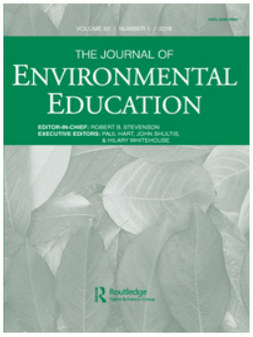

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RESEARCH ARTICLE

An education for sustainable development self-efficacy scale for primary pre-service teachers: construction and validation

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ABSTRACT

A scale was developed to assess primary school Teachers' Self-Efficacy on Education for Sustainable Development (TSESESD). It includes four domains of competences: values and ethics, systems thinking, emotions and feelings, and actions. The scale development is consistent with key principles of educational and social psychology research. Nine hundred twenty-four (924) primary education student teachers and 88 in-service primary teachers participated in the study. Findings demonstrated that TSESESD has good psychometric properties, strong validity and reliability scores, adequate internal consistency (Cronbach $\alpha = 0.97$), and satisfactory mean inter-correlation of items within domains (M = 0.78). TSESESD is considered a reliable instrument for teacher preparation programs aiming to develop primary school teachers' self-efficacy in ESD.

KEYWORDS

education for sustainable development; pre-service teachers; self-efficacy scale

Introduction

Our world is facing difficult challenges for current and future generations. Sustainable development seems to be the bridge, among environmental, economic, and social goals, between global north and south, among governments, civil society, and business, as well as between policy and action. Regarding the above, Education for Sustainable Development (ESD) is about "enabling citizens to constructively and creatively address present and future global challenges and create more sustainable and resilient societies" (UNESCO, 2018). Moreover, ESD emphasizes lifelong learning that empowers learners "to take informed decisions and responsible actions for the environmental integrity, economic viability and just society for present and future generations" (UNESCO, 2014b, p. 12). Environmental Education (EE) and ESD constitute an integral part of formal education, and the majority of teacher preparation university programs across the world encompass the ESD dimension into their curricula.

On the other hand, self-efficacy is one of the most influential factors of human behavior (Gardner & Pierce, 1998). In his social cognitive model, Bandura (1977, p. 3) defined self-efficacy as "an individual's confidence in her or his ability to organize and execute a course of action to solve a problem or accomplish a task." Moreover, several studies have demonstrated positive interrelationships between teachers' self-efficacy and higher levels of students' achievement and motivation as well as with teachers' instructional practices, enthusiasm, commitment, and job satisfaction (Caprara, Barbaranelli, Steca, &

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1. An English version of TSESESD can be obtained from http://www.felab.edu.uowm.gr/wp-content/uploads/2018/06/TSESESD_ENG.pdf.
2. The factor loadings from the explorative factor analysis can be obtained from http://www.felab.edu.uowm.gr/wp-content/uploads/2018/06/TSESESD_Factors-Loadings.pdf.

Malone, 2006; OECD, 2014; Tschannen-Moran & Barr, 2004). Self-efficacy beliefs have also been shown to motivate students' learning through goal setting, self-monitoring, self-evaluation, and use of learning strategies (Zimmerman, 2000).

In the present study, an effort is made to develop an instrument that produces valid and reliable data regarding Teachers' Self-Efficacy for ESD (TSESESD). This scale is based on the rationale that ESD teachers need to possess a set of competences to successfully fulfill their educational roles (e.g., planning of teaching, reflecting the educational work, visioning the profile and performance of school, and looking for partners outside the school) (Sleurs, 2008). Although the notion of competence is very complex, the CSCT project (curriculum, sustainable development, competences, teacher training) developed a coherent set of competences that can inspire teachers' training institutes aiming to integrate ESD into their curricula (Sleurs, 2008). This particular framework was used for the purpose of the present study through the adoption of four domains of competences: Values and Ethics, Systems Thinking, Emotions and Feelings, and Actions.

The goal of the present study was to develop a self-efficacy instrument for teachers regarding ESD that meets the following criteria:

- has strong psychometric properties relevant to educational tests and survey instruments,
- is appropriate for both pre-service and in-service primary school teachers, and
- is comprehensive in nature, encompassing the current trends of ESD competences and self-efficacy.

Assessment and evaluation are essential components of any educational plan, so, such an instrument could be valuable in helping universities and teacher educators worldwide to assess teachers' self-efficacy in ESD, thus facilitating and improving the effectiveness of respective teachers' preparation and professional development programs.

Background and literature review

Education for sustainable development

ESD, bearing the pedagogical heritage of EE, has become one of the most promising and emerging priorities of our day (Wals, 2012). Major international meetings for sustainable development, such as the recent UN Conference on Sustainable Development (UN, 2012) as well as those focusing on ESD (e.g., UNESCO, 2014a), recognize the potential of ESD to empower people to transform themselves and the society they live in by developing knowledge, skills, attitudes, and competences toward a sustainable future. Within this context, the role of educators is crucial, as they are in the best position to provide their students with the appropriate sustainability concepts and competences (UNESCO, 2005a). Over the past decades, several organizations and researchers have developed frameworks of environmental literacy or eco-literacy to address these challenges sufficiently (e.g., Hollweg et al., 2011; McBride, Brewer, Berkowitz, & Borrie, 2013; NAAEE, 2004). Furthermore, several teacher preparation programs or program models have been organized aiming to meet ESD requirements (e.g., UNESCO, 2005b; UNESCO, 2010). Such initiatives either focus on teachers and student teachers who already have an interest in sustainability or attempt a comprehensive inclusion of ESD within pre-service teachers' education.

