Science Education International
30(4), 274-283
https://doi.org/10.33828/sei.v30.i4.4

to less experienced category having <10 years of full-time teaching the science instruction had in the classroom. The percent of experienced teachers with more than 10 years of teaching experience in science was 47.4%. The sample represented 202 (57.7%) teachers from Colombo zone, while the percentage of teachers from Homagama zone was 42.3% (148) with the informed consent.

Instrumentation

This study utilized a questionnaire, which consisted of three sections: (1) teacher demographics (Q1-Q6), (2) TSE (Q7-Q26), and (3) PD programs (Q27-Q32). The Teachers' Sense of Efficacy Scale (TSES) (Tschannen-Moran & Woolfolk Hoy, 2001) was adapted to assess the TSE of the science teachers. The instrument asked participants to rate their capabilities; "How much can you." utilizing the following anchored scale: 1 = Nothing, 3 = Very Little, 5 = Some Influence, 7 = Quite a Bit, and 9 = A Great Deal. The TSES has been extensively utilized and subjected to factor analysis procedures to assess construct validity (Tschannen-Moran & Woolfolk Hoy, 2001). The present study utilized the amended long summated rating scale (20 items) consisting of three distinct domains so that efficacy for IS (7 items), efficacy for CM (7 items), and efficacy for student engagement (6 items). Section three of the survey instrument contained the statements related to teachers' perceptions of teacher education program with reference to its orientation toward development of TSE as well as mastering skills in teaching scientific inquiry. Elements related to the development of self-efficacy were identified from the empirical research findings as identified in terms of four sources of self-efficacy by Bandura (1986, 1997). Similarly, teacher education was also operationalized from the empirically evident indicators in terms of the extent of teacher preparation in mastering skills in teaching scientific inquiry. The empirically evident facts were collectively considered and eight indicators/elements were constructed as measured from the questions (27–34). It consisted two indicators with enactive mastery experiences (27–28), two indicators with vicarious experiences (30–31), two indicators with verbal persuasion (32–33), and another two indicators in association with psychological arousal source (30,34). Adhering to the ethics such as informed consent and confidentiality, which assured the self-esteem and self-respect of the participants, the pilot study was administered personally just once, over a period of 1 month. Table 2 illustrates the summary of the items under two constructs after the pilot test.

A general linear model (GLM) univariate analysis using SPSS 21.00 program was used for descriptive statistics and association between perceived TSE and perceived level of teacher preparation through PD for inquiry-based science teaching, and effect size was using partial eta squared.

RESULTS

Teachers' Perceived Self-efficacy in Teaching Scientific Inquiry

For the 350 science teachers who participated in the survey, the mean perceived overall TSE in teaching scientific inquiry was 7.24 ± 0.44, while mean perceived TSE in student engagement (TSESE) in scientific inquiry activities was 6.91 ± 0.50. The mean perceived TSECM when students engage in scientific inquiry activities reported 7.56 ± 0.56, while that of in IS in relation to the scientific inquiry was 7.34 ± 0.50.

Perceived TSESE

As per the descriptive in Table 3, the lowest perceived TSE in TSESE reported for motivating students who show low interest in scientific inquiry (6.52 ± 0.71) and for improving understanding of a student who is failing in scientific inquiry (6.57 ± 0.72). On the other hand, teachers held quite high beliefs in their ability to get their students to believe they can do well in scientific inquiry (7.07 ± 0.71) and also in helping students value learning through scientific inquiry (7.27 ± 0.69). The self-reported efficacy in fostering student creativity was

Table 1: Descriptive statistics for respondents' profile

Characteristic	Frequency	Percentage
Gender		
Male	61	17.4
Female	289	82.6
Education level		
Degree holders	111	31.7
Non degree holders	239	68.3
Area of certification		
Qualified with Training or National Diploma	150	42.9
Qualified with postgraduate qualifications	138	39.4
Professionally non-qualified	62	17.7
Teaching experience in science		
Less experienced (Less than 10 years)	184	52.6
More experienced (more than 10 years)	166	47.4
Education Zone		
Colombo	202	57.7
Homagama	148	42.3

Science Education International
30(4), 274-283
https://doi.org/10.33828/sei.v30.i4.4

6.93 ± 0.69. The mean score of around 6 suggests that there is, however, low self-efficacy in overall beliefs in student engagement associated with scientific inquiry in science. About 47.7% of the science teachers held moderate beliefs that they could motivate students who show low interest in scientific inquiry in teaching scientific inquiry. About 52.6% of respondents believed they could make quite an influence in fostering student creativity (SE5) while the percentage with high belief was 16.9%. With regard to improving understanding of a student who is failing in scientific inquiry (SE6), the percentage with high belief was low (11.1%).

