JOURNAL OF BALTIC SCIENCE EDUCATION
ISSN 1648-3898

PROSPECTIVE PHYSICS TEACHERS' SELF-EFFICACY BELIEFS ABOUT TEACHING AND CONCEPTUAL UNDERSTANDINGS FOR THE SUBJECTS OF FORCE AND MOTION

Abstract. *The aim of this study is to determine the self-efficacy beliefs of prospective physics teachers about teaching the subjects of Force and Motion and their conceptual understanding on the subjects. Also, relationship between the self efficacy beliefs and conceptual understanding was investigated. Additionally, the effects of a teaching sequence upon aforementioned variables were examined. Data was collected through Force Concept Inventory and The Scale of Self-Efficacy about Teaching the Subjects of Force and Motion. The findings revealed that prospective physics teachers didn't have a sufficient conceptual understanding of Force and Motion, although they had high self efficacy beliefs about teaching the subject. A positive but weak correlation between self efficacy beliefs and conceptual understanding was found. The teaching sequence led to a statistically significant improvement in the prospective teachers' self efficacy beliefs about teaching and their conceptual understanding of the subjects. The teaching sequence also led to enhance congruence between the variables.*

Key words: *conceptual understanding, force and motion, physics education, self efficacy, teacher self efficacy.*

Rabia Tanel
Dokuz Eylul University, Izmir, Turkey

Rabia Tanel

Introduction

Meaning of the Self-Efficacy and Relationship between Students' Self-Efficacy and Their Academic Achievement

Self-efficacy is the central construct in Bandura's (1986) social cognitive theory (Zeldin & Pajares, 2000). According to social cognitive theory, people are more likely to fulfil tasks which they believe they have the ability to perform and are less likely to accomplish tasks which they believe they have less ability to perform (Zeldin & Pajares, 2000). Self-efficacy has been defined differently by different researchers, but all these definitions have approximately the same meanings. Bandura (1986) defined it as "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances" (as cited in Compeau & Higgins, 1995, p. 191). Möller, Pohlmann, Köller and Marsh (2009, p. 1134) defined self-efficacy as "a person's subjective appraisal of his or her ability to succeed in a particular task" (see also the other definitions made by Gist & Mitchell, 1992, p. 183; Tschannen-Moran, Woolfolk Hoy & Hoy, 1998, p. 207). A student's self-efficacy was defined as "students' beliefs about their capabilities to successfully perform academic tasks" by Pajares (1996, p. 325).

Research has revealed that students' self-efficacy beliefs are related to and influence their academic performances (Multon, Brown & Lent, 1991; Pajares, 1997; Pajares, 2002) and achievement (Gist & Mitchell, 1992; Möller et al., 2009; Pajares, 1997; Pajares & Schunk, 2001; Zimmerman, 2000). Self-efficacy beliefs are strong predictors of students' motivation and learning (Zimmerman, 2000) and students' ability to fulfil academic tasks (Pajares, 1996).

Unlike these researches, Stephans and McCormack (1985) and Wenner (1993) found a negative correlation between science concept knowledge and self-efficacy. There are also studies reporting that physics self-efficacy does not significantly correlate with achievement (Abak, Eryılmaz & Fakıoğlu, 2002; Shaw, 2004). There is a need for further research since conflicting results have been obtained by the studies that examine the relationship between self efficacy beliefs and achievement (particularly those concerning science and physics).

Meaning of Teacher Self-Efficacy and Relationship between Teachers' Self-Efficacy and Students' Achievement

Teacher efficacy has found an important place in research of teacher education (Pajares, 1997). Like self-efficacy, teacher self-efficacy has been defined differently by different researchers but almost all have the same meaning. Teacher efficacy is "the extent to which teachers believe they can affect student learning" (Dembo & Gibson, 1985, p. 173). (see also the other definitions made by Chan, 2008, p. 1057; Lin & Tsai, 1999, p.1; Riggs & Enochs, 1989, p.5; Tschannen-Moran et al., 1998, p.233).

Generally, teachers' sense of efficacy has been assessed based on two factors: sense of personal teaching efficacy (PTE) and sense of teaching efficacy (general teaching efficacy-outcome expectancy) (TE) (Lin & Tsai, 1999; Pajares, 1997; Riggs & Enochs, 1989; Weasmer & Woods, 1998). Weasmer and Woods (1998) defined TE as teachers' perceptions that teaching can influence students' learning and defined PTE as an individual teacher's belief in her or his own effectiveness, a perception that may be situation specific. They pointed out that one's personal teaching efficacy governs one's motivation, thought processes, emotions, and willingness to expend energy, and they explained that a teacher's sense of being able to adapt to change is directly related to his or her PTE. "The dimension of PTE has been used to predict teacher behaviour with most accuracy" (Ashton, Webb, & Doda, 1983 as cited in Riggs & Enochs, 1989, p. 6). Yürük (2011) found that pre-service elementary teachers' personal science teaching efficacy is the strongest predictor of their anxiety about teaching science. However, she did not find science teaching outcome expectancy was significantly correlated with either science teaching anxiety or personal science teaching efficacy. Hoy and Woolfolk (1990) also advised not to use total efficacy score by summing PTE and TE scores, according to them the results of such a combination can be misleading because in their study TE changed in one direction whereas PTE changed in the opposite direction.

Teacher self-efficacy has been significantly related to student achievement (Cantrell, Young & Moore, 2003; Pajares 1997; Pajares & Schunk, 2001; Riggs & Enochs, 1989; Tschannen-Moran et al., 1998). In classrooms where teachers have high levels of teaching efficacy, high levels of learning occur (Weasmer & Woods, 1998). Gibson and Dembo (1984) reported that there are important behavioural differences between teachers who have high and low efficacy beliefs, and those differences provide variety in student achievement (as cited in Dembo and Gibson, 1985, p. 176).

Tschannen-Moran et al. (1998) noted that the efficacy beliefs of experienced teachers seem to be resistant to change. Therefore, further research with prospective teachers whose self efficacy toward teaching is not yet fully established could produce better results with regard to improving teachers' self-efficacy beliefs. Consequently, the development of teacher efficacy beliefs among prospective teachers has generated a great deal of research interest (Tschanen-Moran et al., 1998). Moreover, due to the known effects of teacher self-efficacy on student achievement, improving the self-efficacy toward teaching among prospective teachers, who are the in-service teachers of the future, will make it more possible to enhance the achievement of the students that they will teach in the future. For all these reasons, it is important to examine and carry out research to improve the self-efficacy beliefs of prospective teachers, and such studies will contribute to the literature.

