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Chinese and US Middle-School Science Teachers' Autonomy, Motivation, and Instructional Practices

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This study examined Chinese and US middle-school science teachers' perceptions of autonomy support. Previous research has documented the link between teachers' perceptions of autonomy and the use of student-oriented teaching practices for US teachers. But is not clear how the perception of autonomy may differ for teachers from different cultures or more specifically how motivation factors differ across cultures. The survey measured teachers' motivation, perceptions of constraints at work, perceptions of students' motivation, and level of autonomy support for students. Exploratory factor analysis of responses for the combined teacher sample ($n = 201$) was carried out for each of the survey assessments. Significance testing for Chinese ($n = 107$) and US ($n = 94$) teachers revealed significant differences in teachers' motivation and perceptions of constraints at work and no significant differences for perceptions of students' motivation or their level of autonomy support for students. Chinese teachers' perceptions of constraints at work, work motivation, and perceptions of student motivation were found to significantly predict teachers' autonomy support. For the US teachers, teacher motivation was the only significant predictor of teachers' autonomy support. A sub-sample of teachers ($n = 19$) was interviewed and results showed that teachers in both countries reported that autonomy was important to their motivation and the quality of science instruction they provided to students. The primary constraints on teaching reported by the US teachers related to materials and laboratory space while the Chinese teachers reported constraints related to the science curriculum and standards.

Keywords: *Teacher beliefs; Attitudes; Comparative study*

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Review of Literature

The current global environment of education is one of standardization and accountability (Delandshere & Petrosky, 2004), which may have damaging effects on the intrinsic motivation, quality of instruction, and job satisfaction of teachers (Jones, Jones, & Hargrove, 2003). In the USA, *No Child Left Behind* has resulted in a 'narrowly defined accountability and standards movement' (Bushnell, 2003, p. 252). Unfortunately, 'most teachers today (as in previous generations) are outsiders to the major decision-making processes that drive classroom practices' (Bushnell, 2003, p. 270).

Similar accountability movements are occurring in other countries such as Canada (McDonald, 2002), the Netherlands (van Veen, Sleegers, Bergen, & Klaassen, 2001), Australia and New Zealand (Delandshere & Petrosky, 2004), Korea (Yeom & Ginsburg, 2007), and Jordan (Mustafa & Cullingford, 2008). In Canada, the Achievement Testing Program has increased standardization of teaching methods for high school subjects (McDonald, 2002). In the Netherlands, the government has exerted increased control over teaching through 'new national student qualification structures' (van Veen et al., 2001, p. 176). While it is clear that there is increased governmental accountability for teachers, the impact of this control on teachers' perception of autonomy is not known. Furthermore, the increasingly mobile teacher workforce accompanied by large numbers of students moving from country to country argues for a closer look at the intersection of instruction, school environment, administrative policies, and teacher motivation (Wang, Lin, Spalding, Odell, & Klecka, 2011).

Cultural Factors Related to Autonomy

The bedrock of science education reform rests on teachers' motivation to engage in new or different instructional practices. Researchers are beginning to unravel the complexities of teachers' motivation through recent work on self-determination theory (SDT) (described further below). But there is limited research that investigates teachers' motivation from a global perspective where educational systems rest on very different beliefs about the role of individuals and society. It is important to understand how culture and motivation intersect for a number of reasons that include the increased mobility of students and teachers in a global society, the need to support teachers' motivation to engage in new instructional practices in science, and perhaps most importantly to shed light on theoretical models of motivation that have historically been developed in western cultures. This study examines how science teachers in two very different countries (the USA and China) are similar or different for factors that contribute to motivation with particular emphasis on perceptions of autonomy. Autonomy in this context refers to the freedom teachers have to make choices about their instruction.

Different cultural groups such as those in China and the US traditionally view an individual's freedom to make choices as based in the societal values related to individualist and collectivist goals (Hofstede, 2001; Triandis, Bontempo, Villareal, Asai, & Lucca, 1988). Individualism and collectivism affect numerous aspects of society,

including family structure, personality, behavior, language, work, education, and politics (Hofstede, 2001). In individualist cultures, the goals of the individual are given greater emphasis than the goals of the collective (Iyengar & DeVoe, 2003; Triandis et al., 1988). In individual rights-based cultures, the rights of the individual are the primary goal while in interdependent duty-based cultures, emphasis is placed on one's relationship to other members of the group (Iyengar & DeVoe, 2003).

Cheng (1998) argues that within schools individualism and collectivism influence the structure and goals of education:

> (i)n the collectivist cultures of East Asia, education is viewed first and foremost as a means of socialization. It is an organized means by which children learn to adapt themselves to the expectations of the larger community. School education is designed to instill in children the norms and expectations of the society. (p. 15)

This emphasis on the group, according to Cheng, explains the uniformity and conformity that characterize Asian education. Furthermore, individualist cultures 'view education as a means of empowering children. The goal is to enable children to grow and respect themselves as individuals. Schools and parents encourage children to develop according to their unique needs and potentialities' (Cheng, 1998, p. 16). Other researchers have reported that science achievement is related to individualist and collective cultural orientations. Hagedorn and Purnamasari (2012) examined data from the Program for International Student Assessment and found that countries that were highly individual tended to have higher scores on science achievement tests than those countries that were collectivist. The authors suggested that testing is both competitive and individual and must be viewed within the cultural context of the society:

> (c)ultures that embrace individualism and competitive achievement therefore may be more likely to score irrespective of instructional quality. Students in countries that are more collective in nature may not take individual tests with the same fervor or understand the high-stakes involved. A lack of competitiveness may further disincline students from testing well. Moreover, students from individualist countries may better equate education with improvement of self-worth; whereas for students in collectivist countries, education may be seen as a vehicle for social acceptance over individual self-respect. (p. 72)

People in the USA typically rank very high, if not the highest, in measures of individualism (Hofstede, 2001; Iyengar & DeVoe, 2003; Triandis et al., 1988). Among people in the USA, 'personal freedom of choice and individual responsibility' (Iyengar & DeVoe, 2003, p. 136) are stressed in contrast to the focus on 'social duties and harmony' (p. 136) found among members of collectivist cultures. Other countries that typically score high on measures of individualism are Australia, Canada, and Great Britain (Hofstede, 2001). While the USA is a prototypical example of individualism, China is a prototypical example of collectivism (Triandis et al., 1988). Other Asian countries, including South Korea, Taiwan, and Singapore and countries in Africa and Latin America are also associated with collectivism (Hofstede, 2001).

Markus and Kitayama (1991) described the connections between individualism and collectivism and Western and Eastern cultures in individual self-construal. In Western culture, typical of the USA and Western Europe, the influence of individualism results in 'a faith in the inherent separateness of distinct persons' (Markus & Kitayama, 1991, p. 226). Consequently, members of individualist cultures define themselves as separate and unique, promote their own goals, and derive self-esteem from their ability to express themselves. In contrast, the influence of collectivism in Eastern culture, typical of Asia, Africa, Latin America, and Southern Europe, results in an emphasis on 'the fundamental connectedness of human beings to each other' (Markus & Kitayama, 1991, p. 227). Members of collectivist cultures define themselves through connections to a social group, promote the goals of others, and derive self-esteem from their ability to preserve harmony within the social group. This distinction between the individualist-focused and the collectivist-focused cultures is significant given the recent criticisms of teaching in the USA as a lonely and isolated profession (Su, 1990).

We know little about how these cultural differences influence teachers' perspectives of their instructional practices. Furthermore, with the growing interest in promoting and understanding students' interests in science and science careers, a better understanding of differences in collectivist and individual cultures can inform educational research into the formation of science identity, motivation to pursue science interests, and the development of science career interests.

In this study, we examined teachers' perceptions of autonomy support for Chinese (collectivist culture) and US (individualist culture) science teachers through measurements of teachers' motivation, perceptions of constraints at work, perceptions of students' motivation, and level of autonomy support for students (described below). Furthermore, though interviews with a sub-sample of teachers in each country, we explored autonomy within science instructional contexts. The goal was to examine the relationships between factors related to teachers' self-determination for these two different types of cultural and educational systems and to understand teachers' perceptions of autonomy across different cultures. Gaining insight into teachers' motivation can assist us in developing more effective teacher professional development programs in an increasingly global educational community.

SDT and Teacher Autonomy

In SDT, Deci and Ryan (1985, 2000) and Ryan and Deci (2000) posit that there are three psychological needs necessary for well-being and personality integration: autonomy, competence, and relatedness. These needs are the source of individuals' desire to be self-determined in their actions. *Autonomy* is characterized by Deci and Ryan (2000) as the freedom or independence to make choices free from external influence. *Competence* refers to one's belief in his or her ability to affect the external environment and is closely related to the concept of self-efficacy. *Relatedness* refers to one's feelings of security and connectedness through relationships with others. Deci and Ryan (2000) maintain that these needs affect psychological growth and development and,

consequently, human behavior. Furthermore, satisfaction of these needs in an individual results in creative and engaged interaction with tasks; conversely, if these needs are not met, an individual will exhibit apathy, alienation and reduced well-being (Deci & Ryan, 2000). According to this theory, the extent to which a specific task meets an individual's need for autonomy, competence, and relatedness determines the individual's level of motivation to engage in the task.

