DETERMINING EFFECTS OF A WEB-BASED TEACHERS' PROFESSIONAL DEVELOPMENT PROGRAMME ON TEACHING SELF-EFFICACY BELIEFS AND CLASSROOM PRACTICE

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Abstract

The design of large-scale professional development (PD) programmes for teachers in the public schooling system faces two challenges. The first is identifying a suitable malleable construct which influences student performance, for designing interventions. Given the positive impact of teacher self-efficacy beliefs on student achievement, improving a teacher's teaching self-efficacy beliefs is a desirable goal for a PD programme. Second, in a large resource-constrained public system, cost-effective reach is important. PD programs that have used technology judiciously for this purpose have shown promise, but the related research has reported mixed results, thus warranting further investigation.

An online PD programme for Class 6-8 teachers in the public schooling system in Gujarat, aimed at improving teaching self-efficacy, provided the empirical context to study the effective use of technology in teacher training. A two-group randomized control trial was implemented to examine the effects of PD programme on self-efficacy beliefs. The PD design was in accordance with Desimone's (2009) five core features PD programme viz. content focus, active learning, coherence, duration and collective participation. The study analyses survey responses of 19135 teachers and the classroom observations of 710 classrooms.

The teachers who attended the online PD reported a positive change in subject-specific self-efficacy beliefs. Mixture modelling of participant activities found four latent profiles based on latent profile analysis of pageview logs of 7037 participants, and six latent classes based on latent class analysis of responses to off-platform activity questionnaire of 7794 respondents. The variation in off-platform activities was significantly associated with the change in self-efficacy beliefs of the participants. The different latent online profiles were mostly associated with variation in change of subject-specific self-efficacy beliefs. The comparison of classroom observation of participant teachers with non-participating teachers found no significant difference in teacher's classroom actions (i.e. teacher activities & use of materials). But found significant difference in teacher's use of textbooks (i.e. reading materials) in science classrooms. Finally, the teacher's self-efficacy beliefs before training were found to be significantly associated with classroom activities, but the association of prior classroom activities to post-training self-efficacy beliefs was limited. The study provides insights on the "what works?" and "for whom?" questions in the context of large-scale PD for teachers.

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1 Introduction

In the field of education, one of the most critical areas of reform is in-service teacher training (Borko, 2004; Desimone, 2009). Professional development (PD) programmes for teachers lead to better policy implementation and higher student achievement (Borko, 2004; Opfer & Pedder, 2011). Access to PD programmes enables in-service teachers to update their knowledge and skills (Opfer & Pedder, 2011). Any changes needed in classroom content or practices, which then influence student learning outcome would need effective PD programmes for teachers (Borko, 2004). PD becomes especially important when there are major curricular changes. Providing training to teachers during such times involves spending large sums of money (Minor et al., 2016), not just on PD but also on systems to guarantee teachers participation in in-service training programmes (Gore et al., 2017).

The importance of PD in the field of education has resulted in many questions: What makes a PD programme effective? And how does a PD programme bring about change, i.e. improvement in student learning and teacher's classroom practices? Research in the field is crucial in this era of evidence-based policymaking. Our study, presented in the following sections, intends to expand on the "what works?" and "how it works?" questions in the literature on professional development programmes for in-service teachers.

1.1 Background

Professional Development Programmes for teachers is a critical area to reform the field of education, and it also involves large sums of money. Evaluation of Professional Development (PD) programmes for teachers have reported both success and failures (Desimone & Garet, 2015). Studies have also found variation in outcomes for participants attending the same programme (Minor et al., 2016). Olofson and Garnett (2018), in their qualitative study, found that participants in the same PD had different views on the objectives of the PD programme. Research has also found that participants in the same PD vary in their preference for and access to the different components of the programme (Qian et al., 2018; Rosaen et al., 2013). Recent studies have attempted to uncover "effective specific activities" after Desimone and Garet (2015) pointed out the need for such work. While some have looked into the effects of different interactions in a PD programme (Li et al., 2016) others have attempted to explore the effects by classifying professional learning activities as formal (or conventional), e.g. seminars, workshops, etc. and informal (or supplementary) collaborative planning, mentoring etc. (Fischer et al., 2018; Múñez et al., 2017).

A few studies have also looked at professional development programmes for teachers in India. Dyer et al. (2004) based on a study of district institutes of education and training (DIET) in Rajasthan, Madhya Pradesh & Gujarat cited a lack of systematic evaluation of on-site training provided to teachers. Saigal's (2012) two case studies in Rajasthan of "situated learning approach" for in-service teacher education highlighted the need for providing teachers with ideas that support them in dealing with issues at their individual school sites. Kidwai et al. (2013) studied two rural districts, one in Assam and the other in Andhra Pradesh and found that the on-site training provided is not aligned to teacher needs. Banerjee et al. (2017) report how training teachers to implement multi-level instructions in Indian states translated to effective classroom implementation and improved student outcomes only when resources for periodic support were made available. A large-scale online training of teachers was conducted by IIT Bombay, but there have been no studies on its impact on teacher's knowledge & beliefs, classroom practice or student outcomes (Atrey et al., 2016; Kannan & Narayanan, 2015). Kuril (2019) described the effect of an online PD on the change-oriented behaviour of school leaders (headteachers and principals) and has recommended the approach can also be applicable to teacher PD. Further evaluation studies are needed to determine effective components of PD programmes in the context of India. Most of the studies conducted in India have been qualitative which provided insights on the "how?" and "why?" of professional teacher development. The IIT Bombay study was a quantitative study that demonstrated the technical feasibility of using technology in large scale teacher training but conducted a satisfaction survey instead of an evaluation of its impact on the teachers. Kuril (2019) was a randomized control trial that evaluated the effects of online professional development and found that the training was effective in improving the behaviour of programme participants.

Improving teachers' teaching self-efficacy beliefs is important for higher student achievement (Goddard et al., 2000; Lumpe et al., 2012; Tschannen-Moran & Hoy, 2001) and adoption of effective classroom practice (Gabriele & Joram, 2007; Gibson & Dembo, 1984; Gregoire, 2003; Levenson & Gal, 2013; Summers et al., 2017). Desouza et al. (2004)

conducted a survey of science teachers in the southern states in India and found a decrease in outcome expectancy beliefs with years of teaching. The researchers recommended monitoring teacher's science teaching self-efficacy beliefs as an outcome of professional development programmes. Dyer et al. (2004), based upon interviews of well-performing teachers, expressed the need for teacher development programmes to focus on improving teachers' beliefs about their own capacity as "change agents". Singh and Sarkar (2015) performed a longitudinal study in Andhra Pradesh and found the need for teacher training programmes to focus on teacher attitudes and beliefs. Sehgal et al. (2017) surveyed teachers and students of private schools in Delhi, Indore, and Gujarat and found that, teaching self-efficacy beliefs were associated with teacher effectiveness in facilitating classroom interactions and regulating student learning. Thus, studies show that improving teaching self-efficacy beliefs is a desirable objective for PD programmes designed for teachers in India.

The focus of our study is a large-scale web-based PD programme offered for science and math teachers (for class 6 - 8) of state-run primary schools in the state of Gujarat, India. The primary objective of the programme was to improve teachers' self-efficacy beliefs. We intend to determine which of the various components of the programme were effective in addressing the primary objective of the programme. Further, we aim to explore the association between teaching self-efficacy beliefs of randomly selected programme participants and their classroom practice.

2 Literature Review

Professional Development programs have been defined by Guskey (2002) to be

"*systematic efforts to bring about change in the classroom practices of teachers, in their attitudes and beliefs, and in the learning outcomes of students*." (p. 381)

Over the years "learning outcomes" of students have come to refer to not just knowledge, as measured on standardized tests, but also beliefs and attitudes. For the purpose of our study, we adopt the definition provided by Merchie et al. (2018):

"*activities explicitly designed for and provided to educators or certified educational professionals with a focus on enhancing their own and their students' knowledge, skills, and attitudes*." (p. 144)

Thus, the definition views PD programme as consisting of purposefully designed activities towards effecting change in teachers and students. Many researchers have proposed models to explain how this change process occurs (Boylan et al., 2018; Clarke & Hollingsworth, 2002; Desimone, 2009; Guskey, 2002). These models enabled designers, facilitators and researchers to design, implement and study effective PD programmes (Boylan et al., 2018). Most models for PD would try to explain the connections between four main components: (a) the intervention (PD programme), (b) impact on the educator's knowledge, beliefs or attitudes, (c) change in educator's classroom practice, and (d) effect on student's knowledge, beliefs or attitudes. The most studied PD models in the literature are; (1) linear causal pathway model by Guskey (2002), (2) a linear model with "non-recursive interactive pathway" by Desimone (2009), and (3) a multipath interconnected model by Clarke and Hollingsworth (2002) (Boylan et al., 2018).

Guskey's 2002 linear path model proposes that change in teachers' beliefs and attitudes occurs after teachers observe improvement in student learning outcomes which followed teachers' change in classroom practice after a PD programme, thus arguing that change in action precedes the change in beliefs. Empirical studies have shown that changes in beliefs do occur before the change in practices, thus challenging the one-way causal pathway of the model (Levenson & Gal, 2013; Summers et al., 2017). Unlike Desimone (2009), the model does not consider (or list) contextual factors that could potentially influence the process. The Clarke and Hollingsworth (2002) model does consider contextual factors and indicates explicit learning pathways for the process of change in teacher's knowledge, beliefs and attitudes, teacher's classroom practice and student's outcome. Desimone's (2009) model provides an analytical framework to evaluate features of the PD programme not incorporated in other models. Incorporating such features allows for evaluating theories of teacher change, i.e. the theory about the features of PD that would lead to change in teacher's knowledge, beliefs or attitudes (Wayne et al., 2008). Postholm's (2012) review found justification for all the five PD features included in Desimone (2009) lending credibility to the model being called a "consensus" model.

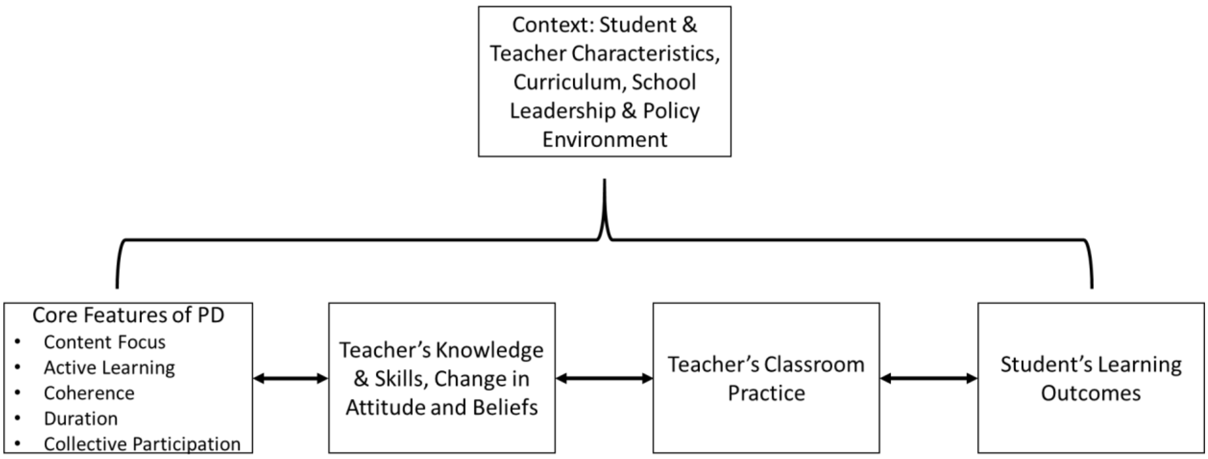

Figure 1 Desimone's (2009) Model of Professional Development of Teachers

2.1 Features of Teachers' Professional Development Programme

Desimone's (2009) model lists content focus, active learning, coherence, duration and collective participation as the core features of a professional development programme. Content focus is not only on the subject matter but also on explaining how students learn the subject matter; this has been shown to be beneficial in improving student achievement. Active learning techniques such as receiving interactive feedback and participating in discussions have been found to be effective in professional development. Coherence refers to how consistent the programme activities are with teacher knowledge and beliefs and the state's education policy. The professional development programme needs to span sufficient duration for intellectual and pedagogical changes to occur. Finally, the collective participation of teachers in the learning process facilitated by interactions among teachers of the same school or grade or department, have been found to be beneficial.

Various studies have been conducted to evaluate the effectiveness of PD programmes. Capps et al.'s (2012) review of the literature indicated that programmes that focused on teacher's reflection on their practice resulted in a significant change in teacher learning. Pehmer et al. (2015) found their video-based PD to be successful because the videos presented authentic teaching practices. Van Aalderen-Smeets and Walma van der Molen (2015) found that their attitude-focussed PD programme for primary teachers helped improved self-efficacy beliefs about science and teaching science. Brownell et al. (2017) found that programmes with individualized support for special education teachers resulted in improved outcomes. Saderholm et al. (2017) noted the failure of large-scale PD in influencing teacher's classroom practice as the content did not focus on authentic classroom environments. Yurtseven and Altun (2018) conducted a qualitative study that indicated self-reflection and peer review contributed to professional development among foreign language teachers.

A few researchers have tried to compare different PD programmes to determine which core features were effective. Heller et al. (2012) compared the impacts of three professional development programmes and found that PD programmes whose content focused on pedagogical practices, i.e. analysis of student's work and classroom best practices resulted in improved performance by teachers. Lindvall et al. (2018) found that the outcomes of two PD programmes offered to school teachers in Sweden varied due to the difference in the content focus of both programmes. Beisiegel et al. (2018) conducted a study to determine which combination of facilitator (external or teacher) and classroom videos (stock or own /peer) in an analysis-of-practice PD programme for elementary mathematics was more effective. The study found that analysing videos of own or peer's classroom session led by a fellow teacher resulted in improved classroom practice. As there was no significant change in teachers' reflective practices, the authors concluded the outcome of the study as being mixed.

Studies have reported a mixed verdict on the features of PD as propounded by Desimone (2009). Desimone and Garet (2015) have noted that the various randomized trials conducted to test the five core features of PD have reported both success and failures. Kennedy (2016) pointed out that incorporating the five features of PD, as listed in the model does not necessarily lead to a successful programme. Merchie et al. (2018) presented an extended list of features for the model, based on a review of published studies, along with a new feature "trainer's quality". Trainer's quality is envisioned as the content knowledge the PD facilitators have along with the skill to provide useful individual feedback to the participants of the PD programme. Thus, the research on PD based on the features listed in Desimone's model is still ongoing, reporting mixed results and warranting further investigation.

2.2 Impact of PD on Teacher's Knowledge, Beliefs and Attitudes

Many studies have been conducted to ascertain the impact of PD programmes on teacher knowledge, beliefs & attitudes primarily to evaluate theories of teacher change. Some studies have found significant positive impacts due to PD programmes. Sandholtz and Ringstaff (2013) found that a PD programme affected the self-efficacy beliefs of teaching science in rural elementary schools one year after the programme. Barr et al. (2015) used Desimone's framework to evaluate the PD programme for Social Science teachers and found that it had significant positive effects on teacher self-efficacy beliefs, but the effect on students was moderate. Carney et al. (2016) studied a state-mandated 45-hour professional development programme for 4000 mathematics teachers and evaluated its impact on participant's knowledge and beliefs. The study found that the facilitator driven PD programme resulted in a significant change in teacher knowledge and self-efficacy beliefs. Kutaka et al. (2017), in their longitudinal study, found that participation in PD had a significant effect on teacher's content knowledge and attitude to mathematics.

Some studies found no significant change or mixed results on teacher knowledge & beliefs. A review of the empirical literature on PD found that six of the 17 empirical studies, listed changing teacher beliefs as the goal of PD and positive effects were reported in four of the six studies (Capps et al., 2012). Polly et al. (2014) report the findings of evaluating an 84-hour PD programme for elementary school mathematics teachers. The study reported a significant positive change in the teacher knowledge but not in beliefs. The evaluation found no significant changes in student performance on the math assessment. Jacob et al. (2017) analysed the effects of commercially available PD programme for mathematics teachers conducted over a period of three years. They found a significant change in the teacher's content knowledge after the first year of the programme and no difference in the following two years. The authors cite the lack of leadership support faced by the programme in the last two years. Also, they state that the content of the programme was sufficient for changing teacher beliefs, but it was insufficient in providing necessary resources and support for teachers to change classroom practice.

Studies have also been conducted to assess the effects of new forms/types of PD programmes on teacher knowledge & beliefs. Bruce and Flynn (2013) found that the three-year PD programme provided to mathematics teachers which involved collaborative inquiry activities of co-planning and co-teaching resulted in a highly significant change in self-efficacy beliefs about teaching mathematics. Enderle et al. (2014) found that PD programmes that provided "guided research experience" to science teachers had a positive effect on teacher self-efficacy beliefs in teaching science, but it did not change their beliefs about the effect of teaching science on student's performance. Schipper et al. (2018) conducted a quasi-experimental study to evaluate the effectiveness of a new form of PD programme, Lesson Study, on teacher's self-efficacy beliefs in the Netherlands. The programme's content focused on student learning and encouraged participants to collaborate and innovate classroom sessions. The study found that self-efficacy beliefs in student engagement of the teacher in the PD programme were significantly higher than the comparison group.

PD programme effects have also been evaluated in developing nation contexts as well. Nawab (2017) found that a state-run PD programme in Pakistan positively improved the attitude of the teachers, but implementation in classroom sessions was adversely affected due to lack of resources and support from management and peers. Chaaban (2017) evaluated a PD programme for English teachers in Qatar towards adopting a constructivist pedagogy and found the programme was successful in causing a significant change in the pedagogical beliefs of the teachers. Thus, various articles in the literature show that Desimone (2009) model is widely referred to and allows for a variety of evaluation studies. But, most of these studies treated the PD programmes as a whole and did not investigate the effectiveness of specific activities within the programme. Desimone and Garet (2015) indicated the need for PD research to investigate the effects of specific components of the programme

One of the key parts of the teacher's knowledge beliefs and attitudes is teaching self-efficacy. Tschannen-Moran and Hoy (2001) define teaching self-efficacy as "the judgement of one's capabilities to influence student engagement and learning". Empirical studies have shown a positive relationship between a teacher's efficacy beliefs and student outcome measures such as achievement, motivation and self-efficacy (Tschannen-Moran & Hoy, 2001). Studies show teacher self-efficacy to be strongly correlated with better student achievement in standardized tests (Goddard et al., 2000; Tschannen-Moran & Hoy, 2001). Research has shown that teachers with higher self-efficacy beliefs, after a PD programme, are more likely to implement instructional practices outlined in the PD programme (Gabriele & Joram, 2007; Gibson & Dembo, 1984; Gregoire, 2003). Teachers with high teaching self-efficacy beliefs feel more confident in trying different teaching activities to improve their student's learning (Summers et al., 2017). Empirical studies have shown that increased teacher self-efficacy beliefs have a positive impact on teacher's classroom practice (Levenson & Gal, 2013) and students' beliefs & performance (Lumpe et al., 2012). Thus, improving teacher's teaching self-efficacy beliefs is a desirable goal for any PD programme.

2.3 Factors Influencing Impact of PD on Teacher's Knowledge, Beliefs and Attitudes

As mentioned earlier, the "consensus" model allows for studying of contextual factors that may affect the influence of a PD programme. Opfer et al. (2011) concluded from a national level cross-sectional survey of teachers in primary and secondary schools in England that change in teachers due to professional learning is based on their beliefs, practices and prior experience of learning. Van Driel et al. (2012), based on a review of studies about PD programmes for science teachers, found that most studies did not consider the impacts of local context and school-level factors. Corkin et al. (2015) study found that the impact of PD for mathematics teachers on their self-efficacy beliefs was moderated by their academic background. Whitworth and Chiu (2015) found that the factors such as experience, motivation, school culture and working conditions affected the impact of professional development on teacher's knowledge, attitude and beliefs. The authors also noted that prior self-efficacy beliefs also impacted the effects of PD. Minor et al. (2016) studied the moderation effect of teacher background on the impact of content in PD on teachers learning and found that what teachers learn depends on their prior knowledge. Schuchardt et al. (2017) studied the effect of varying the duration of instruction in a PD programme for mathematics teachers and found that the effect varied based on the teacher's prior knowledge and experience. Desimone and Hill (2017) in their study of factors influencing the impact of PD on middle school science teachers in the US, suggested the need for investigating effects of demographic factors such as gender and race. Martin and Thomson (2018) found how cultural practices of deference to elders and persons with higher authority and maintaining knowledge as secrets hampered the professional development programme of in-service teachers featuring collaborative projects in Kiribati. In summary, teachers' prior academic background, work experience self-efficacy beliefs and local/cultural context significantly impact the effect of PD intervention on teacher beliefs, knowledge and attitudes.

2.4 Impact of PD on Teacher's Classroom Practice

Various evaluations of PD programmes have looked at impacts on teachers' classroom practices. Desimone et al. (2013) established that PD based on subject content or strategies of teaching the content have a positive impact on the teachers' classroom practice. Smith (2015) studied the effects of PD among primary school teachers teaching science in Ireland and found positive impacts on teacher's confidence and adoption of effective classroom practices. Fischer et al. (2018) analysed teachers' self-reported participation in PD programmes and classroom instructional practices along with student performance in a national science exam. The study found that PD does affect teacher's classroom practices, but classroom practices had a small impact on student learning

However, some studies have also reported no change in the classroom practice of the participating teachers (Olofson & Garnett, 2018; Piasta et al., 2017; Saderholm et al., 2017). Piasta et al. (2017) evaluated a large-scale state-sponsored PD programme administered to language teachers in Ohio, USA. The study found no significant change in teacher knowledge, beliefs and practices. The authors cited improper delivery of PD as one of the reasons for their findings. Olofson and Garnett (2018) found that a PD programme with content focused on constructivist pedagogy did not improve participants' adherence to student-centric instructions.

Studies have found that PD programmes that had components based on peer observations and peer feedback improved participants' classroom practices (Beisiegel et al., 2018; Gore et al., 2017; Hamilton, 2013). Brownell et al. (2017) found that a PD programme with individualized support for special education teachers resulted in improved outcomes both in classroom instruction and student outcomes. Thus, there is a need for evaluating the role of specific components of a PD on teacher and student outcomes.

2.5 Factors Influencing Impact of PD on Teacher's Classroom Practice

Mixed outcomes of PD on teacher's classroom practice have resulted in studies on determining the factors that influence the impact of the programme on participants' instructional strategies. Chaaban (2017) found mandatory curriculum pacing as one of the reasons why English teachers in Qatar were unable to adhere to the guidelines of their PD programme during classroom sessions. Studies also found that lack of resources and leadership support in the school prevents teachers from implementing what they have been trained for in the PD programme (Jacob et al., 2017; Nawab, 2017). Sandholtz and Ringstaff (2013) in their longitudinal study of state-funded PD programme found that effects on instructional practice, one year after the programme, were influenced by contextual factors such as school resources, local policies and support from administration and peers. Additionally, studies have found that teachers with more work experience were likely to adopt effective classroom practices (Fischer et al., 2018; Luft, 2001). In summary, contextual factors like policy, infrastructure and management support and prior experience influence the impact of the PD programme on change in classroom practices.

2.6 Studies on learner engagement/participation

A few PD evaluation studies have also tried to study the difference in levels of participation of teachers, its causes and effects. De Vries et al. (2013) surveyed secondary school teachers to study the relationship between the differences in teacher participation in PD programme and the teachers' beliefs about teaching and learning. They could classify participants into three groups viz. low, medium and high based on their level of participation. Their study found that higher the participation in PD, stronger were their beliefs in student-centred teaching. Prior work had also used levels of participation with different teacher characteristics to arrive at four or five types of teacher participation in PD programmes. In recent work, researchers studied patterns of accessing the PD material for different groups of teachers to determine how prior knowledge affects engagement with the contents of the online PD programme (Qian et al., 2018). Rosaen et al. (2013) evaluated components of a web-based PD which showcased videos of an authentic case study of other teachers designing, teaching and evaluating reading lessons. These videos were accompanied by questions posed for self-reflection and experts' analysis and comments on the videos. Interviews of participants indicated that the case-studies were found to be useful, but the response on accompanying questions and expert comments was mixed. The mixed response, the authors' state, is an outcome of differences in participating teacher's prior knowledge and experiences.

The prominent field that deals with studying a learner's engagement/participation in a programme is Educational Data Science (EDS). EDS grew due to Massive Open Online Courses (MOOCs) which generated huge amounts of data on participant's interaction with educational content (Romero & Ventura, 2017; Tseng et al., 2016). EDS is constituted of various sub-fields like Learning Analytics, Educational Data Mining, Institutional/ Academic Analytics, etc.(Romero & Ventura, 2017). As per Tseng et al. (2016), EDS can be defined as "the application of processes and systems to extract knowledge or insights from educational data in various forms, either structure or unstructured". Researchers who studied the patterns of participant engagement in MOOCs were able to classify them into either four (Kizilcec et al., 2013) or seven (Ferguson & Clow, 2015) groups. (Kizilcec et al., 2013) classified participants based on how often they viewed videos and submitted assignments and found four types: "completing, auditing, disengaging and sampling". Ferguson and Clow (2015) also considered participant's interaction on the discussion forum which resulted in seven distinct groups. Anderson et al. (2014) explored the relation of online activities (watching videos, reading discussion forums, assignments submissions & completion of quizzes) with the achievement of learners in MOOCs and found that watching lecture videos correlated highly with learning outcomes.

Learner interaction data in MOOCs had been used to help identify participants who would discontinue the course (Brooks et al., 2014; Tabaa & Medouri, 2013). Researchers who have worked on analysing patterns of participant engagement proposed the application of the findings towards identifying areas of improvement in courses (Coffrin et al., 2014), designing courses that accommodate different learning styles (Milligan et al., 2013) and understanding how to retain learners till the end of the course (Ramesh et al., 2013). Kalakoski et al. (2015) proposed the use of methods in educational data sciences to improve job training for professionals. Recent studies on teacher quality improvement programmes have adopted latent class analysis to evaluate its participation and adoption (Kunst et al., 2018; Lamont et al., 2018). Latent class analysis enables the identification of similar groups of individuals within a heterogeneous population. Kunst et al. (2018) explored the association of different latent profiles of goal orientation of teachers with their participation in professional development programmes showing how different goal orientation profiles led to higher or lower participation in PD programmes. While, Lamont et al., (2018) used latent class analysis to identify different classes of teachers based on their adoption of educational technology in their classrooms to evaluate the adoption of the professional development programme. Thus, analysing the activities of the learner using recent analytical methods would provide a better understanding of the factors affecting learning and the changes in content and presentation that would be required.