The Relationship between Self-Efficacy and Course Content

Self-efficacy is a situation/task/context-specific construct (Chan, 2008; Chiou & Liang, 2012; Henson, Kogan & Vacha-Haase, 2001; Pajares, 2002; Riggs & Enochs, 1989; Schoon & Boone, 1998; Tschannen-Moran et al., 1998). Schoon and Boone (1998, p. 554) explained this by stating that "a teacher may have a high self-efficacy when it comes to teaching language arts and a low self-efficacy when it comes to

ISSN 1648–3898

teaching science." Efficacy beliefs will best predict the performances that most closely correspond with such beliefs and, if the purpose of a study is to achieve explanatory and predictive power, self-efficacy judgments should be consistent with and tailored to the domain of functioning and/or the task under investigation (Pajares, 2002). Schunk and Pajares (2009) stated that a lack of congruence in specificity between efficacious beliefs and related variables may reduce the predictive power of self-efficacy (Chiou & Liang, 2012). Chan (2008) pointed out that the task and context-specific nature of efficacy beliefs makes it necessary to develop domain-specific teacher self-efficacy scales. A specific measure of science teaching efficacy beliefs should both accurately predict the future science teaching success of pre-service teachers and the degree to which they will positively influence student achievement in science (Cantrell et al., 2003; Riggs & Enochs, 1989). However, determining the appropriate level of specificity in the measurement of efficacy beliefs is a difficult task (Tschannen-Moran et al., 1998). Pajares (1996) stated that global student self-efficacy measures obscure what is being measured (as cited in Tschannen-Moran et al., 1998, p. 240), and Tschannen-Moran et al. (1998) suggest that determining the appropriate level of specificity depends on the purposes of the research.

Bleicher and Lindgren (2005) argue that pre-service teachers' personal science teaching self-efficacy beliefs are influenced by their conceptual understanding of the content knowledge they are expected to teach. If pre-service teachers have personal success in the learning of science, for example, they will be more confident about teaching science. Ishak (2008) found that self-efficacy beliefs about teaching secondary school physics varied depending on the topic. For example, students were less confident about teaching radioactivity and electronics topics. Therefore, developing a specific measurement of teacher self-efficacy for a specific subject would be useful and more informative.

Fewer studies about prospective teachers' self-efficacy on teaching have been reported in Turkey. Moreover, only one study (Ishak, 2008) on self-efficacy for teaching a specific physics subject was found in the literature. There has been no such study reported in Turkey, so far. For these reasons, investigating the prospective teachers' self efficacy beliefs for teaching a special physics subject is important.

Students' Conceptual Understandings on the Subjects of Force and Motion

It is known that students have some common sense beliefs about motion and force (Bayraktar, 2009; Hestenes, Wells & Swackhamer, 1992; Hestenes and Halloun, 1995; Hestenes, 2006; McDermott & Redish, 1999; Temizkan, 2003). According to the research, these beliefs are "incompatible with Newtonian concepts in most respects" (Hestenes et al., 1992, p. 141; Hestenes & Halloun, 1995, p. 504), and they are "often vague and undifferentiated" (Halloun & Hestenes, 1985, p. 5; Hestenes & Halloun, 1995, p. 504).

Common sense beliefs are universal in the sense that they are much the same for everyone, although there is some variation among individuals and cultures. They are also very resistant to change (Hestenes, 2006). Many studies have shown that students (Bayraktar, 2009; Savinainen & Scott, 2002), prospective teachers and also teachers (Bayraktar, 2009) in different cultures have similar kinds of difficulties in their understanding of the concepts of force and motion, and they hold similar misconceptions.

Teachers have important roles concerning their students' understandings; therefore it is undesirable that teachers have misconceptions, but Eryılmaz (1992) has identified that not only ordinary students but also honour students and even physics teachers highly misunderstand some concepts of mechanics (as cited in Temizkan, 2003).

Development of Self-Efficacy Beliefs Together with Conceptual Understandings

As mentioned before, given the favourable effects of high teacher self-efficacy upon student achievement, it is important to improve prospective teachers' self-efficacy toward teaching because this will probably enhance the achievement of the students they will teach in the future. Then, do only the efforts enhance teacher self-efficacy suffice for this purpose?

Pajares (2002) stated that people's behaviour can often be better predicted by their beliefs about their capabilities than by what they are actually capable of accomplishing. Pajares also explained that this does not mean that people can accomplish tasks beyond their capabilities simply by believing that they can; it is also related to knowledge as well as self beliefs and skills. Furthermore, teachers' high confidence about the efficacy of their instruction may make them resistant to changing any part of their instruction, or may prevent them from conceptual change (Pajares, 1997). Thus, not only teacher self-efficacy toward teaching the subjects of force and motion should be high, but also the level of conceptual understanding should be concordant with teacher self-efficacy. Research is needed to explore this congruence.

To develop students' understanding, Savinainen and Scott (2002, p. 58) recommended "the use of interactive approaches where an on-going dialogue between teacher and students focuses on the development of conceptual understandings and where the students have time and opportunity to talk through their developing understandings, with the support of the teacher." Furthermore, studies have shown that the use of learner-centered approaches in the classroom has an impact on the personal efficacy of teachers (Magno & Sembrano, 2007). It will be a contribution to the literature both to carry out a teaching sequence involving learner-centered activities implementing the suggestions of Savinainen and Scott (2002), and to present the results about how this teaching sequence influences prospective physics teachers' self-efficacy levels regarding teaching the subjects of force and motion, their conceptual understanding levels about these subjects, and the relationship between the two.

Purpose of the Study

On the basis of the above-mentioned studies and the reasons explained, the purposes of the present study include the following, presented in two subsections:

Study I. Survey

1. To explore prospective physics teachers' self-efficacy levels regarding teaching the subjects of force and motion.
2. To explore prospective physics teachers' conceptual understanding levels for the subjects of force and motion.
3. To explore the relationship between prospective physics teachers' understandings and self-efficacy about teaching the subjects of force and motion.