Existing literature in ESD competences suggests that ESD theoretical framework needs to become more alive and integrated within the existing teacher education curriculum in order to promote the awareness and development of ESD competences among student teachers (Cebrián & Junyent, 2015). In addition, there have been recommendations and calls for initial teacher-education institutions to integrate ESD competences into their programs (UNECE, 2012).

Self-efficacy

Based on Bandura's (1977) social learning theory, his cognitive model of self-efficacy is defined as "beliefs in one's capabilities to organize and execute the courses of action required to produce given

attainments" (p. 3). Teachers' efficacy became known as a judgment of teachers' capabilities to bring about desired outcomes or a capacity to influence learning (Klassen, Tze, Betts, & Gordon, 2011). Self-efficacy encompasses two components, i.e., the beliefs in one's ability to successfully perform the behavior (efficacy expectation), and that the performance of the behavior will have a desirable outcome (response–outcome expectancy) (Moseley & Taylor, 2011). Moreover, there is a distinction between self-efficacy for performance (e.g., "I already know how to do this") and self-efficacy for learning (e.g., "I can learn this if I put my mind to it") (Ormrod, 2012). The former (self-efficacy for performance) is more in-line with the current ability levels of upper level pre-service teachers and in-service teachers to teach ESD topics. On the other hand, the self-efficacy for learning is more relevant to the entry-level pre-service teachers as they must realize ESD theory and praxis. In the present study, the emphasis is mainly on self-efficacy for performance, as the present abilities of pre-service and in-service teachers to teach ESD are explored. Generally, self-efficacy is one of the most powerful motives of behavior, as it has a strong relationship with the decision to perform a task, the amount of effort to be expanded and the level of persistence (Gardner & Pierce, 1998). Although self-efficacy beliefs affect all aspects of social life, in the present study, they are considered through teachers' practice in ESD.

A teacher needs two resources to perform any task successfully; the requisite skill or knowledge and self-efficacy (Bandura, 1997). Self-efficacy appears to have an impact on the individuals' learning. Teachers with high teaching self-efficacy tend to explore more alternative methods of instruction, to seek improved teaching methods, and to experiment more extensively with instructional materials. In addition, teachers possessing high self-efficacy have been found to exhibit higher levels of professional commitment, to produce higher students' achievement across a range of academic subjects, and, finally, teachers' self-efficacy has important implications for overall school effectiveness (Bray-Clark & Bates, 2003). The literature indicates interesting associations of self-efficacy with various aspects of knowledge, such as conceptual understanding (Bleicher & Lindgren, 2005), alternative conceptions (Schoon & Boone, 1998), science content knowledge (Lloyd et al., 1998), understanding of science content and/or science teaching strategies (Palmer, 2006), web pedagogical content knowledge (Lee & Tsai, 2010) or pedagogical content knowledge related to EE (Kennelly, Taylor, & Maxwell, 2008). Content Knowledge (CK) refers to teachers' deep understanding of the subject matter taught at school. Shulman (1986) identified the Subject Matter Knowledge (SMK) and the Pedagogical Content Knowledge (PCK) as two major components of teachers' knowledge necessary for teaching. PCK is about teachers' understanding and enactment of how to help a group of students understand specific subject matter using multiple instructional strategies, representations, and assessments while working within the contextual, cultural, and social limitations in the learning environment (Park & Oliver, 2008). Scholars tend to agree on three primary components of PCK: knowledge of subject matter or content, knowledge of pedagogy and knowledge of context including prior student knowledge and the environment of instruction (Otto & Everett, 2013). According to the same authors, the teacher's efficacy is an affective affiliate of PCK.

However, with regard to knowledge, literature makes a distinction between perceived and actual knowledge (Effeney & Davis, 2013; Martinussen, Ferrari, Aitken, & Willows, 2015). These two dimensions may be differently linked with self-efficacy. Especially in ESD, Effeney and Davis (2013) note that although self-efficacy of pre-service primary school teachers increases with increased levels of perceived knowledge, perceived and actual knowledge may have no relationship. They also argued that a low level of sustainability content knowledge is logically followed by a dearth in pedagogical content knowledge.

In the present study, along with student teachers' self-efficacy in ESD, we came to a methodological decision to explore their perceived Content Knowledge (pCK) (or perceived Subject Matter Knowledge—pSMK) and perceived Pedagogical Content Knowledge (pPCK) as well. Although the perceived knowledge is a "softer measure" of knowledge than actual knowledge, and conceptually is more relevant to self-efficacy as tends to reflect teachers' confidence in what they know and are able to do, we did not include it in the self-confidence scale. Our decision was mostly based on the founding description of social cognitive theory (Bandura, 1989) where knowledge (along with other cognitive factors) interact with environmental and behavioral factors (e.g., self-efficacy) to influence human behavior.

