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Development and Application of an Instrument to Measure Greek Primary Education Teachers' Biology Teaching Self-efficacy Beliefs

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The self-efficacy beliefs of in-service elementary school teachers in Greece were examined in an attempt to evaluate their biology teaching skills. For this purpose, we constructed a valid and reliable instrument consisting of a Likert-type questionnaire that was distributed to the target population and to which 202 teachers responded. Results revealed Greek primary education teachers have, in general, moderate to high biology teaching self-efficacy beliefs (BioTSEB), whereas those that had not attended any biology courses during their academic studies had lower self-estimates. Teachers' BioTSEB are also affected by factors such as years of teaching experience, the number of science courses attended and the quality of their previous studies, together with the grade levels they were assigned to teach during their in-service years.

Keywords: *Self-efficacy, Teachers, Biology Teaching, Primary Education*

INTRODUCTION

In the Greek primary education curricula (Law 1366, v.B, 18/10/2001; Laws 1373-1376, v.B, 18/10/2001) there are many biology concepts included in the subjects "Study of the Environment" (for the first four grades, 1st - 4th) and "I explore the natural world" (grades 5th and 6th). The former subject must not be confused with "Environmental Studies", as it is mostly analogous to the "Science, Technology, Society and Environment" subject found in many national curricula (Pedretti, 2003). The latter subject is analogous to "Science". Today and since 1982, with the establishment of the first Primary Education Departments in Greece (Law 1268/1982, §46), for someone to become a teacher, one needs to obtain a University degree from any one of the nine Primary Education University Departments all over the country, which means that one is required to successfully complete *4 years* of study. Prior to that, one could become a teacher by obtaining a degree from a "Pedagogical Academy", which was a *2-year* course. In 1990, a Presidential Act (130/1990) gave teachers possessing the Pedagogical Academy degree the right to "upgrade" it by attending a 2-year course at a University of their choice in order to become "equated" to teachers possessing the University degree. Thanks to a Professional Development Programme financed by the European Union, most of the in-service teachers upgraded their degrees to that of a University degree. Taking into account that different universities do not follow similar syllabi – in fact there are major differences between these – it is evident that in-service primary education teachers in Greece have different educational backgrounds.

In the past, biology courses in Primary Education Departments were rare. Nowadays, some of these Departments have no biology courses at all in their syllabi, others offer them on a non-obligatory basis

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State of the literature

- Teachers' science teaching self-efficacy beliefs have been widely studied but few studies exist focusing on teachers' self-efficacy beliefs on specific knowledge domains.
- Self-efficacy beliefs in biology have been studied in only two cases: one measuring college students' self-efficacy beliefs and the other one measuring pre-service biology teachers' self-efficacy beliefs. None of them measures primary teachers' self-efficacy beliefs in biology.
- Many studies have proven that teachers feeling self-efficient adopt innovative techniques and policies in the classroom.
- Very few in-service teachers in Greece have attended biology courses during their undergraduate studies and this could be a problem in their self-efficacy beliefs in biology teaching.

Contribution of this paper to the literature

- This paper presents the development of the first valid and reliable instrument (Bio-TSEB) to measure primary education teachers' biology self-efficacy beliefs.
- A wider application of BioTSEB could reveal which factors in teachers' education programs need revision in order to positively affect teachers' self-efficacy beliefs in biology teaching.
- This study reveals that biology as a cognitive subject and biology teaching (or at least science teaching) courses are necessary to be included in teachers' education programs as the more they exist in these programs the more self-confident the teachers become in biology teaching.

while a very few offer them on an obligatory and more systematic basis. As a result, biology is one of the subjects that most Greek in-service primary education teachers are expected to teach by relying mostly on their school knowledge, without ever having studied it in their undergraduate courses. Bearing in mind that, at least in Greece, teachers are obliged to teach biology concepts along with language, history etc. this makes their task even harder.