Study II. Experimentation

1. To explore how the teaching sequence influences prospective physics teachers' self-efficacy levels about teaching the subjects of force and motion.
2. To explore how the teaching sequence influences prospective physics teachers' conceptual understanding levels about the subjects of force and motion.
3. To explore how the teaching sequence influences the relationship between prospective physics teachers' self-efficacy of teaching and the understandings of the subjects of force and motion.
4. To explore the views of prospective physics teachers on the teaching sequence.

Self-efficacy belief toward teaching the subjects of force and motion can be defined as what teachers think about their abilities both to teach the subjects of force and motion effectively and efficiently, and to enhance students' achievement in these subjects.

This is a two-phase study. The samplings, instruments, procedures, analysis, and results of the first and second studies are presented respectively. The discussions and conclusions found at the end of the paper collectively interpret the results of both studies.

Methodology of Research

Research Model

The survey model was used to present the existing case in the first study and a one-group, pretest-posttest design of the pre-experimental method was used in the second part of the research.

ISSN 1648–3898

Sample

The participants of the first study were 136 prospective physics teachers voluntarily participated in the research from the Education Faculty in Dokuz Eylül University in Turkey. The teacher education program for physics teachers in Turkey is a five-year program. Students from each year of the program are included in this sampling group. All the students in the sample had been taught the subjects of force and motion at the university when the data were collected.

The participants of the second study were 43 first year prospective physics teachers attending the Education Faculty in Dokuz Eylül University, in Turkey. The teaching sequence carried out in a subject-specific pedagogy course (Mechanics Teaching). Therefore all the students attending the Mechanics Teaching course were participants of the second study.

Research Instruments

Force concept inventory and the scale of self-efficacy about teaching the subjects of force and motion were used in order to collect the data in this research. Detailed explanation of the measurement tools is given below.

Furthermore, the students were asked to provide their beliefs in written form in order to learn their views regarding the teaching sequence. They were specifically told not to write down their names so that they could freely express their opinions without any prejudice.

Force concept inventory

Changes in conceptual understanding regarding the subjects of force and motion were measured by administering the Force Concept Inventory (FCI), which is the "most widely used and thoroughly tested assessment instrument" (McDermott & Redish, 1999, p. 760). The FCI is a multiple choice test that determines students' understanding of the conceptual field of force and related kinematics, and it can be used as a diagnostic tool to identify and classify misconceptions and also to evaluate instruction (Hestenes et al., 1992). Since common sense beliefs are universal, and Turkish prospective teachers have common misconceptions related to force and motion, based on the aforementioned features of FCI, using FCI was decided upon as the best method for measuring prospective teachers' conceptual understanding about force and motion.

FCI was designed by Hestenes, Wells and Swackhamer in 1992, and its revised version was reported by Halloun, Hake, Mosca and Hestenes in 1995. A Turkish translation of the 1995 version of the FCI (Halloun et al., 1995) was used. This revised version has 30 items. The validity and reliability analysis of the Turkish translation of the revised FCI used in this study was made by Temizkan (2003; p. 33-35). The Cronbach's alpha (α) reliability coefficient of the FCI is .74 (Temizkan, 2003). Additionally, an almost exact same Turkish translation of the revised FCI is available from its designers (as a pdf file) to authorized educators at the web address, http://modeling.asu.edu**.** The correct responses of students on each item were added to obtain total scores on the FCI. Higher scores on the test mean academic success on the subject of force and motion, and also fewer misconceptions.

The scale of self-efficacy about teaching the subjects of force and motion (The SETFM scale)

Self-efficacy is measured by asking people their belief in their own abilities to perform specific target tasks (Möller et al., 2009). A variety of scales have been used in the studies on measures of efficacy (Tschannen-Moran et al., 1998). In numerous research studies, the measurement of teacher efficacy has also been designed and refined (Cantrell et al., 2003; Denzine, Cooney & McKenzie, 2005).

Riggs and Enochs (1989) developed a subject matter instrument to measure efficacy for teaching science: the Science Teaching Efficacy Belief Instrument (STEBI). Nevertheless, Ishak's (2008) study is the only available resource that includes a scale specifically developed for a particular physics subject.

Development of the SETFM scale: Ishak's (2008) research inspired the development of the scale items.

Ishak (2008) listed the force and motion subjects (such as speed, acceleration, Newton's first law) and asked how confident teachers are in teaching the specific subjects in his scale. Different from Ishak's items, the SETFM scale contains statements like "I can teach what the concept of acceleration is," as well as more specific statements like "I can explain what the magnitude of an object's acceleration depends on." Because of the character of predicting teacher behaviour with the most accuracy, all scale items were prepared in a personal teaching efficacy dimension. The SETFM scale asked students to express their confidence in teaching specific knowledge on the subject of force and motion. This method of measuring self-efficacy beliefs represents a task-specific assessment (Pajares & Graham, 1999).

The scale items were intended to involve all possible cases with regard to the subjects of force and motion. Next, the scale items developed were revised by two experts in physics education, who decided that the scale can measure prospective teachers' self efficacy beliefs regarding teaching the subjects of force and motion.

The Likert-type scale including the developed items was administered to 160 prospective physics teachers. The Kaiser-Meyer-Olkin Measure of Sampling Adequacy value for the scale data was computed to be 0.93, while Bartlett's Test of Sphericity sig. value was 0.000. Factor analysis was performed to examine the construct validity of the scale. Principal components analysis revealed that the first factor accounted for 54% of the variance. The contribution of the following factors to total variance was quite low when compared to the contribution of the first factor. This result indicates that the scale has a single-factor structure (Çokluk, Şekercioğlu & Büyüköztürk, 2010). When deciding on the number of factors, it is very important to question whether the instrument has a theoretically expected factor design (Çokluk et al., 2010). As was already mentioned, the scale items were developed in the dimension of personal teaching efficacy, with a single dimension. Furthermore, the items were developed for the purpose of teaching only the subjects of force and motion (which is not expected to be divided into sub-dimensions). The scale items are highly interrelated. Therefore, a single-dimensional scale was expected. For these reasons, the scale was decided as having a single-factor structure. Upon examination of the component matrix table obtained as a result of the principal components analysis repeated for a single factor, the items' factor loading values were seen to range between 0.59 and 0.82, and it was decided that none of the items needed to be removed from the scale. As a result of the reliability analysis performed to determine the scale's reliability, the Cronbach's alpha coefficient was found to be 0.96 with item loading values ranging between 0.57 and 0.80. The SETFM scale consists of 22 items in a five-point Likert scale.