While the needs for autonomy, competence, and relatedness originate from human nature, environmental conditions can facilitate or hinder satisfaction of the needs. A sub-theory of SDT, cognitive evaluation theory (CET), describes the relationship between competence and autonomy and factors that affect intrinsic motivation (Deci & Ryan, 1985). Intrinsically motivated tasks are innately rewarding; that is, the individual feels satisfied without an external reward. According to CET, people find different tasks intrinsically motivating based on how those tasks satisfy their individual needs to be autonomous and competent.

There is evidence that environmental conditions can affect needs satisfaction in different contexts such as work (Deci et al., 2001; Gagne & Deci, 2005; Pelletier, Seguin-Levesque, & Legault, 2002), education (Black & Deci, 2000; Chirkov & Ryan, 2001; Deci, Nezlek, et al., 1981), and sports (Hagger, Chatzisarantis, Barkoukis, Wang, & Baranowski, 2005). In education, parents and teachers enhance the intrinsic motivation of students when they provide students with opportunities to be autonomous, or self-determined, in their learning (Black & Deci, 2000; Chirkov & Ryan, 2001; Deci, Nezlek, et al., 1981). When teachers' work environments support their autonomy there is an increase in intrinsic motivation (Deci et al., 2001; Gagne & Deci, 2005; Pelletier et al., 2002).

Extrinsic motivation occurs in any situation in which the outcome of the task motivates engagement rather than the enjoyment of the task (Ryan & Deci, 2000). Extrinsically motivating situations can have a broad range of effects on an individual. The organismic integration theory (OIT), a second sub-theory of SDT, defines the continuum of extrinsic motivation (Deci & Ryan, 1985). According to OIT, the extent to which individuals internalize and integrate the value of the extrinsically motivated task determines the extent to which they feel autonomous when engaging in the behavior. For example, if a teacher has internalized the importance of using inquiry to teach science, she might feel autonomous when following departmental requirements to teach at least one lesson using inquiry each week. Previous research has explored the varying degrees of extrinsic motivation and differences in how individuals regulate extrinsically motivated behavior (Ryan & Connell, 1989). The degree to which an individual perceives him/her-self to be autonomous can be described by the self-determination continuum (Deci & Ryan, 2000). When a person is intrinsically motivated to complete a task, he/she feels more autonomous; conversely, a person who is extrinsically motivated to complete a task feels less autonomous.

In educational and work settings, there are often tasks that must be completed because of the importance of the outcome rather than the enjoyment of the task. The crucial difference is how the individual identifies with the value of the task. In

the case of teacher autonomy, the greatest benefit occurs when teachers complete a task because it has more value to them, causing them to feel more autonomous in their engagement. Diminishing autonomy can prevent teachers from controlling the basic aspects of their daily work. SDT provides a framework for evaluating diminishing teacher autonomy and predicting its effects on motivation, instructional methods, student learning, professionalism, and teacher retention.

Instructional methods. Teacher autonomy affects the instructional methods that teachers use. Theory suggests that teachers with less autonomy and less self-determined motivation are less likely to support autonomy in their students (Deci, Spiegel, Ryan, Koestner, & Kauffman, 1982; Pelletier et al., 2002; Sheldon & Biddle, 1998). In one experimental study, teachers were subjected to differing levels of administrative pressure (Deci et al., 1982). One group of teachers was told that their role was to facilitate student learning of a task while the second group was told their role was to ensure that students learned how to complete the task. Teachers who were held accountable for the performance of their students asked more controlling questions, made more directive statements, and spent more time talking than teachers who were instructed to focus on facilitating learning (Deci et al., 1982).

In case studies of high school biology teachers, teachers with more autonomy used teaching strategies that were less traditional and more student-centered (Gess-Newsome & Lederman, 1995). These teachers used the textbook less and modified their teaching schedule to fit their needs. Autonomous teachers were also more mindful of students' needs in the planning and delivery of instruction. Gess-Newsome and Lederman (1995) also found that biology teachers with less autonomy were more likely to teach from the textbook and less likely to modify their schedule based on student learning. Similarly, Lee, Chang, and Tsai (2009) found that earth science teachers that were more learner centered tended to have students with more favorable attitudes toward learning science.

Student motivation and learning. Reduced autonomy negatively affects teachers' motivation and attitude, and reduced autonomy also negatively affects student motivation and learning. The majority of research related to SDT in education has examined the factors that facilitate or impede student motivation. In general, when students perceive their teachers as more supportive of their autonomy, students have higher intrinsic motivation and perceived competence (Chirkov & Ryan, 2001; Deci, Schwartz, Sheinman, & Ryan, 1981). High levels of intrinsic motivation in students have also been linked to improved learning and understanding (Deci, Vallerand, Pelletier, & Ryan, 1991). In a study of 72 elementary students, choices provided during an educational math game had positive effects on student learning and motivation (Cordova & Lepper, 1996). Even though the choices available to the students did not impact the instructional material of the game, students who were provided with choices were more engaged, learned more, and felt more competent in their abilities. A study of 137 college students enrolled in organic chemistry found a negative

correlation between students' perceptions of the control exerted by their professors and students' intrinsic motivation for the course (Black & Deci, 2000). Furthermore, low perceptions of autonomy support from the instructor were correlated with low academic performance.

Professional status and teacher retention. Teachers who are given too many directives by administrators sometimes feel like technicians rather than professionals. Poole (2008) found that power and organizational structures in school that prevent teachers from contributing to decision-making activities or from acting autonomously can infringe on their professional identity. Furthermore, teachers may experience frustration with the confusing and contradictory messages they receive about their role as professionals. At the same time that teachers are extolled as critically important contributors to the education of students, they are often not allowed the freedom to apply their skills and knowledge to the best of their abilities (Ingersoll, 2007). Lack of motivation and poor attitudes can have serious consequences on teacher retention. Teachers may leave public schools to work in private schools or charter schools where autonomy is greater (Crawford, 2001). Other teachers may leave the profession completely. Ingersoll (2001) analyzed more than 6,000 teachers' reasons for changing jobs or professions and found that dissatisfaction with the job was one of the leading factors affecting their decision. Reasons for job dissatisfaction included lack of autonomy and support from administrators (Ingersoll, 2001). These conditions may make teachers more likely to leave their jobs by exiting through the 'revolving door' described by Ingersoll (2001). Given the ongoing shortage of science teachers, understanding the relationship between autonomy and motivation can provide insight into how to retain experienced and valued teachers.

In 2002, Pelletier et al. explored the relationships between teachers' self-determination, work environment, perceptions of student motivation, and the amount of autonomy support provided to students. The study involved Canadian teachers ($n = 254$) of grades 1–12 who taught a variety of subjects. Participants completed four survey assessments, each assessment corresponding to one of the study variables. The authors proposed three models and used structural equation modeling to determine which model had the best fit. Figure 1 shows the final structural model. Pelletier et al. (2002) found that teachers' self-determination toward work mediates the effects of perceived constraints at work and students' self-determination toward school. The authors found that teachers who perceive the school climate as controlling were more likely to have negative feelings and decreased motivation toward teaching (Pelletier et al., 2002). Furthermore, the teachers who reported less autonomy in their work environment and lower levels of self-determination toward their work were less likely to support the autonomy of their students during learning (Pelletier et al., 2002). These studies show that autonomy is emerging as a critical theoretical thread that defines and connects teacher and student engagement.

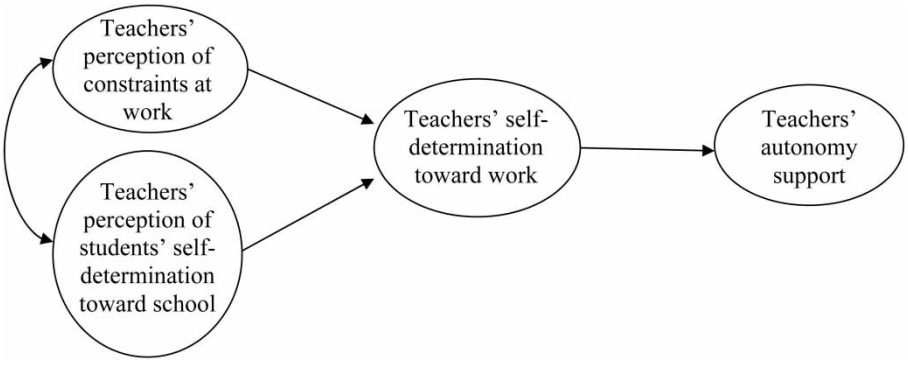


Figure 1. Modified from the structural model developed by Pelletier et al. (2002)

Research on Culture, Education, and SDT

Research linking SDT to culture has provided some evidence of the influence of individualist and collectivist culture on autonomy. In a study of elementary students, Iyengar and Lepper (1999) examined the influence of Eastern/Western culture on autonomy, motivation, and performance. Students of European American and Asian American backgrounds were divided into three groups. In the first group, the students were allowed to select an activity on which to work. In the second group, students were assigned an activity by the experimenter. In the third group, students were assigned an activity by their mothers. The Asian American students had the highest levels of motivation and performance when the task was assigned by their mothers. The European American students had the highest level of motivation and performance when they were allowed to select the activity. Both groups of students had the lowest levels of motivation and performance when the activity was selected for them by the experimenter.