Bandura's (1977) theory of social learning supports that we are motivated to perform an action if we are confident that we will perform it successfully (self-efficacy expectation). When applied to teaching, self-efficacy refers to the teacher's conviction that he or she has had adequate training or experience to overcome obstacles to student learning and that he/she can "successfully perform specific teaching tasks in a teacher's current teaching situation (specific school/ classroom/ students)" (Dellinger et al. 2008, p.753). We must not confuse teachers' self-efficacy beliefs with teachers' efficacy per se, as the latter focuses on successfully affecting student performance, which may also be the result of factors unrelated to teachers' performance (Dellinger et al. 2008). Teachers' self-efficacy beliefs have been widely studied (Gibson and Dembo 1984; Soodak and Podell 1993; Woolfolk and Hoy 1990). There are also numerous studies on science teaching self-efficacy beliefs of teachers (in-service or pre-service) (Bleicher 2007; Browers 2001; Cakiroglu 2008; Cantrell et al. 2003; Caprara 2006; Cheung 2008; Palmer 2006; Ramey-Gassert et al. 1996; Rice and Roychoudhury 2003; Riggs and Enochs 1990; Yilmaz and Cavas 2008). There are, however, very few studies which have focused on specific knowledge domains (Gorell and Hwang 1995). As Pajares and Schunk (2001) have suggested, teachers' self-efficacy beliefs must be measured in content-specific domains as these may differ from one domain to the other. This is consistent with Bandura's (1986) definition of self-efficacy belief as being a situation-specific construct, rather than a global one.

Research also supports the view that science teaching self-efficacy increases when teachers learn more about a subject (Kind 2009; Markic et al. 2006). In Greece, as mentioned above, very few teachers have attended biology courses during their undergraduate studies; therefore they have not had the chance to learn more about this subject. This could affect their self-efficacy beliefs in teaching biology, which in turn may affect various aspects of the teaching procedure such as biology instruction time, as well as the achievement of students in biology, at the elementary level (Smolleck et al. 2006).

Two instruments have been developed especially for self-efficacy beliefs in biology: the one by Baldwin, Ebert-May and Burns (1999) which aims at measuring college students' self-efficacy beliefs, and another by Savran and Cakiroglu (2001), which is intended for pre-service biology teachers and in fact is a Science Teaching Efficacy Beliefs Instrument (STEBI), as developed by Riggs and Enochs (1990) and adapted to Turkish standards. There has not, however, been any study which –making use of a valid and reliable instrument– focuses particularly on primary education teachers' self-efficacy beliefs in teaching biology. Developing such an instrument (BioTSEB), will be useful. Although the instrument was developed and applied to the Greek case, it may also be adapted for use in other countries, as well.

Item construction and refinement

The present instrument is based on the subscale "Personal Science Teaching Efficacy Belief" which is part of the "Science Teaching Efficacy Beliefs

Instrument" (STEBI) that Riggs and Enochs (1990) have developed and which we enriched with more items. The subscale-B of the STEBI instrument that measures "outcome expectancy" was not included as our interest focused on teachers' self-efficacy that closely relates to the education they had received as pupils or students. Although teachers' "outcome expectancy" may be an important factor that could affect biology teaching in various ways, it may also be affected by factors not necessarily related to the education teachers have received. The 13 items of the STEBI subscale-A were altered in two ways: firstly, the term "biology" was substituted for "science" wherever necessary and, further, items were translated to Greek. We then added 35 extra items - based on findings from the literature or our own experience with in-service and pre-service teachers – in order to estimate whether teachers:

- ✓ *feel efficient in using innovative teaching methods in biology. Guskey (1988) has shown that teachers with high self-efficacy beliefs embraced innovative techniques in the classroom, while Wolters and Daugherty (2007) found a positive correlation between a high teachers' efficacy-level and positive teachers' practices and policies used in the classroom.*
- ✓ *feel they can motivate their students in biology (Ashton and Webb 1986; Podell and Soodak 1993; Roeser et al. 1993 as mentioned in Caprara et al., 2006) and whether they are willing to teach biology.*
- ✓ *feel they have adequate pedagogical content knowledge to teach biology. It is widely recognized that pedagogical content knowledge plays an important role in the development of a science teacher's self-efficacy beliefs (Abell 2008; Gess-Newsome 1999; Mulholland and Wallace 2001).*
- ✓ *feel familiar with specific biology concepts, functions, etc. so that they would feel confident to teach them.*