Procedure

The researcher analysed the data obtained from 136 students, to whom both the FCI test and the SETFM scale were administered. In the Physics Education Department of Buca Education Faculty, mechanics subjects are offered in two successive semesters (fall and spring) as Physics I and Physics II. Both of these courses are compulsory and 4-credit courses. The subjects of force and motion are taught during Physics 1. The FCI and the SETFM scale were administered to the students at the end of the first semester, meaning that all the students had been taught the subjects of force and motion both during their high school years and university education.

Teaching Sequence

The teaching sequence carried out included activities that allow prospective physics teachers to be informed about general and their own particular misconceptions about the subjects, to have the opportunity to remedy their misconceptions and improve their conceptual understanding, and to think about and discuss with their peers and instructors how to teach these subjects. The students in their first year were taught the subjects of force and motion during the first semester in the course Physics 1. This course (Physics 1) is given for 4 course sessions a week in a 14 week long semester. A course (Mechanics Teaching) offered during the second semester of the first year in the Department of Physics Education aims to allow students to perform some activities so that they are informed about misconceptions regarding certain mechanics subjects they have learned and about how to teach these

ISSN 1648–3898

subjects (a subject-specific pedagogy course). The content of this course means that carrying out the sequence fits the purpose. Thus, it was decided to carry out the sequence with first-grade students in the Mechanics Teaching course.

The teaching sequence continued for about 7 weeks during the 14-week second semester. The mechanics teaching course is given for 2 course sessions a week. The SETFM scale and the FCI were administered twice, once before and once after the experimental procedure.

Prior to the teaching sequence, the concept of misconception as well as certain activities to remedy the students' misconceptions (experiments, animations, analogies, concept cartoons, stories, games, etc.) was introduced to the test group through other mechanics subjects during the first weeks of the mechanics teaching course. The students were shown what a concept map is, for what purpose it is used, and how it is constructed.

During the sequence, the students were first introduced to common misconceptions and learning difficulties reported in the literature on the subjects of force and motion without any mention of the FCI questions. Discussions were held with the students about the correct conceptions and possible sources of such misconceptions and difficulties. Next, the students were given activities to develop concept maps about the subject. The concept maps they developed were presented in the classroom to all students.

The data obtained from the pretest FCI were examined and individual misconceptions held by each student were listed separately. Here, the primary aim was to allow students to remedy their own misconceptions. Subsequently, each student was informed by the researcher about the main misconceptions they had about the subjects of force and motion. Each student carried out assignments that involve their creative suggestions about what might be the origins of the misconceptions presented by the researcher, how they can remedy their own misconceptions, and how they can help students with similar misconceptions in the future when they teach these subjects, based on the knowledge and methods they learned at the beginning of the course. Prior to the next course session, the students' assignments were revised and, in the following session, they were provided with feedback about their assignments. Successful assignments were presented to the students and relevant discussions were held.

Following the individual assignment activity, students with shared misconceptions were grouped together and were asked to perform a more sophisticated group assignment by synthesizing their individual assignments for remedying their own misconceptions. By following the same procedure in individual assignments, the researcher revised these group assignments before the next session, when the students were given feedback about the assignments. Again, successful ones were presented to the class, and new discussions were held about the subject.

As a final activity, in groups that shared the common misconception, the students prepared posters about a common misconception on the subjects. These posters were then presented to the students and the instructor. The students and the instructor rated the posters separately, and the mean of these scores was used. The students were given grades for each activity, and these grades made up their midterm grade. The students had been informed at the beginning of the semester that they would be graded on the activities. During the sequence, no question in the FCI test was given to the students again, and none of the activities were based on any of the FCI questions.

Data Analysis

Mean and standard deviations were calculated. To test the normality of the data, Kolmogorov-Smirnov analysis was used and then, Wilcoxon Signed Ranks Test, Kendall's tau test was performed on the non-parametric data and bivariate correlation test was performed on the parametric data.

Results of Research

Descriptive Results of the SETFM Scale

Table 1 shows the descriptive results for the scale. The students' total ratings in the scale have a mean value of 92.30 (mean efficacy 4.20). This high value indicates that the prospective physics teachers perceive themselves as competent for the statements given about teaching the subjects of force and motion. As seen in Table 1, the self-efficacy beliefs of the senior year prospective teachers toward teaching these subjects are significantly higher than the students in earlier years.

Table 1. Descriptive statistics of the SETFM scale results.

Class	N	Mean	Std. Deviation
1	43	89.98	10.88
2	23	90.35	13.87
3	26	88.54	9.83
4	21	92.14	11.42
5	23	103.00	9.59
Total	136	92.30	12.04

Descriptive Results of FCI

Table 2 presents the descriptive results for the FCI. The students obtained a mean total score of 15.25 (standard deviation 5.05) in the test.

Table 2. Descriptive statistics of the FCI results.

Class	N	Mean	Std. Deviation
1	43	14.58	4.94
2	23	13.78	4.65
3	26	13.96	4.13
4	21	16.85	5.93
5	23	17.95	4.65
Total	136	15.25	5.05

Hestenes (2006) stated that a 60% score for FCI can be regarded as a threshold in the understanding of Newtonian mechanics based on empirical reasons. This means that a student must score at least 18 out of 30 in the FCI test so that s/he can be considered to have comprehended the subject. On the other hand, the rate of 85%, which is regarded as the mastery threshold by Hestenes (2006), corresponds to at least 26 correct responses in the FCI. This mean FCI score (15.25) is below the threshold of understanding for the subjects. 46 out of 136 students scored above the understanding threshold, while only 5 of them exceeded the mastery threshold. 90 students obtained FCI scores below the understanding threshold.

As is clear from Table 2, the higher the mean FCI score, the higher the completed level of study, excluding the first-year students.

