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Research Article

Following up on the impact of a distance learning teachers' professional development program in science: A longitudinal case study

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ABSTRACT

This paper follows up on the impact of a distance learning teachers' professional development program on their self-efficacy beliefs in the long term. Specifically, it measures the personal self-efficacy beliefs and outcome expectancy beliefs of a group of 122 in-service elementary teachers before the start of the program, immediately after its completion, and two years later. The quantitative was used as the data collection method of the research. The results advocate that both the personal self-efficacy beliefs and the outcome expectancy beliefs of the research participants improved immediately after the program was completed and the former remained relatively improved two years after completion of the program, while the latter returned to the levels they had had before attending the program. Recommendations are made for future research.

Keywords: follow-up, self-efficacy, teachers' professional development

INTRODUCTION

The teachers' professional development plays a significant role in the quality of education, as it affects the teaching practices, the learning outcomes, and children's achievement (Darling-Hammond et al., 2017; Raymond & Gabriel, 2023; Shahzad & Naureen, 2017). Researchers have dealt with this issue and noted the meaning of teachers' professional development in strengthening their identity (Noben et al., 2021). In this frame, they have reported opinions, and criticism concluding that the evaluation of these programs is sine-qua-none and that these programs must be constantly evaluated and updated to be effective (Hsieh et al., 2023; Tzovla & Kedraka, 2021). Follow-up is common in various scientific fields such as medicine, pharmacy, or engineering (Civaner, 2020), but it is not systematically applied in education.

On that issue, we have to note the evaluation of educational programs must be a systematic, continuous, and dynamic process that is carried out from its planning until its end and aims to give feedback to the providers with all the necessary information, regarding the efficiency and effectiveness of the program so that they then make decisions regarding the continuation, modification, and redefinition of the program. Overall, the follow-up enhances the opportunity for the providers to gather necessary data for the programs' value over time and reflect on the programs' goals. In addition, this process is beneficial for the participants, who recall whether they apply the knowledge and skills they have acquired, explore different perspectives in their teaching, reflect critically on it, strengthen their self-efficacy, and get feedback on what they gained from their participation in the program (Freer & Keefer, 2022; Rettig, 2019).

A key oversight of professional development program evaluation is the timing of the evaluation. Usually, it is carried out immediately after the completion of the program, which certainly offers valuable information about its effectiveness but has short-term value. Moreover, given the limited resources for education, the need to evaluate teachers' professional development programs emerges even more imperatively. It is very beneficial economically and pedagogically for this to extend in the long term as a follow-up process, which gives information for the maintenance of the program's results over time. In this regard, follow-up evaluation is a process, which is not understood separately from a professional development program, it is not the end of the evaluation of an educational intervention but part of it. Although there is increased interest in professional development programs, few of them follow up on their effects on teachers systematically and in the long term (Abdulghani et al., 2017).

LITERATURE REVIEW

Follow-Up in Teachers' Professional Programs

A narrow range of studies has been conducted on the follow-up evaluation of the teachers' professional development programs. Richardson's (1994) follow-up on teachers' beliefs two years after their participation in a professional development program, that addressed the teaching of reading found that these were maintained, Knapp and Peterson (1995) investigated the effects of a four-week workshop on cognitively guided instruction in teachers. He follows-up them three and four years later and found that the majority were still using cognitively guided instruction, but participants differed in how they perceived this instruction and how they applied it. Franke et al. (2001), who conducted a post-service survey of teachers four years after completing a program on students' mathematical thinking reported that they cultivated some such thinking in their students. Raikou (2019) also investigates the effects of an educational intervention on the ability to develop critical thinking in pre-service kindergarten teachers six years after the initial intervention and noted that the educational intervention has an impact on them six years later.

Furthermore, Adams and Craig (1981) conducted a survey of the practical evaluations applied by university institutions that are members of the American Association of Colleges for Teacher Education, the results of which showed that only 45% follow up their graduates as employees a year after completing their studies and 4% follow them three years later. Katz et al. (1981) also investigated the value of follow-up for improving teachers' professional development programs and identified 26 studies, but they presented methodological problems, and their results were presented poorly. Zimpher and Ashburn (1985) carried out a meta-analysis of teachers' professional development programs based on follow-up and noted the following as reasons why the results of these studies have not been implemented: the lack of interest of providers, the inability to understand the significance of follow-up, the lack of fundings and the lack of methodology. In addition, Yogev (1997), who also conducted a meta-analysis of follow-up studies of teachers' professional development programs notes that the limited implementation of innovations in education can be attributed to a lack of follow-up.

Follow-Up in Teachers' Professional Development Programs for Self-Efficacy Beliefs in Sciences

In order to contribute to the less-developed literature on the follow-up of teachers' professional programs, the present research aimed to follow up on the maintenance of teachers' self-efficacy beliefs who teach biological concepts in elementary school. Bandura (1993) defines self-efficacy beliefs as "personal assessments of one's abilities to organize and perform a series of actions in order to achieve specific goals" (p. 2) and separates them into personal self-efficacy beliefs and outcome expectancy beliefs. The former relates to the individual's judgment about his/her personal worth and ability to achieve a goal in relation to a certain environmental condition, while the latter relates to the belief that one can successfully perform the behavior required to produce results (Bandura, 1993). The level of self-efficacy of teachers affects their perceptions, the self-evaluation of their professional role (Handrianto et al., 2023), and the quality of their work (Muliati et al., 2022). Teachers with high self-efficacy adopt teaching practices that promote active student participation (Handrianto et al., 2023), and enjoy personal, and job satisfaction (Gcabashe & Ndlovu, 2022; Najwan et al., 2022).

Regarding the measurement of self-efficacy beliefs in the sciences, several measuring instruments have been created. Among them, Riggs and Enochs (1990) developed "Science Teaching Efficacy Belief Instrument" (STEBI) to measure in-service elementary school teachers' (STEBI-A) and pre-service elementary school teachers' (STEBI-B) self-efficacy beliefs in sciences. This questionnaire consists of two subscales:

(a) personal science teaching efficacy and

(b) science teaching outcome expectancy.

In this paper, we present research that uses the instrument STEBI, as we also used this tool after adapting it to measure teachers' self-efficacy beliefs in teaching biological concepts in elementary school (Tzovla & Kedraka, 2020; Tzovla et al., 2022). As the review brought up a limited amount of research related to biological concepts, it was decided to also examine research related to the teachers' self-efficacy in teaching sciences, as biology belongs to the sciences and is taught in elementary schools as a united school subject (Tzovla & Kedraka, 2020).