A total number of 48 items were finally produced. The authors (biologists teaching in University Education Departments) and two in-service teachers (both M.A.-holders) were used for checking the face validity of the remaining 48 instrument. They checked if the 48 items were consistent with the purpose for which the instrument was developed, if they were understandable, accurate, clear, etc. Following their observations, four (4) more items were further excluded as being inaccurate. For the rest of the 44 items, the work-team yielded a Content Validity Ratio (CVR) (Lawshe 1975) CVR=1.00, which, in terms of statistical significance, supports the content validity of the instrument (Shultz & Whitney 2005).

All the remaining 44 items were designed as a five-point Likert-type:

- ✓ *in 21 of them teachers had to answer whether they strongly agreed, agreed, neither agreed nor disagreed, disagreed or strongly disagreed.*
- ✓ *in 23 of them teachers had to state whether they believed they had enough familiarity with 23 specific biology concepts, functions or system concepts to feel confident to teach them effectively: very familiar, familiar enough, moderately familiar, a little familiar or not at all familiar. The concepts were selected from the Greek National Curriculum for Elementary Education – in other words, these are concepts that teachers already teach or may teach in the future.*

Scoring was accomplished by assigning a score of five to positively-phrased items receiving a "strongly agree" or "very familiar" response; a score of four to "agree" or "familiar", and so on throughout the response categories. Negatively-worded items were scored in an opposite direction with "strongly agree" receiving a score of one. Items attempting to measure teachers' self-efficacy in biology teaching were accompanied by questions focusing on factors that may affect teachers' self-efficacy. Teachers' pre-service training has changed dramatically during the last 25 years in Greece, and biology appears only recently in teachers' pre-service education. Therefore factors such as age, total in-service years, or type of basic degree when first appointed may influence teachers' self-efficacy beliefs in biology teaching. As a result, relevant questions were included in the questionnaire. Donovan et al. (1999) argued that, in order to be able to teach understandably, pre-service teachers must, themselves, be given the opportunity to experience learning through understanding. Therefore, asking teachers if attending science teaching courses during their undergraduate studies helped them feel more self-efficient in biology teaching or how they valued those courses, seemed necessary. It must be noted that some of these questions may be meaningless in the context of other countries' educational systems and could be substituted by other more appropriate ones. For example, primary school teachers in Greece are assigned to teach a certain grade each year. The decision is taken after discussions held between the teachers and the headmaster of the school. The fact that some teachers prefer teaching lower rather than higher grades may be interpreted as a difficulty on their part to teach Science and Mathematics and a relevant question need be included in the questionnaire.

In order to test the null hypothesis that teachers' scores in BioTSEB are not dependent on the above-mentioned variables, we performed nonparametric tests for 2 (Mann-Whitney U test) or more (Kruskal-Wallis H) - where needed - independent samples since normality tests revealed that normal distribution requirements were not fulfilled. The data were analyzed by the authors making use of the statistical programme SPSS v16.1 (SPSS Inc.).

Pilot testing and scoring

In order to conduct the pilot testing of the instrument we delivered the questionnaire to 29 teachers to whom we had easy access. We tried to attain a heterogeneous sample (not all men, not all of the same age or years of experience). Feedback from participants was good and the estimated Cronbach's alpha revealed a high degree of reliability for the test scores (α= 0.98): we therefore accepted the instrument as it was and went ahead with practical application. Neither the participants from the pilot study nor their scores were included to the final analysis.

Research sample

This instrument development study was realized in the academic year 2008-2009. The instrument was either e-mailed or personally delivered to teachers working in public primary schools in the districts of Athens, East Attica and Arcadia (i.e., both urban and rural areas). There is no current evidence from the literature that teachers working in different areas of Greece may feel more or less self-efficient in teaching biology. However, we might expect differences among teachers who have completed their undergraduate studies in different institutions, as they may have attended completely different courses as mentioned above.