The Relationship between Prospective Teachers' Understandings and Self-Efficacy Regarding Teaching the Subjects of Force and Motion

A normality test was performed to decide which analysis should be done to examine the correlation between the total scores in the SETFM scale and the students' FCI scores (N=136). The Kolmogorov-Smirnov analysis was performed to see whether the SETFM data fit a normal distribution (significance value 0.000), and it revealed that the distribution was not normal. Therefore, the researcher performed Kendall's tau test, which is used for correlation analysis in non-parametric tests. The result of this test

ISSN 1648–3898

revealed a positively significant but low correlation between the SETFM data and FCI data (significance level: 0.000, correlation coefficient: 0.253).

All these analyses demonstrated that the prospective physics teachers believe that they can successfully teach the subjects of force and motion, but their achievement in the FCI is not parallel to their beliefs. Thus, there is a discrepancy here. This problem led the researcher to ask the following question: can we strengthen the correlation between students' understanding of the subjects of force and motion and their self-efficacy toward teaching these subjects? Since there was a gap between the conceptual understanding of the prospective physics teachers about the subjects of force and motion and their self-efficacy beliefs about teaching the subjects, the second element of the research was conducted.

Pre and Post-Test Descriptive Results of Experimentation Group's Self-Efficacy Beliefs about Teaching and Conceptual Understandings for the Subjects of Force and Motion

Descriptive statistics of the SETFM scale and the FCI pre and post-test results for the application group are given in the Table 3.

Table 3. Descriptive statistics of the SETFM scale and the FCI results for experimentation group.

	Mean	Std. Deviation
FCI pre-test	14.58	4.94
FCI post-test	16.95	4.68
The SETFM scale pre-test	86.37	10.30
The SETFM scale post-test	90.40	9.56

Note. Minimum score 22, maximum score 110 for the scale of SETFM
Minimum score 0, maximum score 30 for FCI

The values in the table indicate that, although the students had high self-confidence about teaching the subjects of force and motion, they actually had moderate knowledge levels – a prerequisite for teaching – according to the results of the FCI test.

The Effects of the Teaching Sequence on the Experimentation Group's Self-Efficacy Beliefs about Teaching and Their Conceptual Understandings about the Subjects of Force and Motion

A Wilcoxon Signed Ranks Test was performed to see whether the sequence resulted in any significant change in the students' beliefs about teaching the subjects and their FCI ratings. The normality tests performed on the data (Kolmogorov-Smirnov analysis) showed that the pretest FCI data ($p=0.074>0.05$) and the pretest SETFM data ($p=0.200>0.05$) had a normal distribution, while posttest FCI data ($p=0.037<0.05$) and posttest SETFM data ($p=0.045<0.05$) did not have a normal distribution. Therefore, analysis of nonparametric paired samples was performed (Table 4). The results of this analysis revealed that, as a result of the sequence, there was a statistically significant improvement in the students' self-efficacy about teaching and their FCI scores.

The number of students who exceeded the threshold of 60% for understanding Newton mechanics (12) increased in the posttest (16). The number of those who exceeded the mastery threshold was 2 in the pretest and 3 in the posttest.

Table 4. Wilcoxon signed ranks test results of FCI scores and the SETFM scale scores of the experimentation group before and after teaching sequence.

	Post test-Pre test	N	Mean rank	Sum of ranks	z	p
The SETFM scale	Negative Ranks	12	17.75	213.00	2.820	0.005
	Positive Ranks	29	22.34	648.00		
	Ties	2				
FCI	Negative Ranks	10	16.40	164.00	3.164	0.002
	Positive Ranks	29	21.24	616.00		
	Ties	4				

The Effect of the Teaching Sequence on the Relationship between Prospective Teachers' Understandings and Self-Efficacy Regarding Teaching the Subjects of Force and Motion

To examine the relationship between the students' self-efficacy about teaching the subjects and conceptual understanding (N=43), and in line with the study's purpose, parametric data were subjected to bivariate correlation test, while Kendall's tau test was performed on the non-parametric data. The Pearson correlation value for the pretest data was found to be 0.311 ($p=0.042<0.05$). This result indicates a positive, significant but weak correlation between the pretest FCI scores and the students' self-efficacy for teaching. For the posttest data, Kendall's tau correlation coefficient was computed as 0.454 ($p=0.000<0.05$). The correlation between the posttest FCI scores and teaching self-efficacy is positive, significant, and stronger when compared to the pretest.

Discussion

Hoy and Woolfolk (1990) reported that prospective teachers in teacher education programs get high scores especially in the sense of personal efficacy. However, Ashton and Webb (1986) (as cited in Lin & Tsai, 1999, p. 2) and Wenner (1993) reported low self-efficacy levels of prospective teachers toward teaching. Those conflicting results indicate that there is a need for further research to see if self-efficacy of prospective teachers change with the teaching subject. In the only one study which can be found in the literature on self-efficacy for teaching physics subjects, Ishak (2008) found that self-efficacy beliefs about teaching secondary school physics varied depending on the topic. He revealed that pre-service physics teachers were less confident about teaching radioactivity and electronics topics but more confident about teaching force and motion topics. Likewise, the present study reports a very high self-efficacy level among prospective physics teachers about teaching the subjects of force and motion.

It has been suggested that prospective teachers' personal sense of efficacy beliefs would increase during teacher preparation and student teaching (Hoy & Woolfolk, 1990; Woolfolk-Hoy and Spero, 2005 as cited in Aydin, Demirdöğen & Tarkin, 2012). The prospective physics teachers' SETFM scale scores were very similar in the 1st, 2nd, and 3rd year students, with a slight increase in the 4th year students, and a marked increase in the 5th year students. In particular, the considerably high teacher self-efficacy displayed by the students in their 5th year could be attributed to several factors. These senior students are now aware that they are about to become teachers and are striving to improve themselves with the goal of finding good jobs. Some of them work in part-time jobs in some institutions (training and study centers) to gain experience. Nearly all of the students have taken the school experience course offered in the curriculum. The school experience course allows prospective teachers to observe how an in-service teacher acts and teaches in a school and classroom environment. Students who thus gain more experience must have increased self-efficacy about teaching. Similarly, Yürük (2011) found that pre-service teachers who perceived a positive experience

ISSN 1648–3898

in science teaching had higher personal science teaching efficacy compared to those who did not have experience or had a negative experience in science teaching.

