004

Czikszentmihalyi, M. (2014). *Flow and the foundations of positive psychology: The collected works of Mihaly Csikszentmihalyi*. Dordrecht: Springer.

Eagly, A. H. (1995). The science and politics of comparing women and men. *American Psychologist, 50*(3), 145–158. doi:10.1037/0003-066X.50.3.145

Eisenberg, N., Hofer, C., & Vaughan, J. (2007). Effortful control and its socio-emotional consequences. In J. J. Gross (Ed.), *Handbook of emotion regulation* (pp. 287–306). New York, NY: Guilford Press.

Fairman, J., & Mackenzie, S. V. (2015). How teacher leaders influence others and understand their leadership. *International Journal of Leadership in Education, 18*(1), 61–87. doi:10.1080/13603124.2014.904002

Fraser, B. (2015). Classroom learning environments. In R. Gunstone (Ed.), *Encyclopaedia of science education* (pp. 154–157). Dordrecht: Springer.

George, R. (2006). A cross domain analysis of change in students' attitudes toward science and attitudes about the utility of science. *International Journal of Science Education, 28*(6), 571–589. doi:10.1080/09500690500338755

Harris, A., & Muijs, D. (2004). *Improving schools through teacher leadership: Professional learning*. Maidenhead: Open University Press & McGraw Hill.
Hater, J. J., & Bass, B. M. (1988). Superiors' evaluations and subordinates' perceptions of transformational and transactional leadership. *Journal of Applied Psychology, 73*, 695–702. doi:10.1037/0021-9010.73.4.695
Hong, Z. R. (2010). Effects of a collaborative science intervention on high achieving students' learning anxiety and attitudes toward science. *International Journal of Science Education, 32*(15), 1971–1988. doi:10.1080/09500690903229304
Hong, Z. R., Lin, H. S., & Lawrenz, F. (2012). Effects of an integrated science and societal implication intervention on promoting adolescents' positive thinking and emotional perceptions in learning science. *International Journal of Science Education, 34*(3), 329–352. doi:10.1080/09500693.2011.623727
Hong, Z. R., Lin, H. S., & McCarthy Veach, P. (2008). Effects of an extracurricular science intervention on science performance, self-worth, social skills, and sexist attitudes of Taiwanese adolescents from single-parent families. *Sex Roles, 59*(7), 555–567.
Hong, Z. R., McCarthy Veach, P., & Lawrenz, F. (2003). An investigation of the gender stereotyped thinking of Taiwanese secondary school boys and girls. *Sex Roles, 48*(11), 495–504.
Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal, 6*, 1–55. doi:10.1080/10705519909540118
Jones, G., Howe, A., & Rua, M. (2000). Gender differences in students' experiences, interests, and attitudes towards science and scientists. *Science Education, 84*, 180–192.
Kind, P., Jones, K., & Barmby, P. (2007). Developing attitudes towards science measures. *International Journal of Science Education, 29*, 871–893. doi:10.1002/(SICI)1098-237X(200003)84:2<180::AID-SCE3>3.0.CO;2-X
Koh, W. L., Steers, R. M., & Terborg, J. R. (1995). The effects of transformational leadership on teacher attitudes and student performance in Singapore. *Journal of Organizational Behavior, 16*, 319–333. doi:10.1002/job.4030160404
Lambert, L. (2003). Shifting conceptions of leadership: Towards a redefinition of leadership for the twenty-first century. In B. Davies & J. West-Burnham (Eds.), *Handbook of educational leadership and management* (pp. 5–15). London: Pearson Education.
Lee, M. H., Tsai, C. C., & Chai, C. S. (2012). A comparative study of Taiwan, Singapore, and China preservice teachers' epistemic beliefs. *The Asia-Pacific Education Researcher, 21*, 599–609.
Lloyd, R., Neilson, R., King, S., & Dyball, M. (2012). Review of informal science learning. London: Wellcome Trust.
Marsh, H. W. (1990). Influences of internal and external frames of reference on the formation of math and English self-concepts. *Journal of Educational Psychology, 82*, 107–116. doi:10.1037/0022-0663.82.1.107
National Science Board. (1998). *Science and engineering indicators—1998*. Arlington, VA: Author.
National Science Foundation, Division of Research, Evaluation, and Communications, Directorate for Education and Human Resources. (1996). *Indicators of science and mathematics education 1995 (NSF 96–52)*. Arlington, VA: Author.
OECD. (2007). *PISA 2006 science competencies for tomorrow's world*. Paris: Author.
OECD. (2013). *PISA 2006 science competencies for tomorrow's world*. Paris: Author.
Ogawa, R. T., & Bossert, S. T. (1995). Leadership as an organizational quality. *Educational Administration Quarterly, 31*, 224–243. doi:10.1177/0013161X95031002004
Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education, 25*(9), 1049–1079. doi:10.1080/0950069032000032199
Patton, M. Q. (2002). *Qualitative research and evaluation methods* (3rd ed.). Thousand Oaks, CA: Sage.
Sasson, R. (2010). *The power of positive thinking*. Retrieved from http://www.successconsciousness.com/index_000009.htm