In a related study, Iyengar and Lepper (1999) examined the role of peer groups on motivation and performance of fifth graders. Again, students were divided into three groups. In group one, students made personal choices. In group two, choices were made for students by fifth-grade students in another class. In group three, choices were made for students by their classmates. Similar to the findings of the first study, Asian American students were more engaged and motivated when their choices had been made by their classmates while European American students were more engaged and motivated when they made personal choices. The results of these two studies suggest that for members of Eastern cultures personal choice may not be as important to motivation and performance as situations in which parents or peers make the decision for them (Iyengar & DeVoe, 2003; Iyengar & Lepper, 1999). These issues of task choice have implications for the implementation of inquiry in science instruction. At the highest levels of inquiry students independently generate questions and make choices and decisions about all major aspects of the science investigation (Colburn, 2000).

Alternative explanations of the results of the studies by Iyengar and Lepper (1999) have been offered by Katz and Assor (2007) and Deci and Ryan (2000). Both explanations involve considering the broader context of the choice situations in light of the psychological need for relatedness. Whereas the explanations by Iyengar and Lepper (1999) focused solely on the need for autonomy, the alternative explanations include consideration of the individual's relatedness to other people. Katz and Assor (2007) state the following:

> In contexts with strong collectivist and hierarchical orientations – typical of students from certain ethnic groups – choice can easily threaten the sense of relatedness and belonging to one's in-group, as well as the need to be appreciated and loved by important authority figures. (p. 438)

In a similar argument, Deci and Ryan (2000) maintain that there can be differences in how autonomy is expressed in different cultures. They argue that members of Eastern cultures 'may feel more volitional and autonomous when endorsing and enacting values of those with whom they identify' (p. 247). A study of 60 Chinese elementary students found evidence that the relationship between the child and the person making the choice was an important factor in the students' motivation (Bao & Lam, 2008). The authors hypothesized that the results they observed might have been due to the fact that the children had internalized the decisions of their mothers thereby causing them to feel autonomous when their mothers made choices for them (Bao & Lam, 2008).

Chirkov and Ryan (2001) examined the relationship between autonomy support by parents and teachers and the well-being and academic motivation of high-school students using participants from Russia and the US Russia was selected for the study because previous studies have documented the culture as more authoritative. It was thus hypothesized that students in Russia would perceive parents and teachers as more controlling. Results showed that Russian students reported parents and teachers as being significantly more controlling that US students. Consistent with SDT, however, perceived autonomy-support predicted greater well-being and academic motivation for Russian and US students (Chirkov & Ryan, 2001).

Purpose

There are two primary gaps in the research on SDT and science education in international contexts. First, there is very little research specific to science teaching and learning. Teacher autonomy is particularly significant in science, because instruction is heavily dependent upon access to space, equipment, and materials needed for laboratory activities. How teachers perceive their autonomy related to instructional practices can impact their use of these materials and, subsequently, the learning opportunities available to students. Second, previous research on SDT and culture has primarily focused on the collection and analysis of quantitative data. The current study used a mixed methods design that would allow the researchers to make comparisons to previous models of motivation as well as probe for differences specific to science teaching and learning.

The purpose of this study was to examine factors that contribute to Chinese and US middle-school science teachers' perceptions of autonomy support. Using the same variables and survey assessments as Pelletier et al. (2002), we used two very different cultures (collectivist) and (individualist) to examine how teacher autonomy may differ by context within the domain of science education. In addition, this study sought documentation of how specific instructional practices and conditions of science teaching may differ across these two different educational systems and how these variables may contribute to teachers' perceptions of autonomy support.

Research Questions

(1) Do middle-school science teachers in China and the USA differ in their perceptions of constraints at work?
(2) Do middle-school science teachers in China and the USA differ in their perceptions of students' motivation toward school?
(3) Do middle-school science teachers in China and the USA differ in their motivation toward work?
(4) Do middle-school science teachers in China and the USA differ in their levels of autonomy support for students?
(5) Do the factors of perceptions of constraints at work, perceptions of students' motivation toward school, and motivation toward work predict middle-school science teachers' levels of autonomy support for students in China and the USA?

Methods

This study used a mixed methods design. Quantitative data were collected through an online survey and qualitative data were gathered from a sub-sample of participants using a series of open-ended questions. All materials were translated using back-translation protocol.

Survey Participants

The participant sample ($n = 201$) consisted of middle-school science teachers (teachers of students aged 10–14) from China and the USA. The Chinese participants were selected through a partial convenience sample working through science education partners (university researchers) in the USA and China. The science education partners recruited a pool of middle-school science teachers through personal contacts for participation in the survey portion of the study. The Chinese participants completed a mixture of online and paper surveys (see Wan, Wong, & Yung, 2011 for additional information on the difficulties in conducting teacher education research in China). All teachers were from the Jiangsu and Shanxi provinces. In the USA, teachers were recruited through email by using contact information available on school websites and email lists of state science teaching associations. All US teachers completed the survey online and were from the states of Tennessee and North Carolina.

Once teachers completed the anonymous survey, they were asked if they would be willing to participate in a follow up interview. A random sample of interview participants was pulled from those that volunteered.

The demographics of the US participants are summarized in Table 1 which includes comparison data from a national survey of middle-school science teachers, *Status of Middle-School Science Teaching* (Fulp, 2002). All but one of the US participants had a current teaching license. Most of the teachers had a regular or advanced licensure. The teachers represented a mixture of rural, suburban, and urban teaching communities as well as years of teaching experience. In order to comply with human subjects regulations we were not allowed to collect school-based data in order to protect the identity of the teachers (due to the international data collection).

The demographics of the Chinese participants are summarized in Table 2 which includes data from the Ministry of Education of the People's Republic of China (2008) on junior secondary science teachers for comparison purposes. Ninety-one percent of the Chinese teachers held a current teaching license and 73% had a degree above the bachelor's level. The teachers represented a range of years of teaching experience.

Table 1. US teacher demographics for gender and race

	N	Study sample percentage	US National percentage[a]
Gender			
Female	79	84	74
Male	15	16	26
Race			
African American	6	6	6
Asian or Pacific Islander	0	0	1
Hispanic	0	0	3
Native American	0	0	1
White (not Hispanic)	88	94	89

[a]Data from the status of middle school science teaching (Fulp, 2002).

Table 2. Chinese teacher demographics for gender and teaching community

	N	Study sample percentage	Chinese National percentage[a]
Gender			
Female	62	58	38
Male	44	41	62
No Response	1	1	0
Teaching Community			
Rural	11	10	39
Suburban	15	14	42
Urban	81	76	20

[a]Data from the Ministry of Education of the People's Republic of China (2008).

Interview Participants

Of the survey participants who volunteered to participate in the interview, a random subset of 10 participants from each country was selected for the interview portion of the study. The US interview participants consisted of seven females and three males. The teachers had an average of eight years of teaching experience. Nine Chinese teachers, five females, and four males, completed the interview portion of the study. Both the USA and Chinese samples contained males and females representing a mixture of teaching communities, education levels, and years of teaching experience.

Survey Assessment

The survey assessment included the *constraints at work* (Pelletier et al., 2002), *Perceptions of Students' Motivation* based on the *Academic Motivation Scale* (Vallerand et al., 1992, 1993), *The Work Inventory Scale* (Blais, Lachance, Vallerand, Briere, & Riddle, 1993), and *The Problems in Schools Questionnaire* (Blais et al., 1993). The four instruments measure aspects related to teacher autonomy and motivation on a seven-point Likert scale. The *constraints at work* (Pelletier et al., 2002) assessment consists of 21 items used to calculate 3 subscales of teaching constraints: constraints from colleagues, administrators, and school curriculum. The reliability of the three subscales was 0.73. The *Perceptions of Students' Motivation* scale is an adaptation from *The Academic Motivation Scale* (Vallerand et al., 1992, 1993) and consists of 28 items. The scale measures seven subscales, each with four items. The subscales correspond to differing levels of student motivation: intrinsic motivation to know, intrinsic motivation toward accomplishment, intrinsic motivation to experience stimulation, extrinsic motivation by identified regulation, extrinsic motivation by introjected regulation, extrinsic motivation by external regulation, and amotivation. Vallerand et al. (1992) reported that exploratory factor analysis (EFA) showed the subscales loaded separately with the reliability of the seven subscales ranging from 0.62 to 0.86.

The Work Motivation Inventory (Blais et al., 1993) includes items that measure motivational level toward work. The survey assessment consists of 18 items and measures teachers' motivation toward work in 6 subscales: intrinsic motivation, integrated motivation, identified motivation, introjected motivation, external motivation, and amotivation. Three questions relate to each subscale. The psychometric properties of the English version of the survey assessment were validated by Tremblay, Blanchard, Taylor, Pelletier, and Villeneuve (2009). Tremblay et al. used confirmatory factor analysis (CFA) to support the six factor structure of the English version of the survey and found the reliability of each subscale to range from 0.64 to 0.83.