In a total of 105 research related to the teaching of sciences, the review revealed that only 11 of them, had followed up with the participants over time after the completion of the educational intervention. Specifically, Batiza et al. (2013) investigated, using the instrument STEBI A, the personal self-efficacy beliefs of secondary school biology teachers who attended a two-week workshop on biology topics. The results indicated that the workshop significantly affected the personal self-efficacy beliefs of the experimental group, which remained high one year later. Crowther and Canon (2002), using the same instrument, measured outcome expectancy beliefs of K-8 teachers in an intensive two-week and four-month post-completion chemistry professional development program. The results reported a significant improvement in outcome expectancy beliefs four months later. Deehan et al. (2020), using the STEBI A, and interviews, investigated self-efficacy beliefs in the sciences of graduate teachers before entering university and after completion and entry into the school. The results note that personal self-efficacy beliefs improved during their studies and remained stable after graduation and entry into the school, but outcome expectance beliefs had a small decrease. Malandrakis (2018), using the STEBI instrument, and interviews explored the self-efficacy of pre-service students in the subject of environmental studies after attending an innovative program focused on the curriculum for environmental studies. Pre-service teachers improved both their personal self-efficacy beliefs and outcomes expectancy beliefs, and this improvement remained stable six months later. McKinnon and Lamberts (2014) investigated self-efficacy beliefs in pre–service teachers and practicing teachers, using the STEBI A and STEBI B, and interviews immediately after implementing a four-hour workshop and 11 months later. Results advocated most participants' personal self-efficacy beliefs improved and remained improved 11 months later when they were observed in the classroom, but outcome expectance self-efficacy beliefs improved only in pre–service and not in practicing teachers.

Moreover, Mentzer et al. (2014), using the STEBI A, measured the outcome expectancy beliefs, in teacher educators during a three-year educational intervention. Beliefs were measured before the start of the program and at the end of each of the three years of the program. The results note an improvement in beliefs during the program. Palmer (2011) investigated Australian teachers' personal self-efficacy in teaching sciences, using the STEBI A, and interviews, before, during, and after two years of an educational intervention. Personal self-efficacy beliefs were low before the start of the intervention, improved immediately after its completion, and remained improved two years later. Peters-Burton et al. (2015) explored the effect of an annual professional development program on the self-efficacy of biology teachers, using STEBI B. The results reported that the self-efficacy of the participants was high from the beginning and remained high four months after the end of the program. Sandholtz and Ringstaff (2014) investigated changes in self-efficacy beliefs of kindergarten and 1st and 2nd grade elementary school teachers during a three-year science professional development program, using the STEBI A. Self-efficacy beliefs were measured before the start of the program and in the spring of each of the three years of the program. The results showed an improvement in beliefs during the program.

Finally, Ulmer et al. (2013) explored the personal self-efficacy beliefs and outcome expectancy beliefs, using the STEBI A, and interviews with teachers who attended a professional development program based on the sciences curriculum in relation to rural education in two phases immediately after the completion of the program and nine months after they had implemented the curriculum. The results reported that the personal self-efficacy beliefs remain stable nine months later, but the outcome expectance beliefs returned to the levels they had been before attending the program. Wingfield et al. (2000) measured teachers' self-efficacy in sciences, using the STEBI A, interviews, and observation before the educational intervention, immediately, after, and one year later. The results indicated that both personal self-efficacy beliefs and outcome expectancy beliefs one year later did not show changes when compared to those that teachers had immediately after the end of the intervention.

Background of the Study

The study is a continuation and extension of previous research carried out by the researchers (Tzovla & Kedraka, 2021; Tzovla et al., 2021a, 2021b), which measured the self-efficacy beliefs of a group in-service elementary school teachers before and after their participation in a teachers' professional development online course. Specifically, in collaboration with the Teaching and Professional Development Laboratory of Bioscientists of the Department of Molecular Biology and Genetics at the Democritus University of Thrace, an online distance learning professional development course, in the teaching of biological concepts was designed and offered to in-service elementary school teachers during the COVID-19 pandemic.

The course was based on a prior investigation of the educational needs of the participants to be structured to their specific needs in terms of content, format, and duration, and to limit dropouts (Tzovla & Kedraka, 2022). The course was based on the principle that learning is considered both an individual and a collaborative process and aimed at social and cognitive interaction, the meaningful involvement of all participants, and the use of the colleague as a "critical friend" with the goal of creating a learning community. Through the discussion forum of each module, the teachers exchanged ideas and interacted in an asynchronous way, created, and implemented activities in their classroom, supported with their ideas the activities of other colleagues, and incorporated peer suggestions into their own teaching intervention. All of the above aimed at enhancing participants' self-efficacy beliefs.

Aim & Research Objectives

The aim of the present research is to follow up on the self-efficacy beliefs of a group of in-service elementary school teachers two years after their participation in a professional development program in the teaching of biological concepts in elementary school. In this frame, the research objectives are the following:

1. How did in-service elementary school teachers' Personal Biology Teaching Efficacy Beliefs (PBTE) change in a period of two years after they had attended a distance learning professional development course?
2. How did in-service elementary school teachers' Biology Teaching Outcome Expectancy Beliefs (BTOE) change in a period of two years after they had attended a distance learning professional development course?

METHOD

Research Context & Sample

Between November 27, 2022, and December 23, 2022, two years after the completion of the online distance course, the link to the questionnaire, bio-STEBI-A, which had been created in Google Forms and had been used during the initial phase of the program, as well as immediately after completing the distance learning program was sent electronically to explore personal self-efficacy beliefs and outcome expectancy beliefs in the 127 teachers who had completed the course (Tzovla et al., 2021b, 2022). Of these, 122 filled out the questionnaire voluntarily. In the introductory note of the questionnaire, the participants were informed about the purpose of the research, that the data collected would be used for research purposes, and that if they wished they could have access to the results of the research. Protocol for respecting general data protection regulation was followed. **Table 1** shows the demographic characteristics of the participants.

Table 1. Participants' demographic characteristics

Variable	Category	Value (%)
Gender	Male	20.5%
	Female	79.5%
Age	≤30	15.6%
	31-40	27.9%
	41-50	27.9%
	≥51	28.7%
Teaching experience (years)	≤5	15.6%
	6-10	9.0%
	11-20	44.3%
	≥21	31.1%
Postgraduate studies	Yes	88.5%
	No	11.5%
Teaching grade	First	14.8%
	Second	10.7%
	Third	11.5%
	Fourth	11.5%
	Fifth	24.6%
	Sixth	25.4%

Research Instrument

To measure participants' self-efficacy beliefs in teaching elementary school biological concepts, the bio-STEBI-A instrument, which was based on Riggs and Enochs' (1990) STEBI-A instrument for measuring in-service elementary school teachers' self-efficacy beliefs in sciences was constructed. Bio-STEBI-A consists of two subscales:

(a) PBTE and

(b) BTOE (Tzovla & Kedraka, 2020; Tzovla et al., 2022).

It was delivered to the participants of the course by email before its start (pre-test) and immediately after its completion (post-test). The results after participation in the online distance learning program reported that the group of teachers participating in the program showed an improvement in two subscales of bio-STEBI-A (Tzovla et al., 2021b).

The questionnaire of the present research was also the bio-STEBI-A and consisted of three sections. The first section concerned demographic data and included items with regard to gender, age, teaching experience (years), basic and additional studies, and the teaching grade that the participants taught during the implementation of this research. The second section included the 13 items of the first subscale, PBTE, of the bio-STEBI-A, while the third section included the 12 items of the second subscale, BTOE of the bio-STEBI-A.

Data Analysis

The SPPS statistical package version 23 (Field, 2013) was used for statistical analysis. A comparison of the three phases of the study was made for PBTE subscale and, respectively, for BTOE subscale of the bio-STEBI A. The answers of three groups were identified through their emails, which were noted with their consent.