We originally distributed 246 and received 202 completed questionnaires. 71.3% of the subjects were women, the most abundant age group among the subjects (42.1%) was that of 41-50 years of age. Among the subjects 32.2% had at least 21 years in-service, whereas 14.9% held a post-graduate degree.

Analysis

We computed the correlation matrix for items 1 to 44. The Bartlett's test of sphericity produced a value of 6791.38 with a significance level <0.000, indicating the suitability of the factor model for the data. The Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy indicating the proportion of variance in our variables that might be caused by underlying factors was 0.927, and thus a factor analysis was appropriate.

It was decided to identify the dimensions of the instrument by analyzing the data we obtained from the participants rather than by delineating pre-determined dimensions and subscales, a procedure often followed by other researchers (Thomas et al. 2008; Erdogan et al. 2009). In order to examine the factor structure behind the instrument, the data were subjected to factor analysis through a principal components method. Secondly, reliability analysis was performed for each of the emerged sub-scales.

Both varimax and oblique rotation were used. The results produced through an oblique rotation were quite similar with the results from varimax rotation with the only differences lying in the order of factor extraction. Varimax rotation produced 8 factors with eigenvalues greater than 1.0. These factors altogether explained 71.9% of result variance. A scree plot was needed as it is considered the best choice for factor retention (Costello and Osborne 2005). According to it, four factors were above the break point where the curve flattens out. This constituted evidence that rotation was necessary for four factors. All items had factor loadings greater than 0.35. The four factors explained 60.7% of the total variance and they were named according to some common characteristics of the items loaded on the same factor (Appendix).

The number of items in each factor, the eigenvalues and variance explanation, as also the mean scores and standard deviation of the factors, are presented in Table 1.

The first factor included 16 items that expressed teachers' beliefs about their familiarity with concepts or functions relative to plants' physiology, ecology and human biology, to feel confident to teach them effectively. We named this factor "Self-efficacy in plants, ecology and human biology concepts" (PEHB). The mean score of factor PEHB was 3.84 (SE=0.05) showing that Greek teachers feel a little confident in teaching concepts that are related to these subjects. The second factor included 17 items: to begin with, all but three of the items of the subscale "Personal Science

Table 1. The number of items in each factor, eigenvalues and variance explained as also the mean scores and standard deviation of the factors

Factors	N of items	Eigenvalues	% of variance	Mean (SD)
PEHB[a]	16	9.54	21.67	3.84(0.76)
PIW[b]	17	8.76	19.91	3.02(0.70)
EMM[c]	7	5.65	12.85	3.18(0.96)
ME[d]	4	2.77	6.30	3.57(0.61)

[a]PEHB= Plants, ecology and human biology self-efficacy.
[b]PIW= Pedagogical Content Knowledge, in-depth understanding and willingness to teach biology.
[c]EMM= Self-efficacy in evolution, molecular biology and microbiology.
[d]ME= Self-efficacy in their ability to motivate students and get them actively engaged in the learning process.

Teaching Efficacy Belief" (STEBI-A) from the "Science Teaching Efficacy Beliefs Instrument" (Riggs and Enochs 1990), adapted to suit our study as already mentioned. And further: seven items relative to their pedagogical content knowledge, their in-depth understanding of biology and willingness to teach biology or science lessons in general. Therefore we named this factor "Pedagogical Content Knowledge, in-depth understanding and willingness to teach biology" (PIW). The mean score of PIW was 3.02 (SE=0.05), showing that Greek teachers have problems in matters of PCK, in-depth understanding and willingness to teach biology. The third factor included 7 items that expressed teachers' beliefs about their familiarity with concepts or functions relative to evolution, molecular biology and microbiology to feel confident to teach them effectively. We named this factor "Self-efficacy in evolution, molecular biology and microbiology" (EMM). The mean score of EMM was 3.18 (SE=0.07). Greek teachers feel neither effective nor ineffective in teaching these concepts due to their low degree of familiarity with them. The fourth factor included 4 items that are relevant to teachers' ability to motivate and encourage students to become actively engaged in the learning process. Therefore we named this factor "Motivation and engagement" (ME). The mean score of ME was 3.57 (SE=0.04) revealing that Greek teachers feel they are a little able to motivate their students and get them actively engaged in biology.