The Problems in Schools Questionnaire (Deci, Schwartz, et al., 1981) measure teachers' autonomy support versus control orientation (Appendix A, questions 17–24). It is composed of eight vignettes. Four items follow each vignette. Each item represents a different level of autonomy support: highly controlling, moderately controlling, moderately autonomy supportive, or highly autonomy supportive. Item responses are on a seven-point Likert scale. Deci et al. report that the internal consistency of each subscale is 0.63–0.80. The four instruments, in Chinese and English, were combined into

one document and uploaded to an online survey program with foreign language capabilities. Introductory and conclusion sections were added to the surveys.

There were 151 USA and 146 Chinese teachers who completed the survey. Participant responses were removed from the sample if the survey was not fully completed, teachers worked at private schools, or if the teacher had entered a single value for an entire section of the survey and the final sample included 94 US teachers and 107 Chinese teachers. Means and standard deviations were calculated for each of the factors being measured in the survey.

Open-ended Interview Questions

The Science Teacher Interview Questions are a set of open-ended questions designed for this study to document teachers' perceptions of issues of autonomy and motivation specific to science instruction (e.g. laboratory and fieldwork, materials management, and inquiry). For example, teachers were asked, 'If you were planning to teach a science lab, what constraints do you have to consider concerning access to materials, lab space, time, or other factors in regards to colleagues, administrators, or school curriculum?' and 'How often do your students get to choose how they are going to learn about a topic?' In the USA, 10 teachers were interviewed using the Science Teacher Interview Questions. Due to limited Internet access on the part of the Chinese teachers, it was not possible to follow the original plan of using voice over Internet software and a translator to interview the Chinese participants. Instead, the nine Chinese participants wrote their responses to the open-ended questions. The Chinese version of the Science Teacher Interview Questions contained additional questions to probe the interviewees as they wrote their responses. For example, for the question above about planning to teach a science laboratory, the Chinese teachers were also asked, 'Do you share lab space, materials, or equipment? Do you use the same tests? Do you cover topics in the same order and at the same pace?'

Analysis of Survey Assessments

EFA. It was not possible to do structural equation modeling or CFA as described by Pelletier et al. (2002) because of the sample size of the study. EFA was carried out on the combined sample of Chinese and US teachers in order to validate the factor (or subscale) structure for each instrument for the combined sample and to ensure that the same items measured each factor. The original instruments were validated on different samples, primarily French–Canadian and US participant samples. Changes in the factor structure of survey assessments due to language translation and cultural differences have been documented in other studies (Fossati, Di Ceglie, Acquarini, & Barratt, 2001; Kitamura et al., 2004; Ryan, Chan, Ployhart, & Slade, 1999). In the case of this study, translation from English to Chinese may have caused variations in the meaning of particular items or groups of items that resulted in changes in the factors being measured. Also, the *constraints at work* assessment was received in French, translated to English, and then translated to Chinese. This series of translations may have resulted in changes in meaning for survey items. For these reasons, EFA was carried out to determine the factor structure

of the combined study sample. For subsequent analyses, the samples of Chinese and US teachers were separated in order to address research questions 1–4 which address significant differences between the two groups.

All items for the four survey assessments were included in the EFAs. The combined sample of Chinese and US teachers had a total *n* of 201. Therefore, the subject to item ratio was greater than 10–1 for the *constraints at work* and the *Work Motivation Inventory*, and the subject to item ratio was greater than 6–1 for the *Perceptions of Students' Motivation* assessment and the *Problems in Schools Questionnaire*. These subject to item ratios meet the recommendations of Costello and Osborne (2005).

The EFAs were conducted using principal axis factoring. Oblique direct oblimin rotation was used because it was assumed that the factors were correlated. The number of factors for each survey assessment was determined based on a combination of measures. The Kaiser criteria were reviewed to determine the approximate number of factors to include. Following this, a scree plot of eigenvalues was obtained. With the exception of the *constraints at work*, factor structures that included factors with fewer than three items were not used. The factors were named based on a review of the survey items that loaded for each factor. Factor means were calculated based on the mean of the participants' responses for all of the items in the factor.

Scale composites were computed based on the weight of each factor as determined from the factor matrix of a one-factor EFA in order to compare the study samples for the four study variables. With the exception of *constraints at work*, the instruments and their subscales support the continuum of self-determination proposed by Deci and Ryan (1985). Consequently, higher scale composites correspond to higher levels of self-determination and vice versa. The equations used to compute the scale composite scores are provided below:

$$\begin{aligned} \textit{Constraints at Work} = {} & (0.995^{*}\text{Support}) + (0.650^{*}\text{Work with students}) \\ & - (0.394^{*}\text{Constraints}), \end{aligned} \tag{1}$$

$$\begin{aligned} \textit{Perceptions of Students' Motivation} = {} & (0.895^{*}\text{Accomplishment}) \\ & + (0.721^{*}\text{Enjoyment}) + (0.689^{*}\text{Job success}) \\ & - (0.523^{*}\text{Amotivation}), \end{aligned} \tag{2}$$

$$\begin{aligned} \textit{Work Motivation Inventory} = {} & (0.861^{*}\textit{Satisfaction}) + (0.793^{*}\text{Identity}) \\ & + (0.108^{*}\text{Income}) - (0.360^{*}\text{Amotivation}), \end{aligned} \tag{3}$$

$$\begin{aligned} \textit{Problems in Schools Questionnaire} = {} & (0.762^{*}\text{High autonomy support}) \\ & + (0.441^{*}\text{Moderate autonomy support}) \\ & - (0.170^{*}\text{Controlling}). \end{aligned} \tag{4}$$

Significance testing. The analysis of significant differences between Chinese and US teachers' for the factors and scale composites of each survey assessment was

completed using independent samples *t*-tests. Equal variances were not assumed for the factors or scale composites. The Bonferoni Correction Adjustment was calculated to ensure that the overall chances of making a Type I error were still less than 0.05 while running multiple tests. The value was calculated by dividing 0.05 by the number of *t*-tests performed (18). The result was a significance level of $p < 0.003$.

Multiple regression. Multiple regression of the scale composites, derived from the EFAs, was used to predict teachers' autonomy support. This approach revealed the extent to which the constructs of teachers' perceptions of constraints at work, students' motivation toward school, and motivation toward work predicted the variable of teachers' autonomy support.

Analysis of Open-Ended Interview Questions

Interpretive grounded theory was used to code the interviews (O'Connor, Netting, & Thomas, 2008). In this use of grounded theory, the data were collected prior to analysis and were based upon previously determined questions. In the first round of coding, the responses to the open-ended interview questions were coded for themes related to instructional practices as well as constraints at work, student motivation, motivation toward work, and autonomy support of students (Table 3). Constant comparisons were made across different interviews to enrich, refine and better interpret patterns within the codes (Hallberg, 2006; O'Connor et al., 2008). In the next level of coding, thematic patterns were analyzed across individual countries and the two countries combined. Two themes that emerged from the interviews were trust and collaboration. A sub-sample of two of the interview transcripts was coded independently by two people. The inter-rater reliability was 0.88 for the two coders.

Once inter-rater reliability was established one researcher coded the remaining interviews. The interview transcripts were read and themes were coded in the margins of the transcripts. Statements and phrases were coded with a number and letter corresponding to the list in Table 3. For example, Leslie stated,

> I teach on a team with two other science teachers whom I plan with. But we all are expected to give the same, common assessments, which we design together. So, we work together on the assessments, so I don't necessarily feel as if I'm giving somebody else's test. I mean, we created it together.

This statement was coded for constraints from administrators, instructional practice using assessment, and collaboration.

Limitations

The results of this study should be considered in light of the study limitations. The sample size of the quantitative portion of the study required that EFA be used to examine the factor structure of the survey assessments rather than CFA. The resulting factor structures of the assessments were similar to the previous factor structures and related to the theoretical framework of SDT; however, the different factor structures

Table 3. Interview coding themes

1. Constraints at work
a. administrators
b. colleagues
c. parents
d. students
e. materials, space, or money
f. school curriculum or standards
g. standardized testing
h. time
i. class size
2. Student motivation
3. Student learning
4. Student autonomy
5. Teacher motivation
6. Teacher autonomy
7. Instructional practice
a. planning and instruction
b. lab activities
c. materials (textbooks, lab equipment, etc.)
d. individualizing instruction
e. assessment
8. Trust
9. Collaboration

limit comparisons to previous studies. Future research is needed with a much larger sample of middle-school science teachers. Also, this study relied on the translation of the survey assessments. As noted previously, translations can affect the psychometric properties of survey instruments due to differences in language structure and cultural references (Fossati et al., 2001; Kitamura et al., 2004; Ryan et al., 1999). Finally, the participants were all volunteers and represented teachers from one geographic area in each of the two countries. It is not known whether or not these teachers' perceptions are representative of the larger population of science teachers in these two countries. We were not able to personally interview the Chinese teachers, and if we had been able to probe responses, we may have been able to develop more insight into the relationships between autonomy and instructional practices. Observations would have been helpful to assess the reliability and validity of the teachers' responses; however, observations would have prevented anonymous participation by the teachers.