2.7 Technology-based PD Programmes

Information Technology being a prominent feature of the 21st century, it is evident that researchers would have studied technology-based programmes. Dede et al. (2009) argued that technology-based PD (online / multimedia) could address the need for access to high-quality resources to a large number of participants at flexible times and at affordable costs. Lieberman and Mace (2010) expressed the need for adopting new technology, specifically multimedia tools, to reduce the cost of PD programme and using social networking tools to enable collaboration sharing of best practices among teachers. Wilson (2013) stated the need for implementing PD with the help of online platforms which are scalable and provide "just in time training" to train a large number of teachers on next-generation science curriculum. Hill et al. (2013), in their review, concluded that there is no significant difference in outcomes for teachers' who attended PD either online or in-person. Holmes et al., (2013) proposed that Twitter can be used by educators to collaborate and learn by following each other hence building a "learning network". Pehmer et al. (2015) in a quasi-experimental study found the video-based PD to be more effective than the traditional PD. M. J. Kennedy et al. (2017) found that a multimedia-based PD to teach vocabulary in inclusive classrooms resulted in positive changes in the teacher's classroom practices. A study found that participating in a mathematics subject group of a social networking site, designed for education - EDMODO, made teachers feel empowered and motivated to change their practice (Trust, 2017). Overall, the research on technology-based PD has shown promising results.

3 Context

In India, the majority of the population (68.84 % as per Census 2011) resides in rural areas where the state is a provider of primary education to many children. Annual national surveys of the numeracy and literary of the children studying in these regions have consistently indicated a dire situation (ASER Center, 2015, 2017). A study of nine states conducted by the National University of Education and Planning Administration (later renamed as National Institute of Education and Planning) in 2015 found a lack of effective policy for in-service teacher training and a shortage of quality teachers(Ramachandran et al., 2016). The study found that the proportion of teachers who received in-service training had dropped from 36.4 % in 2005-06 to 25.8 % in 2012-13. As per the available latest DISE Elementary State Report Cards of 2016-2017 (page 27), only 46% of Upper Primary teachers had received in-service training in the previous year i.e. 2015-2016. Reasons for limited coverage of training have been attributed to school management decisions, state policy, or in the case of small schools with few teachers, the absence of a formal policy of arranging a substitute to relive the teacher to attend training. Limited resources with the state for education and high demand for quality teachers warrants the need for improving in-service training for primary school teachers (Kundu, 2019; Ramachandran et al., 2016). Taking cognisance of the state of teacher training the need for a national level online teacher training platform was presented by the National Council for Teacher Education(National Council for Teacher Education, 2017). The availability of such a platform was argued to be ideal for providing continuous professional development for teachers. On 5th Sept 2017, such a portal, Digital Infrastructure for Knowledge Sharing (DIKSHA), was launched to cater to the needs of online learning of teachers. It was envisioned that each state will move their in-service teacher training on to the portal after making the required changes.

In 2017 SETU, an online training platform for principals and head teachers of govt schools in Gujarat was designed and delivered by Ravi J Matthai Centre for Educational Innovation (RJMCEI), IIM Ahmedabad in coordination with Gujarat Council Education Research and Training. Evaluation of the programme found improvement among school leaders and showed that a web-based medium could be suitable for professional development(Kuril, 2019). Subsequently, SAMARTH, designed by RJMCEI and Govt. of Gujarat, an online professional development programme, was offered to Science and Mathematics teachers employed by the Gujarat state in 2018.

Prior to SAMARTH, the literature presents one only large scale technology PD in India offered by IIT Bombay (Atrey et al., 2016; Kannan & Narayanan, 2015) called the "Teach 10000 Teachers (T10KT)". The aim of the programme was to improve the teaching skills of faculty in the engineering and science discipline. It consisted of synchronous sessions conducted by the expert which participants attend from remote centers in the first half of the day. In the later half, participants would undertake assignments and tutorials. Also, the training consisted of asynchronous components made available via Moodle. The effectiveness of the training was evaluated only on the level of satisfaction reported by the participants of the PD (Kannan & Narayanan, 2015). Another state-wide online PD, SETU (Kuril, 2019) was offered to school leaders and had expert made content, authentic case-study and project work. The evaluation of the programme showed significant improvements among the participants of the programme. The positive response to the components within the SETU programme resulted in SAMARTH adopting a similar template but for teachers teaching Maths and Science in grades 6, 7 and 8.

Aspects of this PD programme for teachers reflected Desimone's five core features.

- Content focus: The programme not only covered subject knowledge on the content but also included videos and cases of examples of how to teach them in class.
- Active Learning: Although most of the content in the programme was in text and videos, the project component of the PD involved teachers undertaking a classroom activity based on the topics covered in the programme, then receiving grades and feedback from peers.
- Coherence: The programme covered content that was planned to be taken up in the first semester of the academic class. All content was in the regional language, i.e. Gujarati. Also, the cases depicting authentic, innovative classroom practices were of teachers from the state primary schools the same as the participants.
- Duration: The online platform was accessible to the participants anytime from the 20th May 2018 till 31st August 2018 (extensions were also provided to teachers on a case by case basis). Thus, sufficient duration was provided to the participants

- Collective Participation: The teachers participating in the programme were from the same state and taught at primary schools under the same management structure. Also, all participants were assigned to teaching Science and Mathematics to standards 6, 7 & 8. The programme also encouraged the use of social networking platforms (Facebook & WhatsApp) thus, meeting sufficient conditions for collective participation among programme participants

The programme consisted of 5 modules, which were segmented into two sections. Section A consisted of two modules covering topics on Science and Mathematics respectively, and Section B of three modules covered topics on Learning Management, Student Comprehensive Evaluation and Use of Information Communication Technology in classrooms. Each topic covered in the modules consisted of text and complimentary video created by subject matter experts. Additionally, the application of the concepts, covered in the topics, were demonstrated from case-studies on innovative teachers curated and maintained by Education-Innovation Bank at Ravi J Mathai Centre for Educational Innovation. At the end of each module, every participant was presented with situational vignettes on the Module topic to which they would select an appropriate response. In order to complete the course, participants were expected to undertake a real-world project based on the end of module vignettes presented in science and mathematics modules. These projects were peer-reviewed using a rubric by four or five anonymous participants providing qualitative feedback and suggestions. The selection of case-studies and design of the end of module questions and the peer-feedback system for projects was intended to improve self-efficacy beliefs among the participants. The description of the programme contents has been presented in Table 1. In line with earlier mentions of low costs in providing online PD, a subsequent programme, SAMARTH 2, designed for 1,50,000 teachers had an overall per teacher budget of Rs. 105 which is about 10% of the expenses for an equivalent onsite program (Chand, 2019).

Table 1 Content of the SAMARTH Programme

Section	Content	Description
Modules: Mathematics, Science, Learning Management, School Evaluation & Use of ICT	Expert's Content	The content consisted of a write-up and Video prepared by the subject matter experts (both State Teacher Training and RJMCEI teams) Both write up and videos were downloadable for offline viewing
	Case Studies	This content was a write-up and video of innovative classroom practice related to the topic from primary school teachers in the same state of Gujarat. Both write up and videos were downloadable for offline viewing
	End of Module Questions	These were Multiple Choice Questions that were based on issues faced by primary school teachers. Upon answering, participants were provided feedback on if their answers were correct/incorrect and why they are correct/incorrect
Project	Project Implementation & Submission	After the end of modules in Science and Mathematics teachers were requested to design and implement a classroom project to address one of the issues posed as a question in the End Module Section. After implementing the project teachers had to submit a report along with photographs on the SAMARTH website
	Review of Peer's Project	All participants had to grade five projects submitted by their peers.
	Receive Project Feedback	Once a participant's project was graded by five peers it was accessible to the teacher to view the grades and comment received on the project and plan changes if required.

4 Research Questions

Prior literature on measuring the effectiveness of PD programme ascribes the outcomes of the evaluation to the PD programme as a whole. While a PD programme consists of "specifically designed activities" (Merchie et al., 2018). All the activities and components within the programme may not be equally effective. Desimone and Garet (2015) have mentioned the need for further research to determine the effectiveness of specific activities within a PD programme. This study adds to the existing literature on effective online PD by determining the effectiveness of specific activities and components and providing an approach to determine effective activities within the programme.

This study intends to explore the effects of the SAMARTH programme on its participants. First, the association of participant activities with the change in teaching self-efficacy beliefs is explored. The outcomes of the study would provide inputs for future designs of PD programmes in the state. Next, it explores the relationship between teachers' self-efficacy beliefs and their classroom practice, as indicated in the Desimone (2009) model. This would provide inputs for future implementation and/or evaluation of PD programmes in the state.

To investigate the association of participant activities with the change in self-efficacy, first, it needs to be determined if there is any change in self-efficacy among the participants of the programme. Then, the heterogeneous groups among participant based on their activities would be identified. Finally, the association of the identified variation in participant activities with the change in efficacy will be analysed. Thus, the study will answer the following questions: -

1. What is the effect of the SAMARTH professional development programme on teachers' teaching self-efficacy beliefs?
2. What are the different latent classes based on participant activities during the SAMARTH professional development programme?
3. What is the association of different latent classes based on participant activities with the change in teaching self-efficacy beliefs?

Next, before the association of participant self-efficacy with classroom practices is analysed, the effect of participating in the programme is determined. Hence, we need to answer the following research questions: -

4. What is the difference in the classroom practices between the participating and non-participating teachers?
5. What is the association of teaching self-efficacy beliefs with classroom practice?

The investigations of the research questions and the results are presented in the following sections. The next section would present the investigation of the different patterns of participant engagement and their association with the change in self-efficacy among the participants. The following section will evaluate the effects on classroom practice and the association of self-efficacy belief with classroom activities. These will be followed by sections on discussion, implications of the study's findings, and limitations and scope of future work.

5 Association of Participant Activities with Change in Self-Efficacy Beliefs

In order to determine what is the association of participant activities during the PD with the reported change in self-efficacy, we need to first determine if there was any change in self-efficacy beliefs among the participants of the PD programme. Survey responses by participants in both the groups at two time points enable the estimation and comparison of the change in self-efficacy beliefs. Next, the different ways in which participants engage with the online content and off-platform activities of the PD programme need to be identified. Finally, we determine the variation in change in self-efficacy associated with the different ways in which participants engaged with the PD content both online and off-platform. This section presents the method and findings of the study.

5.1 Method

In this section, we provide details of the subjects of the study, the data that was gathered for the investigation and the analysis that was adopted to answer the research questions.

5.1.1 Participants and Random assignment

The Government of Gujarat provided a list of 19,605 teachers for online training on the SAMARTH platform. A randomized two-group study with pre-test and post-test surveys was designed to measure the effect on change in self-efficacy among participants of the online training. Two groups (Group A and Group B) were planned such that group A was offered the training first (May – August 2018) while group B would attend training later (September – December 2018). Participants of both groups A and B filled the pre-training survey while registering in May 2018. Then group A participants filled the post-training surveys at the end of their PD in August 2018 while group B filled the survey in September 2018 at the start of their programme. Thus, the surveys filled by participants in May 2018 were taken as pre-test while those filled at end of August 2018 by group A and the beginning of September 2018 by group B as post-test

Power analysis and determination of sample size were performed using Optimal Design Plus Empirical Evidence Software (Raudenbush et al., 2011) to perform power analysis and determine the sample size for our study. The teachers in the study are the census of all science and math teachers teaching maths and science in government primary school for standard 6,7 and 8 in the state of Gujarat. Assignment to Group A or Group B of the teachers was done based on the school's cluster code. Hence, we performed analysis to determine the minimum detectable effect size of the study with a varying number of clusters. According to the state list, the average number of math and science teachers per cluster was 4.63 (19605 teachers /4230 clusters). Thus, we modelled the size of the cluster as 4. Taking the Intra Cluster Correlation as 0.25 (Spybrook et al., 2011) we found that a total number of 1500 clusters (750 treatment group & 750 control group) permit a minimum detectable effect size of 0.1. In the list provided there were 2928 clusters with 4 or more teachers.

The following steps were coded in R (R-Core Team, 2016) to ensure random assignment along with the desired group size:

i. A random sequence of 50000 cluster codes was generated from the list of cluster codes of the selected set without replacement using a pseudo-random generator
ii. The cluster codes were then assigned in sequence to either group based on the following rules
    - If Group A size is less than the desired ratio of Group B, then the cluster is assigned to Group A, else to Group B
    - If Group A size is greater than 10,000, then cluster assigned to Group B.

Of the 19,605 teachers, 13,896 registered and completed the Pre-training survey by the end of May. 7,331 Group A participants began their training immediately after filling the survey. 6,565 teachers in Group B started training in September after Group A teachers had completed their programme. After the start of training, teachers were missing from the initial list due to the administrative process of transfers and incorrect entries in the earlier list. These teachers were randomly allocated to either Group A (3,204) or Group B (2,035) but assigned with codes that indicate that the participants were inducted into the programme after May. Thus, a total of 19,135 participants registered for the programme in May 2018.

5.1.2 Data

For the study, we needed participant responses to a standard self-efficacy scale and also the online and off-platform activities of the PD participants.

5.1.2.1 Survey Instruments

Participant's self-efficacy beliefs were measured via online surveys when registering for the programme in May – June 2018. After the treatment group completed the programme, in Aug-Sept 2018, teachers in both the control and treatment group were asked to fill a retrospective Pre and Post training survey to measure change due to the PD programme. Teaching Self-efficacy was measured using the scale provided by Tschannen-Moran and Hoy (2001). As self-efficacy beliefs are subject-specific teachers' self-efficacy beliefs about teaching Science and Mathematics were captured using instruments STEBI (Riggs & Enochs, 1990) and MTEBI (Enochs et al., 2000).

The Teaching Self-Efficacy scale consists of three subscales: Instructional Strategy, Classroom Management & Student Engagement. The instructional strategy scale measures a teacher's efficacy belief in being able to adopt an effective instructional approach in a classroom. Example items in the sub-scale are: "To what extent can you use a variety of assessment strategies?" and "How well can you implement alternative strategies in your classroom?". The classroom management sub-scales with items like "How much can you do to calm a student who is disruptive or noisy?" and "How much can you do to get children to follow classroom rules?" measure teacher efficacy beliefs about managing classrooms. Finally, the student engagement scale looks at teacher beliefs about being able to successfully engage students in their classroom sessions with items like "How much can you do to get students to believe they can do well in schoolwork?" and "How much can you do to motivate students who show low interest in schoolwork?".

The subject-specific self-efficacy scales, STEBI & MTEBI, each consist of two sub-constructs the personal subject teaching efficacy belief and the subject teaching outcome expectancy beliefs. The personal subject teaching efficacy belief subscales measure the teacher's own efficacy belief about teaching the subject using items like "I generally teach science (maths) effectively" and "I find it easy to explain to students why science experiments (mathematics) work(s)". The outcome expectancy sub-scale consists of items like "When the science (mathematics) grades of students improve, it is most often due to their teacher having found a more effective teaching approach” and “Students' achievement in science (mathematics) is directly related to their teacher's effectiveness in science (mathematics) teaching”, which measure teacher’s belief in the outcomes of their teaching. All scales were translated to Gujarati by experts and validated by back-translation. The responses to the survey were recorded on a 5-point Likert scale.

5.1.2.2 Online page-view activity of participants

Online activities of the participants on the platform were captured by logging pageviews on Google analytics. This provided pageview logs of the participants on the SAMARTH website. Pageview logs of all Group A participants were downloaded using R (R Core Team, 2019) with RSelinium package (Harrison, 2019). This allowed for sequential download of weekly activity of the participants as logged on google analytics server. Once downloaded, the logs were checked for any missing file and scheduled for scripted download to ensure that there was no participant activity and that there was no mistake by the downloading script. The downloaded logs were analysed using R with R-Studio (RStudio Team, 2019) and jsonlite package (Ooms, 2014) to extract time spent by each participant on each navigated page of the platform. Time spent on the content was calculated by taking the difference between consecutive timestamps of the pageview logs. Additionally, time spent on pages at the end of the session was estimated using the user level average time spent on the page when the pageview was not at the end of the session. As each content had a specific page URL, it enabled easy calculation of time spent (in minutes) on specific contents by the participant. The total time spent was calculated for each participant on expert made contents of Science, Math, Classroom Management, School Comprehensive Evaluation and ICT use and also the corresponding case studies. Additionally, the time spent on grading peer projects and reviewing feedback by peers on projects was also calculated.

5.1.2.3 Off-platform activities of participants

Further, after the end of the programme, each teacher filled a questionnaire which was based on Veletsianos et al., (2015) study of offline study practices of participants in a Massively Open Online Course. A questionnaire was prepared based on Veletsianos et al. (2015)’s study of offline activities that participants of online courses undertake when learning. The items in the questionnaire were checked for face validity by experts and a few teachers in state-run schools who had undergone online training. This survey was translated to the regional language and then back translated to confirm the accuracy of the translation. The questionnaire was filled online, by participants at the end of the programme. The questionnaire consisted of items on notetaking activities eg. "How many PDF files did you download?" and "Did you take/maintain notes related to the course offline?" and interactional activities eg. "Did you discuss the content of the programme with other participant teachers?" and "Did you join any Whatsapp or Facebook group for discussing the course content?"

5.1.3 Analysis

This part presents the analysis undertaken to answer the research questions.

5.1.3.1 Confirmatory Factor Analysis and Measurement Invariance

We analysed the survey responses of both group A and Group B using Mplus 8.4 (Muthén & Muthén, 2017). We first conducted a confirmatory factor analysis and also tested for measurement invariance. Confirmatory factor analysis was performed separately for each subscale. The response to survey items was treated as categorical, and the weighted least square (WLS) estimator was used in the analysis. Measurement model consisting of both Pre-test and Post-Test responses was evaluated separately in Group A & Group B. Model Fit was evaluated based on criteria provided by Hu and Bentler (1999) & Marsh et al. (2004) i.e. CFI >= .95, TLI >= .95, RMSEA <= .06, & SRMR <= .08. Items with standardized loadings less than 0.5 and with correlation with other items were dropped. The figure below depicts the model implemented for confirmatory factor analysis.

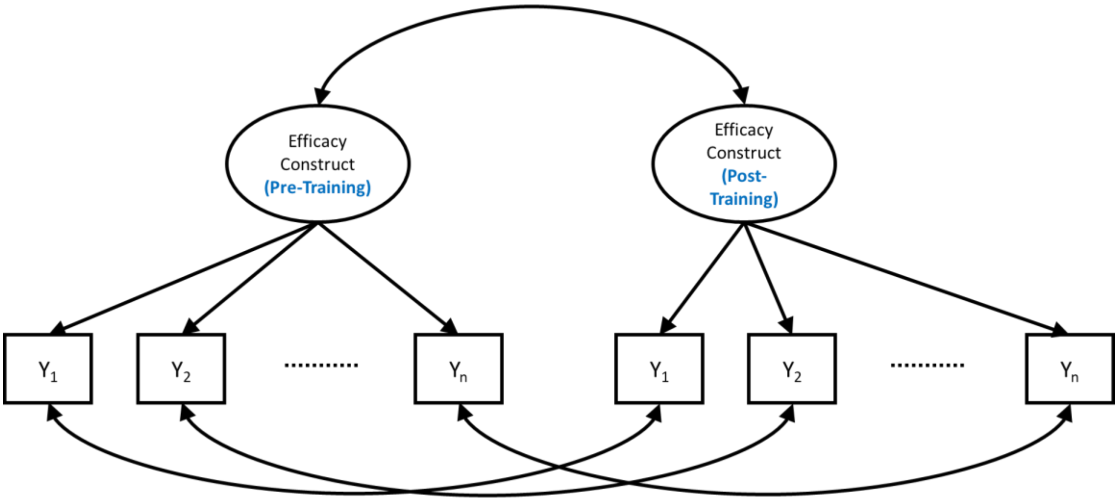

Figure 2 Measurement Model of Self-Efficacy constructs

Tests for Measurement Invariance of the Constructs were performed on the measurement models. Two Models were specified; 1) Non-Invariant: All parameters of the model were free to be estimated in Group A & Group B separately, but factor means were fixed to zero and scale factors fixed to one and 2) Invariant: factor loadings and thresholds were fixed across groups, but with factor means fixed to zero in Group B and free in Group A and scale factors fixed to one in Group B and free in Group A. Difference in Chi-Square, CFI & RMSEA was evaluated to determine if the measurement was invariant across Group A & Group B.

5.1.3.2 Attrition Analysis

The number of respondents to the survey dropped between the pre-training and post-training. Hence it needs to be tested if there is any significant difference in pre-training self-efficacy beliefs of the participants who did not fill the post-survey compared to the participants who did respond.

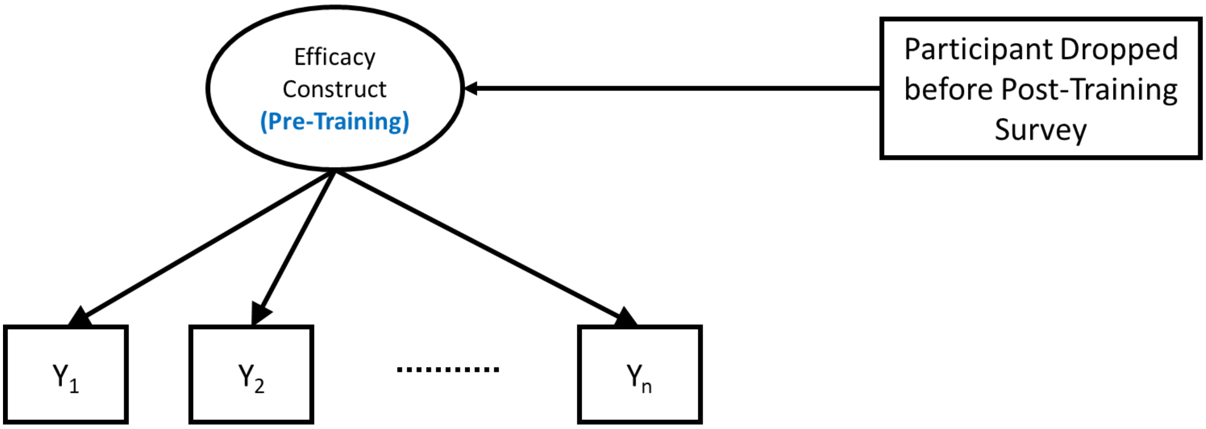

Figure 3 Model to evaluate attrition of respondents based on pre-training survey

We used the above model in Figure 3 to evaluate the difference in pre-training self-efficacy beliefs between respondents and non-respondents.

5.1.3.3 Latent Change Analysis

As we wished to determine the change in self-efficacy over the two time points across both the groups we adopted the latent change model proposed by Alessandri et al. (2017). Alessandri et al. (2017)'s method of second-order multi-group latent curve modelling (SO-MG-LCM) for Pretest-Posttest Design, was implemented to determine the change in self-efficacy beliefs among members. The analysis method involved setting up of second-order latent variables which measured baseline and change in the latent constructs. The article's example was adapted for categorical responses using the Mplus user guide and reference materials available on their website. The article describes a four-step approach of which the first three involve analysing three models viz. a. No Change, b. Change only in the intervention Group, c. Change in both intervention and control group. Finally, after finding the best fitting model from the first three running d. the best fitting model but with baselines restricted to be equal. As we wish to measure and identify the change in both groups, we ran the model which estimated change in both groups. Additionally, we regressed the estimated change on participant covariates of age, gender, work experience and qualifications. The structural model implemented for the analysis is presented in Figure 4.

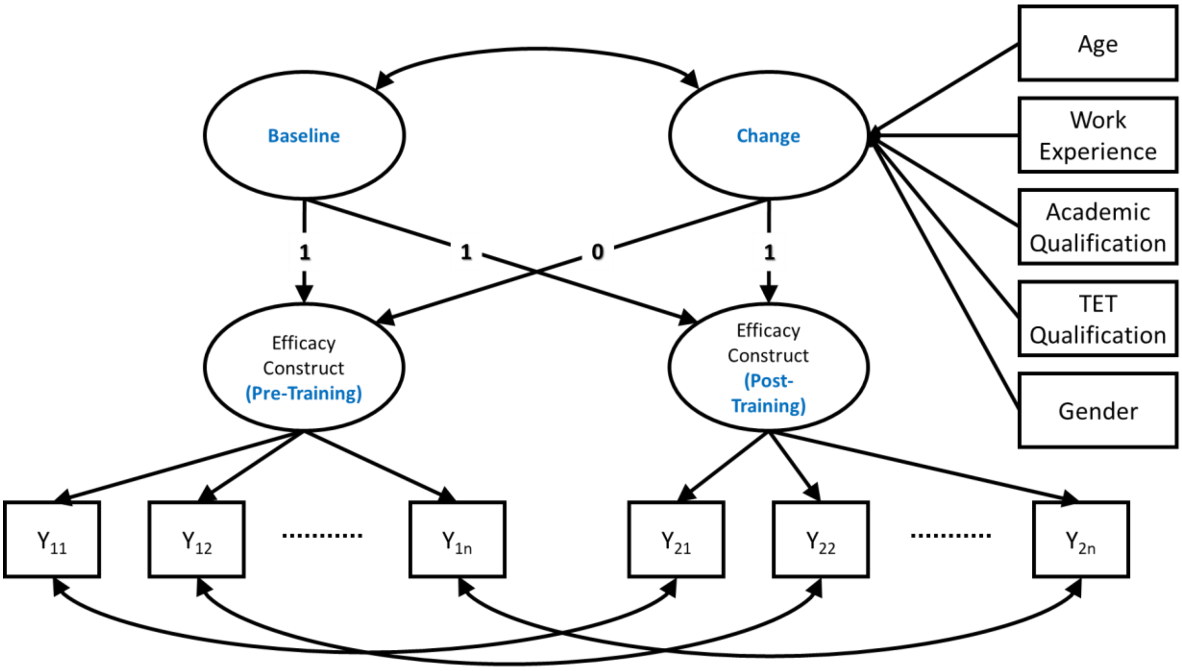

Figure 4 Model for Latent Change Analysis

The latent change in self-efficacy among participants of group A and group B was then compared using the model test feature of Mplus (Muthén & Muthén, 2017). The following hypothesis is tested using the Wald test, where Δ_A is the mean change in Group A and Δ_B is the mean change in Group B.