Reliability and Discriminant Validity of Emerged Factors

The Cronbach's alpha for each of the four factors (Table 2) suggest there is a high level of internal consistency among the items for the first three sub-scales. Only the fourth factor (ME) has a low (0.60) Cronbach's alpha. Although the widely recognized threshold for Cronbach's alpha is 0.7 (Nunnally 1978), Moss et al (1998) consider a value of 0.6 as acceptable and DeVellis (1991) as undesirable. The low alpha of the subscale ME can be explained by the small number of items (4) that constitute this factor.

The subscales are correlated at the 0.01 level therefore discriminant validity of the subscales should be tested - to check whether they overlap. Low values (<0.85) of the correlations corrected for attenuation reveals that the factors (subscales) do not overlap. It can be concluded from the data presented in Table 2, that factors PEHB and EMM are more correlated. This is explained by the fact that both factors consisted mostly of items that referred to teachers' beliefs about their familiarity with specific concepts or functions to feel confident to teach them effectively. In fact, we initially expected these items to be grouped in the same factor. Their splitting into two different factors, as also the higher mean score of the PEHB factor, can be explained by the fact that teachers aren't familiar with concepts such as evolution that are apparent in the EMM factor as they *may not even have been taught these concepts*, and therefore find difficulty in teaching them.

RESULTS

Greek primary school teachers' self-efficacy in biology teaching is moderate to high as they scored 3.87(±0.63) in the Bio-TSEB. Examining teachers' gender, age, teaching background etc., provided us with some very useful information on how these variables affect teachers' self-efficacy beliefs in biology teaching. Factors that affect –in a statistically significant manner– Greek teachers' self-efficacy beliefs in biology teaching are presented in Table 3.

In particular, teachers younger than 30 years old had the lowest self-efficacy in biology teaching, whereas the highest self-efficacy beliefs were among teachers between 41 to 50 years of age (Table 3). As the years of teachers' experience increase, so does their self-efficacy beliefs in biology teaching. Teachers with 0-5 years experience showed the lowest self-efficacy beliefs and the highest those with more than 11 years in-service. Thereafter, however, after that point the more experience gained does not contribute to higher self-efficacy beliefs in biology teaching.

Table 2. Cronbach alpha, observed correlations and corrected correlations among the four factors of the BioTSEB

	PEHB	PIW	EMM	ME
PEHB	(0.96)	0.62*	0.75*	0.37*
PIW	0.66	(0.93)	0.57*	0.48*
EMM	0.80	0.61	(0.93)	0.34*
ME	0.49	0.64	0.45	(0.60)

N=202 Greek teachers.

Cronbach alphas are presented on the diagonal and in parenthesis, observed correlations above the diagonal and correlations corrected for attenuation (John and Benet-Martinez 2000) below the diagonal.