The FCI results revealed that the prospective teachers had not mastered the subjects as well as they thought they had. To teach a subject, a teacher should certainly have good content knowledge, along with pedagogical training. The prospective physics teachers had high self-efficacy about teaching the subject, but were inadequate in their content knowledge. About 76% of the prospective physics teachers in the sample group obtained FCI scores that are below the understanding threshold, which could raise concern because prospective teachers who are to teach these subjects to their students in the future should have mastered them. However, this finding is actually not surprising. Hestenes et al, (1992) and Bayraktar (2009) also reported similar results in their studies. FCI scores of students are always much lower than the instructors expect for introductory physics courses (Hestenes & Halloun, 1995). Henderson (2002) pointed out that, since the FCI test is so easy and quick to administer, many physics instructors have given it to their classes and have been surprised by the low scores of their students. Likewise, Hestenes et al. (1992) indicated that most physics professors think that, at first sight, FCI questions are too trivial to be informative, and they are then shocked when they realize their own students' lower scores.

The increasing FCI scores for senior students provides support for results of Bayraktar (2009). The first-year students discredited this generalization by scoring higher than the second and third-year students, which was probably because they had been recently taught about the subject. Students in the second and third years most probably forget about these subjects since they are not included in any course in the curricula of the second and third years of their studies. Later, the mean scores of the fourth- and fifth-grade students becomes higher, which can be attributed to their developed sense and greater desire to become teachers, some of them already being employed, full or part-time, in institutions like training and study centers, and to the fact that they have taken physics education courses.

A significant but weak relationship was detected between the students' (N=136) FCI scores and teacher self-efficacy scores. Considerably high teacher self-efficacy scores despite low FCI scores is an important point that needs consideration. Aydin, Demirdöğen and Tarkin (2012) stated that pre-service teachers sometimes have a very optimistic views about their abilities in teaching and classroom practices, views which are not realistic. Prospective teachers often underestimate the complexity of the teaching task and their capabilities for doing a number of simultaneous tasks well (Tschannen-Moran et al., 1998), and this might be the reason for the high self-efficacy scores of the prospective physics teachers. Likewise, Weinstein (1988) found that prospective teachers have a strong tendency towards unrealistic optimism. As mentioned previously, although much research has reported that there is a positive relationship between self-efficacy and achievement, some research has reported a negative relation between them. Moreover, Abak, Eryılmaz and Fakıoğlu (2002) and Shaw (2004) reported that physics self-efficacy does not significantly correlate with achievement. As Shaw (2004) and Ishak (2008) have pointed out, the relationship between self-efficacy and performance may change based on the subject. In this study, a positive relationship between pre-service teachers' self-efficacy and conceptual understandings of the subjects of force and motion was revealed.

The teaching sequence statistically and significantly improved the prospective teachers' understanding of the subjects of force and motion. The prospective physics teachers receiving the teaching sequence had a pretest FCI score of approximately 49%, which increased to about 57% in the posttest. The pretest score obtained from the sample group reflects the conceptual understanding of these prospective teachers before the teaching sequence about the subjects of force and motion, subjects they had already learned both at their high school level and during their first semester at university. The difference between the pretest and posttest demonstrates the improvement in their conceptual understanding and thus the effect of the teaching sequence upon their conceptual understanding. Therefore, even though it seems slight, the difference could be taken as significant because, as is known, FCI test items include erroneous common sense beliefs beside correct Newtonian answers (McDermott & Redish, 1999), and common sense concepts are very resistant to change (Hestenes, 2006).

A high level of teacher self-efficacy may hinder conceptual change (Pajares, 1997). In this sense, the statistically significant increase in the FCI scores of the prospective physics teachers as a result of the teaching sequence (despite their already high self efficacy beliefs toward teaching the subjects before the sequence) indicates the importance of the teaching sequence offered.

It was found that the teaching sequence resulted in a statistically significant improvement in the self-efficacy of the prospective teachers toward teaching the subject. As teacher self-efficacy is a predictor of their future behavior, and thus their students' achievement, this is a satisfying result. Moreover, an increase was also found in the relationship between their self-efficacy beliefs toward teaching the subjects and their understanding of the subjects. Pajares (2002) emphasized that, although an individual's self-efficacy beliefs provide clues about his/her future behaviour, they alone cannot be enough to determine their behaviour; skills and knowledge are also required along with these beliefs. This necessitates the expectation of high self-efficacy beliefs toward teaching as well as an adequate level of content knowledge. Therefore, the increased correlation between the prospective teachers' self-efficacy beliefs toward teaching the subjects of force and motion and their understandings of these subjects is perhaps the most important result of the study.

According to Isiksal (2010), a commonly shared belief among education researchers since the mid 1990s has been that teachers should have a deep understanding of subject matter and pedagogy. Enochs, Smith and Huinker (2000) pointed out that it is not sufficient to prepare teachers only in areas of content knowledge and pedagogy. Subject-specific pedagogy is also as important as content knowledge and pedagogy for teacher education. This study has shown the need to include subject-specific pedagogy courses as well as subject matter and pedagogy courses in the curricula of education faculties.

The students stated that, through the activities they performed, they recognized that, although they thought they knew the subject well, they had certain misconceptions, but that now they have remedied their misconceptions and learnt all this information well. Moreover, they also stated that, through these activities, they understood that knowing how to teach a subject is as important as knowing about that subject, and that this would be useful in their professional performance in the future. To quote one of the students, "I guess I remedied all of my misconceptions. Because when you show people their mistakes and ask for solutions, that person will not repeat the same mistake."

Conclusions and Implications

In this study, primarily the prospective physics teachers' self efficacy beliefs about teaching and their conceptual understandings for a specific subject (force and motion) and the relationship between these two variables was investigated. It was revealed that the prospective physics teachers had very high self-efficacy for teaching the subjects but they didn't have a sufficient conceptual understanding. A significant but weak relationship was detected between their self efficacy beliefs about teaching and their conceptual understandings for the subjects of force and motion.

Finally, how the teaching sequence which was designed to enhance the conceptual understandings of the prospective physics teachers influences their self efficacy beliefs about teaching and their conceptual understandings for the subjects, and whether the teaching sequence would enhance the concordance between the two were investigated. It was found that the teaching sequence improved the prospective teachers' understanding of the subjects and their self-efficacy levels about teaching the subjects. Increased self-efficacy levels of the prospective physics teachers through the teaching sequence lends support to the previously mentioned suggestion that efforts to improve teachers' self-efficacy beliefs should be directed at prospective teachers whose teacher self-efficacy has not been established enough to resist change.