Null Hypothesis: $H_0: 0 = \Delta_A - \Delta_B$

Alternate: $H_1: 0 \neq \Delta_A - \Delta_B$

5.1.3.4 Mixture Modelling: Latent Class and Latent Profile Analysis

A mixture modelling approach was used to determine the heterogeneity in online and offline activities among the participants of the programme. Mixture Modelling approach enables the identification of homogenous groups within a given population, but unlike cluster analysis, they involve formal statistical methods to confirm the number of clusters instead of subjective choices and provide cluster membership probabilities which enable easy interpretation of groups. Mixture modelling allows for uncertainty and measurement errors by allowing individual respondents fractional memberships in all groups. In mixture modelling, if the data analysed is categorical, then the process is referred to as latent class analysis and if data is continuous as latent profile analysis. The statistical benefits of the method and availability of computing power and software enable the implementation of mixture modelling for data mining purposes in large scale educational technology research.

Categorical responses to the off-platform activities of participants were used to determine latent classes, while calculated time spent on specific course pages was used to determine latent profiles among the participants. Nylund et al. (2007) recommend the use of Bayesian Information Criteria (BIC) or Bootstrapped Likelihood Ratio tests (BLRT) to determine the appropriate number of homogenous classes/profiles. The article notes that for a high number of observations (n > 1000) the performance of Likelihood Ratio tests (LRT), viz. VLMR LRT & ALMR LRT is reliable. Also, the article mentions that the LRTs are robust and valid even if the distribution of data within classes/profile is non-normal. The following steps were followed to determine the final number of latent groups among the learners.

1. Get a stable and reproducible solution
2. Run Likelihood Ratio tests using OPTSEED and TECH 11
3. Run Bootstrapped LRT using OPTSEED and TECH 14

5.1.4 Association of participant's class and profile membership with the change in Self-Efficacy

We used the latent change model to regress the change in self-efficacy upon the class membership indicators and participant covariates. The model parameters of the efficacy constructs were fixed to the estimates obtained while determining the change in self-efficacy due to the PD programme. The participants' probability of latent class and latent profile membership determined previously was saved with corresponding participant identifiers. This membership information of the Group A Participants was merged with the survey response data using R. The use of Most likely class membership is valid if the entropy is 0.8, which indicates a good separation of the latent classes or profiles. Entropy less than 0.8 indicates a fuzzy classification. In such cases, it is suitable to use the probability of membership for analysis of association with change in self-efficacy beliefs. As the sum of the probability of class/profile membership over all the classes and profiles is 1, i.e. a linear dependence among the variables of class & profile membership, some transformation was required. So, the class and profile membership probability (p) was transformed using the following equation

$$f(p) = \frac{e^p - 1}{e^1 - 1} \qquad \forall\ p\ \in\ [0,1]$$

This transformation kept the values within 0 and 1, while also allowing the use of membership probabilities in all classes/profiles in the analysis. The following figure [Figure 5] depicts the model implemented in Mplus to perform the analysis.

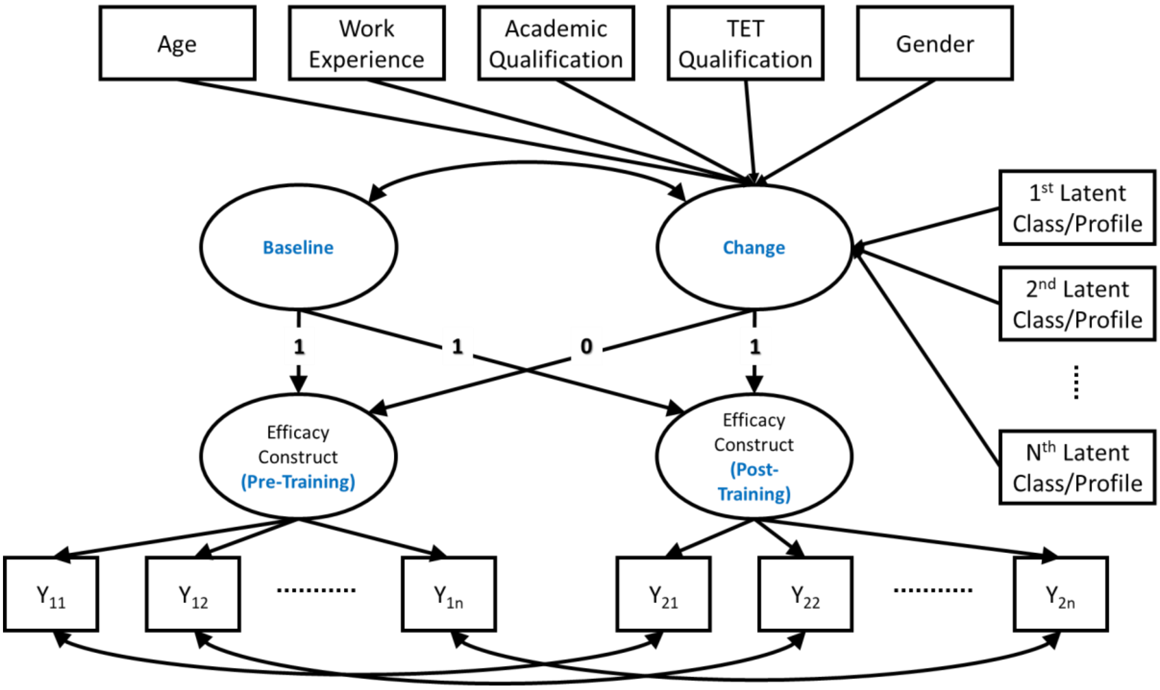

Figure 5 Model to analyse the association of latent class/profiles to change in Self-Efficacy beliefs

5.2 Findings

This section presents the findings of the analysis of A total of 19135 teachers registered for the programme with an average work experience of 80.16 months (SD = 59.37) and an average age of 32.66 years (SD = 5.63). Among the registered participants, 76.35 % had qualified the teacher's eligibility test, 42.91 % indicated their gender as female, 51.66 % were graduates, and 42.23 % had earned either a post-graduation degree or higher. The details of participants and the group level distribution are presented in the table below

Table 2 Descriptive of Participant Background

	Total	Group A	Group B
Total Registrations	19135 (100%)	10535 (100%)	8600 (100%)
Gender			
Male	10905 (56.99%)	5919 (56.18%)	4986 (57.98%)
Female	8210 (42.91%)	4604 (43.7%)	3606 (41.93%)
Other	19 (0.1%)	12 (0.11%)	7 (0.08%)
Missing	1 (0.01%)	0 (0%)	1 (0.01%)
Education			
Certificate/Diploma/Undergraduate	1293 (6.76%)	655 (6.22%)	638 (7.42%)
Graduate	9824 (51.34%)	5427 (51.51%)	4397 (51.13%)
Post-Graduate and above	7926 (41.42%)	4398 (41.75%)	3528 (41.02%)
Missing	92 (0.48%)	55 (0.52%)	37 (0.43%)
Teacher Eligibility Test			
Qualified	14610 (76.35%)	8137 (77.24%)	6473 (75.27%)
Not Qualified	4524 (23.64%)	2398 (22.76%)	2126 (24.72%)
Missing	1 (0.01%)	0 (0%)	1 (0.01%)
Age (Yrs.)			
Range	18 - 58	19 - 58	18 - 58
Mean	32.66	32.53	32.81
Std. Deviation	5.63	5.56	5.72
Work Experience (Months)			
Range	0 - 456	0 - 456	0 - 456
Mean	80.16	81.13	78.81
Std. Deviation	59.37	59.85	58.68

Chi-square tests of participant proportions based on gender, education and TET qualification indicate significant difference at the 95% level. Even unpaired t-test of age and work experience across groups indicate a significant difference at 95% level. These results most likely because of the large sample size. Bar plots of the participant distribution in both groups have been depicted in Figures 6 to 10. The plots indicate that the distribution of participants along gender, education, TET qualification, age and work experience is similar in both groups.

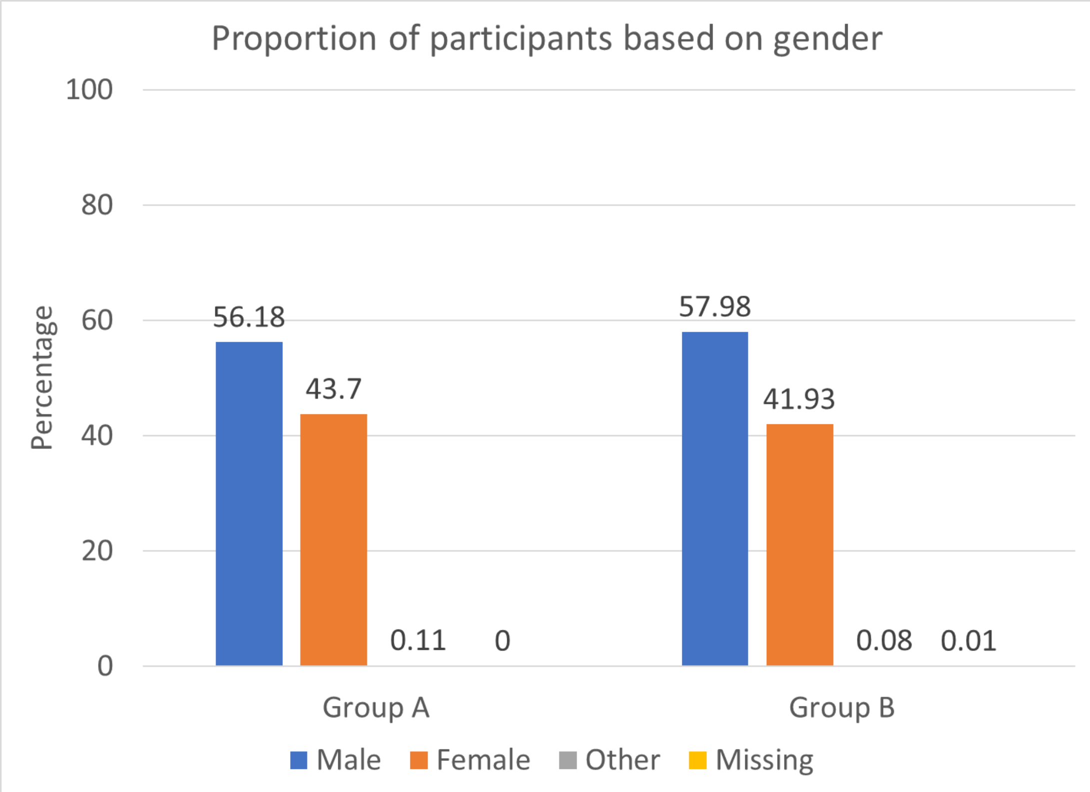

Figure 6 Gender distribution across both groups

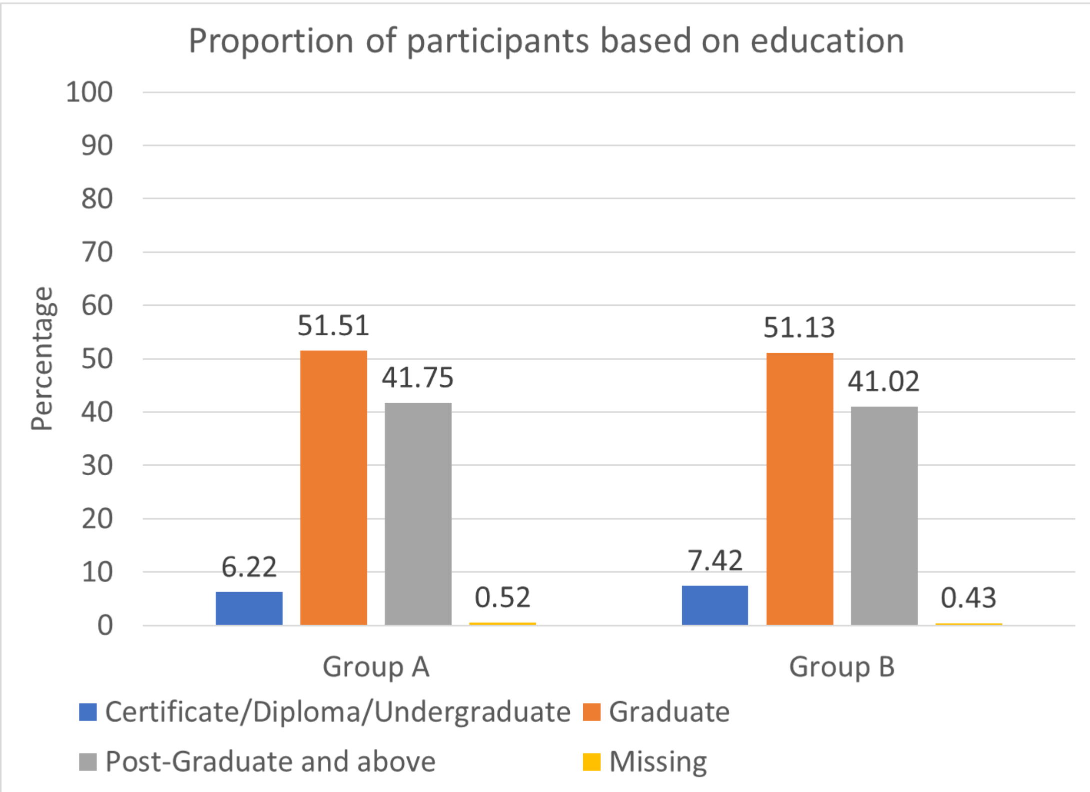

Figure 7 Distribution of educational qualification across both groups

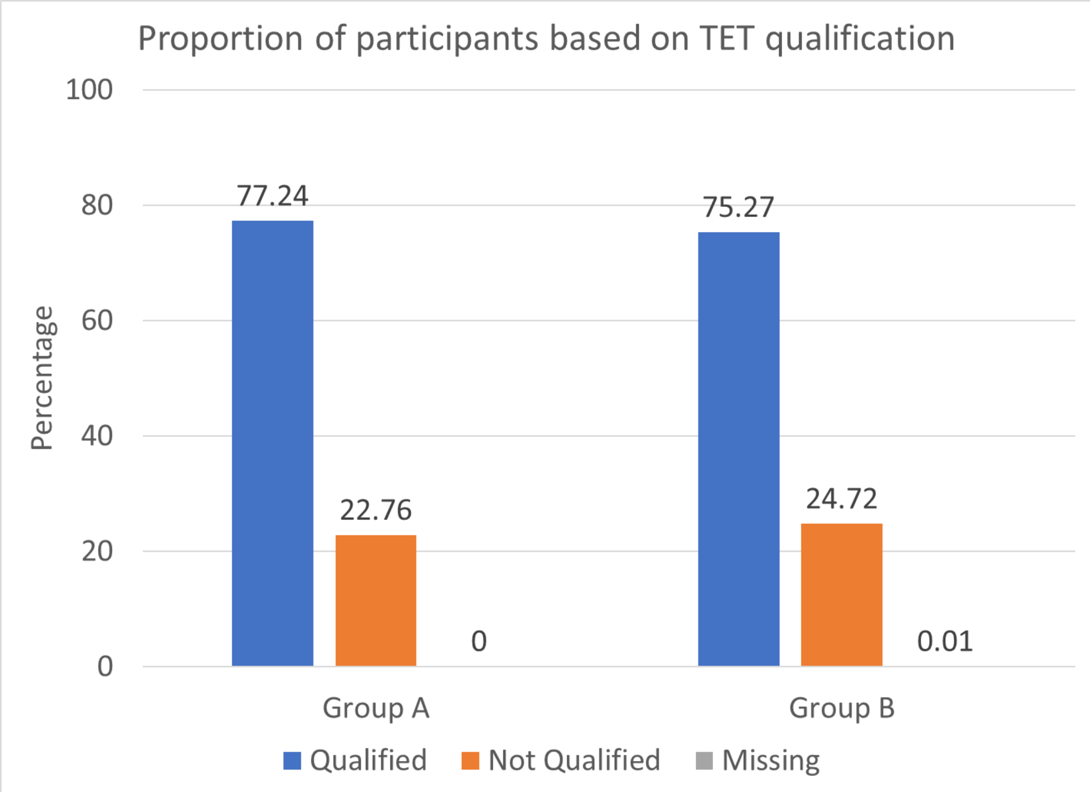

Figure 8 Distribution of Teacher Eligibility Test (TET) qualification across both groups

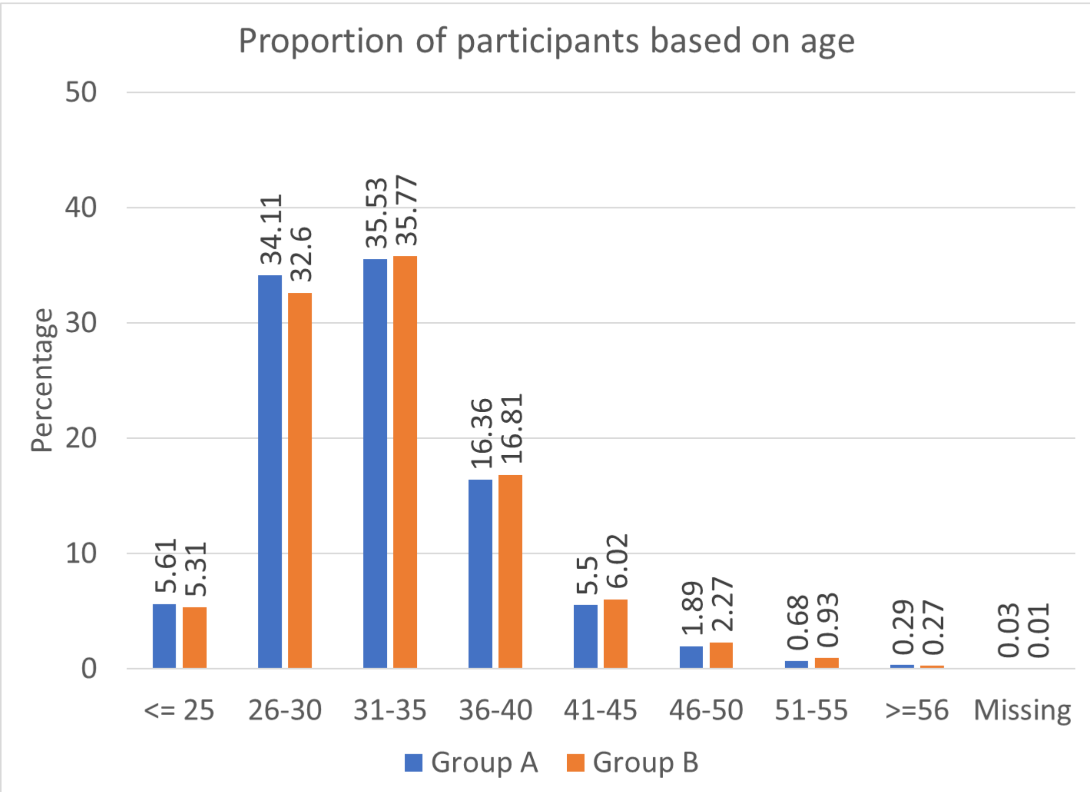

Figure 9 Distribution of age across both groups

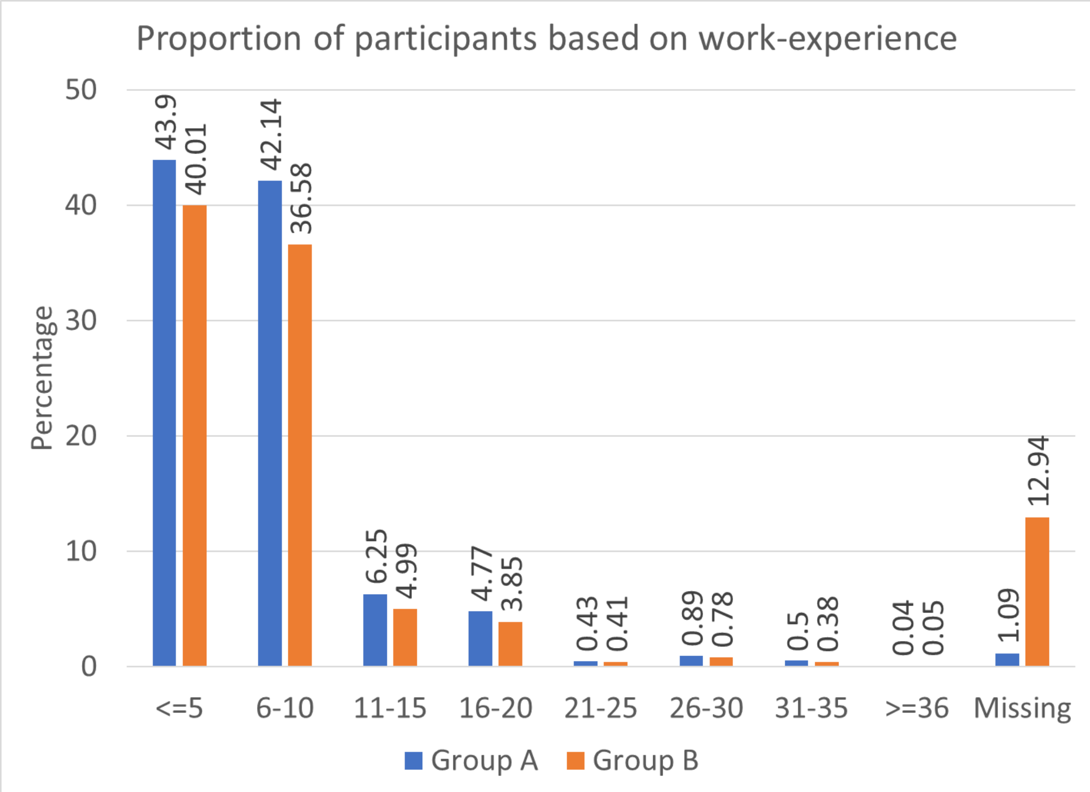

Figure 10 Distribution of work experience across both groups

5.2.1 Multigroup Confirmatory factor analysis

The analysis of survey responses resulted in a good model for measuring the latent constructs. The Item wise descriptive of survey responses is provided in Appendix A. All constructs at both time points and in both groups demonstrated composite reliability above 0.7 and had average variance explained near to 0.5. Based on the Chi-Square difference test, the measure of constructs in both groups was not invariant. As the number of observations is large, we evaluated measurement models using the difference in CFI and RMSEA as proposed by Chen (2007) and Meade et al. (2008). It was found that measures of two constructs were not invariant across the two groups of participants. The following table presents the findings of measurement invariant testing on the latent constructs.

Table 3 Measurement Invariance of Self-efficacy constructs

			Model Measurement Invariant	
	Δ CFI	Δ RMSEA	Chen (2007)	Meade et al.(2008)
			ΔCFI ≤ .005 & ΔRMSEA ≤ .01	ΔCFI ≤ .002
Teaching Self-Efficacy				
Instructional Strategy (IS)	.004	.006	YES	NO
Classroom Management (CM)	.002	.015	NO	YES
Student Engagement (SE)	.001	.013	NO	YES
Science Teaching Efficacy Belief Instrument				
Personal Science Teaching Efficacy beliefs (STE)	.003	.001	YES	NO
Science Teaching Outcome Expectancy beliefs (SOE)	.002	.004	YES	YES
Mathematics Teaching Efficacy Belief instrument				
Personal Mathematics Teaching Efficacy beliefs (MTE)	.001	.002	YES	YES
Mathematics Teaching Outcome Expectancy beliefs (MOE)	.001	.004	YES	YES

Note: CFI: Comparative Fit Index; RMSEA: Root Mean Square Error of Approximation

5.2.2 Attrition Analysis

Attrition analysis indicates that there was a significant difference in pre-training self-efficacy beliefs in the participants who responded to the post-training survey compared to ones who did not. In terms of teaching self-efficacy beliefs, non-respondents in Group A had significantly lower pre-training efficacy beliefs in Instructional Strategy ($\beta = -.119$, $p<.05$) and Student Engagement ($\beta = -.092$, $p<.05$). While, non-respondents in Group B had significantly higher pre-training efficacy beliefs in Classroom Management ($\beta = .181$, $p<.05$). Pre-training efficacy beliefs in Instructional Strategy ($\beta = .096$ $p>.05$) and Student Engagement ($\beta = .134$, $p>.05$) of the non-respondents in Group B was not significantly different. Also, pre-training efficacy beliefs in Classroom Management ($\beta = -.021$, $p>.05$) of non-respondents in Group A was not significantly different.

For subject specific efficacy beliefs, the non-respondents in Group A had significantly lower pre-training efficacy in Science Teaching ($\beta = -.220$, $p<.05$), Science Teaching Outcome Expectancy ($\beta = -.093$, $p<.05$), Math Teaching ($\beta = -.168$, $p<.05$) and Math Teaching Outcome

Expectancy (β = -.067, p<.05). Non-respondents in Group B had significantly lower pre-training efficacy beliefs in Science Teaching (β = -.218, p<.05). While pre-training efficacy beliefs of Science Teaching Outcome Expectancy (β = -.072, p>.05), Math Teaching (β = -.117, p>.05) and Math Teaching Outcome Expectancy (β = -.098, p>.05) were not significantly different.

5.2.3 Change in Self-Efficacy Beliefs

Preliminary analysis of comparing the change in self-efficacy beliefs in group A to group B showed a positive improvement among the participants. Using the change in averages of response to survey items before and after PD we calculated the effect size of the treatment. We found small effects on general teaching efficacy beliefs i.e. Classroom Management ($\Delta\mu_A$ = .15, $\Delta\mu_B$ = -.02, SD_{pooled} = .66, Cohen's d = .26), Instructional Strategy ($\Delta\mu_A$ = .21, $\Delta\mu_B$ = .21, SD_{pooled} = .65, Cohen's d = .39) & Student Engagement ($\Delta\mu_A$ = .13, $\Delta\mu_B$ = -.04, SD_{pooled} = .64, Cohen's d = .27). The analysis found that the participants reported moderate effects on subject specific self-efficacy beliefs i.e Science Teaching Efficacy ($\Delta\mu_A$ = .24, $\Delta\mu_B$ = .00, SD_{pooled} = .36, Cohen's d = .66), Science Teaching Outcome Expectancy ($\Delta\mu_A$ = .24, $\Delta\mu_B$ = -.01, SD_{pooled} = .40, Cohen's d = .61), Math Teaching Efficacy ($\Delta\mu_A$ = .19, $\Delta\mu_B$ = -.01, SD_{pooled} = .36, Cohen's d = .56), & Math Teaching Outcome Expectancy ($\Delta\mu_A$ = .26, $\Delta\mu_B$ = .01, SD_{pooled} = .41, Cohen's d = .61).

