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# Exploring pre-service teachers' self-efficacy, content knowledge, and pedagogical knowledge concerning education for sustainable development

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**ABSTRACT**

The current study utilized a pre-and post-intervention design to assess pre-service teachers' self-efficacy, perceived content knowledge, and perceived pedagogical knowledge before and after a teaching practicum in the Pakistani context. The data were collected in two phases. In the pre-practicum phase, data were collected from 419 pre-service teachers enrolled in B. Ed, M. Ed, and MA Education programs to assess the general level of self-efficacy for teaching ESD-related concepts, their perceived content knowledge, and perceived pedagogical knowledge concerning ESD. In the post-practicum phase, the data were collected from 215 participants who participated in the first phase and consented to participate in the second phase. One-way ANOVA, Independent sample t-test and paired sample t-test were utilized for data analysis. Results suggest significant differences in pre-service teachers' self-efficacy based on the university, program, and age. Similarly, a difference was found between pre-service teachers' perceived content knowledge based on the university they were enrolled in. The difference in pedagogical knowledge was also found based on university and gender. Further, the post-practicum analysis suggests a significant difference in pre-service teachers' self-efficacy, perceived content knowledge, and pedagogical knowledge after undergoing a teaching practicum. Conclusion, limitations, and recommendations are provided at the end of the paper.

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Self-efficacy; content knowledge; pedagogical knowledge; education; sustainable development; teacher education; sustainability education

## 1. Introduction

Researchers around the world have raised concerns regarding the preparation of prospective teachers in the field of environmental education and education for sustainable development (ESD) (Gansle, Noell, and Burns 2012; Kennelly, Taylor, and Maxwell 2008; McKeown and Hopkins 2003). The contemporary social, economic, and environmental issues and the literacy demands necessitate that pre-service teachers leave teacher education programs as an effective and efficacious teacher (Leader-Janssen and Rankin-Erickson 2013; Singer-Brodowski 2017). The United Nations (UN) has also recognized and emphasized the importance of teacher education in attaining a sustainable future (UNDP, 2015; UNECE, 2013; UNESCO, 2014). The demand for integration of ESD in the educational system is paralleled by the demand for teachers' preparation for the future (Ferreira, Ryan, and Tilbury 2007). In the context of Pakistan, as an effort to integrate sustainable

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development (SD) into the educational system, various courses pertinent to the SD (e.g. ESD, Education for sustainability (ES), Environmental Education, etc.) have been offered in teacher-education programs. Despite the inclusion of various ESD-related courses in the curriculum, very limited research has been carried out to study the outcomes of these initiatives (Kalsoom and Khanam 2017; Kalsoom and Qureshi 2021; Nousheen et al. 2020). Teacher-education programs are expected to develop Pre-service teachers' self-efficacy, Content Knowledge (CK), and Pedagogical knowledge (PK), pertinent to various subjects and concepts (van Dinther, Dochy, and Segers 2015; Velthuis, Fisser, and Pieters 2014). None of the studies, precisely in Pakistan, ever investigated the effect of ESD-related courses on pre-service teachers' Perceived Content Knowledge (pCK), Perceived Pedagogical Knowledge (pPK), and their self-efficacy for teaching ESD. Given this, the current research aimed at assessing the secondary pre-service teachers' (hereafter pre-service teachers) pCK, pPK, and self-efficacy for teaching ESD-related concepts.

The pre-service teacher's self-efficacy belief for teaching ESD is an important variable to study as it defines the pre-service teachers' level and persistence of efforts in the face of barriers to teaching ESD in future classrooms (Evans, Tomas, and Woods 2016). Swackhamer et al. (2009) argued that teachers' self-efficacy can be enhanced by enhancing their knowledge of the subject content. Evans, Tomas, and Woods (2016) stated that an increase in pre-service teachers' understanding and knowledge of sustainability-related concepts leads to an increase in their self-efficacy to integrate ESD into their professional careers. Many researchers identified teachers' lack of knowledge, experience, and efficacy as a few of the key barriers to the implementation of ESD in the classroom (Borg et al. 2012; Hart and Nolan 1999; Kang 2019).

A considerable number of studies have been carried out to assess prospective teachers' self-efficacy, pCK, and pPK (Elliott and Inwood 2019; Richardson, Byrne, and Liang 2018; Zhou 2015). However, the literature on these concepts in the perspective of ESD, EfS, or Sustainability Education is scarce, especially in Pakistan. Given this, the current study aimed at investigating the pre-service teachers' pCK, pPK, and their self-efficacy for teaching ESD in the Pakistani context. The objectives of the current study are as follow.

- Exploring the Pakistani pre-service teachers' self-efficacy for teaching ESD
- Exploring the Pakistani pre-service teachers' pCK and pPK concerning ESD
- To assess the difference in the pre-service teachers' self-efficacy, PCK, and PPK based on demographical variables i.e., age, gender, program, and university enrolled in.
- To assess any difference in the pCK, pPK, and self-efficacy mean scores of pre-service teachers before and after the teaching practicum

## 2. The study framework

The study framework has been developed around the constructs of self-efficacy, content knowledge, and pedagogical knowledge. The current study builds on the assumption that pre-service teachers' content knowledge and pedagogical content pertinent to ESD may serve as a key enabler for their ability to teach and integrate ESD in their future professional endeavors. Moreover, pre-service teachers' exposure to a practical environment i.e. teacher practicum, will help them build their content knowledge, pedagogical knowledge, and their self-efficacy for teaching ESD-related concepts.

### *2.1. Self-efficacy*

Self-efficacy is one of the most important factors to understand the individual level of effort and persistence in the face of obstacles and aversive experiences (Bandura 1977). Self-efficacy refers to the individual belief in their capabilities to perform certain tasks and attain a level of

performance (Zimmerman 1995). Bandura (1997) defined self-efficacy as "a belief in one's capabilities to organize and execute the courses of action required to produce given attainment. Self-efficacy has two components i.e. efficacy expectations and outcome expectations. The efficacy expectation refers to the individual belief in their ability to execute certain behavior successfully in order to attain the desired outcome. On the other hand, the expectancy outcome refers to the individual's belief that a certain behavior will lead to the desired outcome (Romano 1996, Bandura 1977). Both the efficacy and expectancy outcomes are important predictors of individual behavior (Romano 1996). In the current study, the term pre-service teachers' self-efficacy refers to the individual's belief/confidence in their ability to teach ESD-related concepts by focusing on the core values, skills/capabilities, attitudes, and behaviors associated with sustainable development.