Scales on self-efficacy

Self-efficacy is among the most influential factors affecting teachers' ability to implement ESD (Moseley, Huss, & Utley, 2010; Moseley, Reinke, & Bookout, 2002). Due to its significance in teachers' professional development, several widely accepted scales assessing science teachers' self-efficacy have been developed (i.e., STEBI-A and STEBI-B, STEBI-CHEM, MTEBI, SETAKIST) (Hoy & Davis, 2006; Tschannen-Moran & Hoy, 2001), all stemming from the initial instrument (STEBI, Enochs & Riggs, 1990).

The Environmental Education Efficacy Belief Instrument (EEEBI), the only instrument created in the context of EE (Sia, 1992), has also been developed by modifying the STEBI–B, and has been used in various studies (e.g., Moseley et al., 2010; Moseley et al., 2002; Gardner, 2009). It contains 23 Likert-type questions and measures both the Personal Environmental Teaching Efficacy (PETE) and the Environmental Teaching Outcome Expectancy (ETOE). Moreover, Moseley and Taylor (2011) modified the EEEBI, the STEBI and two factors from the Ohio State Teacher Efficacy Scale (OSTES) (Tschannen-Moran & Hoy, 2001) to create the Environmental and General Science Teacher Efficacy Assessment (EGSTEA) that aims to examine both environmental and general science efficacy. Based mainly on the above instruments, there are certain studies (e.g., Moseley et al., 2010) suggesting that teachers do not feel particularly capable of implementing EE due to the lack of appropriate preparation and training. On the other hand, some research (e.g., Moseley et al., 2002) indicates that teachers do possess high environmental education teaching self-efficacy, even prior to an environmental education teaching experience; however, this experience resulted in a reevaluation of their teaching ability as they learned more about teaching methodologies needed to teach EE/ESD issues effectively.

Earlier studies of EE in teacher preparation programs concluded that pre-service teacher education institutions in the USA were not systematically preparing future teachers to effectively teach EE (McKeown-Ice, 2000) and suggested that EE should not be viewed as an "add on," but needs to be an explicit component of the existing courses (Heimlich, Braus, Olivolo, McKeown-Ice, & Barringer-Smith, 2004). Furthermore, Evans, Stevenson, Lasen, Ferreira, and Davis (2017) argue that, even though sustainability may be mandated within school curricula, sustainability education is not a mandated component of initial teacher education or teacher professional standards in most countries. There are, however, several initiatives seeking to re-orient pre-service teacher education toward environmental sustainability (Ferreira, Ryan, & Tilbury, 2014), and, regardless of the success of such initiatives, thousands of future teachers all over the world are being prepared to implement school EE/ESD.

Therefore, the progress of EE and the emergence of ESD necessitate the development of a new instrument that will be specially focused in ESD and on pre-service and in-service primary school teachers' self-efficacy. Actually, Sia's (1992) EEEBI scale resulted from a direct transformation of STEBI-B, where the term "environmental education" just replaced the term "science," since it was considered that environmental education is mostly based on science education (Moseley et al., 2010). In this case, the pedagogically innovative characteristics of ESD are not included in EEEBI, as this scale covers general aspects of the teaching process without paying attention to critical methodological elements of ESD, such as the holistic and interdisciplinary approach, critical and systems thinking, dealing with values, fostering of action competence, and so on. Furthermore, the emphasis within ESD on socio-economic and political dimensions of environmental and other sustainability issues and the need to invest on relevant methodological approaches to deal with these dimensions are distant from the rational of EEEBI.

Methodology

The instrument development framework

For the needs of the present study, we developed the "Teachers Self-Efficacy Scale for Education for Sustainable Development" (TSESESD). A review of the literature in theoretical and applied studies in Science Education, EE/ESD (e.g., Hollweg et al., 2011; Nolet, 2009; Sia, 1992; Sleurs, 2008; Warren, Archambault, & Foley, 2014) provided the basis for developing our conceptual framework; teachers' ability in ESD includes five domains of competences: (a) knowledge, (b) values and ethics, (c) systems thinking, (d) emotions and feelings, and (e) actions. Traditionally, the concept of competence was

restricted to the cognitive and/or psychomotor domains focusing on knowledge and skills, but OECD (2002) introduced a broader framework to deal with competences. This framework incorporates not only knowledge, cognitive, and practical skills, but also social and behavior components (i.e., abilities, motivations, emotions, and values) because it seems there is a complex relationship between knowledge and self-efficacy (Bleicher & Lindgren, 2005).

On the other hand, conceptual understanding may be a predictor of self-efficacy development and vice-versa or both constructs are coevolving. According to Pajares (2002), this is the chicken-or-egg quandary that has been discussed in the self-efficacy literature and is rather unlikely to be resolved due to the reciprocal relationship between motivation and human performance.