Perceived TSECM

Out of the three subscales of self-efficacy, the mean perceived TSECM associated with scientific inquiry in science reported comparatively a higher level, as illustrated in Table 3.

As shown in Table 2, the mean score of around 7 suggested that there was high self-reported efficacy in overall beliefs in CM associated with scientific inquiry in science. More than 50% of the participating science teachers reported quite a high belief that they could motivate students who showed low interest in scientific inquiry in teaching scientific inquiry.

Table 2: Summary of the items under two constructs after the pilot test

Construct	Dimensions	No. of items		Cronbach's α
		Initial	Final	
Support from teacher education program		8	6	0.722
Teacher self-efficacy		24	20	0.901
	Teacher self-efficacy student engagement	8	6	0.809
	Efficacy classroom management	8	7	0.870
	Efficacy instructional strategies	8	7	0.825

Table 3: Descriptive statistics for each factor under three sub scales of teacher self-efficacy

Components of teaches self-efficacy	n	Factors	Mean±standard deviation (1-9)
Student engagement	350	SE1–Helping students to think critically	7.15±0.69
		SE2–Motivating students who show low interest in scientific inquiry	6.52±0.71
		SE3–Getting students to believe they can do well in scientific inquiry	7.07±0.71
		SE4–Helping students value learning through scientific inquiry	7.27±0.69
		SE5–Fostering student creativity	6.93±0.69
		SE6–Improving understanding of a student who is failing in scientific inquiry	6.57±0.72
Classroom management	350	CM1–Making teacher's expectations clear about student behavior	7.22±0.70
		CM2–Establishing routines to keep activities running smoothly	7.27±0.73
		CM3–Getting students to follow classroom rules	7.56±0.66
		CM4–Calming a student who is disruptive or noisy	7.51±0.71
		CM5–Establishing a classroom management system with groups of students in scientific inquiry activities	7.58±0.70
		CM6–Keeping a few problem students from running an entire lesson	7.51±0.74
		CM7–Responding to defiant students	7.65±0.73
Instructional strategies	350	IS1–Responding difficult questions in scientific inquiry from students	7.56±0.65
		IS2–Gauging (assessing) student's comprehension in scientific inquiry what teacher has taught	7.22±0.70
		IS3–Crafting good questions for scientific inquiry for students	7.38±0.71
		IS4–Using a variety of assessment strategies for assessing scientific inquiry	7.07±0.71
		IS5 – Providing an alternative explanation, for example, when students are confused in scientific inquiry	7.56±0.66
		IS6–Implementing alternative strategies for scientific inquiry in the classroom	7.07±0.61
		IS7–Providing appropriate challenges for very capable students in scientific inquiry	7.58±0.71

Science Education International
30(4), 274-283
https://doi.org/10.33828/sei.v30.i4.4

Perceived TSEIS

According to Table 3, it is notable that teachers' self-reported efficacy beliefs in IS of scientific inquiry were at a satisfactory level, particularly with diverse groups of students, for example, those confused in scientific inquiry (7.56 ± 0.66) as well as those who were capable in scientific inquiry (7.58 ± 0.71). In addition, the participating teachers held quite a high belief that they could respond to difficult questions in scientific inquiry from students (7.56 ± 0.65). On the other hand, the results showed relatively low sense of belief in applying alternative strategies for scientific inquiry in the classroom (7.07 ± 0.61) as well in using a variety of assessment strategies for assessing scientific inquiry (7.07 ± 0.71). This would be a notable fact in constructive alignment in teaching scientific inquiry.

The mean score of around 7 suggested that there was a moderately high self-efficacy in overall beliefs in IS associated with scientific inquiry in science. The majority (more than 50%) of science teachers noted quite a high belief that they could perform the IS of responding, assessing, and providing an alternative explanation for both students who were confused as well as those very capable in scientific inquiry in teaching scientific inquiry.

PD Program Toward Scientific Inquiry

The perceived support from PD programs toward scientific inquiry was investigated in terms of efficacy sources of social cognitive theory and results are shown in Table 4.

Table 4 showed that use of enactive mastery experiences engaging long-term inquiry-based research projects (2.60 ± 1.09) and enactive mastery teaching experiences during student teaching/induction year (3.14 ± 1.18) in PD programs which could develop science teachers' self-efficacy for teaching scientific inquiry was comparatively lower than that of using vicarious experiences. It was notable that use of vicarious experiences through modeling specific set of professional behaviors of scientific inquiry teaching (3.33 ± 1.13) was moderately high in science PD programs. On the other hand, it reported relatively high use of PD programs allowing verbal persuasion such as collaborative training techniques that draw on the features of small group interactions (3.39 ± 1.11). At the same time, it was evident that during PD programs for scientific inquiry, science teachers had been guided by less experienced teacher educators with less confidence and less competence as a science educator, which led to weaken self-efficacy beliefs through negative appraisals than to strengthen such beliefs.