The outcomes of the SO-MG-LCM analysis are tabulated in the following three tables one each for Teaching Self-Efficacy Beliefs (Table 4), Science Teaching Efficacy Beliefs (Table 5) and Maths Teaching Efficacy Beliefs (Table 6).

5.2.3.1 Change in Teaching Self-Efficacy beliefs

Analysis shows a positive but not significant change in teaching self-efficacy beliefs of classroom management (β = .175, p>.05) and instructional strategy (β = .083, p>.05) among the non-participants of the programme. Also, there was a positive but not significant change in teaching self-efficacy beliefs in classroom management (β = .203, p>.05) and student engagement (β = .161, p>.05) among the participants of the programme. We did find that the self-efficacy beliefs on instructional strategy among the participants (β = .344, p<.05) and on student engagement among non-participants (β = .283, p<.05) is significantly positive.

Table 4 Teaching Self-Efficacy Beliefs

	Change in Classroom Management (CM)		**Change in Instructional Strategy (IS)**		**Change in Student Engagement (SE)**	
	Group A	Group B	Group A	Group B	Group A	Group B
	β	β	β	β	β	β
Intercept	.203	.175	.344**	.083	.161	.283*
Gender: Female	-.109***	-.035	-.081**	-.095**	-.078**	-.071*
Age	.004	-.053*	-.005	-.042*	.008	-.061**
Work Experience	.008	.040	.018	.042	.004	.046
TET Qualified	-.048	-.031	-.020	-.017	-.019	-.113*
Education: (PTC/Diploma)						
Graduate	.117	.094	.131	.035	.079	.043
Post Grad and above	.137	.063	.133	.047	.093	.003
Model fit						
χ2	903.710		2482.290		1026.161	
df	148		146		146	
CFI	0.989		0.965		0.987	
TLI	0.989		0.963		0.987	
SRMR	0.017		0.025		0.017	
RMSEA	0.024		0.042		0.026	
RMSEA 90% CI	[0.022 0.025]		[0.041 0.044]		[0.025 0.028]	

Note: * $p < .05$, ** $p < .01$, *** $p < .001$; χ2: Chi-Squared ; df: Degrees of Freedom; CFI: Comparative Fit Index; TLI: Tucker-Lewis Index; SRMR: Standardised Root Mean Residual; RMSEA: Root Mean Square Error of Approximation; Observation Nos:- Group A : 10357 & Group B : 7463

The Wald tests of the coefficients indicate that the change in teaching efficacy beliefs of instructional strategy (Wald (1) = 3.687, p > .05), classroom management (Wald(1) = 0.389, p > .05), and student engagement (Wald(1) = 0.020, p > .05) did not significantly differ between the participants and non-participants.

The baseline self-efficacy beliefs are negatively and significantly associated to the change in teaching self-efficacy beliefs in both the participants (Classroom Management: β = -.415, p<.05, Instructional Strategy: β = -.403, p<.05 and Student Engagement: β = -.432, p<.05) and non-participants (Classroom Management: β = -.281, p<.05, Instructional Strategy: β = -.263, p<.05 and Student Engagement: β = -.273, p<.05). This indicates that participants with the low baseline self-efficacy had the most positive change.

Females reported significantly lesser change in self-efficacy beliefs than men in both the participants (Classroom Management: β = -.109, p<.05, Instructional Strategy: β = -.081, p<.05 and Student Engagement: β = -.078, p<.05) and non-participants (Instructional Strategy: β = -.095, p<.05 and Student Engagement: β = -.071, p<.05). In the non-participants group age was negatively associated to change in classroom management (β = -.053, p<.05), instructional strategy (β = -.042, p<.05), and student engagement (β = -.061, p<.05) self-efficacy beliefs. Educational background of the participants had no significant effect on the change in teaching self-efficacy beliefs. But TET qualified candidates among non-participants were negatively associated with the change in student engagement self-efficacy beliefs (β = -.113, p<.05).

5.2.3.2 Change in Subject Specific Self-Efficacy beliefs

For the subject-specific self-efficacy beliefs, we find that there was a significantly positive change in teaching efficacy (Science: β = .813, p<.05 & Maths: β=.833, p<.05) and teaching outcome efficacy (Science: β=.833, p<.05 & Maths: β=.901, p<.05) among the participants of the programme. Comparing the change in efficacy between participants and non-participants using Wald tests we find that there was a significant difference in the subject teaching efficacy beliefs (Science: Wald(1) = 34.489, p < .05 & Maths: Wald(1) = 9.914, p = .05). Similarly, the difference in change in subject teaching outcome expectancy (Science: Wald(1) = 26.586, p < .05 & Maths: Wald(1) = 23.583, p < .001) between participants and non-participants was significant.

Also, the baseline self-efficacy beliefs were found to be negatively and significantly associated to the change in subject-specific self-efficacy beliefs in both the participants (Science Teaching Efficacy: β = -.666, p<.05, Science Teaching Outcome Expectancy: β = -.452, p<.05, Math Teaching Efficacy: β = -.660, p<.05, and Math Teaching Outcome Expectancy: β -.548, p<.05) and non-participants (Science Teaching Efficacy: β = -.276, p<.05, Science Teaching Outcome Expectancy: β = -.219, p<.05, Math Teaching Efficacy: β = -.311, p<.05, and Math Teaching Outcome Expectancy: β = -.288, p<.05).

Table 5 Science Teaching Efficacy Beliefs

	Change in Science Teaching Efficacy (STE)		**Change in Science Teaching Outcome Expectancy (SOE)**	
	Group A	Group B	Group A	Group B
	β	β	β	β
Intercept	.813***	.076	.833***	.077
Gender: Female	-.021	-.128***	-.127***	-.098**
Age	-.027	-.038	-.031	-.024
Work Experience	.002	.021	-.010	.013
TET Qualified	-.045	.021	-.032	-.057
Education: (PTC/Diploma)				
Graduate	-.004	.134*	.087	.124
Post Grad and above	-.018	.133*	.054	.074
Model fit				
χ2	6089.571		4089.346	
df	723		436	
CFI	0.977		0.974	
TLI	0.977		0.974	
SRMR	0.056		0.041	
RMSEA	0.029		0.031	
RMSEA 90% CI	[0.028 0.030]		[0.030 0.032]	

Note: * p < .05, ** p < .01, *** p < .001 ; χ2: Chi-Squared ; df: Degrees of Freedom; CFI: Comparative Fit Index; TLI: Tucker-Lewis Index; SRMR: Standardised Root Mean Residual; RMSEA: Root Mean Square Error of Approximation; Observation Nos:- Group A: 10357 & Group B: 7463

The female participants report significantly less change in self-efficacy beliefs compared to men. Interestingly, the change in subject teaching self-efficacy beliefs among non-participants was significantly positive for teachers with a graduate degree and above compared to teachers with only a diploma or professional teaching certificate (Science:- Graduate: β = .134, p<.05, Post-Graduate and above: β = .133, p<.05, & Maths:- Graduate: β = .197, p<.05, Post-Graduate and above: β = .203, p<.05). Work experience was positively associated with the change in maths teaching efficacy (β = .054, p<.05) among non-participants, but work experience was negatively associated to it (β = -.048, p<.05) in the participants group. Finally, we note that age was negatively associated with the change in math teaching self-efficacy among non-participants (β = -.070, p<.05) and change in math teaching outcome expectancy among participants (β = -.046, p<.05).

Table 6 Mathematics Teaching Efficacy Beliefs

	Change in Math Teaching Efficacy (MTE)		Change in Math Teaching Outcome Expectancy (MOE)	
	Group A	Group B	Group A	Group B
	β	β	β	β
Intercept	.473***	.109	.813***	.211
Gender: Female	-.075***	-.162***	-.070**	-.086**
Age	.001	-.070**	-.046*	-.018
Work Experience	-.048*	.054*	.006	.025
TET Qualified	-.058	.036	-.002	.011
Education: (PTC/Diploma)				
Graduate	.090	.197**	.022	.000
Post Grad and above	.051	.203**	.018	-.010
Model fit				
χ2	5878.807		6035.060	
df	719		440	
CFI	0.98		0.965	
TLI	0.98		0.966	
SRMR	0.057		0.055	
RMSEA	0.028		0.038	
RMSEA 90% CI	[0.028 0.029]		[0.037 0.039]	

Note: * $p < .05$, ** $p < .01$, *** $p < .001$; χ2: Chi-Squared ; df: Degrees of Freedom; CFI: Comparative Fit Index; TLI: Tucker-Lewis Index; SRMR: Standardised Root Mean Residual; RMSEA: Root Mean Square Error of Approximation; Observation Nos:- Group A: 10357 & Group B: 7463

5.2.4 Variation in participant online and off-platform activities

The data on participants' online and off-platform actions were analysed separated to identify homogenous groups; first, we present the findings on analysing off-platform activities followed by online time spent by participants.

5.2.4.1 Latent Off platform Classes

Of the 10535 who registered in Group A, 7935 filled the post-training survey of which only 7794 participants responded to the Off-platform activity Questionnaire. The items in the questionnaire could be split into two categories one dealing with Notes gathering (labelled as Notetaking) and the other involving interactional activities, e.g. participating in discussions, joining social media groups & sharing content. Responses to questions in these categories were analysed separately.

5.2.4.1.1 Note-taking activities

The items dealing with note-taking activities were "How many PDF files did you download?", "How many Videos did you download?" and "Did you take/maintain notes related to the course offline?". Responses to the first two questions were converted to binary (yes & no) by retaining the responses to "None" and recoding all other responses "Yes".

Table 7 Response to Off-Platform Activity Survey - Note-Taking Activities

How many PDF files did you download?	**None**	**Yes**
	5.86 % (457)	94.14 % (7337)
How many Videos did you download?	**None**	**Yes**
	11.97 % (933)	88.03 % (6861)
Did you take/maintain notes related to the course offline?	**No**	**Yes**
	25.44 % (1983)	74.56 % (5811)

Note: Observations: 7794

The latent class analysis of the responses indicates a two-class solution based on both BLRT and also BIC. The parameters of the two-class solutions were stored to determine the overall classes based on the off-platform activities of the participants.

Table 8 Latent Class Analysis of Note-Taking Activities

Classes	AIC	BIC	SABIC	Entropy	VLMR LRT	ALMR LRT	BLRT
1	18036.37	18057.25	18047.72				
2	17036.11	17084.84	17062.59	.809	<.001	<.001	<.001
3	17044.11	17120.68	17085.72	.9	.5	.5	1

Note: AIC: Akaike Information Criteria; BIC: Bayesian Information Criteria; SABIC: Sample-Size Adjusted BIC; VLMR LRT: Vuong-Lo-Mendell-Rubin likelihood ratio test; ALMR LRT: Adjusted Lo-Mendell-Rubin likelihood ratio test; BLRT: Bootstrapped Likelihood ratio test; Observations: 7794

5.2.4.1.2 Interactional activities

Interactional activities dealt with actions such as engaging in course content with other teachers, sharing the content collected from the course and even joining a group on a social media platform. The table below presents the relevant items of the questionnaire, along with the responses. All responses to the second item were converted to "Yes" or "No" by retaining the responses to "No" and recoding all other responses as "Yes". Missing values were indicated to the Mplus program, which applied listwise deletion before analysing the responses.

Table 9 Response to Off-Platform Activity Survey - Interactional Activities

Question		
Did you share your notes, PDFs or video with other participants?	**No**	**Yes**
	68.26 % (5320)	31.74 % (2474)
Did you discuss the content of the programme with other participant teachers?	**No**	**Yes**
	18.80 % (1465)	81.20 % (6329)
Did you discuss the content of the programme with other teachers who were not participating?	**No**	**Yes**
	58.74 % (4578)	41.25 % (3215)
Did you join any Whatsapp or Facebook group for discussing the course content?	**No**	**Yes**
	67.27 % (5243)	32.68 % (2547)
Did you contact any of the teachers whose case-study was presented in the course?	**No**	**Yes**
	85.82 % (6689)	14.18 % (1105)

Note: Observations: 7794

The analysis of the responses indicates a four-class solution based on BLRT. But, according to information criteria, viz. BIC, it is noted that a three-class solution is also a viable option. Thus, we recorded parameters of the two, three and four class solutions to determine the overall classes based on the off-platform activities of the participants.

Table 10 Latent Class Analysis of Interactional Activities

Classes	AIC	BIC	SABIC	Entropy	VLMR LRT	ALMR LRT	BLRT
1	44057.17	44091.97	44076.08				
2	42681.03	42757.6	42722.64	.443	<.001	<.001	<.001
3	42554.3	42672.63	42618.61	.478	<.001	.001	<.001
4	42528.3	42688.41	42615.32	.559	<.001	.001	<.001
5	42535.17	42737.04	42644.89	.566	.5396	.5495	1

Note: AIC: Akaike Information Criteria; BIC: Bayesian Information Criteria; SABIC: Sample-Size Adjusted BIC; VLMR LRT: Vuong-Lo-Mendell-Rubin likelihood ratio test; ALMR LRT: Adjusted Lo-Mendell-Rubin likelihood ratio test; BLRT: Bootstrapped Likelihood ratio test; Observations: 7794

5.2.4.1.3 Off-platform activities

Taking the class parameters from solutions of both Notetaking and Interaction activities, a two latent class model was setup. Analysis indicated that the parameter of two Notetaking classes and three Interactional classes as a suitable solution based on the lowest value of BIC.

Table 11 Latent Class Analysis of Off-Platform Activities - NoteTaking and Interactional

Classes	AIC	BIC	SABIC	Entropy
Notetaking: 2 Class & Interaction: 2 Class	59552.27	59684.53	59624.15	0.625
Notetaking: 2 Class & Interaction: 3 Class	59421.74	59602.73	59520.11	0.574
Notetaking: 2 Class & Interaction: 4 Class	59390.02	59619.73	59514.87	0.565

Note: AIC: Akaike Information Criteria; BIC: Bayesian Information Criteria; SABIC: Sample-Size Adjusted BIC; VLMR LRT: Vuong-Lo-Mendell-Rubin likelihood ratio test; ALMR LRT: Adjusted Lo-Mendell-Rubin likelihood ratio test; BLRT: Bootstrapped Likelihood ratio test; Observations: 7794

Thus, we have a 6-class solution (2 of Notetaking and 3 of Interaction) based on participant responses to the off-platform questionnaire viz. Low Notetaking & Low Interactions (9%), Low Notetaking & Intermediate Interactions (4.3%), Low Notetaking & High Interactions (0.3%), High Notetaking & Low Interactions (28.7%), High Notetaking & Intermediate Interactions (41.9%) and High Notetaking & High Interactions (15.8%). Below we plot the probability of participants undertaking each of the off-platform activities for all the six classes.

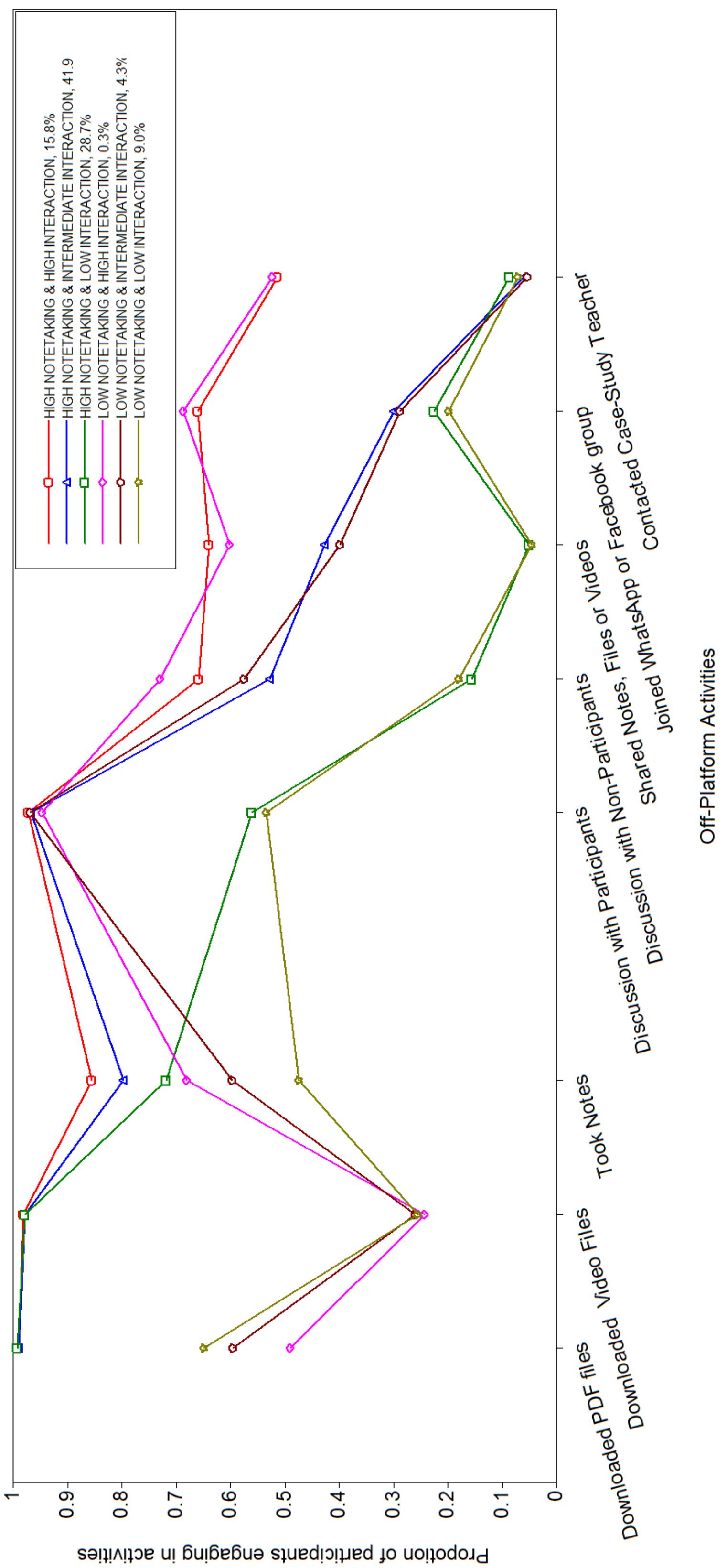

Figure 11 Latent Off-Platform Classes and Probability of engaging in Off-platform Activities

5.2.4.2 Latent Online Profiles

Pageview Logs of 8,131 participants was downloaded from google analytics. The timestamped entry of the page URL was used to determine the time spent on the page content. A site map of the PD website was used to help identify the valid logs for further analysis. As the logging of pageviews was being maintained on an external server (Google), logs for some participants were incomplete. Since all participants had to visit all case study pages and end module questions, any participant logs not showing visits to these pages were dropped from the analysis. Additionally, logs that did not indicate a visit to project-related pages were also dropped from the analysis. Finally, we analysed pageview logs of 7037 Group A participants to identify the different online engagement profiles.

The summary of the time spent on the content by the participants is tabulated as a percentage of the total time logged online. From the range, mean and median values it can be inferred that the time spent on each item of the content has a long-tailed distribution.

Table 12 Summary of Online Activities of Participants

Online Content	**Time (as % of total time)**			
	Range	Mean	Std. Dev.	Median
Science Expert Content	0.77 - 38.95	11.795	4.44	11.526
Science Case Study	0.43 - 23.41	7.163	2.84	6.86
Math Expert Content	0.37 - 24.11	7.39	3.34	6.932
Math Case Study	0 - 21.71	6.115	2.31	5.888
Learning Management Expert Content	0 - 18.49	4.459	2.19	4.073
Learning Management Case Study	2.14 - 43.49	17.011	4.98	16.957
SCE Expert Content	0 - 10.08	1.239	1.07	0.914
SCE Case Study	0 - 15.39	2.418	1.22	2.18
ICT Use Expert Content	0 - 13.01	1.618	1.25	1.253
ICT Use Case Study	0.15 - 17.83	4.337	1.9	4.104
Grade Peer Projects	0 - 17.80	1.787	1.35	1.413
View Peer Feedback on Project	0 - 13.52	0.951	1.15	0.589

Note: Observations: 7037

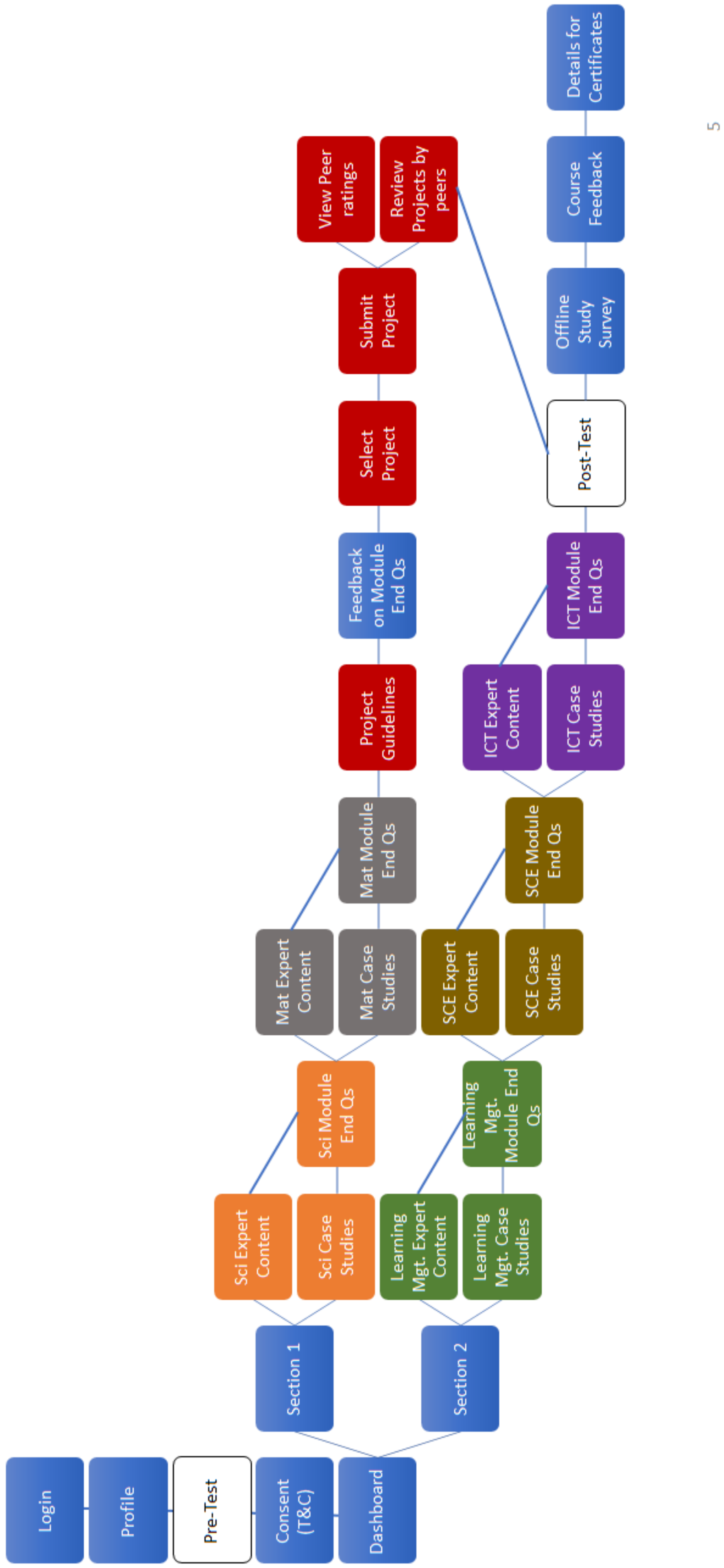

Figure 12 Site Map of the SAMARTH website

The percentage of time spent on content was used for analyses because this enabled comparisons between time spent on one content over another while accounting for user-level variations due to internet speeds, reading proficiency and length of module content. Also, the values were median centred for easy identification of the latent profiles in the output. The latent profile analysis shows LRTs favours a four-profile solution. As the distribution of time spent is long-tailed, LRT tests are more valid than BLRT to determine the correct number of latent profiles. Thus, we accept the four-profile solution of the analysis.

Table 13 Latent Profile Analysis of Online Activities

Profiles	AIC	BIC	ABIC	Entropy	VLMR LRT	ALMR LRT	BLRT
1	359844.9	360009.5	359933.3				
2	355959.6	356213.4	356095.8	.974	.0241	.0247	<.001
3	353412.5	353755.5	353596.6	.932	<.001	<.001	<.001
4	351354.1	351786.2	351586	.773	<.001	<.001	<.001
5	349597.4	350118.7	349877.2	.801	.3918	.3945	<.001

Note: AIC: Akaike Information Criteria; BIC: Bayesian Information Criteria; SABIC: Sample-Size Adjusted BIC; VLMR LRT: Vuong-Lo-Mendell-Rubin likelihood ratio test; ALMR LRT: Adjusted Lo-Mendell-Rubin likelihood ratio test; BLRT: Bootstrapped Likelihood ratio test; Observations: 7037

Thus, we have a 4-profile solution based on participant responses to the off-platform questionnaire viz. Project Feedback (5%) – participants who spent more time on project feedback pages, Subject Module (57.9%) – participants who spent more time on Subject module consisting both of content by experts and subject-specific case-studies, Case-Study Content (30 %) – Participants who spent more time on case-study components instead of the expert content and Expert Content (7.1%) – Participants who spent more time on expert content instead of the case-studies. Below we plot the means of median-centred percentage time spent by participants on the online content for all four latent profiles.