RESULTS

Comparative Results of the Three Phases of the Study on the Personal Biology Teaching Efficacy Subscale

Table 2 presents the percentages of responses grouped into three categories (strongly disagree/disagree, undecided, agree/strongly agree) to the 13 items of PBTE subscale for the 122 participants in all three phases of the study i.e., phase A (pre-test) before attending the online distance learning program, phase B (post-test) immediately after completion of the online distance learning program, and phase C (post-post-test) two years after completion of the program. Between the first two phases of the study the percentages in the "agree/strongly agree" category increased in all positively worded items (2, 5, 8, 12, 18, and 23) immediately

Table 2. Personal Biology Teaching Efficacy (n=122)

	P-A (pre-test)			P-B (post-test)			P-C (post-post-test)		
	SD/D	U	A/SA	SD/D	U	A/SA	SD/D	U	A/SA
2. I am continually finding more effective ways to teach biological concepts.	4.9	23.8	71.3	0.0	4.1	95.9	3.3	13.1	83.6
3. *Even when I try very hard, I do not teach biological concepts as effectively as I do most subjects.	34.4	38.5	27.0	44.3	32.0	23.8	49.2	31.1	19.7
5. I know to teach biological concepts effectively.	24.6	49.2	26.2	2.5	18.0	79.5	4.1	33.6	62.3
6. *I am not very effective in monitoring biological concepts experiments.	36.1	45.9	18.0	59.0	25.4	15.6	53.3	32.8	13.9
8. I generally teach biological concepts effectively.	9.8	55.7	34.4	0.0	21.3	78.7	3.3	31.1	65.6
12. I understand biological concepts well enough to be effective in teaching them in primary education.	12.3	36.9	50.0	0.8	26.2	73.0	0.8	24.6	74.6
17. *I find it difficult to explain to students how biological concept experiments work.	45.9	38.5	13.9	63.9	25.4	10.7	61.5	27.0	11.5
18. I am typically able to answer students' biological concepts questions.	6.6	35.2	56.6	0.8	13.1	86.1	2.5	23.8	73.8
19. *I wonder if I have the necessary skills to teach biological concepts.	27.0	42.6	30.3	56.6	25.4	18.0	59.0	27.0	13.9
21. *Given a choice, I would not invite the principal to evaluate my biological concepts while teaching.	50.0	31.1	17.2	65.6	21.3	13.1	52.5	31.1	16.4
22. *When a student has difficulty understanding biological concepts, I am usually at a loss for how to help the student understand them better.	67.2	23.0	9.0	76.2	16.4	7.4	71.3	19.7	9.0
23. When teaching biological concepts, I usually welcome student questions.	4.9	18.0	77.0	0.8	7.4	91.8	0.0	8.2	91.8
24. *I do not know what to do to turn students on to biological concepts.	51.6	36.1	10.7	79.5	13.9	6.6	69.7	22.1	8.2

Note. P: Phase; SD: Strongly disagree; D: Disagree; U: Undecided; A: Agree; SA: Strongly agree; *Negatively worded items; & Items of instrument have been adapted to measure biological concepts at initial measurement (Tzovla & Kedraka, 2020)

after the completion of the program and correspondingly decreased in all negatively worded items (3, 6, 17, 19, 21, 22, and 24).

A particularly characteristic increase in the "agree/strongly agree" percentages between the two phases of the study is noted in the item "I know to teach biological concepts effectively", where before attending the program almost one in four (26.2%) agreed and after the program, this percentage jumped to 79.5%, as also in the item "I generally teach biological concepts effectively" with an increase from 34.4% to 78.7%. According to the negatively worded item, "I am not very effective in monitoring biological concepts experiments " in phase A 36.1% disagree, while after the attendance of the program, 59% disagree, while in item "I wonder if I have the necessary skills to teach biological concepts" the 27% who disagree rose to 56.5% after the attendance of the program.

Comparing the percentages in all three phases of the study, we note that the percentages in the category "agree/strongly agree" in the positively worded statements increased after attending the program and had a small decrease in the third phase, that is, almost two years after the program. Exceptions are the statements "I understand biological concepts well enough to be effective in teaching them in primary education" whose percentage increased further in the third phase, and "when teaching biological concepts, I usually welcome student questions", which remained the same. Correspondingly, the percentages of "disagree/strongly disagree" in negatively worded statements increased immediately after attending the program and this had a small decrease after two years.

It is noteworthy that in all 13 statements of PBTE subscale, the percentages of agreement (or disagreement) in the third phase decreased from the second phase (or respectively increase) after attending the program but remained greater (or respectively smaller) than the initial phase of the study.

Figure 1 and **Table 3** present the means (and standard deviations) of the teachers' responses in all three phases of the study, on a 5-point scale (1=strongly disagree, ..., 5=strongly agree) for the 13 items and the overall mean of PBTE subscale. Cronbach's alpha indicated the internal reliability of the subscale in all three phases to calculate the overall PBTE mean.

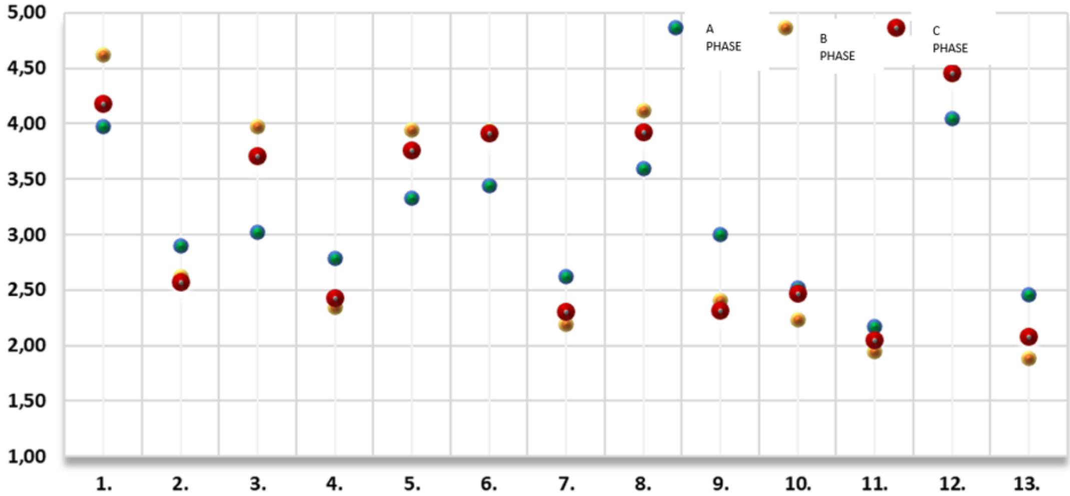

Figure 1. Means of PBTE items in all three phases of survey (1=strongly disagree, ..., 5=strongly agree) (Source: Authors)

Table 3. Means (& standard deviations) of teachers' responses in all three phases of survey to PBTE (n=122)