Predictors of Self-efficacy in Student Engagement for Inquiry-based Science Teaching

A (GLM univariate) procedure was used to test association among school characteristics (school type and education zone in which the school is situated), two subscales of self-efficacy (CM) and IS in teaching scientific inquiry) and self-efficacy in student engagement in scientific inquiry. The GLM procedure resulted (Table 4, model) except the education zone; all other variables were positively associated with science teachers' self-reported efficacy in student engagement for scientific inquiry in secondary classes (Grade 6-13). Among the tested variables, only school type, TSECM, self-efficacy in IS, and perceived support from PD programs reported as significant predictors of TSESE with regard to scientific inquiry teaching. The results of GLM are shown in Table 5.

When an insignificant variable of education zone was removed, it found school type, TSECM, self-efficacy in IS, and perceived support from PD programs as significant predictors of TSESE, indicating that there was a positive relationship among these four variables and the self-efficacy in student engagement. The R square value was 0.345, which means 34.5% of the variation in self-reported mean self-efficacy level in student engagement for scientific inquiry could be explained by school type, TSECM, self-efficacy in IS, and perceived support from PD programs.

The relationship between school type and self-reported mean self-efficacy level in student engagement for scientific inquiry differed across measures. The results also showed the mean self-reported efficacy in student engagement differ significantly for two pairs of type of schools; between type 1AB and type 3 ($r^2 = 0.293$, $\rho = < 0.001$) and between type 1C and type 3 ($r^2 = 0.246$, $\rho = 0.004$). The mean perceived efficacy in student engagement among science teachers in type 1AB and also in type 1C was significantly higher compared to that of those in type 3 schools.

Table 4: Descriptive statistics for each professional development program under efficacy sources

Self-efficacy sources	n	Factors	Mean±standard deviation(1-5)
Enactive mastery experiences	350	TEP1–Engaging long-term inquiry based research projects	2.60±1.09
		TEP2–Employing (enactive mastery) teaching experiences during student teaching/induction year	3.14±1.18
		TEP3–Simulated lessons with feedback	2.29±1.17
Vicarious experiences	350	TEP4–Modeling specific set of professional behaviors of scientific inquiry teaching	3.33±1.13
Social/verbal persuasion	350	TEP5–Collaborative training techniques that draw on the features of small group interaction	3.39±1.11
		TEP6–Guiding science teachers by less experienced teacher educators with less confidence and less competent as a science educator	3.00±1.24
		Prepared with adequate length of training session	3.30±1.07

Science Education International
30(4), 274-283
https://doi.org/10.33828/sei.v30.i4.4

Table 5: Results from general linear models univariate procedure

Variable	Mean±standard error (1-9)	B	p-value	Conclusion	Comparison
Education zone			0.627	Not Sig. diff.	H>C
Colombo	6.55±0.04				
Homagama	6.59±0.04				
School type			<0.001	Sig. diff.	1AB>1C>T3
Type 1AB	6.77±0.03				
Type 1C	6.70±0.06				
Type 3	6.25±0.06				
TSECM		0.209	<0.001	Sig. diff	
TSEIS		0.406	<0.001	Sig. diff.	
TEP		0.070	0.002	Sig. diff.	

TSECM: Teacher self-efficacy in classroom management, TSEIS: Teacher self-efficacy in instructional strategies

Among the teacher efficacy related subscales, the positive interaction would imply that teachers' perceived self-efficacy in CM ($r^2 = 0.209$, $\rho = < 0.001$) and in IS ($r^2 = 0.406$, $\rho = < 0.001$) were likely to have an impact on increasing perceived self-efficacy in student engagement of scientific inquiry. The results further revealed that the impact of perceived self-efficacy in IS on that of student engagement for the scientific inquiry was higher than that of CM. Similarly, teachers' perceived support from PD programs toward scientific inquiry teaching in science reported having a slight catalytic effect on their increased perceived self-efficacy in student engagement of scientific inquiry in the classroom ($r^2 = 0.070$, $\rho = 0.002$).

DISCUSSION

Despite the emphasis laid on inquiry-based science instruction in producing scientifically literate citizens in most of the recent science education reform documents (AAAS, 1993; NRC, 1996, 2000), its enactment in the science classroom is still a potentially fruitful area for further research. Teachers' self-efficacy as a critical factor in teacher performance in scientific inquiry has not amply researched in the Sri Lankan context. This study has important implications in filling this research gap. The outcomes of this study indicate teachers' perceived self-efficacy, support from science teacher PD programs, and the impact of school-related and teachers' efficacy related predictors on their self-reported efficacy in student engagement in relation to enactment of inquiry-based instruction in science classrooms.