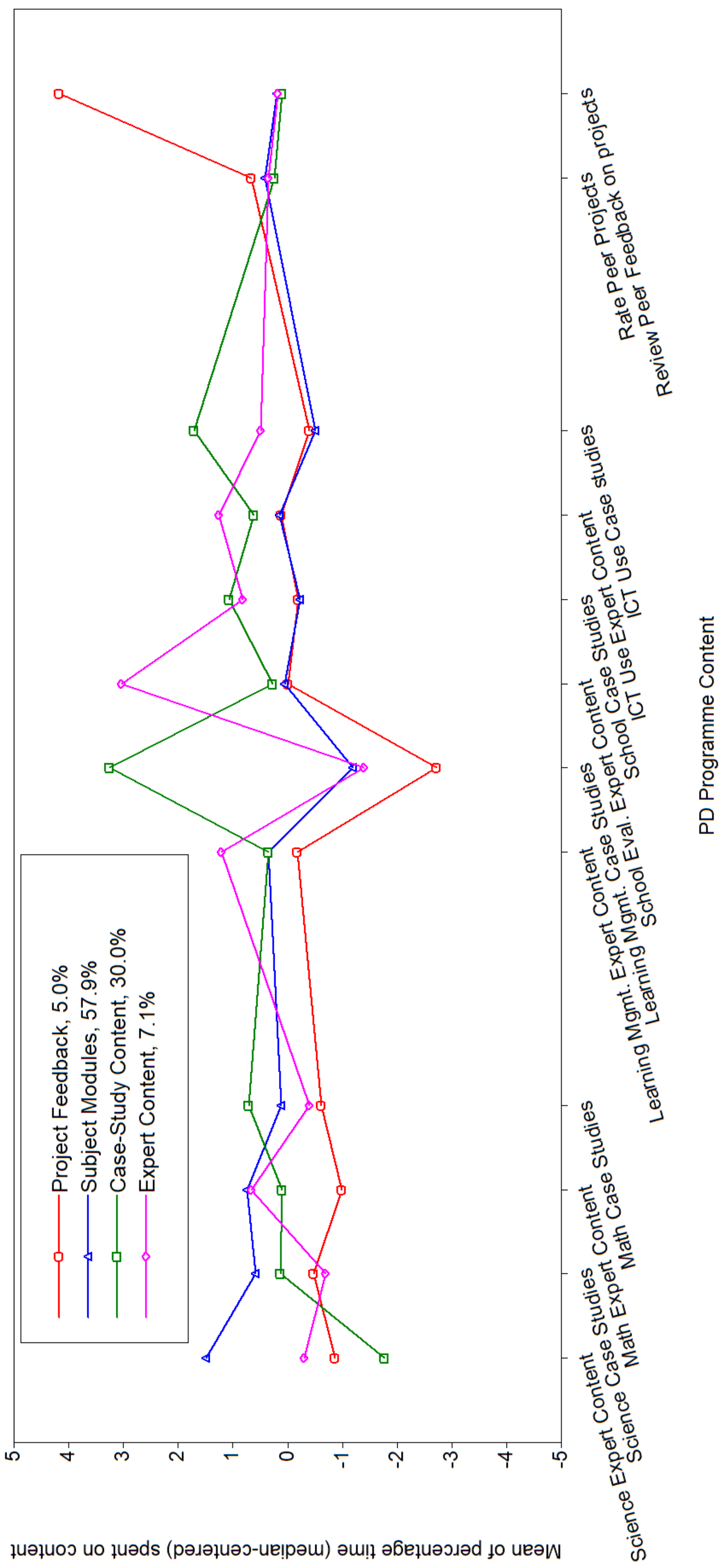

Figure 13 Latent Online Profiles and Mean of Time spent on online content

5.2.5 Association of participant latent classes and change in self-efficacy

The association of off-platform classes and online activity profiles to change in self-efficacy was estimated separately for each of the self-efficacy constructs. The following presents the findings of the analysis.

5.2.5.1 Off-platform activity

The change in self-efficacy was regressed upon the probabilities of participants' membership to six activity classes based on levels of notetaking and interactions. The results of the analysis are presented separately based on the self-efficacy scales: Teaching self-efficacy (Table 14.), Science teaching efficacy (Table 15.) and Math Teaching efficacy (Table 16.).

We found that participants with high notetaking and high interactions reported significantly positive association to change in teaching self-efficacy beliefs about classroom management ($\beta = .053$, $p<.05$) and Instructional Strategy ($\beta = .090$, $p<.05$). Also, high notetaking and high interacting participants were associated to reporting higher subject-specific self-efficacy beliefs like Science Teaching Efficacy ($\beta = .164$, $p<.05$), Science teaching outcome expectancy ($\beta = .180$, $p<.05$), math teaching expectancy ($\beta = .105$, $p<.05$) and math teaching outcome expectancy ($\beta = .177$, $p<.05$). Participants undertaking high notetaking but intermediate interaction showed significantly positive association to change in teaching self-efficacy beliefs : Classroom management ($\beta = .074$, $p<.05$), Instructional Strategy ($\beta = .117$, $p<.05$), and Subject Specific Teaching Efficacy : Science teaching efficacy ($\beta = .146$, $p<.05$), Science teaching outcome expectance ($\beta = .157$, $p<.05$), Math teaching efficacy ($\beta = .097$, $p<.05$) and Math teaching outcome expectancy ($\beta = .162$, $p<.05$).

Table 14 Association of Change in Teaching Self-Efficacy with Off-platform Activities

	Change in Classroom Management (CM)	Change in Instructional Strategy (IS)	Change in Student Engagement (SE)
	β	β	β
Notetaking: Low & Interactions: Low	-.015	.017	-.037
Notetaking: Low & Interactions: Intermediate	-.029	-.019	-.031
Notetaking: Low & Interactions: High	.000	.074***	.058***
Notetaking: High & Interactions: Low	.062	.099**	.021
Notetaking: High & Interactions: Intermediate	.074*	.117***	.042
Notetaking: High & Interactions: High	.053*	.090***	.031
Gender: Female	-.105***	-.076*	-.067**
Age	.000	.000	.009
Work Experience	.023	.009	.007
TET Qualified	-.046	.019	-.026
Education: (PTC/Diploma)			
Graduate	.155*	.115	.086
Post Grad and above	.179*	.113	.099
Model Fit			
χ2	737.530	1976.643	577.696
Df	115	114	111
CFI	0.971	0.889	0.974
TLI	0.968	0.880	0.971
SRMR	0.021	0.029	0.019
RMSEA	0.027	0.046	0.023
RMSEA 90% CI	[0.025 0.028]	[0.044 0.048]	[0.022 0.025]

Note: * $p < .05$, ** $p < .01$, *** $p < .001$; χ2 : Chi-Squared ; df : Degrees of Freedom; CFI : Comparative Fit Index; TLI : Tucker-Lewis Index; SRMR : Standardised Root Mean Residual; RMSEA : Root Mean Square Error of Approximation; Observations :- 7681

The findings show that participants with high notetaking but low interactions had a significant positive association with change in self-efficacy beliefs of Instructional strategy (β = .099, p<.05). Also, participants engaging in high notetaking and low interactions are positively associated with the change in subject-specific self-efficacy beliefs: Science teaching efficacy (β = .122, p<.05), science teaching outcome expectancy belief (β = .132, p<.05), math teaching efficacy belief (β = .071, p<.05) and math teaching outcome expectancy belief (β = .148, p<.05).

Table 15 Association of Change in Science Teaching Efficacy Beliefs with Off-platform Activities

	Change in Science Teaching Efficacy (STE)	Change in Science Teaching Outcome Expectancy (SOE)
	β	β
Notetaking: Low & Interactions: Low	.018	.037
Notetaking: Low & Interactions: Intermediate	.008	.020
Notetaking: Low & Interactions: High	.028***	.047***
Notetaking: High & Interactions: Low	.122***	.132***
Notetaking: High & Interactions: Intermediate	.146***	.157***
Notetaking: High & Interactions: High	.164***	.180***
Gender: Female	-.019	-.123***
Age	.012	.007
Work Experience	-.005	.001
TET Qualified	-.015	-.004
Education: (PTC/Diploma)		
Graduate	.050	.199**
Post Grad and above	.028	.179*
Model Fit		
$\chi 2$	3662.764	2460.477
Df	483	305
CFI	0.930	0.931
TLI	0.929	0.930
SRMR	0.049	0.037
RMSEA	0.029	0.030
RMSEA 90% CI	[0.028 0.030]	[0.029 0.031]

Note: * $p < .05$, ** $p < .01$, *** $p < .001$; $\chi 2$: Chi-Squared ; df : Degrees of Freedom; CFI : Comparative Fit Index; TLI : Tucker-Lewis Index; SRMR : Standardised Root Mean Residual; RMSEA : Root Mean Square Error of Approximation; Observations :- 7681

The analysis also showed that participants with low notetaking and high interactions had a positive association to change in self-efficacy of instructional strategy ($\beta = .074$, $p<.05$) and student engagement ($\beta = .058$, $p<.05$). Although participants with low notetaking and high interactions had a significant positive association with changes in science teaching efficacy ($\beta = .028$, $p<.05$), science teaching outcome expectancy ($\beta = .047$, $p<.05$) and math teaching efficacy ($\beta = .017$, $p<.05$), they reported a significantly negative association to change in math teaching outcome expectancy ($\beta = -.022$, $p<.05$). The proportion of participants reporting low notetaking and high interactional activities is only 0.3%, and these results may be affected because of the small size. Participants with low notetaking and intermediate interactions had a small but significant positive association to change in maths teaching outcome expectancy ($\beta = .068$, $p<.05$). Finally, the participants with low notetaking and low interactions reported a non-significant association to change in self-efficacy beliefs in all sub-constructs except for mathematics teaching outcome expectancy where it is positive and significant (β = .052, p<.05).

Table 16 Association of Change in Maths Teaching Efficacy Beliefs with Off-platform Activities

	Change in Maths Teaching Efficacy (MTE)	Change in Math Teaching Outcome Expectancy (MOE)
	β	β
Notetaking: Low & Interactions: Low	-.017	.052*
Notetaking: Low & Interactions: Intermediate	.015	.068***
Notetaking: Low & Interactions: High	.017**	-.022**
Notetaking: High & Interactions: Low	.071**	.148***
Notetaking: High & Interactions: Intermediate	.097***	.162***
Notetaking: High & Interactions: High	.105***	.177***
Gender: Female	-.032**	-.058*
Age	.013	.002
Work Experience	-.028	.005
TET Qualified	-.012	.032
Education: (PTC/Diploma)		
Graduate	.070*	.108
Post Grad and above	.052	.103
Model Fit		
χ2	3446.454	3493.175
Df	481	307
CFI	0.956	0.923
TLI	0.954	0.922
SRMR	0.046	0.045
RMSEA	0.028	0.037
RMSEA 90% CI	[0.027 0.029]	[0.036 0.038]

Note: * p < .05, ** p < .01, *** p < .001 ; χ2 : Chi-Squared ; df : Degrees of Freedom; CFI : Comparative Fit Index; TLI : Tucker-Lewis Index; SRMR : Standardised Root Mean Residual; RMSEA : Root Mean Square Error of Approximation; Observations :- 7681

Age and work experience did not have any significant association with the change in self-efficacy. Participants who had cleared the teacher eligibility test (TET) were not significantly correlated to change in teaching. Participants who identified as female reported significantly less change in teaching self-efficacy (classroom management: β = -.105, p<.05 , instructional strategy : β = -.076, p<.05, student engagement: β = -.067, p<.05)and subject-specific self-efficacy (Science:- science teaching outcome expectancy, β = -.123, p<.05 , Math:- math teaching efficacy: β = -.032, p<.05, math teaching outcome expectancy, β = -.058, p<.05) compared to males.

5.2.5.2 Online activity

Change in self-efficacy was regressed upon the four latent profiles of participants to explore the association of participants online activity with the change in self-efficacy. The findings of the analysis have been presented separately based on teaching self-efficacy beliefs (Table 17), Science teaching efficacy beliefs (Table 18) and mathematics teaching efficacy beliefs (Table 19).

Table 17 Association of Change in Teaching Self-Efficacy with Online Activity Profile

	Change in Classroom Management (CM)	Change in Instructional Strategy (IS)	Change in Student Engagement (SE)
	β	β	β
Project Feedback	.010	.047*	-.003
Subject Module Section	.024	.049	-.016
Case Study Content	.027	.044	.011
Expert Content	.012	.025	.004
Gender: Female	-.081**	-.053**	-.052
Age	.019	.026	.029
Work Experience	.016	-.008	-.009
TET Qualified	-.069	-.044	-.066
Education: (PTC/Diploma)			
Graduate	.169*	.171*	.096
Post Grad and above	.194*	.159*	.116
Model Fit			
χ2	600.390	1715.221	433.217
df	101	100	97
CFI	0.974	0.892	0.978
TLI	0.972	0.884	0.976
SRMR	0.019	0.028	0.016
RMSEA	0.027	0.048	0.022
RMSEA 90% CI	[0.025 0.029]	[0.046 0.050]	[0.020 0.025]

Note: * $p < .05$, ** $p < .01$, *** $p < .001$; χ2 : Chi-Squared ; df : Degrees of Freedom; CFI : Comparative Fit Index; TLI : Tucker-Lewis Index; SRMR : Standardised Root Mean Residual; RMSEA : Root Mean Square Error of Approximation; Observations :- 6933

In case of association of latent profiles based on online pageviews with teaching self-efficacy beliefs we find significant association of participants who spent more time on project feedback with efficacy beliefs of instructional strategy (β = .047, p<.05). But change in subject specific self-efficacy beliefs had a significant positive association with participants focused on Project feedback (science teaching efficacy: β = .109, p<.05, science teaching outcome expectancy: β = .089, p<.05, maths teaching efficacy: β = .069, p<.05, and math teaching outcome expectancy: β = .096, p<.05), Subject Modules (science teaching efficacy: β = .193, p<.05, science teaching outcome expectancy: β = .187, p<.05, maths teaching efficacy: β = .110, p<.05, and math teaching outcome expectancy: β = .229, p<.05), Case Study Content (science teaching efficacy: β = .196, p<.05, science teaching outcome expectancy: β = .169, p<.05, maths teaching efficacy: β = .116, p<.05, and math teaching outcome expectancy: β = .207, p<.05) and Expert Content (science teaching efficacy: β = .097, p<.05, science teaching outcome expectancy: β = .085, p<.05, maths teaching efficacy: β = .072, p<.05, and math teaching outcome expectancy: β = .115, p<.05). Apart from TET qualification and age, participant's background of work-experience and education had some small effect in at least one of the self-efficacy constructs.

Table 18 Association of Change in Science Teaching Efficacy Beliefs with Online Activity Profile

	Change in Science Teaching Efficacy (STE)	Change in Science Teaching Outcome Expectancy (SOE)
	β	β
Project Feedback	.109***	.089***
Subject Module Section	.193***	.187***
Case Study Content	.196***	.169***
Expert Content	.097***	.085***
Gender: Female	.005	-.105***
Age	.015	.009
Work Experience	-.021	-.003
TET Qualified	.015	.009
Education: (PTC/Diploma)		
Graduate	.010	.191*
Post Grad and above	-.018	.167*
Model Fit		
χ2	3351.693	2223.883
df	441	275
CFI	0.930	0.933
TLI	0.928	0.932
SRMR	0.054	0.039
RMSEA	0.031	0.032
RMSEA 90% CI	[0.030 0.032]	[0.031 0.033]

Note: * $p < .05$, ** $p < .01$, *** $p < .001$; χ2 : Chi-Squared ; df : Degrees of Freedom; CFI : Comparative Fit Index; TLI : Tucker-Lewis Index; SRMR : Standardised Root Mean Residual; RMSEA : Root Mean Square Error of Approximation; Observations :- 6933

We found that female participants reported a lower change in self-efficacy beliefs of Instructional strategy (β = -.081, p<.05) and classroom management (β = -.053, p<.05) than the male participants. Work experience was found to have a negative but significant association to changes in math teaching efficacy (β = -.039, p<.05). Finally, analysis shows that participants with graduate degrees reported higher change in classroom management efficacy beliefs (β = .169, p<.05), instructional strategy (β = .171, p<.05) and science teaching outcome expectancy (β = .191, p<.05) compared to participants with diploma or high school certificates. Similarly, participants with post graduate degree or more also reported a higher change in self-efficacy belief in classroom management (β = .194, p<.05), instructional strategy (β = .159, p<.05) and science teaching outcome expectancy (β = .167, p<.05).

Table 19 Association of Change in Maths Efficacy Belief with Online Activity Profile

	Change in Maths Teaching Efficacy (MTE)	Change in Math Teaching Outcome Expectancy (MOE)
	β	β
Project Feedback	.069***	.096***
Subject Module Section	.110***	.229***
Case Study Content	.116***	.207***
Expert Content	.072***	.115***
Gender: Female	-.069**	-.050*
Age	.012	.009
Work Experience	-.039*	-.015
TET Qualified	-.004	.019
Education: (PTC/Diploma)		
Graduate	.112	.084
Post Grad and above	.066	.061
Model Fit		
χ2	3054.320	3218.271
df	439	277
CFI	0.956	0.922
TLI	0.955	0.922
SRMR	0.048	0.050
RMSEA	0.029	0.039
RMSEA 90% CI	[0.028 0.030]	[0.038 0.040]

Note: * p < .05, ** p < .01, *** p < .001 ; χ2 : Chi-Squared ; df : Degrees of Freedom; CFI : Comparative Fit Index; TLI : Tucker-Lewis Index; SRMR : Standardised Root Mean Residual; RMSEA : Root Mean Square Error of Approximation; Observations :- 6933

5.2.5.3 Summary

In summary, the preliminary analysis indicated a small positive effect on general teaching efficacy and a medium effect on subject specific self-efficacy belief among the participants of the programme. Analysis using the latent change model confirmed that the change in subject-specific self-efficacy beliefs of the PD participants was significantly positive. The baseline self-efficacy beliefs were negatively associated with a change in self-efficacy beliefs indicating that participants with the low baseline self-efficacy had the most positive change. This means that participants reporting low self-efficacy beliefs at the start of the programme gained the most by attending the online PD. Attrition analysis showed that non-respondents to post-training self-efficacy beliefs survey tended to be participants with low self-efficacy beliefs. Given the negative association of change with prior self-efficacy beliefs, we can speculate that the non-response possibly lowered the measured effect of the PD. The data indicates that female participants reported significantly less change in self-efficacy beliefs compared to men. Further qualitative investigations of the participants could reveal the reasons for the variety of effects due to gender. In the case of the subject-specific teaching self-efficacy beliefs in the non-participant group (Group B) teachers with a graduate degree and above reported to have a significantly positive change in self-efficacy compared to teachers with only a diploma or professional teaching certificate.

Analysis of participant activities showed significant variation in how learners interacted with the content on and off the SAMARTH platform. We identified four latent profiles based on online pageview logs and six latent classes based on off-platform activities that the participants reported. The change in self-efficacy was regressed upon indicators of latent class membership to six activity classes based on levels of off-platform activities of notetaking and interactions. Participants with low notetaking and intermediate interactions reported significantly less change in self-efficacy beliefs in all sub-constructs except mathematics teaching outcome expectancy. Also, High notetaking and High/Intermediate interaction were associated with significantly higher change in all self-efficacy constructs. Age and work experience did not have any significant association with the change in self-efficacy. Female participants had significantly less change in self-efficacy compared to males in all efficacy constructs except in Science Teaching Efficacy.

Performing the same analysis for latent online profiles showed that participants with different online profiles did not have a significant association to change in self-efficacy in the general self-efficacy beliefs while there was a positive change in subject-specific efficacy beliefs. Participants with online profiles which focussed more on subject module content and case study content indicated a higher change in self-efficacy in subject-specific efficacy constructs. Apart from TET qualification all of the background contexts of age, work experience and education had some small effect in at least one of the self-efficacy constructs.

6 Association of Self-Efficacy Beliefs with Classroom Activities

The first three sections confirmed that the participants of the online programme reported a significant improvement in their self-efficacy beliefs. Further, it was found that the participants engaged differently with the contents of the programme, both on and off the learning platform. This section investigates the effects on the classroom activities of the participant teacher. Finally, we analyse the association of self-efficacy beliefs with classroom activities and materials use of the teacher.

6.1 Method

6.1.1 Instrument for class observation

Classroom observation was conducted using Stallings Classroom Snapshot Instrument (Stallings et al., 2014; World Bank Group, 2017). Using the instrument, an observer captures periodic data of Teacher activity, Material used by the teacher, and Student activity, approximately ten times in a single classroom session. One observation consists of an average of three classroom sessions over a period of one or two weeks. The instrument does have the potential for Hawthrone effects where teacher's actions will be influenced by the presence of an observer in the classroom (Burns & Luque, 2015; World Bank Group, 2017). Thus, in using the observation tool it is assumed that, during the observations, teachers will perform to the best of their abilities.

6.1.2 Sample selection

We used Optimal Design Plus Empirical Evidence Software (Raudenbush et al., 2011) to perform power analysis and determine the sample size for our study. Classroom observations were to be performed by state officials who have classroom observation as part of their administrative roles and responsibilities. The nature of the instrument and the number of classroom visits allowed for each official to observe up to two teachers within their administrative region. Hence, we sought sample size for randomized cluster trials for finding the minimum detectable effect size at the power of 0.8, for a cluster size of 2 and Intra Class Correlation of 0.25 (Spybrook et al., 2011). It was found that classroom observation of 500 clusters consisting of 2 teachers, could detect small effect sizes (0.2) for 0.8 power at the significance level of 95%. From the list of registered teachers, 500 clusters (250 Group A and 250 Group B) were randomly selected in proportion to their distribution within each district. Within each cluster, two schools were selected, where the school had only one registered teacher. In the first week of observations, a few schools dropped out, requiring the addition of 70 clusters (35 Group A and 35 Group B).

6.1.3 Training of Classroom Observers

For conducting classroom observations, 37 Block Resource Coordinators (BRCCs) from the 33 districts and four Municipalities were trained face-to-face on using the Stallings Classroom Snapshot Instrument. The BRCCs then trained and supervised the Cluster Resource Co-ordinators in the 570 selected clusters within their respective district/municipalities. Classroom Observation was to be conducted by the Cluster Resource Center Coordinators (CRCCs) in the selected schools. All Observations were recording using Open Data Kit (ODK) Collect (Hartung et al., 2010) Android App on the observer's smartphone. The training consisted of setting up a smartphone for entering observations, performing the observations and submitting a completed form. All the process steps and observation guidelines were included in a manual (in Gujarati), which was shared digitally with BRCCs (at district level) and CRCCs (at cluster level). An English version of the manual is included in the appendix of this document for reference. The training also consisted of observation of a pre-recorded classroom session for practice.

6.1.4 Data collection

A classroom snapshot form was created for use with ODK collect Android App. This form was shared with all observers within a district using a shared folder in google drive. The ODK collect application allowed recording inputs even when the device was out of cellular coverage. Once the observer submitted the form, the captured data was updated on a google sheet maintained in a google drive folder specifically restricted only to the corresponding district. This google sheet allowed BRCCs and the observers to track classroom observations. Especially BRCCs could check if their observations were recorded and if the timings (interval of observations) were acceptable. A google script scheduled to run overnight would gather the raw observations recorded in all the district level google sheets into a single google sheet document accessible to the research team at IIM Ahmedabad.

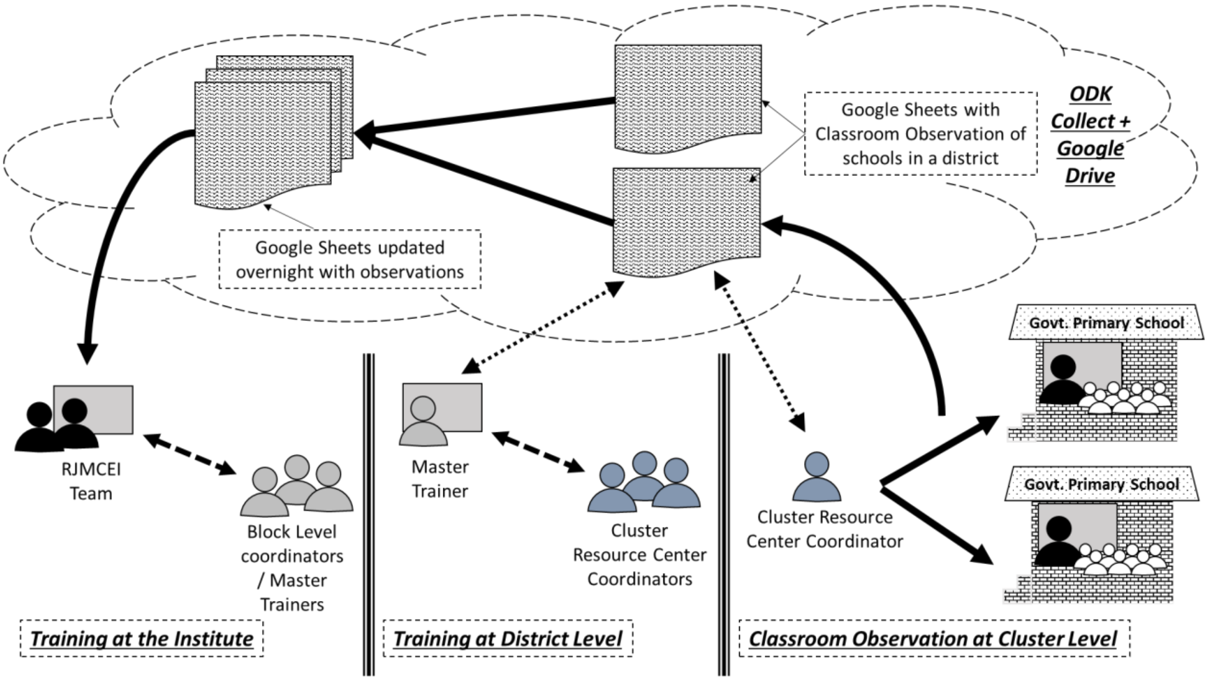

Figure 14 Layout of Classroom Observation and Data Collection

6.1.5 Observation Schedule

Each CRCC was instructed to observe three classroom sessions of the assigned teacher over a period of two weeks as part of a single round of classroom observation. Three rounds of observation had to be conducted during the following time slots.

- 1st round: 18 June 2018 to 30 June 2018
- 2nd round: 16 July 2018 to 28 July 2018
- 3rd round: 20 August 2018 to 1st Sept 2018

6.1.6 Analysis

For the purpose of analysis, the raw observation data was cleaned using R to remove observations with incorrect timings. Then, a classroom activity for each of the three rounds was extracted based on the date of observation. Finally, the data was merged with the teacher's background information and responses to the self-efficacy survey. The dataset was then analysed using Mplus. As we are interested in the change in classroom practices of the teacher, we only analyse classroom observations of the teaching activities and the materials used by the teacher.