### *2.2. Perceived knowledge*

The term perceived knowledge refers to the individual belief regarding the knowledge they possess irrespective of the fact what they actually know (Park et al. 2014). It involves an individual's perception/feeling regarding the extent to which they possess declarative and procedural knowledge pertinent to a specific subject/area (Mintz et al. 2020, Leader-Janssen and Rankin-Erickson 2013). In the literature, three types of teachers' knowledge have been discussed i.e. i) content knowledge, ii) pedagogical knowledge, and iii) pedagogical content knowledge (Shulman 1986). However, others contested that the CK and PK comes under the umbrella of Pedagogical Content Knowledge (PCK) (Carlson et al. 2019). From an ESD perspective, the term pCK refers to the pre-service teachers' perception of their knowledge related to ESD and sustainability while pPK refers to the individual believes that they have the knowledge pertinent to instructional strategies required for teaching ESD-related concepts (Malandrakis et al. 2019, Shulman 1986). Since the emergence of these concepts, many researchers used them in a variety of subject areas e.g. Mathematics (Ball, Thames, and Phelps 2008; Krauss et al. 2008), Science (Magnusson, Krajcik, and Borko 1999; Carlson et al. 2019), Social studies (Gudmundsdottir and Shulman 1987), English (Howey and Grossman 1989), Engineering (Viiri 2003), Sustainability Education (Malandrakis et al. 2019) so on and so forth. Keeping in view the importance of ESD in our lives and emphasis on the ESD integration into the educational system, both pre-service and in-service teachers must have the requisite knowledge of the content (CK) and strategies (PK).

The perceived knowledge and self-efficacy of the pre-service teachers are two important components of effective teaching (Abell 2008; Lee and Tsai 2010; Malandrakis et al. 2019). For example, Gunning and Mensah (2011), while assessing the self-efficacy of science teachers, stated that merely possessing scientific knowledge is not enough, teachers must know how science should be taught. Moreover, while discussing the integration of technology in teaching, Ertmer and Ottenbreit-Leftwich (2010) stated that "although knowledge of technology is necessary, it is not enough if teachers do not feel confident using that knowledge to facilitate student learning". Leader-Janssen and Rankin-Erickson (2013) found a high correlation between pCK and self-efficacy and stated that with the increase in pCK, pre-service teachers tend to build higher self-efficacy. Lee and Tsai (2010) stated that teacher's self-efficacy belief has a significant association with the attitude towards incorporating a certain type of instructional technique into pedagogical practices. Malandrakis et al. (2019) stated that pCK, pCK, and self-efficacy are even more important in teaching complex, interdisciplinary, and open curriculum courses like ESD as they require well-trained and knowledgeable teachers who possess the appropriate knowledge, competence, instructional techniques, and have trust in their ability to implement them.

### *2.3. Self-efficacy and teaching practicum*

Self-efficacy has remained a debated topic in the teacher-education literature. Bandura (1977) identified four sources of individuals' self-efficacy beliefs i.e. mastery experience, vicarious

experience, verbal persuasion, and physiological state. Many researchers have identified and emphasized the importance of a structured teacher practicum in enhancing pre-service teachers' self-efficacy beliefs (Fives, Hamman, and Olivarez 2007; Heppner 1994). Fives, Hamman, and Olivarez (2007) opined that during teaching practicum "student-teacher experience proves a prolonged mastery experience, with opportunities for both vicarious experiences and verbal persuasion, which serve to facilitate the development of the pre-service teachers' teaching efficacy beliefs". Knoblauch and Hoy (2008) also found similar results and stated that a challenging teaching environment provides the pre-service teachers with an opportunity for mastery of difficult tasks and hence enhances pre-service teachers' sense of efficacy. However, on the other hand, many researchers argued that teaching practicum may lead to work-related stress (Klassen and Durksen 2014). The teacher practicum presents unique difficulties for preservice teachers, including teaching, preparing, developing connections with students and colleagues, and understanding school procedures. (Klassen and Durksen 2014). One of the daunting challenges for pre-service teachers is the transformation from being a student to that a teacher (Caires, Almeida, and Martins 2009; Klassen and Durksen 2014). However, Caires, Almeida, and Martins (2009) argued that pre-service teachers gradually overcome these challenges and the sense of becoming a teacher enhances their self-confidence, efficacy, and attitude toward teaching.

#### *2.3.1. Context of the study*

The focus of the current study was to assess pre-service teachers' level of perceived content knowledge, perceived pedagogical knowledge, and their self-efficacy belief for teaching ESD-related concepts before and after the practicum. Understanding the current level of teachers' perceived content knowledge, perceived pedagogical knowledge, and self-efficacy are important as they would help determine how well pre-service teachers are prepared to teach and integrate ESD in their teaching, especially when teaching in physical classrooms.

In Pakistan, there are three pathways to becoming a secondary teacher. The first one is two and a half years Bachelor's in Education program (B.Ed.). The second one is the two years master's in education (MA Education) program. The third one is Master's in Education (M.Ed., 1 year; Bachelor's in Education is a pre-requisite for this program). All these programs aim at imparting the necessary content and pedagogical knowledge pertinent to various subjects and preparing pre-service teachers for their future roles. Multiple subjects covering sustainability-related concepts e.g. Pakistan studies, teaching of social sciences, contemporary trends and issues in education, environmental education, education for sustainable development, and so forth, have been incorporated into these teacher-education programs. These courses cover a wide array of sustainability-related issues from a global and local perspective and are being taught using various pedagogical approaches. The current study has selected the final year students for data collection to cater to their knowledge gap as all the participants have enough content knowledge and their ability level is almost same. While all the selected universities offer initial teacher education programs, the sequence of the subject varied across these universities. After the completion of course work, pre-service teachers must undergo forty days of teaching practice for the completion of the degree. The purpose of this teaching practice is to provide prospective teachers with an opportunity to assimilate into the professional environment and gain practical experience. During this teaching practice, pre-service teachers plan and execute their lessons, participate in various activities in schools, and work under the supervision of an experienced teacher.

## 3. Research methodology

### *3.1. Study process and participants*

The current study utilized a pre-post intervention design for surveying pre-service teachers enrolled in B.Ed. (2.5 years), M.Ed., and MA Education programs in four public sector universities

during the Fall-2019 and Spring-2020 semester (September 2019 – Jun 2020). The data were collected from the pre-service teachers in two phases. All ethical considerations were taken into account before the collection of the data. An email was forwarded to all the concerned heads of departments seeking their permission to collect data from the students. Once the permission was sought, all the respondents were asked for their consent to participate in the current research. All the pre-service teachers consented to participate in the current research. After the necessary formalities, the questionnaire was distributed among the potential respondents.