The teaching sequence also enhanced the relationship between prospective teachers' self-efficacy about teaching and their conceptual understandings for the subjects. This means that the gap between the conceptual understanding of the prospective physics teachers about the subjects of force and motion and their self-efficacy beliefs about teaching the subjects shrunk through the teaching sequence.

This study has shown the need to include subject-specific pedagogy courses in the curricula of education faculties. In this way, students can have enough time and opportunity to talk about their misconceptions and conceptual understandings and how they can teach the subjects. The secondary school teaching departments (physics, chemistry, biology, and mathematics) of the education faculties in Turkey have added courses for subject-specific pedagogy in their curricula for the last few years. Further studies are required to examine the effects of such courses on student achievement, conceptual understanding, and affective characteristics etc.

Other methods should be tried, and different applications should be made to fill the gap between teachers' conceptual understanding and teacher self efficacy toward teaching the subjects of force and motion, as was done in the present study, as well as for teaching other subjects.

There is a need for further research with a control group, a real trial design to demonstrate the impact of similar experimental procedures more exactly. Additionally, the reader should be cautioned regarding generalizability of the research findings. Further studies should be performed with larger samples for generalizability.

References

Abak, A., Eryılmaz, A., & Fakıoğlu, T. (2002). Üniversite öğrencilerinin seçilmiş duyuşsal karakteristiklerinin belirlenmesi. In: *Proceedings of the V. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi.* Ankara: ODTU, 2002.

Aydin, S., Demırdöğen, B., & Tarkin, A. (2012). Are They Efficacious? Exploring Pre-service Teachers' Teaching Efficacy Beliefs During the Practicum. *The Asia-Pacific Education Researcher*, *21* (1), 203-213.

Bayraktar, Ş. (2009). Misconceptions of Turkish pre-service teachers about force and motion. *International Journal of Science and Mathematics Education,* 7, 273-291. doi: 10.1007/s10763-007-9120-9.

Bleicher, R. E., & Lindgren, J. (2005). Success in science learning and preservice science teaching self-efficacy. *Journal of Science Teacher Education,* 16, 205-225. doi: 10.1007/s10972-005-4861-1.

Cantrell, P., Young, S., & Moore, A. (2003). Factors affecting science teaching efficacy of preservice elementary teachers. *Journal of Science Teacher Education*, *14*, 177-192. doi: 10. 1023/A:1025974417256.

Chan, D. W. (2008). General, collective, and domain-specific teacher self-efficacy among Chinese prospective and in-service teachers in Hong Kong. *Teaching and Teacher Education*, 24, 1057-1069. doi:10.1016/j.tate.2007.11.010.

Chiou, G., & Liang, J. C. (2012). Exploring the Structure of Science Self-Efficacy: A Model Built on High School Students' Conceptions of Learning and Approaches to Learning in Science. *The Asia-Pacific Education Researcher*, *21* (1), 83-91.

Compeau, D. R., & Higgins, C. A. (1995). Computer Self-Efficacy: Development of a Measure and Initial Test. *MIS Quarterly*, *19* (2), 189-211.

Çokluk, Ö., Şekercioğlu, G., & Büyüköztürk, Ş. (2010). *Sosyal Bilimler için Çok Değişkenli Istatistik: SPSS ve LISREL Uygulamaları* [Multivariate Statistics for the Social Sciences: SPSS and LISREL Applications]. Ankara: Pegem Akademi.

Dembo, M. H., & Gibson, S. (1985). Teachers' Sense of Efficacy: An Important Factor in School Improvement. *The Elementary School Journal*, *86* (2), 173-184.

Denzine, G. M., Cooney, J. B., & McKenzie, R. (2005). Confirmatory factor analysis of the Teacher Efficacy Scale for prospective teachers. *British Journal of Educational Psychology,* 75, 689-708. doi: 10.1348/000709905X37253.

Enochs, L. G., Smith, P. L., & Huinker, D. (2000). Establishing factorial validity of the mathematics teaching efficacy beliefs instrument. *School Science and Mathematics,* 100, 194-203. doi: 10.1111/j.1949-8594.2000.tb17256.x.

Gist, M. E., & Mitchell, T. R. (1992). Self-Efficacy: A Theoretical Analysis of Its Determinants and Malleability. *The Academy of Management Review*, *17* (2), 183-211.

Halloun, I., Hake, R., Mosca, E., & Hestenes, D. (1995). *Revised form Force Concept Inventory*. Retrieved 1/05/2009, from http://modeling.asu.edu

Halloun, I. A., & Hestenes, D. (1985). Common-sense concepts about motion. *American Journal of Physics*, *53*, 1056-1065. doi: 10.1119/1.14031.

Henderson, C. (2002). Common concerns about the Force Concept Inventory. *The Physics Teacher, 40*, 542-547. doi: 10.1119/1.1534822.

Henson, R. K., Kogan, L. R., & Vacha-Haase, T. (2001). A reliability generalization study of the teacher efficacy scale and related instruments. *Educational and Psychological Measurement, 61*, 404-420. doi: 10.1177/00131640121971284.

Hestenes, D. (2006). Notes for a modeling theory of science, cognition and instruction. In: *Proceedings of GIREP 2006 Conference: Modelling in Physics and Physics Education.* Amsterdam: The AMSTEL Institute of the Faculty of Science, Universiteit van Amsterdam, 2006.

Hestenes, D., & Halloun, I. (1995). Interpreting the Force Concept Inventory. *The Physics Teacher*, *33* (8), 502-506.

Hestenes, D., Wells, M., & Swackhamer, G. (1992). Force Concept Inventory. *The Physics Teacher*, *30* (3), 141-158.

Hoy, W. K., & Woolfolk, A. E. (1990). Socialization of student teachers. *American Educational Research Journal,* 27, 279-300. doi: 10.3102/00028312027002279.

Ishak, M. Z. (2008). *Improving the training of pre-service physics teachers in Malaysia using didactic analysis* (Doctoral dissertation, the University of Waikato, New Zealand). Retrieved 3/12/2009, from http://hdl.handle.net/10289/2544.