**Correlations statistically significant (p<0.01)*

Table 3. Teachers' scores in BioTSEB according to various factors

	N	BioTSEB score[a]	S.D.
Teachers' age (χ^2=16.298, df=3, p=0.001)			
≤30	37	3.53	0.59
31-40	58	3.84	0.60
41-50	85	4.01	0.60
≥51	22	3.95	0.68
Years of experience (χ^2=18.922, df=3, p=0.000)			
0-5	41	3.50	0.56
6-10	42	3.90	0.61
11-20	49	3.98	0.58
>20	65	3.97	0.64
Degree by assignment (Mann–Whitney U =4150.500, p=0.024)			
Pedagogical Academy	106	3.96	0.63
University degree	96	3.76	0.61
Grades mostly undertaken (χ^2=16.949, df=4, p=0.002)			
None[b]	8	4.03	0.53
1st & 2nd	56	3.67	0.57
3rd & 4th	49	3.76	0.59
5th & 6th	69	4.11	0.56
Various	20	3.78	0.85
Direction of studies teachers have attended as pupils (χ^2=21.620, df=2, p=0.000)			
Science	38	4.28	0.62
Humanities	151	3.76	0.60
Technological	2	4.15	0.02
Number of biology courses teachers have attended during their undergraduate studies (χ^2=31.947, df=4, p=0.000)			
0	83	3.59	0.62
1	71	3.94	0.54
2	34	4.25	0.54
3	2	4.19	0.76
4	1	4.40	-
Number of science teaching courses teachers have attended during their undergraduate studies (χ^2=15.351, df=3, p=0.002)			
0	1	3.91	-
1	33	3.58	0.59
2	100	3.84	0.65
3	36	3.90	0.57
4	17	4.33	0.46
Teachers' evaluation of the degree that undergraduate science teaching courses contributed to feeling self-efficient in biology teaching (χ^2=48,759, df=2, p=0.000)			
Did not help at all	100	3.62	0.55
Neutral	47	3.82	0.50
Helped a lot	54	4.37	0.58
Teachers' evaluation of the sufficiency of the undergraduate science teaching courses (χ^2=34,718 df=2, p=0.000)			
Insufficient	143	3.70	0.56
Neither	41	4.20	0.60
Sufficient	18	4.44	0.56

[a]: *1(low self-efficacy beliefs) - 5 (high self-efficacy beliefs)*

[b]: *Teachers that had just entered service*

Of great interest was the finding that teachers who graduated from a Pedagogical Academy (offering a 2-year degree-course) had higher self-efficacy beliefs in biology teaching than teachers that graduated from a University department (a 4-year degree-course). We attributed this to the fact that teachers with a 2-year degree have typically more years of in-service experience as Pedagogical Academies ceased to exist since 1982 and –as mentioned– the extra years of experience contribute to higher self-efficacy beliefs.

A PhD or a Master's degree do not affect in a statistically significant manner teachers' self-efficacy beliefs in biology teaching. The grades that teachers have mostly taught during their professional career seem to play an important role in their self-efficacy beliefs in biology teaching. Teachers that often undertake to teach

higher grades (fifth or sixth grade) obtained a higher score in the BioTSEB than teachers that undertake to teach the lowest grades (first or second class). This may be explained as follows: either teachers with low self-efficacy in biology and science teaching avoid higher grades or the teaching of biology would gradually enhance self-efficacy beliefs. The high score (4.03) of 8 teachers that had just entered service may be attributed to the fact that they as yet had no image as to the necessary skills required to successfully teach biology.

The direction of studies teachers have followed as pupils seems to affect in a statistically significant manner their self-efficacy beliefs in biology teaching. Those that had had a Science-orientated schooling obtained higher scores in BioTSEB than those with a Humanities-orientated education, which can be explained by the fact that pupils that follow the Humanities orientation attend fewer biology courses.

The number of biology courses that teachers have attended during their undergraduate studies seems to positively affect their self-efficacy beliefs in biology teaching and the same applies regarding the number of Science Teaching courses. In fact statistically significant differences ($p<0.05$) are found among those who have attended none or one biology course and those that have attended at least two biology courses during their undergraduate studies, revealing that only one course in biology cannot improve in a statistically significant manner teachers' self efficacy beliefs. The number of Science Teaching courses that teachers have attended during their undergraduate studies also seems to positively affect their self-efficacy beliefs since those that have not attended such a course have lower self-efficacy beliefs in biology teaching. As the number of Science Teaching courses increases so does teachers' self-efficacy beliefs (positive correlations, $p<0.01$). This is in accordance with Bleicher's finding (2004) who has suggested that the number of Science Teaching courses that future teachers attend during their undergraduate studies positively affects their science teaching self-efficacy beliefs. When teachers were asked to evaluate the degree to which the undergraduate science teaching courses they attended contributed to feeling self-efficient in biology teaching, those that evaluated them as helpful scored higher in the BioTSEB and there are statistically significant differences between them and those that evaluated these courses as neutral or not helpful. This reveals that what counts is not only the number of courses that teachers undertake but also the way these courses are taught. Teachers' evaluation of the adequacy of the undergraduate Science Teaching courses revealed that those that considered their Science Teaching courses as adequate, scored –in a statistically significant manner– higher than the others. Those that considered these courses as inadequate scored lower than the rest.