In the first phase (pre-practicum) a total of 1230 survey questionnaires were distributed among the pre-service teachers studying in these four universities. Out of these 1230 questionnaires, 815 were pen and paper questionnaires while 415 were online questionnaires (google form) forwarded via email to the targeted pre-service teachers. During the first phase, the author personally visited all the universities and distributed the questionnaire among the available on-campus pre-service teachers. The concerned teacher-educators were approached to seek permission for distributing questionnaires among the pre-service teacher at the end of the class. Once the permission was sought, the questionnaire was distributed among the pre-service teachers and necessary guidelines were provided. To avoid personal influence during the process, all the respondents were asked to complete the questionnaire by themselves. A box was placed in a designated place (librarian desk) in the on-campus library, and all the respondents were asked to leave the filled questionnaire in the designated box. The researcher personally collected the filled questionnaire from the library desk. This data collection process took almost four weeks to complete. Out of 815 distributed pen and paper questionnaires, 341 were returned to the librarian of the concerned institution. Out of these 341 pen and paper questionnaires, 267 were filled completely while 74 were partially filled or necessary details were missing. Similarly, a list of pre-service teachers' emails enrolled in teacher-education programs was obtained from the university administration office. After obtaining email addresses, an email for taking their consent for participation in the current research was forwarded to all the respondents. The same pen and paper questionnaire was again developed on Google Forms and then forwarded to 415 participants who consented to participate in the current research. Out of 415 emailed questionnaires, only 152 respondents responded to the online questionnaire.

Both the pen and paper and email surveys generate a response rate of 34.07%. Once the data were collected from all the respondents, the data was entered into SPSS software. The respondents' age ranges from 18 years to 28 years. Out of 419 respondents, 68% were female and 32% were male. Kalsoom, Khanam, and Quraishi (2017) also found an uneven ratio of males and females in their study with the pre-service teachers.

In the second phase (post practicum phase), the pre-service teachers were again approached through email (collected in the first phase) for their consent to participate in the second phase of the research. After receiving their consent, the questionnaire was forwarded to 419 respondents who participated in the first phase. Out of 419 participants, only 215 participants responded to the email and registered their responses. The responses were recorded in the google form and were later entered into the SPSS sheet for data analysis. The details of the respondents are given in Table 1 below.

### *3.2. The tool*

The current study adopted the scale developed by Malandrakis et al. (2019). The scale consists of two parts; the first part measures teacher self-efficacy while the second part measures perceived content knowledge and pedagogical knowledge. The teacher self-efficacy scale consisted of 24 items related to values and ethics, system thinking, emotions, feeling and empathy, and actions. Pre-service teachers were asked to rate each item on 5 points Likert scale ranging from 1 ("not at all confident) to 5 (absolutely confident) based on their confidence in the ability to teach these concepts. Similarly, the teachers' perceived knowledge scale was divided into two

**Table 1.** Demographics of the participants.

| | | University | | | | |
|---|---|---|---|---|---|---|
| | | U1 | U2 | U3 | U4 | Total |
| Gender | Male | 43 | 34 | 26 | 30 | 133 |
| | Female | 77 | 57 | 88 | 64 | 286 |
| Age | 18-21 | 36 | 27 | 52 | 36 | 151 |
| | 22-25 | 64 | 35 | 49 | 50 | 198 |
| | 26 & above | 20 | 29 | 13 | 8 | 70 |
| Program | B.Ed (2.5) | 56 | 49 | 72 | 56 | 233 |
| | M.Ed | 36 | 21 | 16 | 20 | 93 |
| | MA Education | 28 | 21 | 26 | 18 | 93 |
| **Total** | | 120 | 91 | 114 | 94 | 419 |

sub-scales i.e. the perceived content knowledge (pCK) scale and the perceived pedagogical knowledge (pPK). The pCK scale consists of 14 items pertinent to pre-service teachers' knowledge pertinent to various sustainability-related concepts. Students were asked to rate each statement based on their perception of the extent to which they possess knowledge related to concept like ESD, sustainability, and environmental issues. Students were asked to rate each item on a 5-point Likert scale ranging from 1 (very little extent) to 5 (to a great extent). Similarly, the pPK scale consists of 17 items. Students were asked to rate each statement on a Likert scale ranging from 1 (not at all confident) to 5 (absolutely confident).

### *3.3. Data analysis framework*

A one-way Analysis of Variance (ANOVA) and independent-sample t-test was utilized to assess differences in mean scores of Pre-service teachers' self-efficacy, pCK, and pPK based on their gender, age, university, and program enrolled. Similarly, paired sample t-test was utilized to assess the differences in pre-service teachers' self-efficacy, pCK, and pPK before and after teaching practicum.

## 4. Results

### *4.1. Pre-practicum results*

A one-way Welch ANOVA was conducted to determine if there is any difference in the pre-service teachers' self-efficacy, pCK, and pPK mean scores based on the university they were enrolled in. Participants were classified into four groups: U1 ($n = 120$), U2 ($n = 91$), U3 ($n = 114$) and U5 ($n = 94$). The pre-service teachers' self-efficacy, pCk, pPK scores were significantly different among different universities groups, Welch's $F$ (3, 220.162) = 90.81, $p < .0005$, $F(3,415) = 8.945$, $p < .0005$, and Welch's $F(3, 222.39) = 6.428$, $p < .0005$ respectively. Moreover, the results of the Games-Howell post hoc analysis for self-efficacy revealed that the difference among various university combinations was also significant (i.e. $p < 0.05$). Further, pre-service teachers' in U1 university exhibited a positive and significant mean difference from all the other universities (see Table 2). Further, the pre-service teachers enrolled in U1 also exhibited significantly higher scores on all the constituents of self-efficacy for teaching ESD compared to the other three universities. Similarly, the results of Tukey post hoc test for pCK shows that significant differences were found within the U1 and U4 (0.45, 95% CI (0.20 to 0.71), $p < 0.05$), U2 and U4 (0.44, 95% CI (0.17 to 0.71), $p < 0.05$), and between U3 and U4 (0.32, 95% CI (0.06 to 0.57), $p < 0.05$). No significant difference was found for pCK between the rest of the university combinations. Also, the results of the Games-Howel post hoc test for pPK show that significant differences were found within the following combinations: U1 and U4 (0.42, 95% CI (0.17 to 0.67), $p < 0.05$), and between U3 and U4 (0.30, 95% CI (0.04 to 0.55), $p < 0.05$). No significant difference was found for pPK between the rest of the university combinations. The results are summarized in Table 2.