Results

In the sections that follow the results of the quantitative and qualitative analyses are presented for perceptions of *constraints at work*, *students' motivation*, *work motivation*, and levels of *autonomy support teachers provide their students*. EFA was used to validate

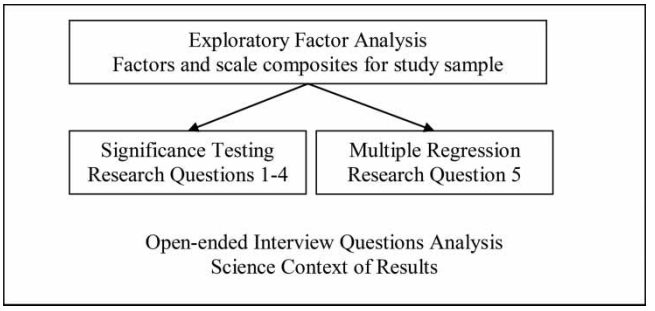


Figure 2. Summary of relationships between analyses, data, and research questions

the factor structure and calculate a scale composite for each of the four instruments for the study sample. Significance testing was used to compare the factors and scale composites to address research questions 1–4 that refer to differences in Chinese and USA teachers' perceptions of work autonomy, student motivation, work motivation, and level of autonomy support for students. Multiple regression of the scale composites for the four survey instruments was used to address research question 5 which refers to how three of the factors, teachers' perceptions of work constraints, student motivation, and level of work motivation, can be used to predict the fourth factor, level of autonomy support teachers provide their students, for Chinese and US teachers. Finally, the results of the interview questions are reported to provide a science context for the quantitative results across the two countries. Figure 2 summarizes the relationships between the analyses, data, and research questions.

EFA

The results of the EFAs for the combined study sample ($n = 201$) for each of the survey assessments are described below. In general, the EFAs resulted in fewer factors than in the original versions of the instruments; however, the new factors were closely related to the original factor structures and the theoretical framework of the instruments. Items that did not have factor loadings greater than 0.40 for any of the factors were removed.

Constraints at work. The result of the EFA for the *constraints at work* was a three-factor structure (Table 4) that explained 48% of the total variance in the responses. The reliability of the factors ranged from 0.66 to 0.85. The seven items in the support factor relate to positive environmental support from administrators, colleagues, parents, and students, and one item relates to school curriculum. The constraints factor contains two items related to constraints on teaching, and the work with students factor contains three items related to motivating and evaluating students.

Factor correlations for the *constraints at work* factors are also reported in Table 4. The constraints factor is significantly negatively correlated with the factors of support and work with students. The significant correlations between the three

Table 4. Internal consistency values (Cronbach alpha), number of items, and correlations for constraints at work factors

Factor	Alpha ($n = 201$)	Number of items	1	2	3
1. Support	.85	7	–	−.40**	.65**
2. Constraints	.66	2		–	−.25**
3. Work with students	.78	3			–

**Correlation is significant at the .01 level (two-tailed).

factors (and among factors in the other survey assessments) support the use of oblique direct oblimin rotation during the EFAs. The *constraints at work* survey assessment is not organized around the self-determination continuum and does not contain a scoring guide like the other instruments; therefore, the factors of constraints, support, and work with students should not be assumed to represent a spectrum of motivation and perceived autonomy like the other instruments.

Perceptions of Students' Motivation: Self-Determination Toward School. The EFA for *Perceptions of Students' Motivation* resulted in a four-factor structure shown in Table 5. The factors had between 4 and 10 items with internal reliabilities ranging from 0.80 to 0.94. The model explained 67% of the total variance in the responses. The accomplishment factor contains 10 items related to students' feelings of satisfaction associated with accomplishments in school. The eight items in the job success factor relate to students' success in future career endeavors such as salary, competence, and prestige. The amotivation factor includes four items reflecting apathy toward education while the enjoyment factor includes four items that reflect pleasure in the experience of learning. The four factors are significantly correlated with one another. Amotivation is negatively correlated with the factors of accomplishment, job success, and enjoyment. When compared to the original factor structure of the *Academic Motivation Scale*, the factors for this study show a similar organization. Together the four factors represent a spectrum of motivation from intrinsic (accomplishment and enjoyment) to extrinsic (job success) to amotivation corresponding to the self-determination continuum.

Table 5. Internal consistency values (Cronbach alpha), number of items, and correlations for perceptions of students' motivation factors

Factor	Alpha ($n = 201$)	Number of items	1	2	3	4
1. Accomplishment	.94	10	–	.68**	−.43**	.66**
2. Job success	.9	8		–	−.38**	.46**
3. Amotivation	.82	4			–	−.41**
4. Enjoyment	.8	4				–

**Correlation is significant at the .01 level (two-tailed).

Table 6. Internal consistency values (Cronbach alpha), number of items, and correlations for the work motivation inventory factors factor

	Alpha ($n = 201$)	Number of items	1	2	3	4
1. Satisfaction	.88	7	–	.04	−.34**	.68**
2. Income	.73	3		–	.09	.20**
3. Amotivation	.70	3			–	−.27**
4. Identity	.78	5				–

**Correlation is significant at the .01 level (two-tailed).

The Work Motivation Inventory: Self-determination toward work. The EFA for the four-factor model of the *Work Motivation Inventory* is summarized in Table 6. This model accounted for 65% of the total variance of the responses. The factors had between three and seven items with internal reliabilities ranging from 0.70 to 0.88. The satisfaction factor includes seven items related to feelings of satisfaction from job success and positive work experiences. The income factor comprises three items that relate to income, salary, and lifestyle, and the amotivation factor includes items that reflect apathy toward work. The fourth factor, identity, includes five items describing career choice as an integral part of identity and personal goals.

As shown in Table 6, the factors of identity, satisfaction, and amotivation are significantly correlated with one another. Income is significantly correlated with identity but not with satisfaction or amotivation. The significant correlations of amotivation with satisfaction and identity are negative. The factor structure for the combined study sample is closely related to the original subscales reported by Blais et al. (1993) and the underlying theoretical framework of self-determination. The four factors of the EFA for the *Work Motivation Inventory* closely align with the spectrum of motivation in the self-determination continuum from intrinsic motivation (success) to extrinsic motivation (income and identity) to amotivation.

The Problems in Schools Questionnaire: Levels of autonomy support. The EFA resulted in a three-factor structure (Table 7) that explained 46% of the total variance in the

Table 7. Internal consistency values (Cronbach alpha), number of items, and correlations for the problems in schools factors factor

	Alpha ($n = 201$)	Number of items	1	2	3
1. High autonomy support	.87	12	–	.34**	−.15*
2. Controlling	.81	9		–	−.05
3. Moderate autonomy support	.85	9			–

*Correlation is significant at the .05 level (two-tailed).

**Correlation is significant at the .01 level (two-tailed).

responses. The factors had between 9 and 12 items and their internal reliabilities ranged from 0.81 to 0.87. The high autonomy support factor includes 12 items that describe responses on the part of the parent or teacher that encourage student autonomy in addressing problems. The items have a focus on dialogue between the students and adults, and in many of the items, the adults ask the students about how they plan to deal with particular situations. The controlling factor includes nine items in which the adult tells the student what to do or uses bribes and punishments to control student behavior. The moderate autonomy support factor also includes nine items and is an intermediate between the high autonomy support and controlling factors. Items include responses in which adults offer students specific suggestions of how they might deal with situations.

The correlations among the factors for *The Problems in Schools Questionnaire* are also shown in Table 7. The factors of high autonomy support and moderate autonomy support were significantly correlated. The controlling factor had a significant negative correlation with high autonomy support, but it was not significantly correlated with moderate autonomy support. The original factor structure of *The Problems in Schools Questionnaire* contains four subscales, highly autonomy supportive, moderately autonomy supportive, moderately controlling, and highly controlling (Deci, Schwartz, et al., 1981). The three factors that resulted from the EFA for the combined study sample are similar. The primary difference is that the EFA included only one-factor measuring control. The three factors reflect a spectrum of teachers' level of autonomy support for their students.

Significance Testing and Interview Question Analysis: Motivation Factor Differences and Reported Experiences for Chinese and US Teachers

The results of the independent *t*-tests comparing factor and scale composite means for the US and Chinese teachers are shown in Table 8. In the sections that follow each factor is discussed in light of the results from the different countries. Interview results are presented by factor with details and contexts related to the factors.

Constraints at work. The USA and Chinese teachers differed significantly for the factors of support, constraints, and work with students (Table 8). US teachers had significantly higher means for the factors of support and work with students indicating higher perceived levels of support from administrators, colleagues, parents, and students and a greater emphasis on the importance of motivating and assessing students. The Chinese teachers had a significantly higher mean for the constraints factor indicating that they perceived greater constraints on their teaching from students and colleagues.