The research sought to describe the changes in self-reported mean TSE in teaching scientific inquiry, in general, as well in terms of student engagement, CM, and IS. Although the reported overall self-efficacy was quite high (7.24 ± 0.44), the levels differed across subscales. In compliance with previous studies (Roberts et al., 2006; Seneviratne et al., 2018; Seneviratne, 2018; Seneviratne et al., 2019a; Stripling et al., 2008; Swan et al., 2011; Wolf et al., 2008), this investigation also found relatively a lower level of efficacy beliefs in student engagement domain compared to other two domains. On the other hand, other studies showed contradictory findings in this regard (Ahokoski et al., 2017; Silm et al., 2017) revealed that teachers had experienced an increase particularly in their efficacy for student engagement related to inquiry learning. Ahokoski et al. (2017) elaborate that this change might be due to the fact that those teachers were able to directly observe students' engagement and enthusiasm while working on an inquiry activity in a training course, which then immediately influenced their confidence on the matter. Silm et al. (2017) also experienced the same fact behind this increase in efficacy in student engagement "it may be that the teachers had positive experiences with IBL, which in turn impacted their general belief on how well they can engage students" (p. 323). This study provides an important insight identifying some underlying factors affecting self-efficacy in student engagement. However, this mixed result of changes in self-efficacy in student engagement along with the underlying reasons for such changes compared to self-efficacy in CM and IS need to be further supported from future research.

Apart from self-efficacy changes, this study also investigated NOS teacher PD programs, in particular, it's tailoring to use self-efficacy sources (as defined by Bandura, 1994) to support science teachers for implementing inquiry-based science instruction in the classroom. The findings showed that the commonly employed source of efficacy in PD programs was verbal/social persuasion (collaborative training techniques that draw on the features of small group interaction). Furthermore, the results revealed a moderate level of use of modeling specific set of professional behaviors of scientific inquiry teaching which has been categorized as powerful vicarious experiences in raising self-efficacy beliefs. The other notable fact was less use of PD programs with enactive mastery experiences, which allows science teachers authentic experiences of scientific inquiry practices. If teachers have more opportunities for mastery experiences such as scientific inquiry projects (Liang & Richardson, 2009), simulated lessons and successful participation in science teaching practice (Kenny et al., 2014; Mansfield & Woods-McConney, 2012), the higher chance is that they will use it in their teachings (Magee & Flessner, 2012; Morrison, 2014). Designing PD programs of such kinds would benefit science teachers as they would then have multiple opportunities to develop their understanding of science and

Science Education International
30(4), 274-283
https://doi.org/10.33828/sei.v30.i4.4

teachers ‘sense of efficacy and attitudes toward inquiry-based learning. *Science Education Journal*, 28(4), 315-325.

Smolleck, L.A., & Mongan, A.M. (2011). Changes in pre-service teachers; self-efficacy: From science methods to student teaching. *Journal of Educational and Developmental Psychology*, 1, 133-145.

Stripling, C., Ricketts, J.C., Roberts, T.G. & Harlin, J.F. (2008). Pre-service agriculture education teachers' sense of teaching self-efficacy. *Journal of Agricultural Education*, 49(4), 120-130.

Swan, B.G., Wolf, K.J., & Cano, J. (2011). Changes in teacher self-efficacy from the student teaching experience through the third year of teaching. *Journal of Agricultural Education*, 52(2), 128-139.

Swars, S.L., & Dooley, C.M. (2010). Changes in teaching efficacy during a professional development school-based science methods course. *School Science and Mathematics*, 110, 193-202.

Tschannen-Moran, M., & Woolfolk, H.A. (2001). Teacher efficacy: Capturing an elusive construct. *Teaching and Teacher Education*, 17, 783-805.

Tschannen-Moran, M., Woolfolk Hoy, A., & Woolfolk Hoy, K. (1998). Teacher efficacy: Its meaning and measure. *Review of Educational Research*, 68(2), 202-248.

Voet, M., & De Wever, B. (2017). Preparing pre-service history teachers for organizing inquirybased learning: The effects of an introductory training programme. *Teacher and Teacher Education*, 63, 206-217.

Wolf, K.J., Foster, D.D., & Berkenholz, R.J. (2008). *Changes in Teacher Self-efficacy and Perceptions of Preparation of Agricultural Education Teacher Candidates*. Cornell, New York: Proceedings of the North Central AAAE Conference. p180-191. Available from: http://www.aaaeonline.org/allconferences.php?show_what=NorthCentral. [Last accessed on 2018 Sep 25].

Zimmerman, W.A., Knight, S.L., Favre, D.E., & Ikhlef, A. (2017). Effect of professional development on teaching behaviors and efficacy in Qatari educational reforms. *Teacher Development*, 21(2), 324-345.