Isiksal, M. (2010). The Relationship among Mathematics Teaching Efficacy, Math Anxiety, and Mathematical Self-Concept: The Case of Turkish Pre-service Elementary Teachers. *The Asia-Pacific Education Researcher*, *19* (3), 501-514.

Lin, S. S. J., & Tsai, C. (1999). *Teaching efficacy along the development of teaching expertise among science and math teachers in Taiwan* (Report No. SE 063931). Boston, MA: National Association for Research in Science Teaching (ERIC Document Reproduction Service No. ED445905).

Magno, C., & Sembrano, J. (2007). The Role of Teacher Efficacy and Characteristics on Teaching Effectiveness, Performance, and Use of Learner-Centered Practices. *The Asia-Pacific Education Researcher*, *16* (1), 73-90.

McDermott, L. C., & Redish, E. F. (1999). Resource letter: PER-1: Physics education research. *American Journal of Physics,* 67, 755-767. doi: 10.1119/1.19122.

Möller, J., Pohlmann, B., Köller, O., & Marsh, H. W. (2009). A meta-analytic path analysis of the internal/external frame of reference model of academic achievement and academic self-concept. *Review of Educational Research*, *79*, 1129-1167. doi: 10.3102/0034654309337522.

Multon, K. D., Brown, S. D., & Lent, R. W. (1991). Relation of self-efficacy beliefs to academic outcomes: A meta-analytic investigation. *Journal of Counseling Psychology, 38*, 30-38. doi: 10.1037/0022-0167.38.1.30**.**

Neber, H., He, J., Liu, B. X., & Schofield, N. (2008). Chinese high-school students in physics classroom as active, self-regulated learners: Coginitive, motivational and environmental aspects. *International Journal of Science and Mathematics Education*, *6*, 769-788. doi: 10.1007/s10763-007-9110-y.

Pajares, F. (1996). Self-efficacy beliefs and mathematical problem-solving of gifted students. *Contemporary Educational Psychology*, *21*, 325-344. doi: 10.1006/ceps.1996.0025**.**

Pajares, F. (1997). Current directions in self-efficacy research. In M. Maehr, & P. R. Pintrich (Eds.), *Advances in Motivation and Achievement* (Vol.10, pp. 1-49). Greenwich, CT: JAI Press.

Pajares, F. (2002). Self-efficacy beliefs in academic contexts: An outline. Retrieved 4/15/2011, from http://des.emory.edu/mfp/efftalk.html.

Pajares, F., & Graham, L. (1999). Self-efficacy, motivation constructs, and mathematics performance of entering middle school students. *Contemporary Educational Psychology*, *24,* 124-139. doi: 10.1006/ceps.1998.0991**.**

Pajares, F., & Schunk, D. H. (2001). Self-beliefs and school success: Self-efficacy, self-concept, and school achievement. In R. Riding, & S. Rayner (Eds.), *Perception* (pp. 239-266). London: Ablex Publishing.

Riggs, I. M., & Enochs, L. G. (1989). *Toward the development of an elementary teacher's science teaching efficacy belief instrument* (Report No. SE 050611). San Francisco, CA: National Association for Research in Science Teaching (ERIC Document Reproduction Service No. ED308068).

Savinainen, A., & Scott, P. (2002). Using the Force Concept Inventory to monitor student learning and to plan teaching. *Physics Education*, *37*, 53-58. doi: 10.1088/0031-9120/37/1/307**.**

Schoon, K. J., & Boone, W. J. (1998). Self-efficacy and alternative conceptions of science of preservice elementary teachers. *Science Education*, *82*, 553-568. doi: 10.1002/(SICI)1098-237X(199809)82:5<553::AID-SCE2>3.0.CO;2-8.

Shaw, K. A. (2004). The development of a physics self-efficacy instrument for use in the introductory classroom. In J. Marx, S. Franklin, & K. Cummings (Eds.), *AIP Conference Proceedings* (pp. 137-140). New York: American Institute of Physics.

Stepans, J., & McCormack, A. (1985). *A study of scientific conceptions and attitudes toward science of prospective elementary teachers*: *A research report* (Report No. SE 046407). Jackson Hole, WY: Northern Rocky Mountain Educational Research Association (ERIC Document Reproduction Service No. ED266024).

Temizkan, D. (2003). *The effect of gender on different categories of students' misconceptions about force and motion.* (Master's thesis, Middle East Technical University, Ankara, Turkey). Retrieved 3/05/2009 from http://etd.lib.metu.edu.tr/upload/1207588/index.pdf.

Tschanen-Moran, M., Woolfolk-Hoy, A., & Hoy, W.K. (1998). Teacher efficacy: Its meaning and measure. *Review of Educational Research*, *68*, 202-248. doi: 10.3102/00346543068002202.

ISSN 1648–3898

Weasmer, J., & Woods, A. M. (1998). I think I can: The role of personal teaching efficacy in bringing about change. *The Clearing House*, 71, 245-248. doi: 10.1080/00098659809599371.
Weinstein, C. S. (1988). Preservice Teachers' Expectations about the First Year of Teaching. *Teaching and Teacher Education*, *4* (1), 31-40.
Wenner, G. (1993). Relationship between science knowledge levels and beliefs toward science instruction held by preservice elementary teachers. *Journal of Science Education and Technology, 2*, 461-468. doi: 10.1007/BF00694428.
Yürük, N. (2011). The Predictors of Pre-Service Elementary Teachers' Anxiety about Teaching Science. *Journal of Baltic Science Education*, *10* (1), 17-26.
Zeldin, A. L., & Pajares, F. (2000). Against the odds: Self-efficacy beliefs of women in mathematical, scientific, and technological careers. *American Educational Research Journal*, *37*, 215-246. doi: 10.3102/00028312037001215.
Zimmerman, B. J. (2000). Self-efficacy: An essential motive to learn. *Contemporary Educational Psychology, 25*, 82-91. doi:10.1006/ceps.1999.1016.

Received: *June 30, 2012* Accepted: *December 25, 2012*

Rabia Tanel Dr., Dokuz Eylül University, Buca Education Faculty, Department of Secondary Science and Mathematics Education, Buca, 35160, Izmir, Turkey.
Phone: +90-232-4204882.
E-mail: rabia.tanel@deu.edu.tr