	P-A (pre-test)	P-B (post-test)	P-C (post-post-test)
	Mean (SD)	Mean (SD)	Mean (SD)
2. I am continually finding more effective ways to teach biological concepts.	3.98 (0.895)	4.61 (0.567)	4.18 (0.843)
3. *Even when I try very hard, I do not teach biological concepts as effectively as I do most subjects.	2.89 (1.003)	2.62 (1.078)	2.57 (0.978)
5. I know to teach biological concepts effectively.	3.02 (0.813)	3.98 (0.698)	3.70 (0.768)
6. *I am not very effective in monitoring biological concepts experiments.	2.79 (0.947)	2.34 (1.019)	2.43 (0.970)
8. I generally teach biological concepts effectively.	3.33 (0.797)	3.94 (0.607)	3.75 (0.753)
12. I understand biological concepts well enough to be effective in teaching them in primary education.	3.44 (0.812)	3.93 (0.713)	3.91 (0.668)
17. *I find it hard to explain students how biological concept experiments work.	2.62 (0.954)	2.19 (0.990)	2.30 (0.917)
18. I am typically able to answer students' biological concepts questions.	3.59 (0.766)	4.11 (0.645)	3.93 (0.805)
19. *I wonder if I have the necessary skills to teach biological concepts.	3.00 (1.037)	2.40 (1.111)	2.31 (1.037)
21. *Given a choice, I would not invite the principal to evaluate my biological concepts while teaching.	2.52 (1.135)	2.23 (1.089)	2.47 (1.173)
22. *When a student has difficulty understanding biological concepts, I am usually at a loss for how to help the student understand them better.	2.17 (0.924)	1.94 (0.939)	2.05 (0.969)
23. When teaching biological concepts, I usually welcome student questions.	4.05 (0.871)	4.44 (0.669)	4.45 (0.644)
24. *I do not know what to do to turn students on to biological concepts.	2.46 (0.899)	1.89 (0.911)	2.08 (0.950)
Mean PBTE	3.46 (0.585)	3.95 (0.563)	3.82 (0.537)
Cronbach's alpha	0.851	0.884	0.852

Note. 1=strongly disagree, ..., 5=strongly agree; P: Phase; SD: Standard deviation; & There was a reversal in calculation of total means PBTE

The means on all positively worded statements of PBTE subscale, as well as the total subscale, showed an increase immediately after attending the program, and these changes were maintained (with a relatively small decrease) two years after attending the program.

Accordingly, the means in all negatively worded statements showed a decrease immediately after attending the program and these changes were maintained (with a relatively small increase) after two years.

It is noteworthy that in the positive statements "I understand biological concepts well enough to be effective in teaching them in primary education" and "when I teach biological concepts, I usually welcome students' questions" the means were maintained in the third phase as well, while in the negative statement "I wonder if I have the necessary knowledge to teach biological concepts" the mean decreased more after two years of attending the program.

Non-parametric tests were used, Friedman's test to test the differentiation of the total subscale in the three phases of the study and the non-parametric Wilcoxon signed rank test to investigate if there is a

Table 4. Differentiation test of teachers' responses to PBTE (n=122) (Wilcoxon signed rank test)

	Statistically significant differentiation between		
	A & B phase	B & C phase	A & C phase
2. I am continually finding more effective ways to teach biological concepts.	z=-6.22^{b} p=0.00	z=-5.42^{b} p=0.00	z= -2.21^{b} p=0.02
3. *Even when I try very hard, I do not teach biological concepts as effectively as I do most subjects.	z=-2.29^{c} p=0.02		z=-2.91^{c} p=0.04
5. I know to teach biological concepts effectively.	z=-8.16^{b} p=0.00	z=-3.67^{b} p=0.00	z=-6.23^{b} p=0.00
6. *I am not very effective in monitoring biological concepts experiments.	z=-3.99^{b} p=0.00		z=-3.18^{c} p=0.00
8. I generally teach biological concepts effectively.	z=-6.64^{b} p=0.00	z=-2.84^{b} p=0.04	z=-4.88^{b} p=0.00
12. I understand biological concepts well enough to be effective in teaching them in primary education.	z=-5.31^{b} p=0.00		z=-5.32^{b} p=0.00
17. *I find it difficult to explain to students how biological concept experiments work.	z=-3.71^{c} p=0.00		z=-2.94^{c} p=0.03
18. I am typically able to answer students' biological concepts questions.	z=-5.64^{b} p=0.00	z=-2.12^{b} p=0.03	z=-3.96^{b} p=0.00
19. *I wonder if I have the necessary skills to teach biological concepts.	z=-4.59^{c} p=0.00		z=-5.11^{b} p=0.00
21. *Given a choice, I would not invite the principal to evaluate my biological concepts while teaching.	z=-2.37^{c} p=0.01		
22. *When a student has difficulty understanding biological concepts, I am usually at a loss for how to help the student understand them better.	z=-2.53^{c} p=0.01		
23. When teaching biological concepts, I usually welcome student questions.	z=-4.78^{b} p=0.00		z=-4.50^{b} p=0.00
24. *I do not know what to do to turn students on to biological concepts.	z=-4.97^{b} p=0.00	z=-2.46^{b} p=0.01	z=-3.49^{b} p=0.00
Mean PBTE	z=-7.54^{b} p=0.00	z=-5.70^{b} p=0.00	z=-5.70^{b} p=0.00

Note. ^{b}Based on negative ranks; & ^{c}Based on positive ranks

statistically significant difference in the median of responses between the A and B phase, between B and C phase and between A and C phase in the 13 subscale items.

Friedman's test showed a statistically significant differentiation (p=0.00) overall in PBTE subscale among the three phases.

Pairwise comparisons with the non-parametric Wilcoxon signed rank test showed statistically significant differentiations between the first and second phase in all items, and between the second and third phase, statistically significant differentiations were noted in only five items (2, 5, 8, 18, and 24), while between the first and third phase, statistically significant differentiations were found in 11 (2, 3, 5, 6, 8, 12, 17, 18, 19, 23, and 24) of the 13 items.

Also, overall, for the subscale, statistically significant differentiations were found in the pairwise comparison between the three phases (**Table 4**).

Comparative Results of the Three Phases of the Study on the Biology Teaching Outcome Expectancy Subscale

The same analysis was followed for BTOE subscale. **Table 5** presents the percentages of responses grouped into three categories (strongly disagree/disagree, undecided, agree/strongly agree) to the 12 subscale items for the 122 participants in all three phases of the study.

Between the first two phases of the study, the percentages in the "agree/strongly agree" category increased in all positively worded statements (1, 4, 7, 9, 11, 14, 15, and 16) immediately after attending the program and correspondingly decreased in all negatively worded statements (10, 13, 20, and 25). However, these differences were smaller than the differences observed in PBTE subscale.

Comparing the percentages between the second and third phase of the study, we observe that the percentages in the "agree/strongly agree" category decreased in positively worded statements, while they increased in negatively worded statements.