**Table 2** . Means, standard deviations, and one-way analyses of variance in self-efficacy, pCK, pPK based on university.

| | U1 | | U2 | | U3 | | U4 | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Variable | M | SD | M | SD | M | SD | M | SD | F (3, 415) | η2 |
| Self-Efficacy | 3.83 | 0.53 | 3.59 | 0.51 | 3.39 | 0.39 | 3.03 | 0.24 | 62.37*** | 0.31 |
| Values & Ethics | 3.47 | 0.64 | 3.35 | 0.66 | 2.99 | 0.65 | 2.49 | 0.61 | 47.84*** | 0.26 |
| System Thinking | 3.62 | 0.76 | 3.26 | 0.76 | 2.96 | 0.70 | 2.41 | 0.56 | 54.40*** | 0.28 |
| Emotions & Feelings | 4.09 | 0.69 | 3.90 | 0.62 | 3.80 | 0.64 | 3.57 | 0.71 | 10.93*** | 0.07 |
| Actions | 4.15 | 0.61 | 3.89 | 0.64 | 3.84 | 0.56 | 3.67 | 0.57 | 12.37*** | 0.08 |
| pCK | 3.66 | 0.67 | 3.49 | 0.76 | 3.53 | 0.69 | 3.23 | 0.72 | 8.94*** | 0.06 |
| pPK | 3.45 | 0.71 | 3.44 | 0.69 | 3.30 | 0.72 | 2.99 | 0.70 | 6.42*** | 0.04 |

***$p < 0.001$

Similarly, the results of one-way ANOVA suggest that there was no statistically significant difference in the mean score of pre-service teachers' pCK and pPK for various age brackets i.e. $p > 0.05$. However, there was a statistically significant difference in the mean scores of various age groups' self-efficacy scores (F (2,416) = 4.019, $p = 0.017$). Moreover, a Tukey post hoc test revealed that a significant difference was found between the mean scores of the age group 26 and above and 18 to 21 years i.e. (0.22, 95% CI (0.04 to 0.39), $p = 0.013$). No significant difference was found by comparing the remaining groups i.e. $p > 0.05$. The respondents belonging to the 26 and higher age group exhibited the highest self-efficacy for teaching ESD ($3.63 \pm 0.49$), followed by 22 – 25 years ($3.47 \pm 0.54$), and 18-21 years ($3.41 \pm 0.51$). Further, one-way ANOVA results on the sub-constituent of self-efficacy for ESD i.e. values and ethics, system thinking, emotions and feelings, and actions based on pre-service teachers' age suggest that no significant difference was found in the self-efficacy constituents except for the system thinking i.e. (Welch's F (2,201.25) = 7.53, $p = 0.001$). Moreover, Games-Howel post hoc test for system thinking suggest significant differences within all the age groups where pre-service teachers with higher age exhibited significantly higher system thinking compared the other age groups. the following combinations: U1 and U4 (0.42, 95% CI (0.17 to 0.67), $p < 0.05$), and between U3 and U4 (0.30, 95% CI (0.04 to 0.55), $p < 0.05$) (Table 3).

Similarly, the results of the one-way ANOVA suggest that no significant difference in the pre-service teachers' pCK and pPK mean scores can be explained based on the program they are enrolled in i.e. Welch's F (2,183.41) = 1.398, $p = 0.25$) and F (2,416) = 2.013, $p = 0.14$). However, the results indicate a significant difference in the mean scores for self-efficacy based on the program students enrolled in (F (2,416) = 3.209, p = < 0.05). Moreover, a significant difference was found in the mean scores of pre-service teachers enrolled in B.Ed. (Hons) and MA Education i.e. (0.15, 95% CI (0.004 to 0.30), $p = 0.049$). No significant difference was found by comparing the remaining groups i.e. $p > 0.05$. The respondents enrolled in B.Ed. program exhibited the highest self-efficacy for teaching ESD ($3.53 \pm 0.50$), followed by M.Ed. ($3.43 \pm 0.53$), and MA Education ($3.38 \pm 0.56$) respectively. Further, the results also suggest that no significant difference can be explained in the constituents of self-efficacy for teaching ESD based on the program they were enrolled (i.e. $p > 0.05$) except for the emotions and feelings dimension i.e. Welch's F (2,186.59) = 4.697, $p = 0.01$. Furthermore, the pre-service teachers enrolled in B.Ed. (Hons) program reported significantly higher mean scores on emotions and feelings dimension compared to the pre-service teachers in other programs. Moreover, within the group analysis suggest no significant difference exists among the remaining two programs i.e. $p > 0.05$ (Table 4).

An independent sample t-test was applied to assess the difference in mean scores based on their gender. The result of the independent sample t-test shows that there was no statistically significant difference in the self-efficacy and pCK of males and females. However, the test found a significant difference in the mean scores of males and females on the pPK (t (227.68) = −2.490, $p = 0.013$). The mean scores show that female pre-service teachers' have higher pPK ($M = 3.55$) compared to their male counterparts ($M = 3.35$).

**Table 3.** Means, standard deviations, and one-way analyses of variance in self-efficacy, pCK, pPK based on age.

| | Age | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1[a] | | 2[a] | | 3[a] | | | |
| Variables | M | SD | M | SD | M | SD | F (3, 415) | $\eta^2$ |
| Self-Efficacy | 3.41 | 0.52 | 3.47 | 0.55 | 3.63 | 0.50 | 4.09* | 0.019 |
| Values & Ethics | 3.03 | 0.72 | 3.10 | 0.73 | 3.25 | 0.78 | 2.13 | 0.010 |
| System Thinking | 2.99 | 0.80 | 3.06 | 0.88 | 3.40 | 0.85 | 5.99* | 0.028 |
| Emotions & Feelings | 3.86 | 0.64 | 3.81 | 0.75 | 3.98 | 0.69 | 1.60 | 0.008 |
| Actions | 3.85 | 0.63 | 3.92 | 0.61 | 3.97 | 0.73 | 1.04 | 0.005 |
| pCK | 3.24 | 0.72 | 3.30 | 0.75 | 3.46 | 0.67 | 2.13 | 0.010 |
| pPK | 3.43 | 0.74 | 3.50 | 0.73 | 3.60 | 0.64 | 1.32 | 0.006 |

*$p < 0.05$
[a]1 = 18–21 Years; 2 = 22–25 Years; 3 = 26 & above.