As knowledge aspects are related to but not included in the self-efficacy construct, in the present study, only the remaining four domains of teachers' competences in ESD were encompassed in TSESESD. However, as competent functioning requires harmony between self-beliefs on the one hand, and possessed skills and knowledge on the other hand (Pajares, 2002), this study also investigated whether student teachers believe they possess sufficient CK (i.e., perceived content knowledge) relevant to particular ESD concepts and issues (e.g., the greenhouse effect, energy footprint, etc.). Furthermore, student teachers' perceived PCK is investigated, specifically concerning pedagogical components of ESD. In addition to the PCK topics suggested in the literature (Sleurs, 2008), items were embedded to emphasize three more dimensions, those of interdisciplinarity, ESD curricula, and evaluation, in that way making the particular perceived PCK approach more content-specific and relevant to the national context (2015).

Items were developed from scratch following the guidelines of Bandura (2006) for self-efficacy scale development as well as the instructions provided by McCoach, Gable, and Madura (2013) for the development of measures of affective constructs. During the development of the scale, only items related to the "teacher as an individual" dimension were included, whereas dimensions considering him or her as a member of the educational community or as a member of the society were excluded (Sleurs, 2008). On that point, two rounds of pilot tests were prepared and administered to participants: (a) the *item pilot*, used to select appropriate survey items from an initial item pool that would be suitable for the final instrument (see Malandrakis et al., 2016); and (b) the *instrument pilot*, conducted to evaluate overall performance of the set of items retained from the item pilot and to examine the instrument's overall reliability and validity (DeWaters, Qaqish, Graham, & Powers, 2013). Each item in TSESESD can be considered as a separate objective and learning outcome in ESD, corresponding to a relevant dimension of ESD self-efficacy, whereas each domain is treated as a relatively distinct psychological construct, with some of them being narrower or broader than others.

Participants

The present study was conducted with a group of student teachers attending three Primary and one Early Childhood Education Departments placed at three universities of Northern Greece: University of Western Macedonia (UWM, $n = 333$), University of Ioannina (UOI, $n = 316$), and Democritus University of Thrace (DUTH, $n = 275$). In Greece, the training of pre-service primary education teachers is carried out in four-year university training programs preparing professionals as generalist teachers with no subject specialization, graduating with a bachelor of education degree and a teaching certificate, which constitute them eligible to teach in grades K–6 (5 to 12 years old) (Mogias, Boubonari, Markos, & Kevrekidis, 2015).

Our research employed a stratified random sampling method to select the participants from lists of currently enrolled students layered by year of study. The final sample consisted of 924 primary school ($n = 804$) and early childhood student teachers ($n = 120$). A distinction was further made between the first-year students (hereafter referred to as "entry level" students, $n = 315$) and the seniors (hereafter referred to as "exit level" students, $n = 609$). Females constituted 86.9% of the participants ($n = 803$); this proportion reflects the average gender distribution of the pre-service primary teacher population in Greek education departments (Mogias et al., 2015). In addition, a convenient sample of 88 in-service teachers was used for the needs of the present study.

Background factors

The instrument also included questions about students' course specialization in high school and the frequency of information sources used about general environmental issues (Table 1).

Data collection and analysis

Participants were informed about the purpose of the study and the voluntary basis of participation. Questionnaires were administered in the classroom during a lecture period in the winter semester of the 2014–2015 academic year. In the revised item pool (*instrument pilot*), participants were asked to indicate their degree of agreement on a 7-point Likert scale. Their answers converted to numerical values according to a predetermined preferred direction of response, with values ranging from 1 ("*not at all*"/"*not sure at all*") to 7 ("*very good*"/"*absolutely sure*"); lower-scale scores indicated lower students' self-efficacy and vice-versa. Data analysis involved the following three steps: in the first step, descriptive statistics were applied to portray mean values (± standard deviations) of the 24 self-efficacy and 31 perceived knowledge items. The second step referred to the instrument validation measurement techniques, and the final step involved regression coefficients to determine probable perceived knowledge effect on TSESESD scores as well as correlation coefficients and one-way ANOVA to further investigate possible statistical differences between sample groups and probable effects of background factors on students' self-efficacy. For all significant testing the limit of 5% ($p \leq 0.05$) was set. Statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) v.19.

Instrument validation

TSESESD was examined for face and content validity, specifically in terms of content clarity, language, difficulty, and relevance to the construct (Malandrakis et al., 2016). Moreover, a panel of five in-service primary education teachers, with a minimum of a decade of classroom experience and familiarity with ESD, were asked to fill in the questionnaire and to put a cross against the items they did not recognize and/or understand. Unclear items were thus reworded (six items). For checking if the students' self-efficacy scale leads to consistent measurement results, we conducted a reliability analysis for the scale and for each of the four domains (Table 2). Data revealed high internal consistency of the entire scale (Cronbach alpha: 0.967; 24 items), whereas each domain also demonstrated high internal consistency (coefficients ranged from 0.853 up to 0.935).