Table 5. Biology Teaching Outcome Expectancy (n=122)

	P-A (pre-test)			P-B (post-test)			P-C (post-post-test)		
	SD/D	U	A/SA	SD/D	U	A/SA	SD/D	U	A/SA
1. When a student does better than usual in biological concepts, it is because the teacher exerted extra effort.	13.1	45.1	41.8	2.5	36.9	59.0	6.6	48.4	45.1
4. When the biological concepts grades of students improve, it is most often due to their teacher finding a more effective teaching approach.	4.9	17.2	77.9	0.0	10.7	87.7	0.0	15.6	84.4
7. If students are underachieving in biological concepts, it is most likely due to ineffective biological concepts teaching.	12.3	39.3	48.4	12.3	32.8	53.3	15.6	37.7	46.7
9. The inadequacy of students' biological concepts background can be overcome by effective teaching.	0.8	12.3	86.9	0.0	6.6	91.8	0.0	7.4	92.6
10. *Teachers are not to blame for the low performance of some students in biological concepts.	32.8	49.2	18.0	30.3	48.4	19.7	27.9	52.5	19.7
11. When a low-achieving child progresses in biological concepts, it is usually due to extra attention given by teacher.	4.9	41.8	53.3	4.1	29.5	64.8	7.4	40.2	52.5
13. *Increased effort in biological concepts teaching produces little change in some students' biological concepts achievement.	35.2	32.8	32.0	46.7	18.9	32.8	41.8	30.3	27.9
14. The teacher is generally responsible for the achievement of students in biological concepts.	15.6	50.0	34.4	10.7	51.6	36.1	16.4	62.3	21.3
15. Students' achievement in biological concepts is directly related to their teacher's effectiveness in biological concepts teaching.	10.7	39.3	50.0	4.9	27.9	65.6	7.4	35.2	57.4
16. If parents comment that their child is showing more interest in biological concepts at school, it is probably due to the performance of the child's teacher.	2.5	36.1	61.5	0.0	18.0	80.3	0.8	23.0	76.2
20. *Effectiveness in teaching biological concepts does not greatly affect performance of low-motivated students.	54.9	32.8	12.3	62.3	27.0	9.0	52.5	36.1	11.5
25. *No matter how well the teacher teaches the biological concepts, he/she cannot help some children to understand the biological concepts in depth.	58.2	27.9	13.9	59.0	27.0	12.3	53.3	31.1	15.6

Note. P: Phase; SD: Strongly disagree; D: Disagree; U: Undecided; A: Agree; SA: Strongly agree; *Negatively worded items; & Items of instrument have been adapted to measure biological concepts at initial measurement (Tzovla & Kedraka, 2020)

Exceptions are the statements "the inadequacy of students' biological concepts background can be overcome by effective teaching", which increased the percentage of agreement in the third phase, the statement "teachers are not to blame for the low performance of some students in biological concepts" that the same percentage is maintained, and "increased effort in biological concepts teaching produces little change in some students' biological concepts achievement", that the percentage decreased.

Figure 2 and **Table 6** show the means (and standard deviations) of the teachers' responses in all three phases of the study, on a 5-point scale (1=strongly disagree, ..., 5=strongly agree) for the 12 items the overall mean of BTOE subscale. Cronbach's alpha indicated the internal reliability of the subscale in all three phases to calculate the total mean of BTOE.

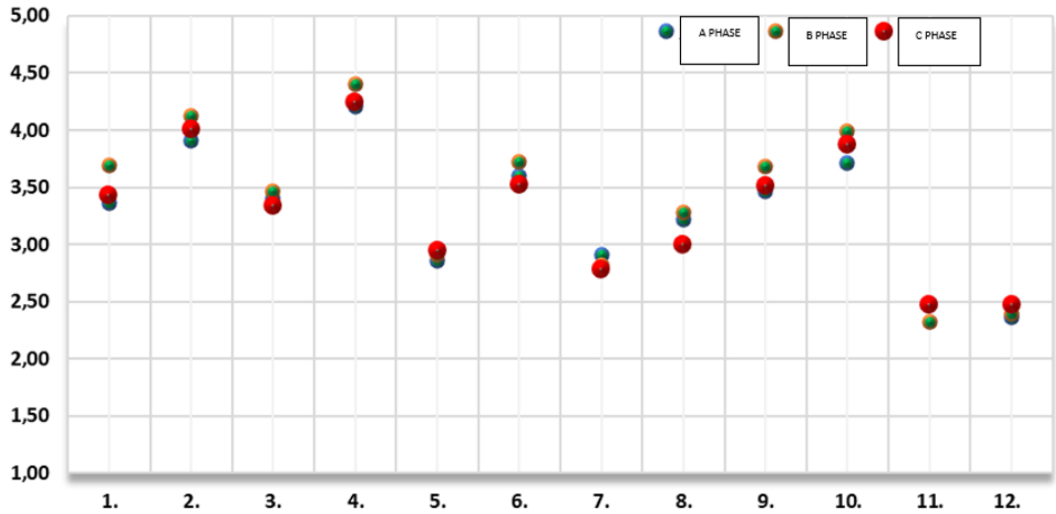

Figure 2. Mean of BTOE items in all three phases of study (1=strongly disagree, ..., 5=strongly agree) (Source: Authors)

Table 6. Means (& standard deviations) of teachers' responses in all three phases of survey to BTOE (n=122)

	P-A (pre-test)	P-B (post-test)	P-C (post-post-test)
	Mean (SD)	Mean (SD)	Mean (SD)
1. When a student does better than usual in biological concepts, it is because the teacher exerted extra effort.	3.36 (0.804)	3.69 (0.708)	3.43 (0.715)
4. When the biological concepts grades of students improve, it is most often due to their teacher finding a more effective teaching approach.	3.91 (0.739)	4.13 (0.573)	4.01 (0.568)
7. If students are underachieving in biological concepts, it is most likely due to ineffective biological concepts teaching.	3.40 (0.820)	3.47 (0.840)	3.34 (0.829)
9. The inadequacy of students' biological concepts background can be overcome by effective teaching.	4.20 (0.680)	4.40 (0.614)	4.25 (0.579)
10. *Teachers are not to blame for the low performance of some students in biological concepts.	2.86 (0.816)	2.91 (0.898)	2.94 (0.806)
11. When a low-achieving child progresses in biological concepts, it is usually due to the extra attention given by the teacher.	3.60 (0.757)	3.73 (0.710)	3.52 (0.741)
13. *Increased effort in biological concepts teaching produces little change in some students' biological concepts achievement.	2.91 (1.020)	2.82 (1.188)	2.78 (1.095)
14. The teacher is generally responsible for the achievement of students in biological concepts.	3.22 (0.838)	3.28 (0.791)	3.00 (0.727)
15. Students' achievement in biological concepts is directly related to their teacher's effectiveness in biological concepts teaching.	3.47 (0.815)	3.68 (0.710)	3.52 (0.730)
16. If parents comment that their child is showing more interest in biological concepts at school, it is probably due to the performance of the child's teacher.	3.71 (0.710)	3.99 (0.601)	3.87 (0.602)
20. *Effectiveness in teaching biological concepts does not greatly affect the performance of low-motivated students.	2.48 (0.893)	2.33 (0.852)	2.47 (0.883)
25. *No matter how well the teacher teaches the biological concepts, he/she cannot help some children to understand the biological concepts in depth.	2.37 (1.022)	2.39 (0.929)	2.48 (1.006)
Mean BTOE	3.52 (0.456)	3.66 (0.407)	3.52 (0.390)
Cronbach's alpha	0.787	0.739	0.720

Note. 1=strongly disagree, ..., 5=strongly agree; P: Phase; SD: Standard deviation; & There was a reversal in calculation of total means BTOE

The small mean increase in positively worded statements between the first and second phases of the study did not appear to be maintained between the second and third phases. In the positively worded statements, the means of the third phase revert almost to the means of the first phase. Of note is that the means increase of negatively worded statements "teachers are not to blame for the low performance of some students in biological concepts", and "no matter how well the teacher teaches the biological concepts, he/she cannot help some children to understand the biological concepts in depth".