**Table 4.** Means, standard deviations, and one-way analyses of variance in self-efficacy, pCK, pPK based on program.

| | B.Ed (Hons) | | M.Ed | | MA Education | | | |
|---|---|---|---|---|---|---|---|---|
| Variables | M | SD | M | SD | M | SD | F (3, 415) | $\eta^2$ |
| Self-Efficacy | 3.53 | 0.50 | 3.43 | 0.54 | 3.38 | 0.56 | 3.21* | 0.02 |
| Values & Ethics | 3.13 | 0.71 | 3.09 | 0.75 | 3.03 | 0.80 | 0.67 | 0.003 |
| System Thinking | 3.18 | 0.83 | 3.01 | 0.81 | 2.97 | 0.85 | 2.71 | 0.013 |
| Emotions & Feelings | 3.95 | 0.67 | 3.73 | 0.63 | 3.76 | 0.78 | 4.49* | 0.022 |
| Actions | 3.95 | 0.58 | 3.90 | 0.68 | 3.81 | 0.63 | 1.69 | 0.008 |
| pCK | 3.35 | 0.70 | 3.48 | 0.74 | 3.28 | 0.78 | 5.02* | 0.01 |
| pPK | 3.55 | 0.70 | 3.43 | 0.76 | 3.40 | 0.76 | 2.01 | 0.01 |

*$p < 0.05$

**Table 5.** Results of pre- and post-practicum self-efficacy, pCK, and pPK.

| | Pre | | Post | | | | |
|---|---|---|---|---|---|---|---|
| | M | SD | M | SD | t (214) | *p* | Cohen's *d* |
| Self-efficacy | 3.41 | 0.52 | 4.01 | 0.24 | 3.01 | 0.000 | 0.21 |
| pCK | 3.26 | 0.90 | 3.85 | 0.35 | 4.48 | 0.000 | 0.31 |
| pPK | 3.29 | 0.82 | 3.91 | 0.35 | 5.31 | 0.000 | 0.36 |

### *4.2. Post practicum results*

The results of the pre-and post-practicum data are given in Table 5. After the first phase, the next step was to compare the pre-service teachers' self-efficacy, pCK, and pPK before and after the teaching practicum. Paired sample t-test was utilized to assess the difference in the mean score before and after the teaching practicum. The result of the paired sample t-test given in Table 5 shows that there is a significant difference in the pre-service teachers' self-efficacy for teaching ESD [t(214) = 3.01, $p<0.05$], content knowledge [t (214) = 4.48, $p<0.05$], and perceived pedagogical knowledge [t (214) = 5.31, $p<0.05$] after teaching practicum. Table 5 shows that the mean score for self-efficacy before teaching practicum was $M=3.41$ which is significantly lower than the mean score at the end of the practicum i.e. $M=4.01$. Similarly, the mean score for pCK and pPK at the start were $M=3.26$ and $M=3.29$ respectively which are significantly lower than the mean after studying the ESD course i.e. $M=3.85$ and $M=3.91$, respectively. The above results show that pre-service teachers' self-efficacy, perceived content knowledge, and perceived pedagogical knowledge has enhanced significantly after teaching practicum.

## 5. Discussion

The current study aimed at investigating the pre-service teacher's self-efficacy for teaching ESD, their pCK and pPK pertinent to ESD. Before discussing the results, the author wants to establish

that the result of the current study comes from a cohort of pre-service teachers studying in four public sector universities. Despite several limitations, the current study offers insight into pre-service teachers' pCK, pPK, and self-efficacy for teaching ESD.

The first objective of the study was to assess pre-service teachers' self-efficacy for teaching ESD. In terms of pre-service teachers' self-efficacy beliefs for teaching ESD, the pre-service teachers reported a moderate score. The findings are in line with the previous studies of Malandrakis et al. (2019) and Saribas, Teksoz, and Ertepinar (2014) who conducted their studies in Greek and American contexts respectively. On the contrary, Effeney and Davis (2013) reported higher confidence scores in the Australian context. However, the results of the current study are comparable (and are in line) with Malandrakis et al. (2019) as both the studies have used similar tools, theoretical framework, domain, and area of focus. The rest of the researchers used different tools developed using different theoretical frameworks, areas of focus, and structures.

The results of the pre-practicum study indicate that a significant difference was found in self-efficacy beliefs among the pre-service teachers enrolled in various teacher education programs. Moreover, the results also established that pre-service teachers enrolled in the B.Ed. program has higher self-efficacy as compared to their counterparts. The primary reason may be that the pre-service teachers enrolled in the B.Ed. program study more sustainability-related concepts and ESD compared to the other two programs. Exposure to more sustainability-related content may provide an opportunity for more knowledge and learning pertinent to sustainability and ESD. Literature also suggests that self-efficacy and content knowledge are highly correlated (Leader-Janssen and Rankin-Erickson 2013). The current research also endorses these results.

Another finding of the pre-practicum phase of the current research indicates that pre-service teachers' confidence scores were higher on the "emotions and feelings" and "action" dimensions. The scores on the other two dimensions i.e. "system thinking" and "values and ethics" were moderate. Although the overall results of the current study are different from the previous studies e.g. Malandrakis et al. (2019) found that pre-service teachers were higher on the affective domain i.e. "Values and Ethics" and "Emotions and Feelings" and lower on the other two dimensions. However, the results of the current study are in line with the studies conducted in the Pakistani context. For example, Nousheen et al., (2020) found that ESD-related courses and pedagogical approaches have a significant effect on pre-service teachers' attitudes (emotions and feelings) and behavior (actions). Kalsoom and Khanam (2017) also reported similar results. The moderate scores on the remaining two dimensions of the pre-service teachers' self-efficacy scale may be associated with the fact that values are difficult to change, and system thinking is a higher-order competency developed after a sequential stage of cognitive development (Assaraf and Orion 2005). Moreover, the development of system thinking competence requires pedagogical innovation including indoor and outdoor activities. The lower score on the system thinking dimension may be because of the lack of innovation in the pedagogical approaches. It has been argued that most teachers are unaware of the pedagogical innovation ESD demands and hence use the traditional teaching methods (Kalsoom and Khanam 2017).