Whereas the survey results highlighted perceived constraints on teaching related to influences from other people (administrators, colleagues, and students) and work with students, the interview results primarily elicited teachers' concerns about non-relational constraints such as science teaching materials and laboratory space, curriculum standards, and class size. Seven of the US teachers cited collaboration with

Table 8. Perceptions of constraints at work for middle school science teachers in China and the USA by factors and scale composite factor

	US mean (SD) (n = 94)	China mean (SD) (n = 107)	t	df	p
Constraints at work					
Support	5.70 (0.67)	4.63 (1.28)	7.57*	165	.00
Constraints	2.55 (1.26)	3.24 (1.60)	−3.44*	197	.00
Work with students	6.15 (0.76)	4.93 (1.43)	7.65*	166	.00
Scale composite	8.66 (1.00)	6.53 (2.34)	8.58*	147	.00
Perceptions of students' motivation					
Accomplishment	3.95 (1.12)	4.81 (1.36)	−4.89*	198	.00
Job success	4.94 (1.38)	4.70 (1.14)	1.33	181	.19
Amotivation	3.10 (1.20)	3.19 (1.51)	−0.46	197	.65
Enjoyment	3.75 (1.06)	4.21 (1.37)	−2.71	196	.01
Scale composite	8.03 (2.67)	8.92 (3.12)	−2.19	199	.03
Work motivation					
Satisfaction	5.81 (0.85)	4.83 (1.36)	6.20*	180	.00
Income	3.80 (1.44)	4.28 (1.29)	−2.48	188	.01
Amotivation	2.24 (1.25)	3.42 (1.28)	−6.61*	197	.00
Identity	5.48 (0.96)	4.44 (1.13)	7.06*	199	.00
Scale composite	8.95 (1.43)	6.91 (2.10)	8.15*	188	.00
Levels of autonomy support					
High autonomy support	5.82 (0.64)	4.83 (1.15)	7.69*	171	.00
Controlling	3.39 (0.90)	3.21 (1.25)	1.21	192	.23
Moderate autonomy support	3.63 (0.89)	4.76 (1.23)	−7.54*	193	.00
Scale composite	5.46 (0.67)	5.23 (1.45)	1.45	154	.15

peers as a positive and motivating factor of their work while the Chinese teachers reported a desire for better relationships and interactions between teachers and students (see discussion of *Work Motivation Inventory* below).

Funding for materials, equipment, and laboratory space. When asked about factors that constrained their teaching and reduced their autonomy the US teachers cited money as the primary factor that restricted their decisions regarding aspects of their teaching. Throughout all 10 of the interviews, money was mentioned directly, in terms of small and shrinking budgets, and indirectly, in terms of limited resources, laboratory materials, and large class sizes resulting from too few teaching positions. In the words of Rene (teacher names are pseudonyms), 'Money is a big problem. That's something we have to be careful with and we don't have as much anymore. And that's always a constraint'. For the Chinese teachers, money was not as prevalent in their responses. Only five of the Chinese teachers described constraints from funding for materials, equipment, or laboratory space.

When asked to describe their ideal teaching situations, eight of the US teachers quickly responded with lists of materials they would like to have for their students.

Most lists included an increase in the number of student computers and more laboratory supplies. For example, Beth stated, 'I would like to have more technology. Every student would have a laptop'. Leslie, who taught 165 sixth-grade students, described the difficulty of purchasing and storing materials in her room for a large number of students. In response to the same question, only half of the Chinese teachers mentioned improvements in materials and classrooms. Shen and Jin expressed a desire for 'beautiful' teaching environments while Chen hoped for 'advanced equipment'.

Six of the US teachers described working in classrooms with desks instead of tables with no access to laboratory space. Susie described her classroom by stating,

> There are some labs that we just can't do, because we don't have the resources for them. . .I have to be able to set up the space and figure out how to do it in a classroom that's not really made for science.

Similarly, the US teachers reported limited storage for materials and equipment. In Tim's case, constraints on building and classroom space meant that the science laboratory had become a classroom. In order to take his students to the laboratory, he said he had to make arrangements with another teacher and swap rooms for the day. The limited access to materials, equipment, and space as described by eight of the US teachers affected their decisions regarding planning, instruction, and assessment.

School curriculum and standards. Both Chinese and US teachers reported constraints as a result of the science curriculum and teaching standards. The impact of the standards was apparent in numerous comments throughout the interviews. Susie summed up the importance of the state curriculum by stating, 'It's the Bible'. The Chinese teachers also mentioned constraints from the 'master syllabus'. Yen expressed her frustration that laboratory investigations were not completed for authentic learning experiences but in order to complete a set of tasks on the master syllabus. Five of the Chinese teachers described how the master syllabus was the primary constraint on their teaching. In the words of Min, 'The master syllabus decides everything'.

Though the autonomy of the teachers was constrained by school curriculum and standards, teachers often prefaced their comments with phrases like, 'I understand the reason for standards'. Tim expressed his appreciation for the standards as guidelines that helped him to stay on track. Similarly, Greg was comfortable with the organization of lessons around the same state standards and essential questions and then individualizing the delivery of instruction for his students. Yen did not want complete autonomy over her teaching, because she felt that it was important to 'achieve the teaching goals first'.

Rather than being frustrated with the existence of state and national standards, teachers in both countries felt constrained by the amount of material they were expected to cover in one school year. Ping stated, 'There is too much to teach and not enough time'. In the words of Beth, 'How did they expect us to cover all of this material?' Tara described the amount of material in the standards as 'impossible' and stated, 'I just feel like I'm skimming the top of everything . . . it's a little disheartening'. Teachers

in both countries felt pressure to cover large amounts of material in a short amount of time and expressed concern that they could not slow down to allow students to explore topics or to re-teach material. Only one of the US teachers, Angela, said that she had to follow a pacing guide that regulated the timing and order of her instruction.

Testing. The Chinese teachers discussed the restrictive role of college entrance exams on their planning and instruction. Jin said that his autonomy was limited by the college entrance exam, because he had to 'teach the knowledge in the textbooks'. Yong mentioned the influence of the college entrance exams throughout his interview referring to it at one point as, 'the examination problem, which shapes our teaching, planning, and evaluation'. Chen noted that he had the most autonomy over evaluations that he designed and used in the classroom. He stated, 'Planning and instruction are limited by the master syllabus. Comparatively speaking, evaluation is better because I can give my own opinion'.

All of the US teachers described the control of standardized assessments that were implemented at the state or district levels. Five of the teachers used standardized test data in collaboration with other teachers in their schools or districts to modify their instructional practices. In Rene's district, school performance on state tests was shared at the beginning of each year 'for everyone to see what schools did well, what schools did not'.

Class size. Six of the US teachers described frustration with large class sizes that were a result of limited classroom space and funding for additional teaching positions. US teachers mentioned class sizes as large as 35. At the schools of some of the US teachers, students with learning disabilities were in special classes for math and language arts and mainstreamed for science and social studies. The broad range of learning abilities intensified the struggle to reach each student. In the words of Rene, 'When I have a big class and I have to cater to every different kid in there…it is hard to know how to reach them'.

Some of the teachers, like Tara, wished for drastic reductions in class size in order to have as few as eight students. Other teachers wished for reductions that were more modest to classes of 20 students. In sharp contrast to the US teachers, the Chinese teachers reported ideal class sizes ranging from 30 to 50 students.

Administration. When teachers talked about administrators, the US teachers tended to describe positive relationships. US teachers described their administrators as trusting and supportive of their teaching. Tara and Greg explained that their administrators were instrumental in creating a supportive community at the school. Other teachers, like Tim and Cody, described a more distant relationship with administrators; they had autonomy over their teaching and lesson planning as long as they covered the expected material. In Leslie's case, her administrator expected 'high level, rigorous lessons', but she was free to select the learning activities for her

students. One of the teachers, Rene, felt that her teaching was constrained by a lack of trust from school and district administrators. She found this lack of trust frustrating and upsetting. She stated, 'In leadership you have to establish a good rapport, and then your team will do well. You have to trust them. . .And when you feel trusted, you tend to do better'.

The Chinese teachers did not explicitly describe their relationships with administrators; however, they made indirect statements in regards to constraints on their teaching. Three teachers reported that they had to consider constraints related to administrators when planning science lessons, and six teachers reported that they had to consider administrative constraints when planning science laboratories. Beyond the school level, one teacher, Shen, stated that his teaching was constrained by government strategies, while Yen said her teaching was constrained by 'educational models and teaching conditions'.

The trend across these qualitative data suggest that US teachers seek greater financial support and resources for the physical environment more than the Chinese teachers. Both groups expressed concerns about the constraints on their teaching from mandated curricular standards. Across the quantitative and qualitative data, the US teachers reported fewer constraints from administration than the Chinese teachers.

Teachers' Perceptions of Students' Motivation. The results of significance testing for the factors and scale composite for the *Perceptions of Student's Motivation* are also shown in Table 8. The Chinese teachers had a significantly higher mean score for the factor of accomplishment indicating that the Chinese teachers perceived that their students are motivated by accomplishments in school to a greater extent than US teachers. There were no significant differences for the factors of job success, amotivation, or enjoyment. There was no significant difference in the scale composite scores for the USA and Chinese teachers. They had similar perceptions of the factors that motivate their students in school and the extent to which they perceive their students to be intrinsically or extrinsically motivated.

When asked about instructional practices in the interviews, results showed that the USA and Chinese teachers' choices of instructional practices were made in consideration of students' interests, needs, and abilities. Teachers described using multiple methods of instruction to engage and motivate students with different interests. Similarly to the US teachers, eight of the Chinese teachers reported that using different types of teaching methods were important to motivating their students and improving student learning.

The USA and Chinese teachers both described modifying their instructional practices at the end of a unit or semester. In Tara's case (a US teacher), she asked students for their suggestions of better ways to teach topics and then used the student feedback to develop new lessons. She said the process was motivating for the students because, 'they get to see their own classmates being successful with something that they came up with'. Fang and Chen (Chinese teachers) described a reflective method of refining their teaching by finding and correcting mistakes in their delivery of information.