Table 7. Differentiation test of teachers' responses to BTOE (n=122) (Wilcoxon signed rank test)

	Statistically significant differentiation between		
	A & B phase	B & C phase	A & C phase
1. When a student does better than usual in biological concepts, it is because the teacher exerted extra effort.	z=-4.39[b] p=0.00	z=-3.09[b] p=0.00	
4. When the biological concepts grades of students improve, it is most often due to their teacher finding a more effective teaching approach.	z=-2.83[b] p=0.00		
7. If students are underachieving in biological concepts, it is most likely due to ineffective biological concepts teaching.			
9. The inadequacy of students' biological concepts background can be overcome by effective teaching.	z=-2.82[b] p=0.00	z=-2.06[b] p=0.04	
10. *Teachers are not to blame for the low performance of some students in biological concepts.			
11. When a low-achieving child progresses in biological concepts, it is usually due to the extra attention given by the teacher.		z=-2.47[b] p=0.01	
13. *Increased effort in biological concepts teaching produces little change in some students' biological concepts achievement.			
14. The teacher is generally responsible for the achievement of students in biological concepts.		z=-2.91[b] p=0.00	z=-2.511[b] p=0.01
15. Students' achievement in biological concepts is directly related to their teacher's effectiveness in biological concepts teaching.	z=-2.46[b] p=0.01		
16. If parents comment that their child is showing more interest in biological concepts at school, it is probably due to the performance of the child's teacher.	z=-3.66[b] p=0.00		z=-3.33[b] p=0.02
20. *Effectiveness in teaching biological concepts does not greatly affect the performance of low-motivated students.			
25. *No matter how well the teacher teaches the biological concepts, he/she cannot help some children to understand the biological concepts in depth.			
Mean BTOE	z=-3.03[b] p=0.02	z=-2.91[b] p=0.04	

Note. [b]Based on negative ranks; & [c]Based on positive ranks

Friedman's test showed a statistically significant differentiation (p=0.014) overall in BTOE subscale among the three phases. Pairwise comparisons with the non-parametric Wilcoxon signed rank test showed statistically significant differentiations between the first and second phases in five items (1, 4, 9, 15, and 16), between the second and third phases statistically significant differentiations were noted in four items (1, 9, 11, and 14), while between the first and third phases only two differentiations were found, specifically in the items "the teacher is generally responsible for the achievement of students in biological concepts" and "if parents comment that their child is showing more interest in biological concepts at school, it is probably due to the performance of the child's teacher". It should be noted that no statistically significant differentiation was found overall in the subscale between the first and third phases (**Table 7**).

Comparatively Analysis of the Two Subscales in the Three Phases of the Study

The results showed that the participants presented rather a neutral position in both subscales that measured their self-efficacy. This attitude was maintained in all three phases of the study, but there was a positive increase after the program was completed, and while it was maintained in the third phase in PBTE subscale, the same did not happen with BTOE subscale, whose mean returned to the mean of the first phase.

Statistical tests (Wilcoxon) showed a statistically significant differentiation in the median of PBTE between the A and B phase and between B and C, but also between A and C phase, while for BTOE there was a differentiation between the A-B phase and between B-C phase, but not between A-C phase (**Figure 3**).

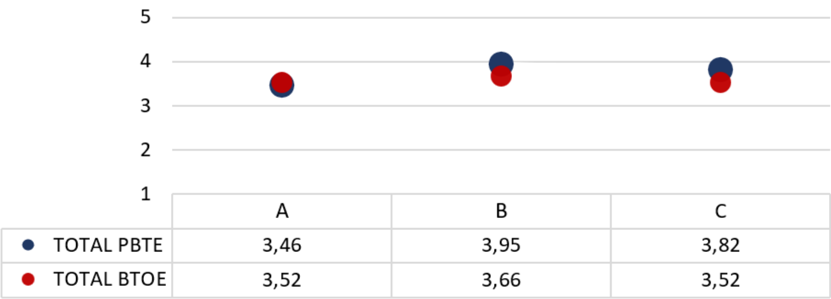

Figure 3. Means of two subscales in three phases of study (1=strongly disagree, ..., 5=strongly agree) (Source: Authors)

DISCUSSION

In the present study, we try to follow up on the effect of a distance learning teachers' professional development program, on the self-efficacy beliefs (PBTE and BTOE) of a group of in-service elementary school teachers. The self-efficacy beliefs of the participants were measured before the start of the program, immediately after its completion, and two years later (pre-test, post-test, and post-post-test).

Specifically, a positive increase was noted in the first subscale (PBTE), after attending the program, which was maintained relatively at the same levels in the third phase, while in the second subscale (BTOE) a slight improvement was observed immediately after attending the distance learning program, which did not seem to be maintained two years after its completion, and the beliefs of outcome expectancy seem to return to the levels of the first phase.

Regarding PBTE subscale since the period of two years is quite long, it seems that the program had long-term effects on the participants' self-efficacy beliefs. These findings are in line with the findings of research that dealt with the same topic (Batiza et al., 2013; Deehan et al., 2020; Malandrakis, 2018; McKinnon & Lamberts, 2014; Mentzer et al., 2014; Palmer, 2011; Sandholtz & Ringstaff, 2014; Ulmer et al., 2013), which advocate the improvement of personal self-efficacy beliefs both after attending a teachers' professional development program and in the long term. Improvement in personal self-efficacy beliefs immediately after the completion of the program indicates that it was purposefully designed and implemented and met the participants' educational needs. In addition, the maintenance of relatively improved personal self-efficacy beliefs two years after its completion reinforces the above, as the program seems to have improved their knowledge, skills, and teaching practices regarding the teaching of biological concepts in primary school through the sharing of materials, experiences, ideas, and practices among peers. Hence, it strengthened their self-efficacy beliefs about their own competencies.

With regard to the second subscale, BTOE, the findings showed that these beliefs improved immediately after attending the program–however, these differentiations are smaller than the differentiations noted in the first subscale–but they did not maintain. These findings agree with the research of Deehan et al. (2020), McKinnon and Lamberts (2014), Ulmer et al. (2013), and Wingfield et al. (2000), which refer to the short-term maintenance of improved outcome expectancy beliefs. The results of the improved outcome expectancy beliefs immediately after the completion of the program can perhaps be explained by the continuous interaction within a dynamic learning community, which was created during the implementation period of the program. Of note was that few studies report improvement and maintenance of self-efficacy beliefs in BTOE subscale either immediately after the completion of the program (Aji & Khan, 2019; Gosselin et al., 2010; Mentzer et al., 2014; Sandholtz & Ringstaff, 2014; Tzovla et al., 2021b) or in the long term (Crowther & Cannon, 2002; Malandrakis, 2018). Possibly, this is due to the wording of the subscale questions as it is referred to by many researchers who indicate the need to use multiple methods to investigate phenomena like those assessed by this subscale (Agu & Ramsey, 2018; Cetinkaya & Erbas, 2011; Deehan, 2016). In addition, the failure to maintain improved outcome expectancy beliefs in the long term may be linked to difficulties faced by teachers in the educational process such as the increase in the number of students per class, time pressure, representation of the teaching work, underfunding of schools, heterogeneity of the classes, and increased bureaucratic demands.