The third objective, in the pre-practicum phase, was related to the pre-service teachers' pCK and pPK concerning ESD. In terms of perceived knowledge, pre-service teachers reported a moderate score on both the dimensions, however, the pre-service teachers scored higher on the pPK dimension compared to the pCK. The results are in line with the study of Malandrakis et al. (2019) who reported similar results. The results may be associated with the fact that teacher education programs offer valuable knowledge regarding the utilization/integration of various pedagogical approaches in general which can also be used while teaching ESD-related concepts.

Similarly, a difference in pre-service teachers' perception of their pCK, pPK, and self-efficacy for teaching ESD is also assessed based on the university and program they were enrolled in, specifically gender, and age. The results suggest that the U1 university pre-service teachers have significantly higher scores on pCK, pPK, and self-efficacy compared to the other three universities. The U1 university

is among the first universities to step forward toward the integration of ESD into teacher education programs. One reason may be the university leadership's commitment to sustainable development as they ranked among the universities in Pakistan highest on the sustainability index. Moreover, the under-discussion university offers a dedicated course namely "education for sustainable development" and content pertinent to sustainable development in various courses. A detailed exploration of various university-level factors may be affecting pre-service teachers' knowledge and self-efficacy. However, the detailed exploration of these factors was beyond the scope of the current study.

Similarly, some differences in the mean self-efficacy and pCK score were found based on the program pre-service teachers enrolled in. As discussed previously, B.Ed. program offers a wide variety of subjects/content related to sustainability and ESD resulting in higher exposure to the sustainability-related concepts (Nousheen et al., 2020, Kalsoom and Khanam 2017). Kalsoom and Khanam (2017) also found that ESD-related courses and content enhance pre-service teachers' knowledge. Similarly, Nousheen et al., (2020) also found that pre-service teachers having higher exposure to sustainability-related content exhibit higher knowledge. The results of the current study are in line with these previous studies. As discussed in the literature, content knowledge has been positively associated with self-efficacy. Therefore, the increase in self-efficacy can be justified based on the program that offers higher content related to sustainability and ESD.

The current study also found that pre-service teachers' perception of their self-efficacy for teaching ESD, CK, and pPK were also associated with the students' age. The results suggest that older pre-service teachers have higher self-efficacy, pCK, and pPK as compared to younger pre-service teachers. Literature suggests that the increase is associated with content knowledge and the use of various strategies (pPK), which is the byproduct of higher pCK with age (Chi 1981). Moreover, there is clear support for the increase in self-efficacy with the increase in age. However, as discussed earlier, this claim can only be justified based on the pre-service teacher's increased knowledge with the age. As content knowledge is associated with the self-efficacy of the pre-service teachers, therefore, it can be inferred that with an increase in age the self-efficacy for teaching ESD is also increased due to an increase in pCK. No significant mean difference was found based on gender except for pPK. Kazu and Erten (2014) also conducted a similar study and found that female pre-service teachers exhibit higher pedagogical knowledge as compared to their male counterparts.

The results of the post-practicum phase indicate the pre-service teachers reported an increase in their self-efficacy beliefs, pCK, and pPK after a forty-day teacher practicum. Teacher practicum has been identified as one of the key mastery experience opportunities for prospective teachers. The results of the current study are in line with the previous research (Fives, Hamman, and Olivarez 2007). The teaching practicum provides a rich opportunity for students to experience a professional environment. The feedback from students, teachers, and supervisor enhances pre-service teacher vicarious experience and verbal persuasion which ultimately enhance their self-efficacy beliefs. Moreover, the teaching practicum also provides pre-service teachers with an opportunity to apply their theoretical knowledge obtained during course work in the professional environment (Walton and Rusznyak 2013). The whole idea of the teacher practicum is to equip pre-service teachers both with the formal CK and PK, Hence, the results of the current study are not surprising reporting an increase in pre-service teachers' pCK and pPK. During the teaching practice, the teacher plans and executes the lesson plan which provides student teachers with the opportunity to enhance their knowledge as well. Further, the feedback and knowledge sharing by the supervisor and collaborative teacher offer further insight into the knowledge of the content as well as the pedagogical approaches.

## 6. Conclusion, limitations, and recommendations

The current research contributes to the discussion and provides insight into the pre-service teachers' beliefs regarding their pCK, pPK, and self-efficacy. It is important to assess the student teachers' pCK, pPK, and self-efficacy for teaching ESD-related concepts as these prospective

teachers will present in future classrooms. Malandrakis et al. (2019) and Effeney and Davis (2013) reiterate in their research pre-service teachers' knowledge and self-efficacy beliefs are crucial to integrating ESD in their future endeavors. This awareness of content knowledge and pedagogical knowledge is crucial, especially in Pakistan where integration of ESD is limited in various disciplines. Given this, the current study provides the current level of content knowledge and pedagogical knowledge, self-efficacy of pre-service teachers for teaching ESD. The result of the study showed there was a significant association between Pre-service teachers' perceived knowledge with their self-efficacy belief regarding teaching ESD. Moreover, a significant difference in the mean scores in the teachers' self-efficacy, pCK, and pPK was found based on age, university, and program. The results suggest that there is a lot of room for the addition of the curriculum pertinent to ESD in various programs, especially master's programs. It is with a great understanding of the current level of pCK, pPK, and self-efficacy, that the confidence and capabilities of future teachers can be improved.

Although the current research offers a useful insight into sustainability research, the current research has certain limitations. First, the current study used a survey method to assess pre-service teachers' perceptions regarding their self-efficacy, pCK, and pPK. Although the survey method provides useful information, future studies may use a mixed-method approach to get a deep insight into these concepts. The mixed-method technique may offer a better insight into the curriculum studied, pedagogical approaches used by the teachers, and different learning activities during the course. Moreover, the current study was delimited to one semester due to the shortage of time and resources. Future studies may adopt a longitudinal or time-series design to study these concepts. Longitudinal studies are important to justify/purify the results in the longer run. For example, a student may exaggerate while reporting scores due to various factors like recency effect and social factors, etc. Similarly, the actual experience may alter Pre-service teachers' confidence in teaching ESD. Another limitation was the use of self-reported measures for which the responses need to be taken at their face value. Students tend to respond positively to social issues and normally tend to provide positive responses to such issues. Therefore, future studies may consider these limitations to assess these concepts in depth. The current research is useful for researchers working in the field of ESD, academicians, and educational leaders to integrate ESD into their curriculum.

## Disclosure statement

No potential conflict of interest was reported by the authors.