To examine the construct validity and factor structure of the instrument, additional procedures were adopted from prior research (e.g., DeWaters et al., 2013; Leeming et al., 1995); developmental-age progression comparisons, contrasted-group comparisons, and exploratory factor analysis, which further explored the dimensionality of the instrument under study (DeWaters et al., 2013; Fabrigar, Wegener, MacCallum, & Strahan, 1999). More specifically, developmental-age progression validity refers to the

Table 1. Greek pre-service teachers' ratings of information sources as contributors to their knowledge of general environmental issues.

Information source	M	SD
Internet	4.12	0.95
TV	3.59	1.04
Friends	3.12	1.09
Family	3.06	1.11
Newspapers/Journals	2.79	1.12
Specialized books	2.34	1.19
Specialized journals	2.14	1.13
Non-Governmental Organizations	2.14	1.16
Radio	2.04	1.08
Seminars	1.91	1.11
Total	**2.73**	**0.74**

Table 2. Statistics of the domains of self-efficacy (TSESESD) and perceived Knowledge scales.

	Items	Range	Mean	*SD*	Cronbach α	Mean entry-level pre-service teachers (±*SD*)	Mean exit-level pre-service teachers (±*SD*)	Mean in-service teachers (±SD)
TSESESD								
Values and Ethics	6	1–7[1]	4.61	1.19	0.906	4.30 (±1.30)	4.70 (±1.12)*[2]	5.06 (±0.95)*[3]
Systems Thinking	5	1–7	4.35	1.18	0.888	4.13 (± 1.30)	4.43 (±1.14)*	4.58 (±0.84)*
Emotions and Feelings	3	1–7	4.60	1.19	0.853	4.34 (±1.28)	4.69 (±1.14)*	4.97 (±0.98)*
Actions	10	1–7	4.35	1.10	0.935	4.20 (±1.24)	4.40 (±1.05)	4.51 (±0.85)
Total	**24**	**1–7**	**4.48**	**0.15**	**0.967**	**4.24 (±0.10)**	**4.56 (±0.16)**	**4.78 (±0.28)**
Perceived Knowledge								
Content Knowledge	14	1–7	4.12	0.98	0.894	3.83 (±0.95)	4.22 (±0.96)*	4.50 (±0.96)*
Pedagogical Content Knowledge	17	1–7	4.22	1.09	0.951	3.86 (±1.12)	4.34 (±1.05)*	4.77 (±0.85)*
Total	**31**	**1–7**	**4.17**	**0.07**	**0.953**	**3.85 (±0.02)**	**4.28 (±0.08)**	**4.64 (±0.19)**

[1] 1 = "not sure at all" to 7 = "absolutely sure."
[2] Significant differences between entry and exit level of pre-service teachers for the total sample.
[3] Significant differences between exit level of pre-service teachers and in-service teachers.
* $p \leq 0.05$ ($p \leq 0.0125$ for Self-efficacy domains, and $p \leq 0.025$ for perceived Knowledge domains, respectively after Bonferroni correction).

comparison of mean scores between different age groups (e.g., Leeming et al., 1995); in our case we would expect that pre-service teachers in their last year of attendance at the university to score higher in all four domains of the scale, as a result of their involvement in the departments' programs. Contrasted-group validity refers to the comparison of mean scores between two different groups, one of which, the "known group" is expected to be more content literate and possess greater self-efficacy scores. Validity of the scale would be supported if the "known group" achieved higher scores in relation to our student population (Benson & Clark, 1982); in our study, a sample of 88 in-service teachers comprised the contrasted group. Finally, Exploratory Factor Analysis (EFA) using Principal Component Analysis (PCA) and orthogonal varimax rotation was used to further examine the instrument's construct validity and dimensionality. In addition, Kaiser-Meyer-Olkin measure and Bartlett's test of sphericity were applied to indicate sampling adequacy. Factor analysis would be expected to distinguish the four domains of the scale. The final step of the analysis involved the investigation of the correlation between TSESESD scale and knowledge, aiming to further explore possible effects of students' knowledge on their self-efficacy.

Results

Background data and information sources on environmental issues

Almost 84% of the participants attended humanities courses during their final year in high school (grade 12) for their entry examinations in the tertiary education level, whereas those who preferred technological and science courses were extremely few (8.8% and 7.7%, respectively). In terms of informal ESD, the Internet scored highest as the students' primary information source on general environmental issues (4.12 on a 5-point scale), followed by TV broadcasting, friends, and family, whereas radio and seminars had the lowest scores. The ratings of information sources as contributors to participants' knowledge of environmental topics are illustrated in Table 1.

Descriptive statistics

Pre-service teachers were found to possess moderate efficacy scores, slightly above the balance point of the 7-point Likert scale (mean value 4.48, $SD \pm 0.15$), ranging between 4.35 and 4.61 (Table 2). More specifically, the domain of "Values and Ethics" (six items), and "Emotions and Feelings" (three items) displayed the highest mean values (4.61, $SD \pm 1.19$ and 4.60, $SD \pm 1.19$, respectively), whereas the domains of "Systems Thinking" (five items) and "Actions" (10 items) the lowest scores (4.35, $SD \pm 1.18$, and 4.35, $SD \pm 1.10$, respectively) (Table 2).