Seligman, M. E. P., Steen, T. A., Park, N., & Peterson, C. (2005). Positive psychology progress: Empirical validation of interventions.. *American Psychologist, 60*(5), 410–421. doi:10.1037/0003-066X.60.5.410
Sheldon, K. M., Elliot, A. J., Kim, Y., & Kasser, T. (2001). What is satisfying about satisfying events? Testing 10 candidate psychological needs. *Journal of Personality and Social Psychology*, *80*, 325–339. doi:10.1037//O022-3514.80.2.325
Silva, D., Gimbert, B., & Nolan, J. (2000). Sliding the doors: Locking and unlocking possibilities for teacher leadership. *Teachers College Record, 102*, 779–804. doi:10.1111/0161-4681.00077
Sullins, E., Hernandez, D., Fuller, C., & Tashiro, J. (1995). Predicting who will major in a science discipline: Expectancy–value theory as part of an ecological model for studying academic communities. *Journal of Research in Science Teaching, 32*, 99–119. doi:10.1002/tea.3660320109
Tabachnick, B. G., & Fidell, L. S. (2001). *Using multivariate statistics* (4th ed.). Needham Heights, MA: Allyn & Bacon.
Tejeda, M. J., Scandura, T. A., & Pillai, R. (2001). The MLQ revisited: Psychometric properties and recommendations. *The Leadership Quarterly, 12*, 31–52. doi:10.1016/S1048-9843(01)00063-7
Tu, X. M. (2006). Adolescent's watchful companion—Bringing attention to adolescent suicides. *Suicide Prevention Column, 1*(4), 45–47.
Wilson, M. (1993). The search for teacher leaders. *Educational Leadership, 50*(6), 24–27.
Yager, S. J., & Lee, O. (1994). The development and sustenance of instructional leadership. In D. R. Walling (Ed.), *Teachers as leaders: Perspectives on the professional development of teachers* (pp. 223–237). Bloomington, IN: Phi Delta Kappa Educational Foundation.
York-Barr, J., & Duke, K. (2004). What do we know about teacher leadership? Findings from two decades of scholarship. *Review of Educational Research, 74*(3), 255–316. doi:10.3102/00346543074003255

Appendix 1. Means, standard deviations, and factor loadings of STLS items

				Factor loadings						
Variable/subscale	*M*	SD	Correlation with total score	1	2	3	4	5	6	7
Idealised influence (3 items/Cronbach's $\alpha = .88$)										
1. I respect my science teacher very much.	2.64	.70	.44	**.73**	.04	.22	.19	.12	.01	.13
2. I really appreciate my science teacher's perspectives.	2.95	.61	.58	**.71**	.21	.07	.13	−.14	.01	−.01
3. My science teacher is my learning model.	2.47	.70	.62	**.65**	.14	.27	.15	.11	.13	−.03
Inspirational motivation (3 items/Cronbach's $\alpha = .83$)										
4. My science teacher always inspires students to accomplish higher academic goals.	2.68	.70	.59	.40	**.71**	−.02	−.02	−.05	.22	−.16
5. My science teacher encourages students very often.	2.58	.72	.61	.36	**.56**	.06	.27	−.18	.06	−.09
6. My teacher is passionate in teaching science.	2.64	.68	.60	.44	**.56**	−.03	.22	−.12	.13	−.05
Intellectual stimulation (3 items/Cronbach's $\alpha = .91$)										
7. My science teacher asks students questions very often.	2.62	.72	.54	.44	.30	**.70**	−.18	.34	.19	−.06
8. My science teacher always produces innovative ideas in class.	2.55	.71	.64	−.03	.14	**.64**	.23	.03	−.10	.11
9. My science teacher always fosters students' critical thinking in class.	2.55	.71	.58	.32	.28	**.58**	−.01	.10	.12	.16
Individual consideration (3 items/Cronbach's $\alpha = .91$)										