It was found that the number of observations dropped from the first round to the third. Hence the data was analysed to check if the attrition in classrooms being observed resulted in any bias towards specific classroom activities. We test for this bias by regressing the observations of the teacher in a cluster in one round, on the dummy variable indicating if the observation was conducted for the teacher in the consecutive round. The following equations (Eq. 1 & Eq. 2) indicate the random intercept regression models used in the test, where i represents teachers, while j represents the clusters to which the teachers belong. These equations were executed in Mplus at the cluster (within) level to account for variations due to observations by CRCCs.

$$
\begin{aligned}
Observation\ in\ Round\ 1_{ij} &= \beta_{0j} + \beta_1 \times Observed\ at\ Round\ 2_{ij} + \beta_2 \times Gender_{ij} + \beta_3 \times Age_{ij} \\
&+ \beta_4 \times Work\ Experience_{ij} + \beta_5 \times TET\ Qualified_{ij} + \beta_6 \times Graduate_{ij} \\
&+ \beta_7 \times PostGraduate\ and\ above_{ij} \qquad \dots Eq.1
\end{aligned}
$$

$$
\begin{aligned}
Observation\ in\ Round\ 2_{ij} &= \beta_{0j} + \beta_1 \times Observed\ at\ Round\ 3_{ij} + \beta_2 \times Gender_{ij} + \beta_3 \times Age_{ij} \\
&+ \beta_4 \times Work\ Experience_{ij} + \beta_5 \times TET\ Qualified_{ij} + \beta_6 \times Graduate_{ij} \\
&+ \beta_7 \times PostGraduate\ and\ above_{ij} \qquad \dots Eq.2
\end{aligned}
$$

Once the bias for the observations is evaluated, we analysed the recorded observations to determine if any change in classroom activities was associated with the group (treatment or control) of teachers. The analysis also took into account the variation due to the subject of the session (maths or science). Multivariate regression analysis was performed using the following set of equations from 3 to 11, representing the two-level random intercept regression model used in the analysis.

Level 1:

$$Observation\ in\ Round\ 1_{ij}$$
$$= \beta_{0j}{}^{1} + \beta_{1j}{}^{1} \times Science_{ij} + \beta_{2}{}^{1} \times Gender_{ij} + \beta_{3}{}^{1} \times Age_{ij}$$
$$+ \beta_{4}{}^{1} \times Work\ Experience_{ij} + \beta_{5}{}^{1} \times TET\ Qualified_{ij}$$
$$+ \beta_{6}{}^{1} \times Graduate_{ij} + \beta_{7}{}^{1} \times PostGraduate\ and\ above_{ij}$$
$$+ \beta_{8}{}^{1} \times Avg\ No\ of\ Students_{ij} \qquad \dots Eq.3$$

$$Observation\ in\ Round\ 2_{ij}$$
$$= \beta_{0j}{}^{2} + \beta_{1j}{}^{2} \times Science_{ij} + \beta_{2}{}^{2} \times Gender_{ij} + \beta_{3}{}^{2} \times Age_{ij}$$
$$+ \beta_{4}{}^{2} \times Work\ Experience_{ij} + \beta_{5}{}^{2} \times TET\ Qualified_{ij}$$
$$+ \beta_{6}{}^{2} \times Graduate_{ij} + \beta_{7}{}^{2} \times PostGraduate\ and\ above_{ij}$$
$$+ \beta_{8}{}^{2} \times Avg\ No\ of\ Students_{ij} \qquad \dots Eq.4$$

$$Observation\ in\ Round\ 3_{ij}$$
$$= \beta_{0j}{}^{3} + \beta_{1j}{}^{3} \times Science_{ij} + \beta_{2}{}^{3} \times Gender_{ij} + \beta_{3}{}^{3} \times Age_{ij}$$
$$+ \beta_{4}{}^{3} \times Work\ Experience_{ij} + \beta_{5}{}^{3} \times TET\ Qualified_{ij}$$
$$+ \beta_{6}{}^{3} \times Graduate_{ij} + \beta_{7}{}^{3} \times PostGraduate\ and\ above_{ij}$$
$$+ \beta_{8}{}^{3} \times Avg\ No\ of\ Students_{ij} \qquad \dots Eq.5$$

Level 2:

$$\beta_{0j}{}^{1} = \gamma_{00}{}^{1} + \gamma_{01}{}^{1} \times Group_{j} + U_{0j}{}^{1} \qquad \dots Eq.6$$

$$\beta_{1j}{}^{1} = \gamma_{10}{}^{1} + \gamma_{11}{}^{1} \times Group_{j} + U_{1j}{}^{1} \qquad \dots Eq.7$$

$$\beta_{0j}{}^{2} = \gamma_{00}{}^{2} + \gamma_{01}{}^{2} \times Group_{j} + U_{0j}{}^{2} \qquad \dots Eq.8$$

$$\beta_{1j}{}^{2} = \gamma_{10}{}^{2} + \gamma_{11}{}^{2} \times Group_{j} + U_{1j}{}^{2} \qquad \dots Eq.9$$

$$\beta_{0j}{}^{3} = \gamma_{00}{}^{3} + \gamma_{01}{}^{3} \times Group_{j} + U_{0j}{}^{3} \qquad \dots Eq.10$$

$$\beta_{1j}{}^{3} = \gamma_{10}{}^{3} + \gamma_{11}{}^{3} \times Group_{j} + U_{1j}{}^{3} \qquad \dots Eq.11$$

Finally, we explore the association of the self-efficacy beliefs of the teacher with their classroom activities. According to the schedule of classroom observations, the first round of observations was conducted towards the end of June. The teachers in the selected classroom had completed the pre-training survey before the first round of the observation. Additionally, the last round of observation is at the end of August, which coincides with the completion of the PD programme of Group A participants. Thus, effectively we can explore the association of the self-reported self-efficacy measures with the first two rounds of classroom observations. The following model (Figure 15) was evaluated using Mplus which regressed two rounds of classroom observation on pre-training self-efficacy while post-training survey responses were regressed on the classroom observations controlling for teacher characteristics (not indicated in the diagram) and cluster variations.

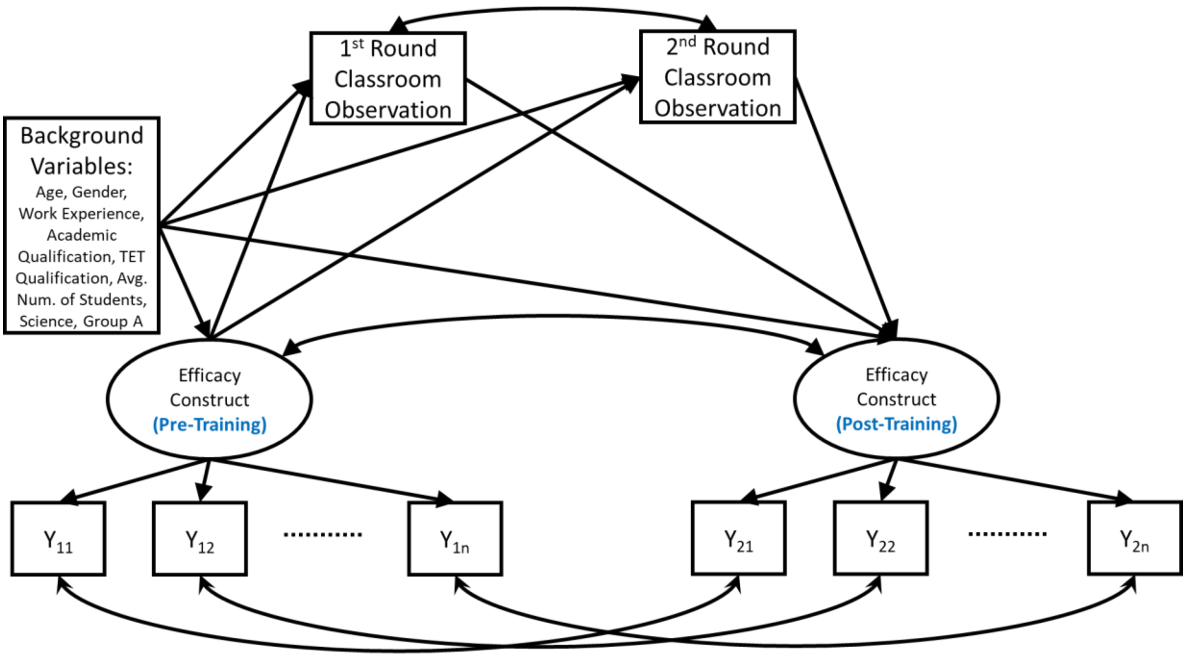

Figure 15 Model to analyse the association of Self-efficacy Beliefs and Classroom Activities

6.2 Findings

A total of 6713 classroom sessions were submitted by 473 CRCs. Only those observations which were recorded between 18 June 2018 and 5th September 2018 were retained for analysis. Observations (253 observations) that could not be linked to the corresponding participant teacher were dropped from further analysis. If a teacher was observed more than once in a single day, then both observations were dropped, to prevent variation in data due to teacher fatigue. If any CRCC was observing more than two teachers, then all observations of the CRCCs were dropped from the analysis. Finally, the observations were checked for valid timings, i.e. the total observation is between 20 to 40 minutes, the time duration between recorded activities is between 2 to 4 minutes, and timestamps showed observations were during school's working day and time.

After cleaning the data, we have 3251 observations of 710 teachers (354 Group A & 356 Group B) from 412 clusters (206 Group A & 206 Group B). Data on teacher activities and the materials used by the teacher in classroom sessions were extracted for further analysis. Summary of the valid observations recorded by the CRCCs has been included in Appendix C. Overall, across all three rounds it was observed that teachers spent about 95% of the class session in Learning activities and about 3% in classroom management. Also, while teaching, most teachers used the Blackboard (~ 35%), Textbooks (~ 20%) and Notebooks (~ 15 %). There was some use of learning aids (~ 7%) and the classroom PC or Smartboard (~ 4 %), while there was less use of group tasks (~ 3%) during classroom sessions.

6.2.1 Analysis of Bias

A random intercept model was implemented to analyse the recorded observations. The observations were regressed on the dummy variable, indicating if the teacher was observed in the next observation round. Findings on attrition bias linked to teacher classroom activities and Materials used by teachers are presented separately.

6.2.2 Observation of Teacher Activities

The standardized estimates obtained from the regression models have been tabulated below in table 20 and table 21. The results of the regression found no significant attrition bias on observation of teacher activities: learning activities (Group A: $\beta = .124$, $p>.05$ & Group B: $\beta = .210$, $p>.05$), Classroom Management activities (Group A: $\beta = -.025$, $p>.05$ & Group B: $\beta = -.196$, $p>.05$) and Off-task activities (Group A: $\beta = -.212$, $p>.05$ & Group B: $\beta = -.120$, $p>.05$) in second round observation for both participating and non-participating teachers.

Table 20 Attrition bias in observation of Teacher Activities from Round 1 to Round 2

Round 1 Observations ->	**Learning Activities**		**Classroom Management**		**Teacher Off Task**	
Group ->	Group A	Group B	Group A	Group B	Group A	Group B
	β	β	β	β	β	β
Observed at Round 2	.124	.210	-.025	-.196	-.212	-.120
Gender: Female	.072	-.012	-.127	.080	.034	-.101
Work Experience	-.014	.007	-.014	-.009	.046	.001
Age	-.082	-.031	.099	-.044	.024	.132
TET Qualified	-.177	.032	.137	-.116	.162	.118
Education: (PTC/Dip.)						
Graduate	.027	-.288	-.205	.392	.232	-.029
Postgraduate & above	.036	-.163	-.211	.204	.223	.011
R^2	.013	.015	.014	.024	.014	.021

Note: * p < .05, ** p < .01, *** p < .001; Observations: Group A = 312 & Group B = 285

Also, there were no significant association of teacher activities: learning activities (Group A: β = -.123, p>.05 & Group B: β = .100, p>.05), Classroom Management activities (Group A: β = .168, p>.05 & Group B: β = -.058, p>.05) and Off-task activities (Group A: β = -.009, p>.05 & Group B: β = -.130, p>.05) in round two with being observed third round of observations.

Table 21 Attrition bias in observation of Teacher Activities from Round 2 to Round 3

Round 2 Observations ->	**Learning Activities**		**Classroom Management**		**Teacher Off Task**	
Group ->	Group A	Group B	Group A	Group B	Group A	Group B
	β	β	β	β	β	β
Observed at Round 3	-.123	.100	.169	-.058	-.009	-.130
Gender: Female	.149	.142	-.086	-.122	-.194	-.125
Age	-.080	-.035	.039	.036	.117	.022
Work Experience	-.010	.053	.029	-.072	-.027	-.008
TET Qualified	-.068	-.071	-.073	.020	.280*	.125
Education: (PTC/Dip.)						
Graduate	-.372*	.007	.368*	-.019	.221	.013
Postgraduate & above	-.292	-.072	.362*	.049	.049	.082
R^2	.021	.013	.016	.009	.030	.012

Note: * p < .05, ** p < .01, *** p < .001; Observations: Group A = 236 & Group B = 265

6.2.3 Observation of Materials used by the teacher

Next, we explore if any attrition in observation is associated with the materials used by teachers in the classroom. The findings of bias in attrition in the observations from the first round to the second round are presented in Tables 22 and 23. It was found that observation in the second round of the participant (Group A) teachers' classroom was positively associated with not using any Materials (β = .212, p<.05) and negatively associated with adopting group work in the classroom (β = -.349, p<.05).

Table 22 Attrition bias in observation of Teacher's Material use from Round 1 to Round 2

Round 1 Observations ->	**No Materials**		**Reading Materials**		**Writing Materials**	
Group ->	A	B	A	B	A	B
	β	β	β	β	β	β
Observed at Round 2	.212*	.069	-.051	-.062	.091	-.303
Gender: Female	.041	.041	.044	-.072	-.039	.022
Age	-.036	.043	-.004	-.062	.028	-.026
Work Experience	.062	.015	.085	.144	-.059	.051
TET Qualified	.143	.160	.061	-.089	.251	-.184
Education: (PTC/Dip.)						
Graduate	.076	-.088	.201	.054	-.392	-.103
Postgraduate & above	.123	-.102	.055	.086	-.422	-.229
R^2	.014	.004	.011	.016	.011	.033

Note: * p < .05, ** p < .01, *** p < .001; Observations: Group A = 312 & Group B = 285

While among the non-participant teachers (Group B) being observed in the second round was positively associated with the use of ICT (β = .242, p<.05). Thus we note that the teacher's use of Reading materials (Group A: β = -.051, p>.05 and Group B: β = -.062, p>.05) , Writing Materials (Group A: β = .091, p>.05 and Group B: β = -.303, p>.05), Blackboard (Group A: β = .204, p>.05 and Group B: β = .209, p>.05) and Learning Aids (Group A: β = -.118, p>.05 and Group B: β = -.127, p>.05) in the first round of the observation were not significantly association to being observed in the second round. We also note that in the first-round observations, the use of blackboard among participant teachers who had qualified the teacher's eligibility tests (β = -.370, p<.05) was significantly less

Table 23 Attrition bias in observation of Teacher's Material use from Round 1 to Round 2

Round 1 Observations ->	**Black Board**		**Learning Aids**		**ICT**		**Group Work**	
Group ->	A	B	A	B	A	B	A	B
	β	β	β	β	β	β	β	β
Observed at Round 2	.204	.209	-.118	-.127	-.170	.242*	-.349*	-.118
Gender: Female	-.024	.077	.120	-.032	-.045	-.049	-.028	.022
Age	.029	.055	-.025	.080	-.064	-.076	-.064	.019
Work Experience	-.083	-.146	.042	-.001	-.039	-.040	.047	.070
TET Qualified	-.370*	.103	-.109	.152	.049	-.121	.133	.215
Education: (PTC/Dip.)								
Graduate	-.166	-.107	.088	-.019	.145	.120	.322	-.187
Postgraduate & above	-.072	-.027	.201	.028	.121	.083	.279	-.102
R^2	.027	.028	.010	.010	.018	.020	.031	.010

Note: * p < .05, ** p < .01, *** p < .001; Observations: Group A = 312 & Group B = 285

Next, the findings of attrition bias in observations from the second round to the third round are presented in Tables 24 and 25. The analysis shows that observations in the third round of the non-participant (Group B) teachers' classroom were negatively associated with the use of writing materials (β = -.320, p<.05) and positively associated to the use of blackboard in the classroom (β = .286, p<.05). We note that the teacher's use of Reading materials (Group A: β = .044, p>.05 and Group B: β = -.198, p>.05) , Learning Aids (Group A: β = -.029, p>.05 and Group B: β = .095, p>.05), ICT (Group A: β = .058, p>.05 and Group B: β = .039, p>.05) and Group Work (Group A: β = -.106, p>.05 and Group B: β = .018, p>.05) in the second round of the observation were not significantly association to being observed in the third round.

Table 24 Attrition bias in observation of Teacher's Material use from Round 2 to Round 3

Round 2 Observations ->	**No Materials**		**Reading Materials**		**Writing Materials**	
Group ->	A	B	A	B	A	B
	β	β	β	β	β	β
Observed at Round 3	-.100	.113	.044	-.198	.081	-.320*
Gender: Female	.007	.035	-.064	-.035	-.078	-.058
Age	-.009	-.026	-.187*	.020	.047	-.122
Work Experience	.025	.120	.280*	.071	-.113	.085
TET Qualified	-.127	-.028	.076	-.019	.224	-.411*
Education: (PTC/Dip.)						
Graduate	.305	.424	.476	-.480	-.873	.361
Postgraduate & above	.404	.500	.354	-.478	-.794	.198
R^2	.009	.016	.033	.032	.027	.059*

Note: * p < .05, ** p < .01, *** p < .001; Observations: Group A = 236 & Group B = 265

We also note that in the second-round observations, the use of writing materials among non-participant teachers who had qualified the teacher's eligibility tests (β = -.411, p<.05) was significantly less. Also, the adoption of group work in classroom sessions of non-participating teachers was associated with teachers who identified as female (β = .383, p<.05). Finally, the use of reading materials by the Group A teachers was positively associated to work experience (β = .280, p<.05) but negatively associated to their age(β = -.187, p<.05).

Table 25 Attrition bias in observation of Teacher Material use from Round 2 to Round 3

Round 2 Observations ->	**Black Board**		**Learning Aids**		**ICT**		**Group Work**	
Group ->	A	B	A	B	A	B	A	B
	β	β	β	β	β	β	β	β
Observed at Round 3	-.080	.286*	-.029	.095	.058	.039	-.106	-.018
Gender: Female	.079	-.052	.154	.158	-.051	-.072	.066	.383*
Age	-.020	.008	.147	.198	.016	-.135	.085	.006
Work Experience	-.127	-.040	-.113	-.193	.038	.001	-.049	.128
TET	-.169	.194	-.054	-.021	.033	.015	.079	.136
Education: (PTC/Dip.)								
Graduate	-.268	-.111	.202	.214	-.014	.163	-.266	-.168
Postgraduate & above	-.147	.033	.134	.193	-.064	.047	-.268	-.232
R^2	.019	.036	.017	.030	.004	.026	.008	.054

Note: * p < .05, ** p < .01, *** p < .001; Observations: Group A = 236 & Group B = 265

In summary, analysis of observation of materials used by teacher showed that group A teachers who spent more time on group tasks during their classroom sessions in the first round of observation were not observed in the second round, but teachers who did not use any materials during sessions were more likely to be observed. Also, for group B, teachers who spend more time using technology in the classroom in the first round were observed in the second round. Similarly, group B teachers in the second round who used the blackboard more, but fewer instances of writing materials in the second round appear to be observed in the third round. Thus, the percentage usage of materials in an earlier observation session seems to be associated with being observed in the subsequent rounds of observation. This makes findings of higher avoidance of materials, usage of technology and blackboard or lesser use of writing materials and implementation of group-tasks in classrooms being associated with attrition bias.

6.2.4 Change in Teacher's Classroom Activities and Materials used

The two-level random intercept model was analysed in Mplus using the Bayes estimator with default priors. The findings of change in teacher activities are reported in table 26, while changes in the use of materials are reported in tables 27 and 28.

Table 26 Change in Teacher's Activities as observed in the third round

	Learning Activities	**Classroom Management**	**Teacher Off Task**
	Est. [95% CI]	Est. [95% CI]	Est. [95% CI]
Between Cluster			
Intercept	**93.361 [82.69 100.69]**	3.548 [-3.73 9.75]	0.904 [-6.42 4.67]
Group A	-0.504 [-2.97 1.98]	0.427 [-1.60 2.42]	-0.425 [-1.48 .64]
Science	-0.499 [-2.44 1.28]	0.734 [-.95 2.31]	-0.377 [-1.47 .70]
Science*Group A	0.168 [-2.39 2.81]	0.155 [-2.07 2.46]	-0.064 [-1.58 1.48]
Within Cluster			
Gender: Female	0.407 [-1.09 1.96]	0.047 [-1.24 1.32]	-0.537 [-1.34 .29]
Age	0.025 [-.18 .25]	-0.005 [-.17 .17]	0.055 [-.06 .18]
Work Experience	0.066 [-.29 .42]	-0.069 [-.35 .21]	-0.009 [-.18 .16]
TET Qualified	2.389 [-.17 4.83]	-0.737 [-2.75 1.27]	-0.913 [-2.16 .33]
Avg. No. of Students	0.011 [-.08 .11]	0.006 [-.07 .08]	0.001 [-.04 .05]
Education: (PTC/Diploma)			
Graduate	-0.776 [-6.86 5.99]	-0.102 [-4.80 5.01]	0.933 [-2.22 4.98]
Post Grad and above	-0.379 [-6.48 6.54]	-0.154 [-4.97 4.99]	0.998 [-2.21 5.11]
R^2 (Between)	**0.330 [.18 .41]**	**0.121 [.04 .19]**	**0.280 [.21 .39]**
R^2 (Within)	0.001 [.00 .01]	0.001 [.00 .01]	0.002 [.00 .02]

Note: Bold indicates that 95% CI (i.e Confidence Interval) does not include zero; Observations = 652

The findings indicate no significant difference in the time spent in teacher activities i.e. Learning activities (-0.504, 95% CI [-2.97 1.98]), Classroom Management (0.427, 95% CI [-1.60 2.42]) and Teacher off-task activities (-0.425, 95% CI [-1.48 .64]) between participant (Group A) and non-participant (Group B) teachers. Also, there was no significant difference in the teacher activities i.e. learning (-0.499, 95% CI [-2.44 1.28]), classroom management (0.734, 95% CI [-.95 2.31]) and Off-task activities (-0.377, 95% CI [-1.47 .70]), associated to the subject of the session. The analysis indicated no significant difference in the activities (Learning Activities: 0.168, 95% CI [-2.39 2.81], Classroom Management: 0.155, 95% CI [-2.07 2.46] & Teacher Off-Task: -0.064, 95% CI [-1.58 1.48]) that could be associated to different subject within the participant group. We do note that participant's background has no significant association to time spent in teacher activities.

Further, the results show that there is no difference in the use of materials associated with participation in the PD programme. There was a significant difference in the use of reading materials (5.844, 95% CI [.40 11.02]) and Learning Aids (9.791, 95% CI [4.80 14.66]) associated to the subject of the sessions observed. The analysis indicated a significant difference in the use of Reading Materials (9.847, 95% CI [2.55 17.58]) that could be associated to the subject of the sessions being observed of the participant teachers.

Table 27 Change in Teacher's Material Use as observed in the third round

	No Materials	**Reading Materials**	**Writing Materials**
	Est. [95% CI]	Est. [95% CI]	Est. [95% CI]
Between Cluster			
Intercept	3.727 [-8.15 13.09]	**43.249 [14.85 61.03]**	7.824 [-14.41 23.50]
Group A	0.705 [-1.63 3.09]	-2.525 [-7.94 2.90]	0.335 [-4.38 4.99]
Science	1.930 [-.40 4.25]	**5.844 [.40 11.02]**	-5.638 [-10.02 -1.56]
Science*Group A	-0.697 [-3.86 2.62]	**9.847 [2.55 17.58]**	-0.585 [-6.31 5.44]
Within Cluster			
Gender: Female	0.281 [-1.50 2.07]	0.068 [-3.99 4.16]	-1.824 [-5.12 1.48]
Age	-0.034 [-.28 .22]	-0.380 [-.90 .19]	0.053 [-.37 .51]
Work Experience	0.155 [-.22 .53]	0.309 [-.54 1.17]	0.223 [-.47 .92]
TET Qualified	-0.110 [-2.90 2.66]	2.567 [-3.78 8.98]	0.893 [-4.38 6.27]
Avg. No. of Students	0.025 [-.07 .13]	-0.214 [-.44 .01]	**0.255 [.07 .44]**
Education: (PTC/Diploma)			
Graduate	-1.557 [-8.33 6.10]	-15.170 [-29.89 1.53]	3.058 [-9.33 16.83]
Post Grad and above	0.335 [-6.55 8.12]	-13.092 [-27.92 3.74]	3.403 [-9.18 17.32]
R^2 (Between)	**0.141 [.08 .20]**	**0.115 [.08 .16]**	**0.063 [.02 .11]**
R^2 (Within)	0.002 [.00 .02]	0.008 [.00 .07]	0.004 [.00 .04]

Note: Bold indicates that 95% CI (i.e Confidence Interval) does not include zero ; Observations = 652

We note that teachers who identified as female had a positive and significant association to time spent using Learning aids (4.543, 95% CI [1.12 8.02]). Also, participant's age was associated to the use of learning aids (0.463, 95% CI [.01 .94]). Finally, we found that the average number of students in the classroom were positively associated to the use of writing materials (0.255, 95% CI [.07 .44]) and ICT (0.251, 95% CI [.10 .40]) in the classroom sessions. The analysis found no association of qualifying teacher eligibility tests, educational qualification and work experience on teacher activities and the materials used in the classrooms

Table 28 Change in Teacher's Material Use as observed in the third round

	Black Board	**Learning Aids**	**ICT**	**Group Work**
	Est. [95% CI]	Est. [95% CI]	Est. [95% CI]	Est. [95% CI]
<u>Between Cluster</u>				
Intercept	**40.387 [10.19 65.79]**	-4.532 [-29.58 10.62]	8.115 [-9.61 23.71]	0.148 [-12.34 7.80]
Group A	5.834 [-.95 12.68]	-2.383 [-6.66 1.91]	-1.854 [-5.12 1.44]	1.517 [-1.21 4.33]
Science	-12.635 [-19.08 -6.17]	**9.791 [4.80 14.66]**	0.795 [-2.96 4.44]	1.937 [-.13 3.72]
Science*Group A	-11.512 [-20.48 -2.36]	-1.038 [-7.68 6.02]	3.019 [-2.12 8.31]	-1.964 [-4.52 .74]
<u>Within Cluster</u>				
Gender: Female	-1.834 [-6.89 3.22]	**4.543 [1.12 8.02]**	-1.290 [-3.93 1.38]	0.423 [-1.25 2.11]
Age	0.049 [-.62 .73]	**0.463 [.01 .94]**	-0.146 [-.51 .23]	-0.016 [-.23 .22]
Work Experience	0.031 [-1.00 1.08]	-0.597 [-1.31 .13]	-0.349 [-.89 .19]	0.197 [-.17 .56]
TET Qualified	3.646 [-4.26 11.67]	-2.606 [-7.93 2.71]	-1.291 [-5.41 2.89]	-0.924 [-3.65 1.82]
Avg. No. of Students	-0.197 [-.47 .08]	0.000 [-.19 .20]	**0.251 [.10 .40]**	-0.004 [-.10 .09]
Education: (PTC/Diploma)				
Graduate	1.491 [-17.03 21.29]	4.209 [-8.87 19.70]	-0.585 [-10.76 10.20]	4.062 [-2.12 11.14]
Post Grad and above	0.178 [-18.57 20.00]	3.486 [-9.91 19.03]	-1.073 [-11.44 9.89]	3.577 [-2.75 10.69]
R^2 (Between)	**0.108 [.07 .14]**	**0.150 [.10 .20]**	**0.076 [.05 .11]**	**0.050 [.02 .09]**
R^2 (Within)	0.038 [.00 .21]	0.010 [.00 .08]	0.016 [.00 .15]	0.004 [.00 .03]

Note: Bold indicates that 95% CI (i.e Confidence Interval) does not include zero ; Observations = 652

Thus, the analysis of the last round of observations shows no significant change in teacher activities viz. learning activities, classroom management and Off-task activities, associated to either the group the teachers belonged to or the subject of the session being observed. The analysis of materials used by teachers also showed no significant difference between the participants and non-participants. We did find that for science classrooms of the PD participants, there was more use of reading materials (i.e., textbook) as compared to science classrooms from the control group.