Regarding the respective perceived Knowledge scores (Table 2), students exhibited the highest mean score in the perceived Pedagogical Content Knowledge (4.22, $SD \pm 1.09$), followed by perceived Content Knowledge (4.12, $SD \pm 0.98$), resulting in a mean perceived Knowledge score of 4.17 ($SD \pm 0.07$). Furthermore, descriptive statistics for each University are presented in Table 3. Student teachers from UWM and UOI shared the highest mean entry-level scores among the three universities. At the exit level, students of UWM had the highest mean scores in all domains. In respect of perceived Knowledge scores, students from UOI had the highest mean entry-level score in perceived CK, whereas UWM students scored highest in perceived PCK at the exit level.

Independent *t*-tests between the entry and exit level within each university were applied, and the interpretation of results was adjusted using the Bonferroni correction procedure to control the familywise error rate. These results showed statistical differences mainly for UWM and, to a lesser extent for DUTH in both TSESESD and perceived Knowledge scales, while that was not the case for UOI (Table 3). One-way ANOVA showed a statistical difference between students of the three academic institutions regarding both self-efficacy ($F(2, 921) = 7.980$, $p = 0.000$) and total perceived Knowledge ($F(2, 921) = 18.153$, $p = 0.000$). On the other hand, post hoc analysis revealed no statistical difference between DUTH and both other universities ($p = 0.093$ for UWM and $p = 0.193$ for UOI) in relation to self-efficacy, and DUTH and UOI ($p = 0.387$) regarding total perceived Knowledge.

TSESESD validity

Independent *t*-tests were performed between students' entry and exit level (developmental-age progression validity) and between pre-service and in-service teachers (contrasted-group validity) in self-efficacy and perceived Knowledge scales, to examine the construct validity of the proposed scale (Table 2). In both analyses statistical differences were detected in three out of four domains in favor of the expected groups ($p \leq 0.0125$ after Bonferroni correction, Table 2). Moreover, students' exit level of perceived CK and perceived PCK scores were significantly higher than those of the entry level, as was the case with in-service teachers' in relation to the exit-level students ($p \leq 0.025$ after Bonferroni correction, Table 2).

Exploratory Factor Analysis (EFA) using Principal Component Analysis (PCA) and orthogonal varimax rotation was performed to determine the structure of correlations among the items in the instrument. The Kaiser-Meyer-Olkin (KMO) measure was 0.964, indicating the data were sufficient for EFA. The Bartlett's test of sphericity [$\chi^2(276) = 19273.957$, $p \leq 0.001$] showed patterned relationships between the items. Using an eigenvalue >1.0, there were four factors which explained a cumulative variance of 72.58%. Examination of the scree plot suggested the retention of these factors. Items of the domains "Values and Ethics," "Actions," and "Emotions and Feelings" presented a rather clear factor loading on three distinct factors. However, of the items in the "Systems Thinking" domain, three were assigned to this fourth factor on the basis of the second highest factor loading (i.e., rather than the highest factor loading), largely because these two factor loadings were very similar and there was a clearer conceptual relevance with the particular factor.

Relationships of self-efficacy scores with perceived knowledge

Table 4 describes the inter-correlations within the domains of TSESESD and perceived Knowledge as well as between these two scales. The inter-correlation among TSESESD domains was ranged between 0.71 and 0.83, resulting in a mean value of 0.78 ($SD \pm 0.04$), whereas in the perceived Knowledge scale it was ranged from 0.68 to 0.94, with a mean value of 0.84 ($SD \pm 0.11$). All these correlations were significant in nature. In addition to this, a strong correlation was identified between TSESESD and perceived Knowledge (0.827), which also is significant at the $p \leq 0.01$ level further providing a basis for the validity of the scale.

Beyond inter-correlations among domains, regression analysis was performed to determine the effect of the perceived Knowledge domains in TSESESD scores. Analysis revealed that 75% of the observed variance (R^2=0.752) in students' self-efficacy scores is explained through perceived Knowledge, indicating

Table 3. Distribution of self-efficacy and perceived Knowledge scores among Universities and level of study ($N = 924$).