(*Continued*)

Appendix 1. (Continued)

Variable/subscale	*M*	SD	Correlation with total score	Factor loadings 1	2	3	4	5	6	7
10. My science teacher is always concerned with each student's progress in learning science.	2.69	.66	.65	.39	.17	−.15	**.73**	.07	.18	.08
11. My science teacher is concerned for each student's needs.	2.42	.72	.62	.32	.19	.17	**.63**	−.04	.01	−.18
12. My science teacher is really concerned for students' understandings on each unit of science.	2.58	.68	.63	.23	.03	.24	**.61**	−.24	.24	.06
Contingent reward (3 items/Cronbach's $\alpha = .80$)										
13. If I complete assignments, I can obtain praise from my science teacher.	2.58	.71	.58	.33	.54	−.10	.31	**.73**	−.34	−.09
14. If I gain an outstanding grade, my science teacher will reward me.	2.96	.49	.53	.09	.20	.12	.05	**.73**	−.08	−.08
15. If I present a great performance, I can obtain praise from my science teacher.	2.73	.64	.56	.21	.10	.07	.00	**.53**	.22	−.04
Management-by-exception (3 items/Cronbach's $\alpha = .81$)										
16. My science teacher does a great job on classroom management.	2.82	.56	.42	.22	.06	.09	.14	.01	**.76**	.04
17. My science teacher points out my misconceptions in science.	2.98	.58	.43	.26	.48	.11	.04	.05	**.74**	−.16
18. My science teacher sets a clear course requirement for students to follow.	2.63	.66	.56	.31	.33	.25	.11	.25	**.73**	−.15
Laissez-faire (3 items/Cronbach's $\alpha = .74$)										
19. My science teacher never sets his/her teaching plan ahead of class beginning.	2.12	.62	.79	−.10	−.02	.06	.19	.12	−.01	**.79**
20. My science teacher is never concerned about students' academic performance.	1.90	.64	.32	.18	.08	.08	.05	.13	−.02	**.78**
21. My science teacher never teaches us how to learn the subject of science.	2.14	.74	.38	−.02	.07	−.10	−.04	−.02	−.01	**.54**

Note: Bold numbers indicate factor loadings of each item on its own subscale.

Appendix 2. Means, standard deviations, and factor loadings of ATSS items

Variable/subscale	*M*	SD	Correlation with total score	Factor loadings 1	2	3	4	5
Learning science in school (8 items/Cronbach's $\alpha = .86$)								
1. I like science class very much.	2.38	.81	.77	**.79**	.14	.22	.16	.20
2. I am interested in scientific experiments.	2.45	.84	.75	**.78**	.20	.22	.14	.17
3. I learn a lot of knowledge in science class.	2.75	.72	.69	**.71**	.32	.22	.11	.21
4. In general, science class is very interesting.	2.44	.78	.68	**.70**	.31	.23	.16	−.02
5. I look forward to science class.	2.32	.77	.65	**.69**	.11	.39	.26	.05
6. I like hands-on experiments.	2.85	.81	.61	**.65**	.00	.33	.31	.06
7. Science class can satisfy my curiosity.	2.50	.77	.68	**.61**	.40	.14	.02	.03
8. Learning science in school makes me feel happy.	2.58	.76	.68	**.52**	.06	.42	.32	.15
Self-concept in science (6 items/Cronbach's $\alpha = .82$)								
9. I am satisfied with my scientific performance.	2.13	.74	.46	.49	**.81**	.43	−.01	.06
10. I am satisfied with my scientific accomplishments.	2.12	.79	.50	.03	**.80**	.05	−.01	.09
11. I am curious about science.	2.53	.77	.74	.16	**.75**	.24	.09	.21
12. I like to read science books.	2.58	.81	.74	.45	**.58**	.12	.19	.10
13. Science is one of my good subjects.	2.12	.85	.73	.37	**.57**	.28	.01	.25
14. My scientific achievements have been in progress.	2.30	.75	.60	.43	**.55**	−.07	.16	.18
Future participation in science (5 items/Cronbach's $\alpha = .87$)								
15. I will take the initiative to learn scientific knowledge.	2.39	.75	.76	.43	.52	**.79**	.25	.23
16. I am excited about the scientific work.	2.45	.77	.72	.30	.12	**.76**	.17	.04
17. It is very interesting to understand the new inventions by science.	2.79	.75	.71	.18	.02	**.74**	.24	.30
18. I hope that I can become a science professional in the future.	2.28	.84	.69	.49	.26	**.73**	.12	.12
19. I want to be a scientist in the future.	2.14	.83	.62	.48	.28	**.66**	.19	.01
Science outside of school (4 items/Cronbach's $\alpha = .78$)								
20. I would like to participate in different kinds of scientific activities.	2.65	.78	.73	.17	.46	.53	**.71**	.34
21. I like watching science television programmes	2.63	.79	.66	.32	.42	.45	**.64**	.17
22. I often take the active to participate in the scientific club.	2.21	.78	.65	.16	.06	.20	**.61**	.06
23. I like to visit science museums.	2.87	.81	.50	.26	.10	.17	**.55**	.13
Importance of science (3 items/Cronbach's $\alpha = .76$)								
24. Science has brought many benefits to mankind.	2.86	.68	.42	.29	.31	.42	.47	**.73**
25. Science can make our life more convenient.	3.02	.76	.50	.17	.20	.28	.10	**.71**
26. I think that science is very helpful in our life.	2.91	.79	.56	.12	.30	.06	.12	**.67**