Ultimately, we conclude that the distance learning teachers' professional development program had a greater effect on PBTE subscale than on BTOE subscale.

CONCLUSIONS, LIMITATIONS, & FUTURE RESEARCH

Although there is increased interest in professional development programs, few of them follow up on their effects on teachers systematically and in the long term (Abdulghani et al., 2017). Notwithstanding, it should be noted that the continuous evaluation of teacher professional development programs is beneficial as feedback for all those involved in it. Follow-up gives information on whether a program brought about changes and transformations, whether these were maintained over time, what the teachers who completed the program expect, and finally allows the participants to realize their professional responsibility (Cochran-Smith & Reagan, 2021). The results of the follow-up evaluation are related to the continuation, modification, or termination of the program. For all the above reasons it is of paramount importance that follow-up is implemented not just once but at regular intervals.

Finally, there are some limitations to our study. One such is the limited amount of previous research on measuring teachers' self-efficacy in teaching biological concepts and the effect of teachers' professional development programs on self-efficacy beliefs in the long term. In addition, the measurement of the self-efficacy beliefs of the participants in the present research was based on the use of a self-report questionnaire. These tools limit the information to those that the research participant wishes to make available to the researcher, hiding information or exaggerating some of it.

All the above leads us to the conclusion that the theme needs to be further explored. More specifically, the research could be strengthened by using qualitative methods such as interviews, to draw safer conclusions. In addition, it would be interesting to continue measuring the self-efficacy beliefs of the participants to follow up on how the program impacts the self-efficacy beliefs of the specific group of teachers over time. Finally, it would be interesting to investigate in depth the role played by the learning community formed during the program and the role of the educational materials used.

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Declaration of interest: Authors declare no competing interest.

Data availability: Data generated or analyzed during this study are available from the authors on request.

REFERENCES

Abdulghani, H. M., Irshad, M., Haque, S., Ahmad, T., Sattar, K., & Khalil, M. S. (2017). Effectiveness of longitudinal faculty development programs on MCQs items writing skills: A follow-up study. *PLoS ONE, 12*(10), e0185895. https://doi.org/10.1371/journal.pone.0185895

Adams, R. D., & Craig, J. R. (1981). A survey of undergraduate teacher education evaluation practices. In S. M. Hord, & R. D. Adams (Eds.), *Teacher education program evaluation, theory, and practice*. R&D Center for Teacher Education.

Agu, P., & Ramsey, J. (2018). A validation of science teaching efficacy belief instrument for biology teachers. *Journal of Education & Social Policy, 5*(4), 146-154. https://doi.org/10.30845/jesp.v5n4p18

Aji, C., & Khan, M. (2019). A flight simulator-based active learning environment. *Open Journal of Social Sciences, 7*, 192-203. https://doi.org/10.4236/jss.2019.73016

Bandura, A. (1993). Perceived self-efficacy in cognitive development and functioning. *Educational Psychologist, 28*(2), 117-148. https://doi.org/10.1207/s15326985ep2802_3

Batiza, A. F., Gruhl, M., Zhang, B., Harrington, T., Roberts, M., LaFlamme, D., Haasch, M. A., Knopp, J., Vogt, G., Goodsell, D., Hagedorn, E., Marcey, D., Hoelzer, M., & Nelson, D. (2013). The effects of the SUN project on teacher knowledge and self-efficacy regarding biological energy transfer are significant and long-lasting: Results of a randomized controlled trial. *CBE–Life Sciences Education, 12*(2), 287-305. https://doi.org/10.1187/cbe.12-09-0155

Cetinkaya, B., & Erbas, A. K. (2011). Psychometric properties of the Turkish adaptation of the mathematics teacher efficacy belief instrument for in-service teachers. *Spanish Journal of Psychology, 14*(2), 956-966. https://doi.org/10.5209/rev_sjop.2011.v14.n2.41

Civaner, M. M. (2020). A follow-up study on the effects of an educational intervention against pharmaceutical promotion. *PloS ONE, 15*(10), e0240713. https://doi.org/10.1371/journal.pone.0240713

Cochran-Smith, M., & Reagan, E. M. (2021). *"Best practices" for evaluating teacher preparation programs.* National Academy of Education. https://doi.org/10.31094/2021/3/2

Crowther, D. T., & Cannon, J. R. (2002). Professional development models: A comparison of duration and effect. In *Proceedings of the Annual International Conference of the Association for the Education of Teachers in Science*.

Darling-Hammond, L., Hyler, M. E., & Gardner, M. (2017). *Effective teacher professional development*. Learning Policy Institute. https://doi.org/10.54300/122.311

Deehan, J. (2016). *The science teaching efficacy belief instruments (STEBI-A and B): A comprehensive review of methods and findings from 25 years of science education research*. Springer. https://doi.org/10.1007/978-3-319-42465-1

Deehan, J., Danaia, L., & McKinnon, D. H. (2020). From students to teachers: Investigating the science teaching efficacy beliefs and experiences of graduate primary teachers. *Research in Science Education, 50*, 885-916. https://doi.org/10.1007/s11165-018-9716-9

Field, A. (2013). *Discovering statistics using IBM SPSS statistics*. SAGE.

Franke, M. L., Carpenter, T. P., Levi, L., & Fennema, E. (2001). Capturing teachers' generative change: A follow-up study of professional development in mathematics. *American Educational Research Journal, 38*(3), 653-689. https://doi.org/10.3102/00028312038003653

Freer, E., & Keefer, Q. (2022). Are drug-free school zones effective? Evidence from matching schools and school-like entities. *Journal of Drug Issues, 52*(3), 283-305. https://doi.org/10.1177/00220426211057905

Gcabashe, N. B., & Ndlovu, N. S. (2022). Exploring business studies teachers' technology self-efficacy on their technology integration to create a learner-centered teaching environment. *International Journal of Learning, Teaching and Educational Research, 21*(12), 238-258. https://doi.org/10.26803/ijlter.21.12.13

Gosselin, D. C., Thomas, J., Redmond, A., Larson-Miller, C., Yendra, S., Bonnstetter, R. J., & Slater, T. F. (2010). Laboratory earth: A model of online K-12 teacher coursework*. Journal of Geoscience Education, 58*(4), 203-213. https://doi.org/10.5408/1.3534859