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## References

Abell, S. K. 2008. "Twenty Years Later: Does Pedagogical Content Knowledge Remain a Useful Idea?" *International Journal of Science Education* 30 (10): 1405–1416. doi:10.1080/09500690802187041.

Assaraf, O. B. Z., and N. Orion. 2005. "Development of System Thinking Skills in the Context of Earth System Education." *Journal of Research in Science Teaching* 42 (5): 518–560. doi:10.1002/tea.20061.

Ball, D. L., M. H. Thames, and G. Phelps. 2008. "Content Knowledge for Teaching: What Makes It Special." *Journal of Teacher Education* 59 (5): 389–407. doi:10.1177/0022487108324554.

Bandura, A. 1977. "Self-Efficacy: Toward a Unifying Theory of Behavioral Change." *Psychological Review* 84 (2): 191–215. doi:10.1037/0033-295X.84.2.191.

Bandura, A. 1997. *Self-Efficacy: The Exercise of Control*.New York: Macmillan.

Borg, C., N. Gericke, H.-O. Höglund, and E. Bergman. 2012. "The Barriers Encountered by Teachers Implementing Education for Sustainable Development: Discipline Bound Differences and Teaching Traditions." *Research in Science & Technological Education* 30 (2): 185–207. doi:10.1080/02635143.2012.699891.

Caires, S., L. S. Almeida, and C. Martins. 2009. "The Socioemotional Experiences of Student Teachers during Practicum: A Case of Reality Shock?" *The Journal of Educational Research* 103 (1): 17–27. doi:10.1080/00220670903228611.

Carlson, J., K. R. Daehler, A. C. Alonzo, E. Barendsen, A. Berry, A. Borowski, … C. D. Wilson. 2019. "The Refined Consensus Model of Pedagogical Content Knowledge in Science Education." In *Repositioning Pedagogical Content Knowledge in Teachers' Knowledge for Teaching Science*, 77–94. Singapore: Springer.

Chi, M. T. 1981. "Knowledge Development and Memory Performance." In *Intelligence and Learning*, 221–229. Boston, MA: Springer.

Effeney, G., and J. Davis. 2013. "Education for Sustainability: A Case Study of Preservice Primary Teachers' Knowledge and Efficacy." *Australian Journal of Teacher Education* 38 (5): n5. doi:10.14221/ajte.2013v38n5.4.

Elliott, P., and H. Inwood. 2019. "Contextualising ESE in Pre-Service Teacher Education in Canada." In *Environmental and Sustainability Education in Teacher Education*, 37–48. Cham: Springer. https://doi.org/10.1007/978-3-030-25016-4_3

Ertmer, P. A., and A. T. Ottenbreit-Leftwich. 2010. "Teacher Technology Change: How Knowledge, Confidence, Beliefs, and Culture Intersect." *Journal of Research on Technology in Education* 42 (3): 255–284. doi:10.1080/15391523.2010.10782551.

Evans, N., L. Tomas, and C. Woods. 2016. "Impact of Sustainability Pedagogies on Pre-Service Teachers' Self-Efficacy." *Journal of Education for Sustainable Development* 10 (2): 243–261. doi:10.1177/0973408216650953.

Ferreira, J. A., L. Ryan, and D. Tilbury. 2007. "Mainstreaming Education for Sustainable Development in Initial Teacher Education in Australia: A Review of Existing Professional Development Models." *Journal of Education for Teaching* 33 (2): 225–239. doi:10.1080/02607470701259515.

Fives, H., D. Hamman, and A. Olivarez. 2007. "Does Burnout Begin with Student-Teaching? Analyzing Efficacy, Burnout, and Support during the Student-Teaching Semester." *Teaching and Teacher Education* 23 (6): 916–934. doi:10.1016/j.tate.2006.03.013.

Gansle, K. A., G. H. Noell, and J. M. Burns. 2012. "Do Student Achievement Outcomes Differ across Teacher Preparation Programs? An Analysis of Teacher Education in Louisiana." *Journal of Teacher Education* 63 (5): 304–317. doi:10.1177/0022487112439894.

Gudmundsdottir, S., and L. Shulman. 1987. "Pedagogical Content Knowledge in Social Studies." *Scandinavian Journal of Educational Research* 31 (2): 59–70. doi:10.1080/0031383870310201.

Gunning, A. M., and F. M. Mensah. 2011. "Preservice Elementary Teachers' Development of Self-Efficacy and Confidence to Teach Science: A Case Study." *Journal of Science Teacher Education* 22 (2): 171–185. doi:10.1007/s10972-010-9198-8.

Hart, P., and K. Nolan. 1999. "A Critical Analysis of Research in Environmental Education." *Studies in Science Education* 34 (1): 1–69. doi:10.1080/03057269908560148.

Heppner, M. J. 1994. "An Empirical Investigation of the Effects of a Teaching Practicum on Prospective Faculty." *Journal of Counseling & Development* 72 (5): 500–507. doi:10.1002/j.1556-6676.1994.tb00980.x.

Howey, K. R., and P. L. Grossman. 1989. "A Study in Contrast: Sources of Pedagogical Content Knowledge for Secondary English." *Journal of Teacher Education* 40 (5): 24–31. doi:10.1177/002248718904000504.

Kalsoom, Q., and A. Khanam. 2017. "Inquiry into Sustainability Issues by Preservice Teachers: A Pedagogy to Enhance Sustainability Consciousness." *Journal of Cleaner Production* 164: 1301–1311. doi:10.1016/j.jclepro.2017.07.047.

Kalsoom, Q., A. Khanam, and U. Quraishi. 2017. "Sustainability Consciousness of Pre-Service Teachers in Pakistan." *International Journal of Sustainability in Higher Education* 18 (7): 1090–1107. doi:10.1108/IJSHE-11-2016-0218.

Kalsoom, Q., and N. Qureshi. 2021. "Impact of Sustainability-Focused Learning Intervention on Teachers' Agency to Teach for Sustainable Development." *International Journal of Sustainable Development & World Ecology* 28 (6): 540–552. doi:10.1080/13504509.2021.1880983

Kang, W. 2019. "Perceived Barriers to Implementing Education for Sustainable Development among Korean Teachers." *Sustainability* 11 (9): 2532. doi:10.3390/su11092532.

Kazu, I. Y., and P. Erten. 2014. "Teachers' Technological Pedagogical Content Knowledge Self-Efficacies." *Journal of Education and Training Studies* 2 (2): 126–144. doi:10.11114/jets.v2i2.261.