Note: Bold numbers indicate factor loadings of each item on its own subscale.

Appendix 3. Means, standard deviations, and factor loadings of PTS items

Variable/subscale	*M*	SD	Correlation with total score	Factor loadings 1	2	3	4
Self-confidence (8 items/Cronbach's $\alpha = .86$)							
1. I like to learn different things.	3.15	.54	.60	**.70**	.21	.18	.03
2. I am looking forward to enjoying different kinds of life experiences.	3.25	.59	.56	**.66**	.17	.17	.10
3. I will do my best to complete my life goals.	3.18	.54	.65	**.65**	.15	.46	.24
4. In spite of failure, I would never give up pursuing my ideals.	3.07	.57	.61	**.63**	.07	.25	.15
5. I have confidence in the future.	3.12	.53	.50	**.57**	.21	.17	.15
6. I believe I will make my dreams come true.	3.24	.53	.58	**.54**	.29	−.02	.24
7. I will try my best to enjoy what I have experienced.	3.19	.53	.57	**.53**	.44	.28	.14
8. I will do my best to complete the work.	3.13	.53	.43	**.51**	.39	.27	.21
Self-satisfaction (8 items/Cronbach's $\alpha = .89$)							
9. I love to share interesting things with my family.	3.21	.68	.60	.48	**.73**	.41	.33
10. I like to share my emotions with friends.	3.02	.67	.45	.39	**.65**	.32	.17
11. I am satisfied with my life.	3.09	.63	.71	.15	**.62**	.34	.04
12. My life is very colourful.	3.04	.68	.75	.40	**.59**	−.04	.20
13. My life is full of laughter and joy.	3.13	.60	.73	.29	**.57**	.33	−.03
14. I enjoy my life.	3.16	.60	.77	.10	**.56**	.20	.14
15. I feel that my life is full of fun.	3.04	.63	.60	.27	**.54**	.22	.29
16. I like the people and things around me.	3.14	.57	.71	.39	**.50**	.19	.33
Optimism (6 items/Cronbach's $\alpha = .83$)							
17. When I am in trouble, I will confront it optimistically.	2.99	.57	.53	.27	.50	**.71**	.17
18. I enjoy my life.	3.09	.63	.71	.19	.50	**.62**	.20
19. I think the future is very hopeful.	2.91	.68	.60	.21	.20	**.59**	.11
20. When I am confronted with failure, I always look on the bright side.	2.85	.73	.59	.23	.26	**.52**	.15
21. I am always positive and look on the bright side of things.	3.14	.61	.74	.16	.31	**.50**	.27
22. Although life is full of ups and downs, I always confront the future with optimism.	3.06	.64	.74	.42	.31	**.46**	.14
Appreciation (6 items/Cronbach's $\alpha = .80$)							
23. I am passionate about everything.	2.94	.67	.74	.49	.27	.45	**.76**
24. I am satisfied with my performance.	2.76	.71	.61	.46	.22	.41	**.63**
25. I like to praise others.	3.04	.68	.51	.18	.43	.35	**.60**
26. I like myself.	2.84	.74	.56	.29	.10	.22	**.58**
27. I appreciate the advantages of others.	3.12	.53	.50	.20	.19	.26	**.57**
28. I appreciate the things around me.	2.94	.63	.63	.18	.41	.17	**.56**

Note: Bold numbers indicate factor loadings of each item on its own subscale.