6.2.5 Association of Self-efficacy beliefs and Classroom Activities

Classroom observations were conducted by CRCCs for teachers, one teaching science and another teaching mathematics. Variation due to cluster-level factors was addressed by group mean-centring the recorded classroom observations. Teacher responses to the general Teaching Self-efficacy instrument (Tschannen-Moran & Hoy, 2001) consisting of self-efficacy belief of classroom management, instructional strategy and student engagement was used for the analysis. Subject-specific self-efficacy construct could not be used as the study design prevented controlling for cluster-level variation using the group-mean centring. We present findings of the analysis separately for each of the sub construct of the Teaching self-efficacy instrument viz. classroom management, instructional strategy, and student engagement. For this analysis, only observations of 652 teachers were used because of missing information on background variables of 58 teachers.

6.2.5.1 Classroom Management

We recollect that the classroom management sub-scales consist of items like "How much can you do to calm a student who is disruptive or noisy?" and "How much can you do to get children to follow classroom rules?" measure teacher efficacy beliefs about managing classrooms. It measures the self-efficacy belief of a teacher to manage their classroom. First, the association of the prior self-efficacy belief of classroom management with teacher activities and the materials used in the classroom during the first two rounds of observation is presented in tables 29 to 32. Then, the association of teacher activities and materials used in the classroom with the post-training self-efficacy beliefs is tabulated in tables 33 to 35.

6.2.5.1.1 Association of Prior Classroom Management Self-Efficacy Beliefs with Teachers' Activities and Use of Materials

Findings show that teacher's time spent on off-task activities in the first-round observations were negatively associated with teacher's self-efficacy beliefs of classroom management ($\beta = -.101$, $p<.05$). Teacher's time spent in learning activities or classroom management in the first and second round were not related to the classroom management self-efficacy belief of the teacher. Also, classroom management self-efficacy is not significantly related to the teacher's time spent in off-task activities in the second round ($\beta = -.023$, $p>.05$). We note in the second-round classroom observation teachers who participated (Group A) in the online training programme who were observed teaching Science spent more time in learning activities (β = .368, p<.05) but less time in classroom management (β = -.321, p<.05) compared to teachers teaching mathematics in the non-participating teachers' group (Group B). There was no significant association of teachers' time spent in teacher activities with teachers' background viz. gender, age, work experience, qualification (eligibility test and educational) and average class size.

Table 29 Association of classroom management self-efficacy beliefs and teacher's activities in the classroom

Teacher Activities ->	**Learning Activities**		**Classroom Mgmt.**		**Teacher Off Task**	
Observation Round ->	**1st Rnd. Obs.**	**2nd Rnd. Obs.**	**1st Rnd. Obs.**	**2nd Rnd. Obs.**	**1st Rnd. Obs.**	**2nd Rnd. Obs.**
	β	β	β	β	β	β
Intercepts	-.071	-.261	.092	.227	.264	.006
Self-Efficacy (Pre-Test)	.026	.072	.051	-.042	-.101***	-.023
Group A	.007	-.196	.006	.178	-.017	.036
Science	.107	-.072	-.002	.122	-.180	-.057
Science*Group A	.005	.368*	-.015	-.321*	.006	-.086
Gender: Female	-.049	.105	.086	-.104	-.003	-.007
Age	-.006	.019	.018	.001	-.009	-.024
Work Experience	.000	.022	-.039	-.028	.041	.004
TET Qualified	-.117	-.018	.168	-.011	.030	.036
Avg. No. of Students	.052	-.001	-.019	.064	-.071	-.076
Education: (PTC/Diploma)						
Graduate	.013	.207	-.130	-.146	.109	-.085
Post Grad and above	.006	.180	-.179	-.136	.171	-.064
R^2	.008	.021	.011	.016	.024*	.010

Note: * p < .05, ** p < .01, *** p < .001; Observations: 652

The analysis of association of use of materials in classroom with teachers' classroom management self-efficacy beliefs are presented in tables 30 to 32. The findings indicate that in the first round of observation teachers' classroom management efficacy beliefs were not significantly associated to the teacher's use of Reading materials(β = -.033, p>.05), Writing materials (β = -.004, p>.05), Black boards (β = .022, p>.05), learning aids(β = .042, p>.05), ICT (β = .013, p>.05) and Group Work (β = -.059, p<.05). Similarly even in the second round of observations there was no significant correlation between classroom management efficacy and the use of Reading materials (β = -.071, p<.05), Writing materials (β = .019, p<.05), Black boards (β = .053, p>.05), learning aids(β = .040, p>.05), ICT (β = .015, p>.05) and Group Work (β = -.013, p>.05).

Table 30 Association of classroom management self-efficacy beliefs and teacher's use of materials in the classroom (No Materials, Reading Materials & Writing Materials)

Materials Used ->	**No Materials**		**Reading Materials**		**Writing Materials**	
Observation Round ->	**1st Rnd. Obs.**	**2nd Rnd. Obs.**	**1st Rnd. Obs.**	**2nd Rnd. Obs.**	**1st Rnd. Obs.**	**2nd Rnd. Obs.**
	β	β	β	β	β	β
Intercepts	-.405	-.383	-.700*	-.551	.562	.674
Self-Efficacy (Pre-Test)	-.024	-.004	-.033	-.071	-.004	.019
Group A	-.040	.023	.012	-.066	.113	.109
Science	.453***	.291*	1.042***	.861***	-.779***	-.683***
Science*GroupA	.116	-.043	.022	.188	-.261*	-.248
Gender: Female	.134	.167	.055	.023	-.005	-.036
Age	.055	.110	.074	-.002	-.030	-.085
Work Experience	.002	-.048	-.082	.043	.037	.004
TET Qualified	.005	-.133	-.027	.069	-.002	-.064
Avg. No. of Students	.039	.020	-.037	.020	.039	-.019
Education: (PTC/Diploma)						
Graduate	-.009	.277	.143	-.018	-.005	-.272
Post Grad and above	.067	.229	.181	.015	-.099	-.315
R^2	.073**	.034.	.280***	.235***	.217***	.175***

Note: * p < .05, ** p < .01, *** p < .001; Observations: 652

The results of the analysis indicate that the use of materials in the classroom was influenced by the subject being taught during the sessions. In the first-round of classroom observation of classrooms where teachers taught science, significantly high use was observed of Reading materials (β = 1.042, p<.05), learning aids (β = .810, p<.05) and ICT (β = .280, p<.05). While during second round observation reading materials (β = .861, p<.05), learning aids (β = .844, p<.05) and ICT (β = .274, p<.05) were used significantly more.

Table 31 Association of classroom management self-efficacy beliefs and teacher's use of materials in the classroom (BlackBoard & Learning Aids)

Materials Used ->	**Black Board**		**Learning Aids**	
Observation Round ->	**1st Rnd. Obs.**	**2nd Rnd. Obs.**	**1st Rnd. Obs.**	**2nd Rnd. Obs.**
	β	β	β	β
Intercepts	.524	.468	-.322	-.796*
Self-Efficacy (Pre-Test)	.022	.053	.042	.040
Group A	-.101	-.028	.187	.017
Science	-1.073***	-1.017***	.810***	.844***
Science*Group A	.124	-.013	-.330**	-.021
Gender: Female	-.017	-.019	.007	.061
Age	-.056	-.048	.027	.109.
Work Experience	.077	-.012	-.043	-.022
TET Qualified	-.079	-.080	-.012	.028
Avg. No. of Students	-.032	-.103*	.008	-.003
Education: (PTC/Diploma)				
Graduate	.133	.130	-.104	.345
Post Grad and above	.118	.229	-.185	.229
R^2	.253***	.271***	.111***	.187***

Note: * p < .05, ** p < .01, *** p < .001; Observations: 652

Also, in the first-round science classrooms were observed to use less of Writing materials (β = -.779, p<.05), Blackboards (β = -1.073, p<.05), and Group Work (β = -.292, p<.05). Even in the second round, we observed less use of Writing materials (β = -.683, p<.05) and Blackboards (β = -1.017, p<.05). We note that the first-round observation teachers who participated (Group A) in the online training programme teaching Science, tended to use less writing materials (β = -.261, p<.05) and learning aids (β = -.330, p<.05) but more of Group work (β = .395, p<.05) compared to teachers teaching mathematics in the non-participating teachers' group (Group B). The analysis also shows that in the second-round observation the use of blackboard by teachers was negatively correlated to the average number of students in the class (β = -.103, p<.05) but positively associated with the use of ICT (β = .159, p<.05). We find no significant association of teachers’ use of any materials with teachers’ background viz. gender, age, work experience and qualification (eligibility test and educational).

Table 32 Association of classroom management self-efficacy beliefs and teacher's use of materials in classroom (ICT & Group Work)

Materials Used ->	**ICT**		**Group Work**	
Observation Round ->	**1st Rnd. Obs.**	**2nd Rnd. Obs.**	**1st Rnd. Obs.**	**2nd Rnd. Obs.**
	β	β	β	β
Intercepts	.045	.067	.300	.250
Self-Efficacy (Pre-Test)	.013	.015	-.059	-.013
Group A	.040	-.036	-.205	-.054
Science	.280**	.274*	-.292*	.014
Science*Group A	-.021	.119	.395**	.121
Gender: Female	-.138	-.136	-.030	.186
Age	-.037	-.010	-.017	.081
Work Experience	-.016	.028	.013	-.052
TET Qualified	.025	.212	.243	-.192
Avg. No. of Students	.081	.159*	-.013	.036
Education: (PTC/Diploma)				
Graduate	-.231	-.307	-.287	-.095
Post Grad and above	-.158	-.395	-.305	-.028
R^2	.033.	.061*	.023.	.022

Note: * p < .05, ** p < .01, *** p < .001; Observations: 652

6.2.5.1.2 Association of Classroom Activities with Classroom Management Self-Efficacy Beliefs reported after PD

Table 33 Association of observed teacher's activities and post-training classroom management self-efficacy beliefs

	Classroom Mgmt. Self-efficacy (Post)	**Classroom Mgmt. Self-efficacy (Post)**	**Classroom Mgmt. Self-efficacy (Post)**
Classroom Activity Obs.	Learning Activities	Classroom Mgmt	Teacher Off Task
	β	β	β
Observation at Round 1	-.056	.022	.066
Observation at Round 2	-.023	.029	-.013
Group A	.341*	.339*	.346*
Science	-.006	-.014	.001
Science*Group A	.260	.261	.250
Gender: Female	-.068	-.066	-.068
Age	-.001	-.001	-.001
Work Experience	.009	.009	.006
TET Qualified	-.098	-.095	-.093
Avg. No. of Students	.065	.060	.065
Education: (PTC/Diploma)			
Graduate	-.197	-.195	-.212
Post Grad and above	-.210	-.207	-.227
R^2	.071**	.071**	.068**

Note: * p < .05, ** p < .01, *** p < .001; Observations: 652

Tables 33 to 35 present the result of regressing post-training classroom management self-efficacy on teacher's classroom activities and use of materials. The results show no significant association between observed teachers' classroom practice and the self-efficacy beliefs of classroom management.

Table 34 Association of observed teacher's use of Materials (No Materials, Reading materials & Writing Materials) and post-training classroom management self-efficacy beliefs

	Classroom Mgmt. Self-efficacy (Post)	**Classroom Mgmt. Self-efficacy (Post)**	**Classroom Mgmt. Self-efficacy (Post)**
Classroom Activity Obs.	No Materials	Reading Materials	Writing Materials
	β	β	β
Observation at Round 1	-.043	.040	.082
Observation at Round 2	-.008	-.025	-.052
Group A	.343**	.342**	.341**
Science	.011	-.031	.017
Science*Group A	.256	.256	.260
Gender: Female	-.060	-.069	-.069
Age	.003	-.003	-.003
Work Experience	.007	.012	.005
TET Qualified	-.093	-.089	-.095
Avg. No. of Students	.064	.064	.058
Education: (PTC/Diploma)			
Graduate	-.200	-.208	-.216
Post Grad and above	-.210	-.221	-.223
R^2	.072**	.071**	.073**

Note: * p < .05, ** p < .01, *** p < .001; Observations: 652

Table 35 Association of observed teacher's use of Materials (Black-Board, Learning Aids, ICT & Group Work) and post-training classroom management self-efficacy beliefs

	Classroom Mgmt. Self-efficacy (Post)	**Classroom Mgmt. Self-efficacy (Post)**	**Classroom Mgmt. Self-efficacy (Post)**	**Classroom Mgmt. Self-efficacy (Post)**
Classroom Activity Obs.	Black Board	Learning Aids	ICT	Group Work
	β	β	β	β
Observation at Round 1	-.025	-.031	-.031	.023
Observation at Round 2	.040	-.040	-.002	.044
Group A	.343**	.351**	.346**	.352**
Science	.002	.049	-.002	-.004
Science*Group A	.256	.240	.251	.237
Gender: Female	-.067	-.065	-.072	-.075
Age	.000	.004	-.002	-.004
Work Experience	.010	.006	.007	.010
TET Qualified	-.091	-.091	-.090	-.088
Avg. No. of Students	.065	.062	.065	.061
Education: (PTC/Diploma)				
Graduate	-.203	-.192	-.210	-.192
Post Grad and above	-.220	-.211	-.220	-.206
R^2	.072**	.070**	.070**	.071**

Note: * p < .05, ** p < .01, *** p < .001; Observations: 652

6.2.5.2 Instructional Strategy

The instructional strategy scale measures a teacher's efficacy belief in being able to adopt an effective instructional approach in a classroom. Example items in the subscale are: "To what extent can you use a variety of assessment strategies?" and "How well can you implement alternative strategies in your classroom?". Initially, the association of the prior instructional strategy self-efficacy belief with teacher activities and materials used in the classroom during the first two rounds of observation are presented in tables 36 to 39. Followed by the association of teacher activities and the materials used in the classroom with instructional strategy self-efficacy beliefs measured after the training, tabulated in tables 40 to 42.

6.2.5.2.1 Association of Prior Self-Efficacy Beliefs of Instructional Strategy with Teachers' Activities and Use of Materials

The analysis shows that teacher's time spent in classroom management activities in the first-round observations were positively associated with teachers' efficacy beliefs of instructional strategy (β = .126, p<.05). While time spent on off-task activities in the first-round observations was negatively associated with teacher's self-efficacy beliefs of instructional strategy (β = -.079, p<.05). We note that in the second-round observation, time spent on classroom management activities, was negatively associated with teacher's efficacy beliefs in instructional strategy (β = -.080, p<.05) before the training.

Table 36 Association of instructional strategy self-efficacy beliefs and teacher's activities in classroom

Teacher Activities ->	**Learning Activities**		**Classroom Mgmt.**		**Teacher Off Task**	
Observation Round ->	**1st Rnd. Obs.**	**2nd Rnd. Obs.**	**1st Rnd. Obs.**	**2nd Rnd. Obs.**	**1st Rnd. Obs.**	**2nd Rnd. Obs.**
	β	β	β	β	β	β
Intercepts	.049	-.442	-.095	.235	-.027	.422
Self-Efficacy (Pre-Test)	-.041	.029	.126**	-.080*	-.079*	.045
Group A	.009	-.192	.007	.177	-.022	.033
Science	.109	-.064	.006	.116	-.193	-.058
Science*Group A	.011	.359*	-.040	-.305	.025	-.092
Gender: Female	-.066	.106	.120	-.125	-.016	.010
Age	-.012	.011	.017	.003	.001	-.018
Work Experience	.004	.026	-.041	-.027	.037	.000
TET Qualified	-.120	-.010	.185	-.023	.015	.039
Avg. No. of Students	.054	-.003	-.025	.068	-.066	-.078
Education: (PTC/Diploma)						
Graduate	.005	.094	-.142	-.068	.135	-.039
Post Grad and above	.004	.084	-.190	-.064	.187	-.031
R^2	.009	.017	.023	.020	.021	.011

Note: * p < .05, ** p < .01, *** p < .001; Observations: 652

Teachers time spent in learning activities in the first and second round were not related to the teacher's efficacy belief of instructional strategy. Also, instructional efficacy beliefs were not related to the teacher's time spent in off-task activities in the second round (β = .045, p>.05). We also note in the second-round observation teachers who participated (Group A) in the online training programme teaching Science, spent more time in learning activities (β = .359, p<.05). There was no significant association of teachers' teacher activities with teachers' background viz. gender, age, work experience, qualification (eligibility test and educational) and average class size. The findings of the relation between the use of materials in the classroom and teachers' instructional Strategy self-efficacy beliefs are presented in tables 37 to 39. The analysis show that in the first round of observation teachers' efficacy beliefs of instructional strategy were not significantly associated to the teacher's use of Reading materials (β = -.038, p>.05), Writing materials (β = -.049, p>.05), Blackboards (β = .033, p>.05), learning aids(β = .031, p>.05), ICT (β = .003, p>.05) and Group

Work (β = -.037, p>.05). While in the second round of observations there was no significant correlation between instructional strategy efficacy and the use of Reading materials (β = -.038, p>.05), Writing materials (β = -.014, p>.05), Blackboards (β = .018, p>.05), and Group Work (β = .006, p>.05). Although in the second-round teachers' efficacy beliefs of the instructional strategy was positively correlated to the use of learning aids (β = .136, p<.05) while being negatively associated with the use of ICT (β = -.066, p<.05).

Table 37 Association of instructional strategy self-efficacy beliefs and teacher's use of materials in the classroom (No Materials, Reading Materials & Writing Materials)

Materials Used ->	**No Materials**		**Reading Materials**		**Writing Materials**	
Observation Round ->	**1st Rnd. Obs.**	**2nd Rnd. Obs.**	**1st Rnd. Obs.**	**2nd Rnd. Obs.**	**1st Rnd. Obs.**	**2nd Rnd. Obs.**
	β	β	β	β	β	β
Intercepts	-.419	-.474	-.692*	-.561	.457	.727
Self-Efficacy (Pre-Test)	.058	.030	-.038	-.062	-.049	-.014
Group A	-.043	.022	.010	-.070	.114	.110
Science	.452***	.292*	1.038***	.852***	-.781***	-.681***
Science*Group A	.107	-.048	.030	.202	-.252*	-.246
Gender: Female	.156	.177	.047	.012	-.021	-.043
Age	.062	.112	.077	.005	-.032	-.089
Work Experience	-.002	-.049	-.082	.041	.039	.006
TET Qualified	.010	-.130	-.033	.058	-.008	-.065
Avg. No. of Students	.036	.019	-.035	.023	.042	-.019
Education: (PTC/Diploma)						
Graduate	-.002	.139	.152	.000	-.005	-.138
Post Grad and above	.069	.114	.187	.013	-.097	-.158
R^2	.076**	.035	.280***	.234***	.219***	.175***

Note: * p < .05, ** p < .01, *** p < .001; Observations: 652

The findings indicate that the use of materials in the classroom was influenced by the subject being taught during the sessions. In the first-round of classroom observation of classrooms where science sessions were conducted, significantly high use was observed of Reading materials (β = 1.038, p<.05), learning aids (β = .815, p<.05) and ICT (β = .281, p<.05). While during second round observation, only the reading materials (β = .852, p<.05) and learning aids (β = .852, p<.05) were used significantly more. Additionally, in the first-round science classrooms were observed to use less of Writing materials (β = -781, p<.05), Blackboards (β = -1.070, p<.05), and Group Work (β = -.299, p<.05). Even in the second round, we observed less use of Writing materials (β = -.681, p<.05) and Blackboards (β = -1.011, p<.05).

Table 38 Association of instructional strategy self-efficacy beliefs and teacher's use of materials in the classroom (BlackBoard & Learning Aids)

Materials Used ->	**Black Board**		**Learning Aids**	
Observation Round ->	**1st Rnd. Obs.**	**2nd Rnd. Obs.**	**1st Rnd. Obs.**	**2nd Rnd. Obs.**
	β	β	β	β
Intercepts	.521	.468	-.285	-.800*
Self-Efficacy (Pre-Test)	.033	.018	.031	.136**
Group A	-.100	-.025	.189	.017
Science	-1.070***	-1.011***	.815***	.852***
Science*Group A	.117	-.018	-.338**	-.047
Gender: Female	-.009	-.020	.012	.099
Age	-.057	-.054	.023	.110
Work Experience	.077	-.009	-.041	-.025
TET Qualified	-.074	-.075	-.006	.046
Avg. No. of Students	-.034	-.104*	.006	-.010
Education: (PTC/Diploma)				
Graduate	.128	.058	-.115	.168
Post Grad and above	.114	.110	-.192	.109
R^2	.254***	.269***	.111***	.203***

Note: * p < .05, ** p < .01, *** p < .001; Observations: 652

Table 39 Association of instructional strategy self-efficacy beliefs and teacher's use of materials in the classroom (ICT & Group Work)

Materials Used ->	**ICT**		**Group Work**	
Observation Round ->	**1st Rnd. Obs.**	**2nd Rnd. Obs.**	**1st Rnd. Obs.**	**2nd Rnd. Obs.**
	β	β	β	β
Intercepts	.049	.096	.259	.275
Self-Efficacy (Pre-Test)	.003	-.066*	-.037	.006
Group A	.041	-.034	-.209	-.055
Science	.281**	.274*	-.299*	.012
Science*Group A	-.023	.130	.405**	.121
Gender: Female	-.139	-.159	-.034	.190
Age	-.039	-.015	-.010	.084
Work Experience	-.015	.032	.010	-.053
TET Qualified	.026	.206	.235	-.192
Avg. No. of Students	.081	.163*	-.011	.036
Education: (PTC/Diploma)				
Graduate	-.234	-.156	-.272	-.046
Post Grad and above	-.160	-.197	-.296	-.013
R^2	.032	.065**	.021	.021

Note: * p < .05, ** p < .01, *** p < .001; Observations: 652

We found that in the first-round observation, teachers who participated (Group A) in the online training programme and were conducting Science sessions, tended to use fewer writing materials (β = -.252, p<.05) and learning aids (β = -.338, p<.05) but more of Group work(β = .405, p<.05) compared to teachers teaching mathematics in the non-participating teachers' group (Group B). Like the previous analysis of self-efficacy beliefs of classroom management, we also find that in the second-round observation the use of blackboard by teachers was negatively correlated to the average number of students in the class (β = -.104, p<.05), but positively related to use of ICT (β = .163, p<.05). We find no significant association of teachers' use of any materials with teachers' background viz. gender, age, work experience and qualification (eligibility test and educational).

6.2.5.2.2 Association of Classroom Activities with Self-Efficacy Beliefs of Instructional Strategy reported after PD

We present the findings of regressing post-training efficacy beliefs of instructional strategy on teacher's classroom activities and use of materials in tables (Tables 40 to 42). The analysis found that efficacy belief in instructional strategy, after PD, had a small negative but significant correlation with conducting classroom session with no materials (β = -.061, p<.05) observed in the first round. Also, we found that the female teachers reported significantly lower self-efficacy beliefs of instructional strategy in the post-training survey compared to male participants.