Other Chinese teachers mentioned modifying their instruction in more subtle ways such as the quantity of homework, allowing students to ask questions in class when they do not understand the content, providing class discussions, and allowing students to choose how they finish class activities. Teachers in both countries mentioned changing the pace of their instruction based on student feedback.

When asked specifically how to motivate students, Greg, a US teacher noted that,

> students tend to pick up on a lack of enthusiasm and a lack of individualized creativity . . . Everyday when you teach in front of students, you're putting on a show. And they're able to pick up on if it's a re-run or if it's a newly televised program.

Work Motivation: Self-determination toward work. For the *Work Motivation Inventory* the USA and Chinese teachers differed significantly for three of the individual factors and the overall construct of teachers' motivation toward work as measured by the *Work Motivation Inventory* (Table 8). The US teachers had significantly higher means for the factors of satisfaction and identity while the Chinese teachers had significantly higher means for the factor of amotivation. There was no significant difference in USA and Chinese teachers' means for the income factor. The scale composite mean scores were significantly different. The US teachers had a higher scale composite mean indicating a higher level of intrinsic motivation for work. The USA and Chinese teachers differed significantly for three of the individual factors and the overall construct of teachers' motivation toward work as measured by the *Work Motivation Inventory.*

During the interviews US teachers reported that collaboration was an important component of their work satisfaction. Eight of the US participants commented specifically about collaboration with their peers. Seven of the teachers reported that collaboration with colleagues was positive. In Leslie's school, Professional Learning Communities met together once a week to plan lessons and the activities that were used in class. Greg and Tara described using email and network drives to share lessons and assessments. Beth and Susie, who taught at smaller schools, were the only science teachers at their grade level. They expressed disappointment in not having peers in their school buildings with whom they could collaborate. Despite the fact that USA teachers noted some loss of individual autonomy through shared decision-making, they felt that collaboration had a positive impact on teaching. Only one teacher, Rene, felt like the amount of collaboration was becoming too restrictive. She stated, 'And now we're being told that we have to decide on certain labs for school in that district. We have to do the same thing. It's almost like, anymore, we can't do our own thing'.

The Chinese teachers did not describe the extent to which they worked collaboratively with other teachers or individually to plan and make student assessments. Two of the questions asked the teachers to indicate if they had to consider their colleagues when planning science lessons and laboratories. Three of the Chinese teachers reported that they had to consider colleagues when planning lessons and four of the teachers reported considering colleagues specifically when planning to teach science laboratories.

Seven of the US teachers felt that autonomy was essential to teacher motivation. Beth stated, 'I love [autonomy] because I can be creative. I can do what my instinct tells me the children need'. Tim said, 'I think [autonomy] is absolutely essential. We couldn't have science teachers without it'. Similarly, six of the Chinese teachers felt that autonomy was important to teacher motivation and quality of instruction. These teachers mentioned the importance of autonomy to motivate teachers to refine their teaching practices and better meet the needs of their students. Like Beth's quote, three of the Chinese teachers said their motivation for teaching came from their students' eagerness to learn and their students' futures.

Three of the US teachers were more cautious about the role of autonomy in teacher motivation alluding to different motivators for different kinds of teachers. In the words of Janet, 'Some teachers are really hard to motivate'. Janet and Tim were personally motivated by autonomy but felt that other teachers might be more motivated by money or job security.

When asked if they were satisfied with the amount of autonomy they had over their teaching, *all of the US teachers responded positively.* Susie's response of, 'Yes, because I have a lot', was typical of the teachers. Rene was satisfied with her current level of autonomy but described concern that it might diminish. She stated, 'Right this minute I guess I could say 'yes', but it could change very quickly. I'm worried that with a different administration we are going to have less of that pretty soon'. In sharp contrast to the US teachers, *only two of the Chinese teachers were satisfied with their levels of autonomy.* The other seven teachers wanted more autonomy. For example, Jin stated, 'I am limited in many aspects with my low autonomy. I cannot teach in the special way that I want to'.

Autonomy support: Problems in School Questionnaire. The USA and Chinese teachers differed significantly for the factors of high autonomy support and moderate autonomy support for students (Table 8). The US teachers had a significantly higher mean for high autonomy support while the Chinese teachers had a significantly higher mean for moderate autonomy support. The teachers did not differ in their means for the controlling factor. There were no significant differences between the USA and Chinese teachers' scale composite means.

During the interviews the US teachers described using a variety of instructional practices with their students, including lecture, discussion, laboratories and inquiry investigations, and small group and individual work. Leslie stated that she used 'a variety of different activities' in order to 'reach the needs of [her] students'. She felt that her autonomy to change the way she presented material was crucial to motivating students.

The Chinese teachers described using laboratory investigations and lecture during their classes. Yong described using experiments to cover physics topics with his middle-school students. For Yong, laboratory investigations were crucial to the learning process in order to 'help students learn why it is instead of what it is'.

Nine of the US teachers felt autonomy was important, because they needed to be able to individualize instruction to meet the needs of their students. They wanted to

be able to select activities and pace instruction based on the characteristics of their students. Tim stated, 'How effective can we be if we're teaching in only one way to everyone? With American education we want to try and educate everyone the same way, and that just doesn't' really work'. Eight of the Chinese teachers also felt that autonomy was important for individualizing instruction. They gave examples of altering the pace of instruction, the amount of homework, and the organization of science content based on the needs of their students. Min said that she tried to teach as 'freely' as possible and change her teaching methods 'according to the extent to which the students master the knowledge'. Yong felt that with autonomy teachers would be able to improve student learning 'without hindering the pace of instruction'.

Multiple Regression

Multiple regression using the scale composites was used to determine how the constructs of teachers' perceptions of constraints at work, teachers' perceptions of students' motivation toward school, and teachers' motivation toward work predicted teachers' autonomy support for students in the USA and Chinese samples. The results for the Chinese teachers are shown in Table 9. Each of the predictor variables made a significant contribution to the prediction of teacher autonomy support. The relationships are positive indicating that higher scale composite scores for the predictor variables correspond to a higher level of autonomy support. Each of the predictor variables made a significant contribution to the prediction of teacher autonomy support for the Chinese teachers.

US teachers' motivation toward work was the only factor found to significantly predict teachers' autonomy support for students (Table 10). Again, the relationship is positive indicating that higher levels of teachers' motivation toward work correspond to higher levels of autonomy support. Constraints at work and students' motivation toward school did not significantly predict autonomy support.

Correlations of scale composites. Table 11 shows the correlations among the scale composites for the Chinese and US teachers, respectively. For the Chinese teachers, all of the correlations are significant and four of the r values are greater than 0.70. These are

Table 9. Summary of multiple regression analysis for predicting teachers' autonomy support for Chinese teachers ($n = 107$) variable

	B	SE *B*	*x*
Constraints at work	.245	.050	.396**
Perceptions of students' Motivation	.105	.038	.225**
Work motivation Inventory	.213	.062	.308**

Note: $R^2 = .69$.

**$p < 0.01$.

Table 10. Summary of multiple regression analysis for predicting teachers' autonomy support for US teachers ($n = 94$) variable

	B	SE *B*	β
Constraints at work	−.005	.073	−.007
Perceptions of students' Motivation	−.005	.029	−.019
Work motivation Inventory	.129	.054	.275*

Note: $R^2 = .07$.

*$p < 0.05$.

Table 11. Correlations of scale composites for Chinese teachers ($n = 107$) and US teachers ($n = 94$) scale composite

	1	2	3	4
Chinese teachers				
1. Constraints at work	–	.64**	.72**	.76**
2. Perceptions' of students' Motivation		–	.72**	.70**
3. Work Motivation			–	.76**
4. Problems in schools				–
US teachers				
1. Constraints at work	–	.29**	.31**	.07
2. Perceptions' of students' Motivation		–	.42**	.09
3. Work motivation			–	.27**
4. Problems in schools				–

**Correlation is significant at the .01 level (two-tailed).

acceptable levels of correlation. If the *r* values were greater than 0.90, multicollinearity, extreme correlation among the variables, would be a concern (Garson, 2010). Four of the six correlations are significant for the US teachers.

Conclusions and Discussion

This study examined factors that contribute to Chinese and US middle-school science teachers' perceptions of autonomy support. In SDT, Deci and Ryan (1985, 2000) and Ryan and Deci (2000) describe three needs important for well-being: autonomy, competence, and relatedness. The extent to which these needs are met determine how self-determined individuals feel and their motivation to engage in tasks. The US teachers in this study reported higher levels of satisfaction with their current levels of autonomy and higher levels of intrinsic motivation than the Chinese teachers. All of the US teachers in the interview were satisfied with their current levels of autonomy citing their independence to select laboratory activities, design assessments, and individualize instruction for their students. Conversely, only two of the Chinese teachers were satisfied with their current levels of autonomy. They described feeling more

limited in their control over decisions regarding how they taught science. The lower levels of work motivation and discontent with levels of autonomy are consistent with SDT and the self-determination continuum (Ryan & Deci, 2000). Furthermore, the Chinese teachers described constraints on their teaching due to college entrance exams. Previous studies in China have documented the strong influence of secondary school examinations on science teaching at the middle school level, and efforts are being made to increase the instructional time spent on application (Wei, 2009).