Handrianto, C., Jusoh, A. J., Rashid, N. A., Imami, M. K. W., Wahab, S., Rahman, M. A., & Kenedi, A. K. (2023). Validating and testing the teacher self-efficacy (TSE) scale in drug education among secondary school teachers. *International Journal of Learning, Teaching and Educational Research, 22*(6), 45-58. https://doi.org/10.26803/ijlter.22.6.3

Hsieh, C. C., Gunawan, I., & Hui-Chieh, L. (2023). Perceived instructional leadership and teacher self-efficacy of online teaching in Taiwan: Mediating effects of teacher professional community. *KEDI Journal of Educational Policy*, *20*(1), 3-21. https://doi.org/10.22804/kjep.2023.20.1.001

Katz, L., Raths, J., Mohanty, C., Kurachi, A, & Irving, J. (1981). Follow-up studies: Are they worth the trouble? *Journal of Teacher Education, 32*(2), 18-24. https://doi.org/10.1177/002248718103200204

Knapp, N. F., & Peterson, P. L. (1995). Teachers' interpretations of "CGI" after four years: Meanings and practices. *Journal for Research in Mathematics Education, 26*(1), 40-65. https://doi.org/10.2307/749227

Malandrakis, G. (2018). Influencing Greek pre-service teachers' efficacy beliefs and self-confidence to implement the new 'studies for the environment' curricula. *Environmental Education Research, 24*(4), 537-563. https://doi.org/10.1080/13504622.2016.1272672

McKinnon, M., & Lamberts, R. (2014). Influencing science teaching self-efficacy beliefs of primary school teachers: A longitudinal case study. *International Journal of Science Education, Part B, 4*(2), 172-194. https://doi.org/10.1080/21548455.2013.793432

Mentzer, G. A., Czerniak, C. M., & Struble, J. L. (2014). Utilizing program theory and contribution analysis to evaluate the development of science teacher leaders. *Studies in Educational Evaluation, 42*, 100-108. https://doi.org/10.1016/j.stueduc.2014.03.003

Najwan, A. A., Zahra, A, Firdaus, A. S., Lapuja, S., Mahrita, Y., Saper, M. N., & Handrianto, C. (2022). Autonomous learning strategy to improve learners' writing skills on package C program in PKBM Barito Banjarmasin. *Journal Pendidikan dan Pemberdayaan Masyarakat* [*Journal of Education and Community Empowerment*], *9*(2), 122-129.

Noben, I., Deinum, J. F., Douwes-van Ark, I. M., & Hofman, W. A. (2021). How is a professional development program related to the development of university teachers' self-efficacy beliefs and teaching conceptions? *Studies in Educational Evaluation, 68*, 100966. https://doi.org/10.1016/j.stueduc.2020.100966

Palmer, D. (2011). Sources of efficacy information in an in-service program for elementary teachers. *Science Education, 95*(4), 577-600. https://doi.org/10.1002/sce.20434

Peters-Burton, E. E., Merz, S. A., Ramirez, E. M., & Saroughi, M. (2015). The effect of cognitive apprenticeship-based professional development on teacher self-efficacy of science teaching, motivation, knowledge calibration, and perceptions of inquiry-based teaching. *Journal of Science Teacher Education, 26*(6), 525-548. https://doi.org/10.1007/s10972-015-9436-1

Raikou, N. (2019). Teacher education at the forefront: Long-term study through the prism of university pedagogy and transformative learning theory. *European Journal of Education Studies, 6*(3), 88-102.

Raymond, S., & Gabriel, F. (2023). An ecological framework for early years teacher self-efficacy development. *Teaching and Teacher Education, 132*, 104252. https://doi.org/10.1016/j.tate.2023.104252

Rettig, M. (2019). *Impact and follow-up study of program completers in the department of education*. https://www.washburn.edu/academics/college-schools/applied-studies/departments/education/data summaries/follow-up-study-report.pdf

Richardson, V. (1994). *Teacher change and the staff development process: A case in reading instruction.* Teachers College Press.

Riggs, I. M., & Enochs, L. G. (1990). Toward the development of an elementary teacher's science teaching efficacy belief instrument. *Science Education, 74*(6), 625-637. https://doi.org/10.1002/sce.3730740605

Sandholtz, J. H., & Ringstaff, C. (2014). Inspiring instructional change in elementary school science: The relationship between enhanced self-efficacy and teacher practices. *Journal of Science Teacher Education, 25*(6), 729-751. https://doi.org/10.1007/s10972-014-9393-0

Shahzad, K., & Naureen, S. (2017). Impact of teacher self-efficacy on secondary school students' academic achievement. *Journal of Education and Educational Development, 4*(1), 48-72. https://doi.org/10.22555/joeed.v4i1.1050

Tzovla E., & Kedraka, K. (2021). Exploring teachers' views on the impact of an online distance learning course on their self-efficacy beliefs. *International Journal of Learning and Development, 11*(3), 1-16. https://doi.org/10.5296/ijld.v11i3.18563

Tzovla E., & Kedraka, K. (2022). Highlighting educational needs in a teachers' professional development program*. European Journal of Alternative Education Studies, 7*(2), 1-12. https://doi.org/10.46827/ejae.v7i2.4487

Tzovla, E., & Kedraka, K. (2020). Personal biology teaching efficacy beliefs and biology teaching outcome expectancy of in-service elementary teachers. *European Journal of Education Studies, 7*(10), 143-159. https://doi.org/10.46827/ejes.v7i10.3286

Tzovla, E., Kedraka, K., & Kaltsidis, C. (2021a). Investigating in-service elementary school teachers' satisfaction with participating in MOOC for teaching biological concepts. *EURASIA Journal of Mathematics, Science and Technology Education, 17*(3), em1946. https://doi.org/10.29333/ejmste/9729

Tzovla, E., Kedraka, K., Karalis, T., Kougiourouki, M., & Lavidas, K. (2021b). Effectiveness of in-service elementary school teacher professional development MOOC: An experimental research. *Contemporary Educational Technology, 13*(4), ep324. https://doi.org/10.30935/cedtech/11144

Tzovla, E., Kedraka, K., & Lavidas, K. (2022). Investigation of in-service elementary school teachers self-efficacy in teaching biological concepts. *Hellenic Journal of Phycology, 19*(3), 254-275. https://doi.org/10.26262/hjp.v19i3.8766

Ulmer, J. D., Velez, J. J., Lambert, M. D., Thompson, G. W., Burris, S., & Witt, P. A. (2013). Exploring science teaching efficacy of CASE curriculum teachers: A post-then-pre-assessment. *Journal of Agricultural Education, 54*(4), 121-133. https://doi.org/10.5032/jae.2013.04121

Wingfield, M. E., Freeman, L., & Ramsey, J. (2000). *Science teaching self-efficacy of first year elementary teachers trained in a site-based program* [Paper presentation]. The Annual Meeting of the National Association for Research in Science Teaching.

Yogev, A. (1997). School-based in-service teacher education in developing versus industrialized countries: Comparative policy perspectives. *Prospects, 27*(1), 131-149. https://doi.org/10.1007/BF02755360

Zimpher, N. L., & Ashburn, E. A. (1985). Studying the professional development of teachers: How conceptions of the world inform the research agenda. *Journal of Teacher Education, 36*(6), 16-26. https://doi.org/10.1177/002248718503600603