DISCUSSION

Teachers' in-service years of experience have been shown to be important in increasing teachers' self-efficacy beliefs (Fritz et al. 1995), which is in accordance with our findings. In fact in our research we found an 11 years' teaching experience to be crucial, as after that point teachers' scores in the BioTSEB were not enhanced. An apparently perplexing finding was the fact that teachers possess a degree from a Pedagogical Academy – colleges of higher education offering 2-year courses, and which functioned in Greece before the establishment of University Departments of Education in 1982 – showed higher scores in the BioTSEB. This should be attributed to the fact that such teachers are older and equipped with more years of in-service experience than the rest of the teachers and is thus not to be put down to the quality of their studies. It is also not to our surprise that teachers who have been assigned to teach 5th and 6th grades obtained higher scores in the BioTSEB. This was expected as in these grades teachers have to deal with more complicated biological concepts than in the lower grades and this experience accounted for higher scores in their BioTSEB.

Greek teachers in our study evidently feel less efficient as concerns Pedagogical Content Knowledge and are less willing to teach biological concepts (factor PIW of the BioTSEB). They also feel less efficient in teaching concepts related to evolution, molecular biology and microbiology (factor EMM of the BioTSEB). This is totally expected for such a sub-group of Greek society, where teaching of evolution is almost non-existent. Indeed, various recent studies have stressed the low acceptance of evolution in the Greek society in general (Miller et al. 2006). The low degree of the teaching of evolution in the Greek educational system has also been pointed out (author's research under submission). Both Greek society and its educational system are interesting as regards their stance towards theories of biological evolution: the educational system has been very successful in totally extricating the teaching of evolution from the whole of its "terrain" without meeting any serious opposition. This has been "achieved" in two simple ways: a) the chapter(s) on evolution is/are always presented last in rank in all biology textbooks and b) evolution is not included in the teaching curriculum of all high school classes and is omitted from the university entrance exams (though school-year 2009-2010 did constitute an exception: on the occasion of "Darwin's Year", the theory of evolution became a component part of the 12th grade's curriculum). The result is that Greek society might be characterized as one of the least educated societies in the modern world, specifically as regards knowledge of evolution. Thus, it seems very much probable that this

lack of proper education may be related to the fact that Greek society possesses one of the lower positions on the acceptance scale of evolution proposed by Miller et al. (2006) – Greece being only a few notches above the USA and Turkey in rank.

On the other hand, Greek primary school teachers feel more self-efficient in teaching concepts that are related to plants, ecology and human biology. This is quite understandable given their training and educational backgrounds. Most of the Pedagogical Academies' curricula were placing emphasis on the teaching of human biology in the form of human anatomy. Meanwhile, in the course of the last decade, an emphasis has been placed on ecology and environmental education courses, in all Greek pre-service and in-service teachers' professional development programs. This seems to reflect on teachers' familiarity with such concepts and explains their reaching a relatively higher score on the PEHB subscale in our study.

Particularly impressive were the results regarding the BioTSEB and its relation to the type of courses that teachers have attended during their school-going years (Science vs Humanities). All teachers with a more scientific background received higher scores in their BioTSEB. Perhaps this is due to the fact that as pupils they entered universities already having a good cognitive background in the subject of biology. Personal convictions of adequacy have been shown to be positively influenced by an early acquisition of knowledge (Tschannen-Moran et al. 1998) and in-depth comprehension of the cognitive subject (Bleicher and Lindgren 2005; Tosun 2000). This is in accordance with our findings that the more biology courses teachers have attended the higher were their scores in the BioTSEB, indicating the importance of subject-specific training in teacher education programs, so that teachers can acquire an in-depth understanding of the key organizing principles of a particular subject (Bleicher 2007).