	University of Western Macedonia ($N = 333$)			University of Ioannina ($N = 316$)			Democritus University of Thrace ($N = 275$)		
	Entry level ($n = 146$)	Exit level (n = 187)		Entry level ($n = 115$)	Exit level ($n = 201$)		Entry level ($n = 54$)	Exit level (n = 221)	
	mean (±SD)	mean (±SD)	*t*-value (*p*)	mean (±SD)	mean (±SD)	*t*-value (*p*)	mean (±SD)	mean (±SD)	*t*-value (*p*)
TSESESD									
Values and Ethics	4.44 (±1.26)	5.04 (±1.03)	−4.740 (.000)*[1]	4.25 (±1.37)	4.44 (±1.10)	−1.385 (.193)	4.02 (±1.22)	4.65 (±1.13)	−3.600 (.000)*
Systems thinking	4.12 (±1.26)	4.71 (±1.09)	−4.583 (.000)*	4.23 (±1.37)	4.23 (±1.09)	−0.004 (.997)	3.96 (±1.22)	4.38 (±1.17)	−2.319 (.021)
Emotions & Feelings	4.46 (±1.28)	4.92 (±1.14)	−3.395 (.001)*	4.27 (±1.35)	4.38 (±1.11)	−0.739 (.484)	4.12 (±1.10)	4.78 (±1.10)	−3.905 (.000)*
Actions	4.19 (±1.23)	4.75 (±1.02)	−4.576 (.000)*	4.29 (±1.28)	4.09 (±0.98)	1.560 (.148)	4.04 (±1.19)	4.38 (±1.06)	−2.037 (.043)
Perceived Knowledge									
Content Knowledge	3.85 (±0.93)	4.70 (±0.97)	−8.075 (.000)*	3.89 (±0.97)	4.03 (±0.84)	−1.413 (.159)	3.69 (±0.99)	3.98 (±0.91)	−2.054 (.041)
Pedagogical Content Knowledge	4.01 (±1.13)	4.74 (±1.02)	−6.231 (.000)*	3.77 (±1.10)	4.02 (±0.97)	−2.090 (.045)	3.65 (±1.11)	4.28 (±1.04)	−3.956 (.000)*

[1] Significant differences between entry and exit level of pre-service teachers within the same university.

* $p \leq 0.05$ ($p \leq 0.0125$ for Self-efficacy domains, and $p \leq 0.025$ for perceived Knowledge domains, respectively after Bonferroni correction).

Table 4. TSESESD and its subdomains inter-correlations with perceived Knowledge and its subdomains.

Spearman's rho	1	*1.a*	*1.b*	*1.c*	*1.d*	2	*2.a*	*2.b*
1. Self-Efficacy		0.905**	0.927**	0.853**	0.951**	0.827**	0.615**	0.866**
1.a Values and Ethics			0.808**	0.714**	0.781**	0.797**	0.591**	0.836**
1.b Systems Thinking				0.788**	0.827**	0.766**	0.572**	0.801**
1.c Emotions and Feelings					0.762**	0.664**	0.471**	0.711**
1d. Actions						0.770**	0.580**	0.801**
2. Total perceived Knowledge							0.888**	0.942**
2.a CK								0.681**
2.b PCK								

*$p \leq 0.05$;
**$p \leq 0.01$;
***$p \leq 0.001$.

a rather strong association and dependence of their self-efficacy scores in ESD with the respective perceived Knowledge in the same field.

Relationships of self-efficacy scores with background factors

No significant differences were found between the participants' self-efficacy and high school course specialization ($F(2, 921) = 0.492$, $p = 0.612$), whereas there appeared to be a significant difference ($p \leq 0.05$) regarding all the information sources. The effect size of these differences varied between η^2=0.064, and η^2=0.055 for family, Internet, and seminars, and η^2=0.018 and η^2=0.017 for radio and TV, respectively.

Discussion and conclusions

During the past three decades, Education for Sustainable Development has systematically been introduced into school curricula around the world providing students with the opportunity to acquire knowledge and develop competences to deal with complex environmental and sustainability issues. University training programs all over the world have already started to prepare primary and secondary student teachers to effectively implement ESD. Regarding traditional disciplines of sciences, humanities, and social sciences, future teachers need to possess rather concrete sets of knowledge and teaching strategies. However, in the context of ESD, they usually must deal with abstract concepts and complex issues including interrelated environmental, socioeconomic and political dimensions as well as to implement open curricula from scratch. In this realm, they also must apply pedagogical strategies favoring interdisciplinary approaches to learning and to develop advanced competences, such as critical and systems thinking, action competence and citizenship. Therefore, to become effective ESD teachers and student teachers need to develop the ability to combine knowledge and approaches deriving from different disciplines (e.g., from sciences and humanities); they also need to critically analyze the essence of different social-environmental concepts and processes to understand the root causes of sustainability issues and discern alternative practices to address them. Eventually, they must be prepared to deal with uncertainty. Therefore, CK and PCK of ESD are rather wider and more difficult to deal with than those of the traditional disciplines.

The self-efficacy instrument proposed by this study (TSESESD) encompasses a coherent set of competences needed for a teacher to be able to fulfill his or her pedagogical role effectively (Sleurs, 2008). Although we acknowledge that perceived knowledge is a "softer measure" of knowledge than actual knowledge, TSESESD was examined for validity along with student teachers perceived CK and PCK as these two parameters are closely associated with self-efficacy. Analysis indicated that TSESESD has good psychometric properties, accompanied by strong validity and reliability scores. The scale can be used to assess ESD primary school student teachers' (or teachers') self-efficacy, since all tests confirmed its validity. The independent *t*-tests, examining developmental progression validity and the contrasted groups' validity, produced several statistically significant differences between entry and exit level students, and between pre-service and in-service teachers. Moreover, the results of the Exploratory Factor Analysis confirmed the existence of the domains used in the present study. It should also be emphasized that the

analysis revealed a rather strong dependence of self-efficacy beliefs on perceived Knowledge, supporting the studies that suggest associations between these two parameters (e.g., Effeney & Davis, 2013).