Kennelly, J., N. Taylor, and T. W. Maxwell. 2008. "Addressing the Challenge of Preparing Australian Pre-Service Primary Teachers in Environmental Education: An Evaluation of a Dedicated Unit." *Journal of Education for Sustainable Development* 2 (2): 141–156. doi:10.1177/097340820800200211.

Klassen, R. M., and T. L. Durksen. 2014. "Weekly Self-Efficacy and Work Stress during the Teaching Practicum: A Mixed Methods Study." *Learning and Instruction* 33: 158–169. doi:10.1016/j.learninstruc.2014.05.003.

Knoblauch, D., and A. W. Hoy. 2008. "Maybe I Can Teach Those Kids. The Influence of Contextual Factors on Student Teachers' Efficacy Beliefs." *Teaching and Teacher Education* 24 (1): 166–179.

Krauss, S., M. Brunner, M. Kunter, J. Baumert, W. Blum, M. Neubrand, and A. Jordan. 2008. "Pedagogical Content Knowledge and Content Knowledge of Secondary Mathematics Teachers." *Journal of Educational Psychology* 100 (3): 716–725. doi:10.1037/0022-0663.100.3.716.

Leader-Janssen, E. M., and J. L. Rankin-Erickson. 2013. "Preservice Teachers' Content Knowledge and Self-Efficacy for Teaching Reading." *Literacy Research and Instruction* 52 (3): 204–229. doi:10.1080/19388071.2013.781253.

Lee, M.-H., and C.-C. Tsai. 2010. "Exploring Teachers' Perceived Self-Efficacy and Technological Pedagogical Content Knowledge with Respect to Educational Use of the World Wide Web." *Instructional Science* 38 (1): 1–21. doi:10.1007/s11251-008-9075-4.

Magnusson, S., J. Krajcik, and H. Borko. 1999. "Nature, Sources, and Development of Pedagogical Content Knowledge for Science Teaching." In *Examining Pedagogical Content Knowledge*, 95–132. Dordrecht: Springer.

Malandrakis, G., P. Papadopoulou, C. Gavrilakis, and A. Mogias. 2019. "An Education for Sustainable Development Self-Efficacy Scale for Primary Pre-Service Teachers: Construction and Validation." *The Journal of Environmental Education* 50 (1): 23–36. doi:10.1080/00958964.2018.1492366.

McKeown, R., and C. Hopkins. 2003. "EE≠ESD: Defusing the Worry." *Environmental Education Research* 9 (1): 117–128.

Mintz, J., P. Hick, Y. Solomon, A. Matziari, F. Ó'Murchú, K. Hall, K. Cahill, C. Curtin, J. Anders, and D. Margariti. 2020. "The Reality of Reality Shock for Inclusion: How Does Teacher Attitude, Perceived Knowledge and Self-Efficacy in Relation to Effective Inclusion in the Classroom Change from the Pre-Service to Novice Teacher Year?" *Teaching and Teacher Education* 91: 103042. doi:10.1016/j.tate.2020.103042.

Nousheen, A., S. A. Y Zai, M. Waseem, and S. A. Khan. 2020. "Education for sustainable development (ESD): Effects of sustainability education on pre-service teachers' attitude towards sustainable development (SD)." *Journal of Cleaner Production*, 250: 119537. doi:10.1016/j.jclepro.2019.119537.

Park, J. H., B. Gu, A. C. M. Leung, and P. Konana. 2014. "An Investigation of Information Sharing and Seeking Behaviors in Online Investment Communities." *Computers in Human Behavior* 31: 1–12. doi:10.1016/j.chb.2013.10.002.

Richardson, G. M., L. L. Byrne, and L. L. Liang. 2018. "Making Learning Visible: Developing Preservice Teachers' Pedagogical Content Knowledge and Teaching Efficacy Beliefs in Environmental Education." *Applied Environmental Education & Communication* 17 (1): 41–56. doi:10.1080/1533015X.2017.1348274.

Romano, J. L. 1996. "School Personnel Prevention Training: A Measure of Self-Efficacy." *The Journal of Educational Research* 90 (1): 57–63. doi:10.1080/00220671.1996.9944444.

Saribas, D., G. Teksoz, and H. Ertepinar. 2014. "The Relationship between Environmental Literacy and Self-Efficacy Beliefs toward Environmental Education." *Procedia - Social and Behavioral Sciences* 116: 3664–3668. doi:10.1016/j.sbspro.2014.01.820.

Shulman, L. S. 1986. "Those Who Understand: Knowledge Growth in Teaching." *Educational Researcher* 15 (2): 4–14. doi:10.3102/0013189X015002004.

Singer-Brodowski, M. 2017. "Pedagogical Content Knowledge of Sustainability." *International Journal of Sustainability in Higher Education* 18 (6): 841–856. doi:10.1108/IJSHE-02-2016-0035.

Swackhamer, L. E., K. Koellner, C. Basile, and D. Kimbrough. 2009. "Increasing the Self-Efficacy of in-Service Teachers through Content Knowledge." *Teacher Education Quarterly* 36 (2): 63–78.

van Dinther, M., F. Dochy, and M. Segers. 2015. "The Contribution of Assessment Experiences to Student Teachers' Self-Efficacy in Competence-Based Education." *Teaching and Teacher Education* 49: 45–55. doi:10.1016/j.tate.2015.02.013.

Velthuis, C., P. Fisser, and J. Pieters. 2014. "Teacher Training and Pre-Service Primary Teachers' Self-Efficacy for Science Teaching." *Journal of Science Teacher Education* 25 (4): 445–464. doi:10.1007/s10972-013-9363-y.

Viiri, J. 2003. "Engineering Teachers' Pedagogical Content Knowledge." *European Journal of Engineering Education* 28 (3): 353–359. doi:10.1080/0304379031000098265.

Walton, E., and L. Rusznyak. 2013. "Pre-Service Teachers' Pedagogical Learning during Practicum Placements in Special Schools." *Teaching and Teacher Education* 36: 112–120. doi:10.1016/j.tate.2013.07.011.

Zhou, G. 2015. "Environmental Pedagogical Content Knowledge: A Conceptual Framework for Teacher Knowledge and Development." In *Educating Science Teachers for Sustainability*. Cham, Springer. doi:10.1007/978-3-319-16411-3_11

Zimmerman, B. J. 1995. "Self-Efficacy and Educational Development." *Self-Efficacy in Changing Societies* 1 (1): 202–231.