The Chinese teachers in this study were less intrinsically motivated toward their work than the US teachers as measured by *The Work Motivation Inventory*. Previous research on the relationship between autonomy and motivation with people from Asian countries has found that more autonomy does not always result in greater motivation (Bao & Lam, 2008; Iyengar & Lepper, 1999). These studies have found that the relationships between the individual and the larger group may have an impact on motivation and the extent to which the individual feels autonomous in certain situations. Data from the interviews corroborate the survey findings. The instruction and autonomy support for students reported by the Chinese teachers in this study were influenced by constraints in their work environment and their perceptions of their students' motivation. Contrastingly, the level of intrinsic motivation was the only significant predictor of teacher autonomy support for the US teachers.

According to SDT and the findings of related studies, higher teacher autonomy results in more autonomy support for students (Deci et al., 1982; Pelletier et al., 2002; Reinders & Balcikanli, 2011; Sheldon & Biddle, 1998). The data from this study support this relationship. For both the USA and the Chinese teachers, there was a positive relationship between teachers' motivation toward work and the level of autonomy they reported providing to students. Furthermore, in the interviews portion of the study, the US teachers, who were more self-determined toward their work and felt more autonomous, also reported more methods of individualizing their instruction to meet the needs of their students and more opportunities for student choice. This is consistent with previous work by Gess-Newsom and Lederman (1995) who found that science teachers that felt more autonomous in their work were more aware of students in their planning and teaching.

Teachers' motivation is a very individualistic characteristic as opposed to constraints at work and students' motivation toward school in which teachers consider the broader community of students, colleagues, administrators, and parents. When asked to consider the motivation of their students, the Chinese and US teachers both reported that their students were motivated primarily by a sense of accomplishment and for future job success. There were no significant differences in the teachers' overall perceptions of their students' motivation.

In the case of constraints at work, the results of the quantitative and qualitative data analyses indicated that middle-school science teachers in the USA and China had differences in their perceptions of constraints at work. The Chinese teachers reported less support in their work environments. In the interview portion of the study, the greatest constraint described by the Chinese teachers was school curriculum and standards. Although teachers in both countries reported constraints related to school

curriculum and standards, the US teachers reported feeling more autonomous in their choices about how to teach the predetermined science content standards. The US teachers felt most constrained by funding issues related to materials, equipment, laboratory space, and class size while the Chinese teachers felt more constrained by expectations related to the school curriculum and standardized testing. Previous researchers have noted that collectivist cultures do not necessarily prefer small class sizes (cf. Tao, Oliver, & Venville, 2013). In Asian cultures, the goal is to socialize the students as this teacher noted,

> maybe you could say (small class size) is better for the teacher, but not better for the children. Children need to have the experience of being in a large group in order to learn to relate to lots of kinds of children in lots of kinds of situations. (Tobin, Wu, & Davison, 1989, pp. 36–37)

The US teachers focused on material items when describing their ideal teaching situations while the Chinese teachers focused on their relationships with students and the classroom environment. These differences may reflect individualist versus collectivist goals, but they may also reflect extreme differences in teaching environments. Additional research is needed to explore differences that may exist in classroom environments.

Teachers in both countries felt that providing students opportunities to be autonomous in their learning was important to student motivation and learning. Previous research has found that students are positively influenced by autonomy support by their teachers (Chirkov & Ryan, 2001; Deci, Schwartz, et al., 1981). The teachers in both countries reported that students were rarely able to select the topic of study due to the school curriculum and standards; however, the teachers did report trying to build in choices regarding other aspects of learning such as the type of laboratory activity or pace of instruction. The choices described by the Chinese teachers, such as allowing students to ask questions or participate in class discussions, were more subtle than those described by the US teachers. Cordova and Lepper (1996) found that students responded positively to choices even when choices did not affect the content of the activity. The attempts of the US and Chinese teachers to provide similar types of choices for their students, while still adhering to the school curriculum and standards, are likely to have similar positive results.

When the constructs of constraints at work, student motivation, teacher motivation, and autonomy support were analyzed together, the findings for the Chinese and US teachers were very different. For the US teachers, motivation toward work was the only significant predictor of the amount of autonomy support they reported providing to students. For the Chinese teachers, their motivation toward work, perceptions of the work environment, and students' motivation were all significant predictors of their autonomy support. This is consistent with the tendency of members of collectivist cultures to place a higher emphasis on relationships with other members of the group than individual goals (Iyengar & DeVoe, 2003; Triandis et al., 1988).

A 2009 study compared individuals from the USA, Russia, and China and the extent to which autonomy support from parents, friends, teachers, and romantic

partners affected self-concept and feelings of well-being (Lynch, La Guardia, & Ryan, 2009). The results of the study revealed that while some differences existed in the strength of the effect of autonomy support for participants from the three countries, in general, autonomy support had a positive impact on self-concept and well-being regardless of country or culture (Lynch et al., 2009). The results of the interview portion of the current study also support the importance of autonomy to members of collectivist cultures. The Chinese teachers all agreed that teacher autonomy was important to teacher motivation and the quality of instruction provided by teachers. Teacher autonomy was deemed especially important for the selection and implementation of laboratory investigations to deepen student understanding of science content.

The interviews with Chinese and US science teachers in this study revealed that teachers really want choice, and they want choice about many aspects of their science teaching. The teachers expressed their desires to determine classroom organization, planning, instruction, assessment, use of laboratory activities, and pacing of instruction. This autonomy was important to the teachers' motivation, and they believed it was critically important to their abilities to meet the needs of their students. Even though China and the USA have very different cultures and educational traditions (Tao, Oliver, & Venville, 2012), the teachers in both countries clearly articulated a complex dynamic between autonomy and constraint.

Over the past 25 years, the amount of control over classroom instruction held by local, state, and national governments has increased dramatically. At the same time that teachers are losing control over classroom instruction, there is an increasing emphasis around the world on holding teachers accountable for student learning as measured through standardized assessments (Bushnell, 2003; Delandshere & Petrosky, 2004; McDonald, 2002; Mustafa & Cullingford, 2008; van Veen et al., 2001; Yeom & Ginsburg, 2007). Large numbers of teachers are leaving the profession; these teachers cite lack of autonomy and support from administrators as primary reasons for their dissatisfaction (Ingersoll, 2001). Unfortunately, consideration of teacher autonomy is limited or absent from educational reform in the USA. In a review of nine US reform documents spanning almost three decades, teacher autonomy was not mentioned once (Yeom & Ginsburg, 2007). Looking across the results of this study and previous research, it is apparent that teacher autonomy is too important to the future of science education not to consider in educational decisions.

Implications

Science teachers need opportunities to feel autonomous in their work. The Chinese and US teachers in this study did not want complete autonomy; rather, they wanted the ability to adapt their science teaching to the needs of their students. The teachers in this study were highly motivated by freedom in planning, instructing, and assessing. Furthermore, the teachers reported that their students were more motivated and engaged when they had autonomy over their learning. The implications of this study suggest that providing teachers with more autonomy would enhance teachers' motivation toward their work. Thus, it could ultimately promote greater teacher job satisfaction,

teachers' motivation to allow their students autonomy, and ultimately higher student achievement.

US science teachers value opportunities to collaborate. The US teachers in this study related positive experiences of collaborating with other science teachers. These findings are promising given the recent surge in collaborative movements like professional learning communities. Teachers may appreciate this type of shared decision-making and reflective practice even though it reduces the autonomy of the individual teacher. Efforts to increase collaboration should be balanced by individual autonomy on the part of the classroom teacher to adapt instruction to the needs of students.

Middle-school science teachers in the USA may need more materials, equipment, and laboratory space. The greatest constraint on the US teachers in this study was limited access to science materials, equipment, and laboratory space. The increase in emphasis on inquiry and hands-on science by the *National Science Education Standards* (National Research Council, 1996, 2000) means that many teachers may perceive the need for more materials and laboratory space. Some of the teachers in this study reported they were working in traditional classrooms with desks and did not have access to laboratory space. Consideration of these factors is of critical importance to the field of science education in which instruction is heavily dependent upon access to materials, equipment, and laboratory space.

Chinese science teachers seek opportunities to build relationships with students and offer their students more autonomy. The Chinese teachers tended to have large classes and they noted a desire for more relaxed classroom environments with higher levels of participation from students. Chinese teachers reported higher levels of amotivation and there may be a need to move quickly to address the Chinese teachers' motivation levels. For example, one teacher noted the desire for more freedom to select activities or alter the pace of instruction. Furthermore, Chinese teachers wanted to offer their students more autonomy such allowing students to ask more questions when they did not understand.

This study supports previous research on the relationship between autonomy and motivation in educational and work settings. Despite vast differences in culture, educational systems, and work environments, the science teachers in this study indicated that autonomy played an important role in their motivation for work and that it influenced the types of instructional methods they used to teach science. The teachers were resolved that autonomy was integral to their abilities to individualize instruction to meet the needs of their students. There is research that suggests that teacher attrition in the USA is related to a lack of teacher autonomy (Ingersoll & May, 2010) and enhanced science teacher autonomy can ultimately increase teacher retention. In addition, increased teacher autonomy may enhance teachers' (both in the USA and in China) use of student-centered and inquiry-based instruction (Gess-Newsome & Lederman, 1995).

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