In terms of ESD self-efficacy beliefs, the Greek student teachers achieved moderate scores, which is in line with the findings of Saribas, Teksoz and Ertepinar (2014) and Gardner (2009), with Turkish and American pre-service teachers respectively. On the other hand, Effeney and Davis (2013) and Boon (2011) reported high confidence scores in Australian pre-service teachers' abilities to engage with education for sustainability, whereas Moseley et al. (2003, 2002) also noted high initial environmental self-efficacy scores for American elementary pre-service teachers, which, although they remained unchanged by the training and teaching experience, dropped significantly seven weeks after teaching. In another study, Moseley et al. (2010), also reported increased EE teaching self-efficacy scores for K–12 teachers after their participation in a two-week intensive summer course.

However, in the previous studies, the research tools used, such as the EEEBI (Gardner, 2009; Moseley et al., 2002, 2003, 2010) or other specially developed scales (Boon, 2011; Saribas et al., 2014) are radically different from TSESESD. The scores from the previous studies are not directly comparable with those of the present study, as they originate from assessment tools having quite different theoretical frameworks, domains, structures, and focus areas from TSESESD.

Another interesting finding is that the domains of competences mostly associated with the affective domain of learning, that is "Values and Ethics," "Emotions and Feelings," displayed the highest scores, whereas those related to ultimate pedagogical goals of ESD, (i.e., "Systems Thinking" and "Actions"), displayed the lowest scores. It is obvious that room exists for improving the pedagogical approaches used by the University Departments of Education, so that action competence (Jensen & Schnack, 1997) and the relevant self-efficacy belief can be developed. The other findings of this research are expected, for example, the low general System Thinking score, given the difficulty of this concept and students' lack of experience in ESD. In terms of perceived Knowledge, future teachers scored slightly higher in perceived PCK than in perceived CK. However, the scores of both these domains were moderate, suggesting reflection on the teaching strategies being used to clarify sustainability concepts and reinforce student teachers' pedagogical beliefs.

The recorded moderate self-efficacy student teachers' beliefs to teach ESD issues seems to be based mainly on their feeling that the pedagogy they possessed is sufficient to deal with these issues. Given that none of the student teachers had prior experience with ESD, this outcome seems to be in line with Moseley et al.'s (2002) findings that teachers have high EE teaching self-efficacy, at least prior to an environmental education teaching experience and before they reevaluate their teaching ability as a consequence of this experience. These findings also suggest that student teachers are not sufficiently aware regarding the inherent complexity of sustainability issues per se; consequently they are not informed about the variety of teaching methods and techniques needed and used in ESD. In addition, the pedagogical characteristics of ESD are consistent with open curricula, both in school and in teacher-training institutions. However, the openness of the curricula and the freedom of planning the educational process suggest the need for well-trained practitioners who possess the appropriate competences and feel able to implement them. Thus, regardless of how ESD teacher training courses are planned, educators need an integrated instrument to assess the extent to which future teachers feel able to plan and implement ESD curricula and relevant educational activities and projects. The validation of TSESESD suggests that this instrument can meet this need.

It should be mentioned that the nonexistence of significant increase of self-efficacy scores at the exit level of the pre-service teachers in one of the participating universities (i.e., Ioannina) is likely because during their studies these (exit-level) students attended a quite different curriculum focusing more on geographical education rather than in ESD. This finding suggests the reconstruction of teacher preparation programs in order to integrate ESD concepts and its pedagogical principles more effectively, without downgrading other relevant educational fields. However, the deeper exploration and explanation of the differences between the universities' scores was beyond the scope of the present study.

To address the limitation posed by the country-specific nature of the present study, and aiming to strengthen the generalizability of TSESESD, along with the content and construct validity as shown earlier and the relationship between shelf-efficacy and perceived Knowledge scales, future research should

include the implementation and testing of the particular instrument in other national and cultural settings (cross-cultural validity). In addition, the use of TSESESD for the assessment of long-term in-service teachers' training programs in ESD could also support its validity. It would be also interesting for future research to deal with another limitation of this study, i.e., the examination of possible differences between perceived and actual knowledge. In this context, correlations should be made between the results of the perceived Knowledge measure of this study and other valid environmental/eco-literacy scales. Although Knowledge measures do not constitute an integral part of the TSESESD, such correlations would substantially benefit the validation and utility of our proposed perceived Knowledge measure.

In conclusion, teachers' education in ESD has already made significant progress at the international level. Many universities have integrated innovative curricula, anticipating the comprehensive preparation of teachers to implement ESD. TSESESD, based on a comprehensive competences' framework (Sleurs, 2008), can be a useful tool for improving ESD teachers' education.

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