Nonetheless, more biology courses in teacher education programs may be important but not sufficient enough to improve teachers' self-efficacy beliefs in biology teaching. Our study revealed that science teaching courses are as important. This is very clearly reflected in Tables 1 and 3 of our study, where it is shown that although teachers feel quite confident in their knowledge of some of the main biological concepts – e.g., DNA, the gene, the chromosome – they seem to be reluctant and show low self-efficacy scores when it comes to helping students understand them. On the other hand, the more Science Teaching courses they have attended, the higher their feeling of efficiency. This, again, is in accordance with previous suggestions, i.e., that it is not so much a question of the number of courses a candidate teacher has attended during his/her studies but rather a question as to how such studies were carried out (Ashton 1984; Jarrett 1999), i.e., the extent to which students were encouraged to think critically, discuss and deepen in their perception of the object of their study. And as Labone (2004) suggests, personal convictions of self-efficacy of future teachers are positively influenced when they are given the chance to watch somebody teach. This is accomplished in Greece in most science teaching courses in Primary Education University departments.

Cocncluding, teachers' self-efficacy in biology teaching is important to explore as it may affect elementary science teaching such as science instruction time, students' achievement in science (Smolleck et al. 2006) and teachers' attitudes toward implementing new instructional practices (Ghaith & Yaghi 1997). Therefore, teachers' BioTSEB should be measured so as to have a clear picture of their self-efficiency beliefs in order that appropriate measures be taken where needed i.e. modification of teachers' educational programs. It would also be interesting to measure pre-service teachers' self-efficacy beliefs in biology teaching and compare them to those of in-service teachers. We believe that the BioTSEB can contribute to this field, always keeping in mind that we need focus on the creation of a self-confident teacher and not merely a self-confident person.

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Appendix. Factor structures and loadings of the 44 items of the BioTSEB.

ITEMS	F1	F2	F3	F4
Human digestive system[a]	0.82			
Connection between digestive and circulatory system[a]	0.81			
Respiration*	0.79			
Muscular system[a]	0.75			
Hearing[a]	0.74			
Connection between respiratory and circulatory system[a]	0.73			
Vision[a]	0.73			
Vertebrates[a]	0.73			
Wastes and recycling[a]	0.71			
Ecosystems[a]	0.70			
Human reproductive system[a]	0.69			
Blood[a]	0.59			
Transpiration[a]	0.57			
Photosynthesis[a]	0.56			
Food chain[a]	0.56			
Immunity[a]	0.54			
I wonder if I have the necessary skills to teach biology		0.75		
I understand biology concepts well enough to be effective in teaching elementary biology		0.75		
I find it difficult to explain to students why biology experiments work		0.73		
Given a choice, I would not invite the principal to evaluate my biology teaching		0.72		
Even when I try very hard, I don't teach biology as well as I do most subjects		0.69		
I know the steps necessary to teach biology concepts effectively		0.67		
I am not very effective in monitoring school biology experiments		0.67		
I am finding it hard to answer my students' questions regarding biology concepts		0.66		
It is hard for me to evaluate whether my students have understood the biology concepts I have taught them		0.60		
I would gladly accept to teach biology concepts to other school classes too, besides the class I am already teaching		0.60		
I am continually finding better ways to teach the biology concepts that are included in the curriculum		0.60		
Given my choice I would avoid teaching Science		0.57		
Since I was an elementary school student I used to be good in Science classes		0.56		
I generally teach biology concepts ineffectively		0.54		
Given my choice I would avoid teaching biology concepts		0.54		
I am typically able to answer students' biology questions		0.53		
I can apply innovative teaching methods in teaching biology concepts		0.50		
DNA[a]			0.85	
Gene[a]			0.83	
Chromosome[a]			0.83	
Natural Selection[a]			0.64	
Evolution[a]			0.64	
Infectious diseases[a]			0.49	
Microorganisms (useful and harmful)[a]			0.49	
When I teach biology concepts my students' interest is great				0.62
When a student has difficulty understanding a biology concept, I am usually at a loss as to how to help the student understand it better				0.56
When teaching biology, I usually welcome student questions				0.50
I don't know what to do to turn students on to biology				0.39

[a] These items were preceded by the phrase: "I have enough familiarity with the following biology concepts, functions or system concepts to feel confident to effectively teach them".