Table 40 Association of observed teacher's activities and post-training Instructional strategy self-efficacy beliefs

	Instructional Strategy Self-efficacy (Post)	**Instructional Strategy Self-efficacy (Post)**	**Instructional Strategy Self-efficacy (Post)**
Classroom Activity Obs.	Learning Activities	Classroom Mgmt	Teacher Off Task
	β	β	β
Observation at Round 1	-.001	-.018	.011
Observation at Round 2	-.101	.037	.082
Group A	.557**	.570***	.574***
Science	.030	.033	.044
Science*GroupA	.153	.128	.123
Gender: Female	-.181	-.186*	-.191*
Age	.007	.006	.008
Work Experience	-.027	-.030	-.031
TET Qualified	-.139	-.134	-.141
Avg. No. of Students	.076	.073	.083
Education: (PTC/Diploma)			
Graduate	-.230	-.247	-.244
Post Grad and above	-.118	-.134	-.132
R^2	.126***	.116***	.130***

Note: * p < .05, ** p < .01, *** p < .001; Observations: 652

Table 41 Association of observed teacher's use of Materials (No Materials, Reading Materials & Writing Materials) and post-training Instructional strategy self-efficacy beliefs

	Instructional Strategy Self-efficacy (Post)	**Instructional Strategy Self-efficacy (Post)**	**Instructional Strategy Self-efficacy (Post)**
Classroom Activity Obs.	No Materials	Reading Materials	Writing Materials
	β	β	β
Observation at Round 1	-.061*	.074	-.009
Observation at Round 2	-.052	-.056	.010
Group A	.575***	.572***	.576***
Science	.079	.008	.037
Science*Group A	.121	.125	.116
Gender: Female	-.174.	-.193*	-.191*
Age	.016	.001	.007
Work Experience	-.033	-.022	-.030
TET Qualified	-.144	-.132	-.137
Avg. No. of Students	.079.	.080.	.076
Education: (PTC/Diploma)			
Graduate	-.235	-.261	-.247
Post Grad and above	-.119	-.147	-.133
R^2	.122***	.124***	.120***

Note: * p < .05, ** p < .01, *** p < .001; Observations: 652

Table 42 Association of observed teacher's use of Materials (Black-Board, Learning Aids, ICT & Group Work) and post-training Instructional strategy self-efficacy beliefs

	Instructional Strategy Self-efficacy (Post)	**Instructional Strategy Self-efficacy (Post)**	**Instructional Strategy Self-efficacy (Post)**	**Instructional Strategy Self-efficacy (Post)**
Classroom Activity Obs.	Black Board	Learning Aids	ICT	Group Work
	β	β	β	β
Observation at Round 1	-.046	-.002	-.031	.007
Observation at Round 2	.052	-.064	.042	.063
Group A	.573***	.578***	.579***	.581***
Science	.040	.093	.034	.038
Science*GroupA	.122	.114	.110	.105
Gender: Female	-.190*	-.187*	-.189*	-.203*
Age	.006	.013	.006	.001
Work Experience	-.026	-.031	-.032	-.027
TET Qualified	-.137	-.136	-.146	-.128
Avg. No. of Students	.080	.075	.071	.074
Education: (PTC/Diploma)				
Graduate	-.250	-.228	-.243	-.241
Post Grad and above	-.141	-.121	-.123	-.131
R^2	.121***	.114***	.117***	.123***

Note: * p < .05, ** p < .01, *** p < .001; Observations: 652

6.2.5.3 Student Engagement

Student engagement scale looks at teacher beliefs about being able to successfully engage students in their classroom sessions with items like “How much can you do to get students to believe they can do well in schoolwork?” and “How much can you do to motivate students who show low interest in schoolwork?”. We look at the associations of the prior student engagement self-efficacy belief with teacher activities and the materials used in the classroom during the first two rounds of observation is presented in tables 43 to 46. Subsequently, we present the association of teacher activities and the materials used in the classroom with student engagement self-efficacy beliefs measured after the training, tabulated in tables 47 to 49.

6.2.5.3.1 Association of Prior Self-Efficacy Beliefs of Student Engagement on Teachers' Activities and Use of Materials

The findings indicate that the teacher's time spent in learning activities (β = .119, p<.05) in the second-round observations were positively associated with teachers' student engagement efficacy beliefs. While time spent on classroom management (β = -.115, p<.05) in the second-round and off-task activities (β = -.096, p<.05) in the first-round observations were negatively associated to teacher's self-efficacy beliefs of student engagement. Teachers' time spent in learning activities (β = .025, p>.05) and classroom management (β = .027, p>.05) in the first round and teacher off-task activities (β = .008, p>.05) observed in the second round were not related to teachers' efficacy belief of their student engagement. We find that the second-round observation teachers who participated (Group A) in the online training programme teaching Science, spent more time in learning activities (β = .393, p<.05) but less in classroom management (β = -.347, p<.05). There are no significant association of teachers' time spent in teacher activities with teachers' background viz. gender, age, work experience, qualification (eligibility test and educational) and average class size.

Table 43 Association of student engagement self-efficacy beliefs and teacher's activities in the classroom

Teacher Activities ->	**Learning Activities**		**Classroom Mgmt.**		**Teacher Off Task**	
Observation Round ->	**1st Rnd. Obs.**	**2nd Rnd. Obs.**	**1st Rnd. Obs.**	**2nd Rnd. Obs.**	**1st Rnd. Obs.**	**2nd Rnd. Obs.**
	β	β	β	β	β	β
Intercepts	.112	-.675	.322	.334	-.274	.414
Self-Efficacy	.025	.119*	.027	-.115***	-.095*	-.008
Group A	.004	-.214	.004	.197	-.006	.036
Science	.106	-.083	-.001	.136	-.176	-.058
Science*Group A	.010	.393*	-.011	-.347*	-.011	-.086
Gender: Female	-.054	.089	.078	-.092	.015	-.004
Age	-.007	.021	.013	-.003	-.003	-.022
Work Experience	.000	.018	-.037	-.022	.040	.003
TET Qualified	-.115	-.013	.171	-.014	.023	.034
Avg. No. of Students	.053	.000	-.019	.063	-.071	-.076
Education: (PTC/Diploma)						
Graduate	.002	.170	-.148	-.118	.150	-.078
Post Grad and above	-.003	.145	-.192	-.107	.204	-.059
R^2	.008	.030	.009	.027	.023.	.009

Note: * p < .05, ** p < .01, *** p < .001; Observations: 652

The analysis of the association of the use of materials in the classroom with teachers' student engagement self-efficacy beliefs are presented in tables 44 to 46. The findings indicate that in the first round of observation teachers' classroom management efficacy beliefs were not significantly associated to the teacher's use of Reading materials (β = -.088, p>.05), Writing materials (β = -.032, p>.05), Blackboards (β = -.011, p>.05), learning aids (β = .044, p>.05), ICT (β = .020, p>.05), and Group Work (β = .041, p>.05). Similarly, even in the second round of observations there was no significant correlation between efficacy beliefs of student engagement and the use of Writing materials (β = -.008, p>.05), Blackboards (β = .029, p>.05), ICT (β = -.004, p>.05), and Group Work (β = .027, p>.05). Although in the second-round teachers' efficacy beliefs of student engagement was negatively correlated to use of reading materials (β = -.088, p<.05) while being positively associated with the use of learning aids (β = .123, p<.05).

Table 44 Association of student engagement self-efficacy beliefs and teacher's use of materials in the classroom (No Materials, Reading Materials & Writing Materials)

Materials Used ->	**No Materials**		**Reading Materials**		**Writing Materials**	
Observation Round ->	**1st Rnd. Obs.**	**2nd Rnd. Obs.**	**1st Rnd. Obs.**	**2nd Rnd. Obs.**	**1st Rnd. Obs.**	**2nd Rnd. Obs.**
	β	β	β	β	β	β
Intercepts	-.600	-.198	-.708*	-.558	.503	.686
Self-Efficacy	.051	-.014	-.025	-.088*	-.032	-.008
Group A	-.051	.026	.014	-.054	.119	.111
Science	.443***	.293*	1.043***	.867***	-.775***	-.680***
Science*GroupA	.129	-.046	.018	.170	-.268*	-.250
Gender: Female	.134	.169	.061	.038	-.003	-.038
Age	.064	.109	.076	.000	-.033	-.089
Work Experience	-.004	-.047	-.082	.045	.039	.006
TET Qualified	.004	-.134	-.029	.065	-.002	-.063
Avg. No. of Students	.040	.020	-.038	.019	.039	-.020
Education: (PTC/Diploma)						
Graduate	-.010	.280	.156	.014	.001	-.276
Post Grad and above	.060	.232	.191	.043	-.092	-.316
R^2	.075**	.034.	.279***	.238***	.218***	.174***

Note: * p < .05, ** p < .01, *** p < .001; Observations: 652

The analysis showed that the use of materials in the classroom was influenced by the subject being taught during the observation sessions. In the first-round of classroom observation of classrooms where teachers taught science, significantly high use was observed for Reading materials (β = 1.043, p<.05), learning aids (β = .808, p<.05) and ICT (β = .278, p<.05). While during second round observation again reading materials (β = .867, p<.05), learning aids (β = .829, p<.05) and ICT (β = .276, p<.05) were used significantly more. Also, in the first-round observation of science classrooms, it was observed that Writing materials (β = -.775, p<.05), Blackboards (β = -1.069, p<.05), and Group Work (β = -.305, p<.05) were used significantly less. Also, observations in the second round showed less use of Writing materials (β = -.680, p<.05) and Blackboards (β = -1.016, p<.05).

Table 45 Association of student engagement self-efficacy beliefs and teacher's use of materials in the classroom (BlackBoard & Learning Aids)

Materials Used ->	**Black Board**		**Learning Aids**	
Observation Round ->	**1st Rnd. Obs.**	**2nd Rnd. Obs.**	**1st Rnd. Obs.**	**2nd Rnd. Obs.**
	β	β	β	β
Intercepts	.533	.449	-.266	-.782*
Self-Efficacy	-.011	.029	.044	.123**
Group A	-.097	-.030	.182	-.004
Science	-1.069***	-1.016***	.808***	.829***
Science*GroupA	.121	-.008	-.322**	.007
Gender: Female	-.019	-.027	-.001	.048
Age	-.060	-.052	.026	.115
Work Experience	.080	-.011	-.043	-.028
TET Qualified	-.078	-.077	-.009	.031
Avg. No. of Students	-.032	-.103*	.009	-.001
Education: (PTC/Diploma)				
Graduate	.129	.111	-.122	.316
Post Grad and above	.117	.216	-.200	.198
R^2	.253***	.269***	.112***	.200***

Note: * p < .05, ** p < .01, *** p < .001; Observations: 652

Table 46 Association of student engagement self-efficacy beliefs and teacher's use of materials in the classroom (ICT & Group Work)

Materials Used ->	**ICT**		**Group Work**	
Observation Round ->	**1st Rnd. Obs.**	**2nd Rnd. Obs.**	**1st Rnd. Obs.**	**2nd Rnd. Obs.**
	β	β	β	β
Intercepts	.112	.066	.256	.368
Self-Efficacy	.020	-.004	.041	.027
Group A	.037	-.034	-.217	-.060
Science	.278**	.276*	-.305*	.008
Science*Group A	-.017	.118	.408**	.128
Gender: Female	-.141	-.137	-.025	.186
Age	-.037	-.012	-.005	.086
Work Experience	-.016	.029	.006	-.055
TET Qualified	.026	.213	.240	-.192
Avg. No. of Students	.082	.159*	-.012	.036
Education: (PTC/Diploma)				
Graduate	-.237	-.310	-.278	-.095
Post Grad and above	-.164	-.396	-.305	-.032
R^2	.033.	.061*	.021	.022

Note: * p < .05, ** p < .01, *** p < .001; Observations: 652

Analysis shows that the first-round observation teachers who participated (Group A) in the online training programme teaching Science, used less writing materials (β = -.268, p<.05) and learning aids (β = -.322, p<.05) but engaged students in more of Group work(β = .408, p<.05) compared to teachers teaching mathematics in the non-participating teachers' group (Group B). The results also show that the use of blackboard by teachers was negatively correlated to the average number of students in the class (β = -.103, p<.05) during the second-round classroom observation. While, the use of ICT in the second round was positively associated to the average number of students (β = .159, p<.05). Findings indicate no significant association of teachers’ use of any materials with teachers’ background viz. gender, age, work experience and qualification (eligibility test and educational).

6.2.5.3.2 Association of Classroom Activities on Self-Efficacy Beliefs of Student Engagement reported after PD

The results of regressing post-training efficacy beliefs of student engagement on teacher's classroom activities and use of materials are presented in tables (Tables 47 to 49).

Table 47 Association of observed teacher's activities and post-training Student Engagement self-efficacy beliefs

	Student Engagement Self-efficacy (Post)	**Student Engagement Self-efficacy (Post)**	**Student Engagement Self-efficacy (Post)**
Classroom Activity Obs.	Learning Activities	Classroom Mgmt	Teacher Off Task
	β	β	β
Observation at Round 1	.023	.048	-.028
Observation at Round 2	-.101	.041	.043
Group A	.304	.316*	.322*
Science	.078	.082	.084
Science*Group A	.209	.186	.176
Gender: Female	-.003	-.014	-.013
Age	-.039	-.041	-.039
Work Experience	.081	.081	.079
TET Qualified	-.060	-.069	-.062
Avg. No. of Students	.075	.075	.078
Education: (PTC/Diploma)			
Graduate	-.254	-.260	-.265
Post Grad and above	-.276	-.279	-.285
R^2	.064*	.066**	.069**

Note: * p < .05, ** p < .01, *** p < .001; Observations: 652

We note that teachers' self-efficacy belief in student engagement, post-training, had a negative but significant association with conducting classroom sessions with no materials (β = -.110, p<.05) observed in the first round

Table 48 Association of observed teacher's use of Materials (No Materials, Reading Materials & Writing Materials) and post-training Student Engagement self-efficacy beliefs

	Student Engagement Self-efficacy (Post)	**Student Engagement Self-efficacy (Post)**	**Student Engagement Self-efficacy (Post)**
Classroom Activity Obs.	No Materials	Reading Materials	Writing Materials
	β	β	β
Observation at Round 1	-.110**	.014	.023
Observation at Round 2	.044	-.032	-.028
Group A	.318*	.321*	.324*
Science	.124	.100	.086
Science*GroupA	.187	.178	.172
Gender: Female	-.006	-.014	-.015
Age	-.038	-.041	-.042
Work Experience	.080	.080	.077
TET Qualified	-.055	-.058	-.063
Avg. No. of Students	.080	.077	.075
Education: (PTC/Diploma)			
Graduate	-.285	-.275	-.280
Post Grad and above	-.295	-.295	-.300
R^2	.071**	.068**	.065**

Note: * p < .05, ** p < .01, *** p < .001; Observations: 652

In summary, considering teachers classroom activities, teachers with high self-efficacy beliefs were observed to spend less time off-task in the first-round of classroom observations. Teachers who reported higher instructional self-efficacy beliefs spent more time in classroom management in the first round, but in second round observations were spending less time in the same activity. Additionally, we observed that participants who were observed to spend more time in learning activities reported lower efficacy beliefs on instructional strategy. The findings related to teachers' materials use showed that teachers prior efficacy beliefs of instructional strategy and student engagement affected the use of materials. Participants who reported higher efficacy beliefs of instructional strategy were observed using more learning aids and less of ICT during their classroom sessions.

Table 49 Association of observed teacher's use of Materials (Black-Board, Learning Aids, ICT & Group Work) and post-training Student Engagement self-efficacy beliefs

	Student Engagement Self-efficacy (Post)	**Student Engagement Self-efficacy (Post)**	**Student Engagement Self-efficacy (Post)**	**Student Engagement Self-efficacy (Post)**
Classroom Activity Obs.	Black Board	Learning Aids	ICT	Group Work
	β	β	β	β
Observation at Round 1	.005	.009	.042	.003
Observation at Round 2	-.028	-.014	-.002	.061
Group A	.324*	.322*	.322*	.328*
Science	.064	.091	.075	.087
Science*Group A	.171	.175	.174	.164
Gender: Female	-.014	-.013	-.008	-.025
Age	-.041	-.039	-.038	-.045
Work Experience	.077	.078	.078	.081
TET Qualified	-.063	-.060	-.062	-.050
Avg. No. of Students	.073	.076	.073	.074
Education: (PTC/Diploma)				
Graduate	-.270	-.267	-.263	-.266
Post Grad and above	-.287	-.288	-.287	-.290
R^2	.065**	.064**	.067**	.070**

Note: * p < .05, ** p < .01, *** p < .001; Observations: 652

Also, participants with higher efficacy in student engagement used less reading materials (textbooks) but more learning aids in classroom sessions observed in round two. Finally, teachers who did not use any materials during their sessions reported lower self-efficacy beliefs of instructional strategy and student engagement in the post-training surveys. Overall, It was found that the teacher's reported self-efficacy correlated significantly with the materials used by the teachers as observed by the CRCCs.

7 Discussion

The previous sections presented the methods used to answer the research questions we posed for the SAMARTH professional development programme along with the findings of the quantitative analysis that were performed. In the context of India, this study addresses the absence of evaluation studies for large scale online professional development programme based on teacher's beliefs & classroom practice. In this section, we discuss the findings and their connections with existing literature. This section will first discuss the effect of the PD programme on teacher's self-efficacy beliefs. Subsequently, we look at the variation in participant activities during the PD programme, followed by its association to variation in their change of self-efficacy beliefs. Then we discuss the effect of PD on the classroom practice of teachers followed by the association of self-efficacy beliefs with teacher's classroom activities. A summary of the answers to our research questions has been tabulated (Table 50) at the end of this section for quick reference.

The SAMARTH programme participants reported a significantly positive change in subject-specific self-efficacy beliefs. Analysis showed a medium effect size i.e. Cohen's $d >= .5$ of the programme on participant's science and math teaching efficacy beliefs. Thus, participating in the programme had an overall positive change in the science and math teaching self-efficacy beliefs of the teachers. Given the design of the PD programme, our findings provide support for the suggestions of providing contextual ideas (Saigal, 2012) and the benefits of a need-aligned training programme (Kidwai et al., 2013). Also, this work provides an independent confirmation of the suitability of the components of a web-based platform for in-service teacher professional development suggested in Kuril (2019). This is in accordance with recent studies that have found the effectiveness of using online teacher professional development programme (An, 2018; Wuryaningsih et al., 2019). The negative associations of baseline measure with the change in self-efficacy indicate a significantly greater change among participants with low baseline self-efficacy score. Earlier research studies have highlighted that detecting a change in efficacy among participants with prior high self-efficacy beliefs is difficult (R. Anderson et al., 1988; Roberts et al., 2001). The findings of positive change in math and science teaching self-efficacy beliefs among the more qualified participants in the control group hint at the need for more qualified teachers in the absence of a similar professional development programme.

The change in self-efficacy beliefs being associated with participant background has been mentioned in previous literature (Corkin et al., 2015; Desimone & Hill, 2017; Minor et al., 2016; Whitworth & Chiu, 2015). Corkin et al. (2015)'s study found that academic and social background influenced the impact of PD teacher's self-efficacy beliefs. The study found that teachers with a lower academic background or belonging to socio-demographic minority groups experienced the most change. Whitworth and Chiu (2015)'s review of the literature found that prior work experience affected the impact of professional development on the teacher. The work cites Luft (2001)'s study which found that early career teachers changed beliefs more easily than their practices while experienced teachers changed practices more than beliefs. Our findings do show a similar effect of work experience with regards to math teaching self-efficacy beliefs. Minor et al. (2016) studied the moderation effect of teacher background on the impact of content in PD on teachers learning and found that what teachers learn depends on their prior knowledge. Desimone and Hill (2017) in their randomized control study of factors influencing the impact of PD on middle school science teachers in the US, suggested the possibility of variation of effects among sub-populations of participants and the need for investigating these variations. Our study found a significantly lower change in self-efficacy beliefs among female participants. Further qualitative studies would be required to determine the causes of variation due to academic background, work-experience, and socio-economic background (i.e. belonging to marginalized group e.g. women) on the effect of the PD programme

There is a significant variation in participants' off-platform activities and online engagement. We observe that not only do participants vary in the content they engage in online, but also in the off-platform activities they undertake. The analysis resulted in four latent profiles based on which content participants viewed and six latent classes based on participants off-platform activities to engage with the programme content. These findings extend the study by Veletsianos et al. (2015) which highlighted that learning activities also happen outside an online course platform. These findings of variation in participant activities also build upon the studies which reported variation in preference and access of PD components by participants of the same PD (Qian et al., 2018; Rosaen et al., 2013). Research has shown that not only do different participants access different course content, but also highlighted that teachers from underserved regions used the online PD less (Bates et al., 2019). These variations in engagement with the PD content both on the platform and outside the platform could be associated with variations in change among participants of the training program.

Zaccarelli et al., (2018) based on case-study research had argued the need to explore the associations between teacher's activities during the PD and outcomes of the PD, in our case change in self-efficacy beliefs. The study found that engaging in off-platform activities of note-taking and interaction had a significant effect on change in subject-specific self-efficacy beliefs. Participants engaged in higher notetaking and interactional activities mostly reported greater change in self-efficacy beliefs. Considering participants' online profiles based on the content viewed there was no significant change in general teaching self-efficacy beliefs. But the change in subject-specific self-efficacy beliefs varied with the participants' online profile membership. These findings add to prior works which used latent class analysis to evaluate teacher training programmes (Kunst et al., 2018; Lamont et al., 2018). It also contributes to recent studies which have attempted to uncover such variations and their effects (Fischer et al., 2018; Li et al., 2016; Múñez et al., 2017).

Overall, these findings highlight the importance of note-taking and indulging in interactions outside the online platform during an online professional development for teachers in contexts such as the present one. The findings highlight the need for online PDs to enable downloading videos and documents of the training content to support note-taking activities. It may be beneficial to encourage the formation of groups among participants on Facebook and/or WhatsApp to facilitate more interactions. These suggestions are in accordance with the work by Cisel (2018), who argued that the lack of support for interactions beyond the platform is a possible reason for fewer learners completing a MOOC. Additionally, Pérez-Sanagustín et al. (2019) have also highlighted the benefits of promoting interactions beyond the learning platform.

Thus, the study shows significant effects of PD on teacher's self-efficacy beliefs and the association of variation in PD content engagement with the variation in change in self-efficacy belief. Next, we consider the classroom observations which were conducted in 412 clusters instead of the 570 that were selected, i.e. about 26 % attrition. Based on prior power analysis, the study on the effect of participation in the training programme lacks sufficient power to detect small effects. Our analysis of attrition bias over the three rounds of observation does show an association of attrition with the materials that the teachers use in the classroom.

The analysis shows no significant difference in teacher activities between the participating and non-participating teachers of the SAMARTH programme. It may be concluded that finding no significant effect of group membership on teacher activities in the classroom could be due to insufficient observations to detect small effects. Regarding the use of materials, we observed that all teachers spent more time using textbooks and the black board in their classroom sessions. In the case of Science classrooms, there is significantly more use of textbook and learning aids. The use of textbook in the science classrooms was significantly more among the participants of the PD programme. Considering that no attrition bias was observed for the use of reading materials/textbooks it can be concluded that change in classroom practice was observed in the use of materials.

Recent studies have reported no change in the classroom practice of the teachers participating in a PD programme (Olofson & Garnett, 2018; Piasta et al., 2017; Saderholm et al., 2017). We note that the change in self-efficacy beliefs due to PD is large, while the consequent change in classroom practice is limited. One possibility could be infrastructural limitations in developing country contexts, which hamper classroom implementation even when PD has successfully improved the teacher's knowledge and beliefs (Jacob et al., 2017; Nawab, 2017). Recent studies in China (Lu et al., 2019), Jordan (Qablan, 2019), and South Africa (Kekana & Gaigher, 2018) have reported on the inability of converting large gains from a PD programme into classroom practice.

After estimating the effect of the PD programme on classroom practice, the study explores the association of self-efficacy belief and classroom practice. Considering the timelines of self-efficacy surveys and the classroom observations, we evaluated the association of efficacy beliefs with only the first and second rounds of classroom observations. Analysis of the association of self-efficacy beliefs and classroom activities indicated few significant relations between self-efficacy and classroom activities. Most associations were observed between self-efficacy beliefs reported before the training and subsequent classroom observations. We find that teachers with higher teaching self-efficacy beliefs spend less time on off-task activities. Teachers with higher efficacy beliefs of instructional strategy spent more time on classroom management during the first round of observation, but in the second round, it was observed that less time was expended on the same activity. This could be due to the time required in arranging classroom materials, setting up of ICT, learning aid materials etc. in the initial days of school was improved upon during the second round of observation. Additionally, we also note the higher use of learning aids and less of ICT by participants with higher efficacy beliefs of instructional strategy. Lesser use of ICT by teachers with higher instructional strategy is in accordance with recent literature which shows that ICT products limit the teacher’s way of teaching (Chand et al., 2020). Also, participants with high self-efficacy of student engagement were observed to use textbook fewer times but incorporated learning aids in their sessions. These findings provide empirical support for the findings of Sehgal et al. (2017) which showed that teaching self-efficacy beliefs were positively associated with classroom interactions. Further, we note that classroom activities and materials seem to have some effect on post-training self-efficacy reported by the participants. First, participants who were observed to mostly conduct sessions with no materials reported lower self-efficacy beliefs of instructional strategy and student engagement. Second, we find that teachers who were observed to have spent more time in learning activities reported lower self-efficacy belief of instructional strategy. Thus, in our context, we find a significant association of prior self-efficacy beliefs of teachers on the teacher activities and materials use, but the association of classroom practice with later self-efficacy beliefs was limited.

Table 50 Summary of findings of the Study

Research Questions	Findings
What is the effect of the SAMARTH professional development programme on teachers' teaching self-efficacy beliefs?	The two-group randomized control study showed a significant positive change in subject-specific self-efficacy beliefs and no effect on the general teaching self-efficacy belief
What are the different latent classes based on participant activities during the Samarth professional development programme?	Application of Mixture Modelling on the participant activities found four latent profiles based on latent profile analysis of pageview logs and six latent classes based on latent class analysis of responses to off-platform activity questionnaire. The four latent profiles separated participants into ones who spent more time on case-study content, expert made content, subject related content (consisting of case-study & expert) and project feedback. The six latent classes of participants were obtained from the combination of two latent classes of Note-taking activities: High & Low and three latent classes of Interactional activities: High, Intermediate & Low.
What is the association of different latent classes based on participant activities with the change in teaching self-efficacy beliefs?	The variation in off-platform actions of notetaking and interactional activities were significantly associated with the change in self-efficacy beliefs of the participants. While variation in online activity was not correlated with change in general teaching self-efficacy beliefs, they were associated with variation in change of subject-specific self-efficacy beliefs.
What is the difference in the classroom practices between the participating and non-participating teachers?	Even though there was no significant difference between teacher's activities, there was a significant change in teacher's use of materials, i.e. textbook in the science classrooms of participant teachers
What is the association of teaching self-efficacy beliefs with classroom practice?	Although self-efficacy beliefs before PD were found to be significantly associated with classroom activities of the teacher, the association of classroom activities to post-training self-efficacy beliefs was limited.

8 Implications

The study found evidence of significant change in self-efficacy beliefs of the participants of the web-based online professional development programme. Participants of the PD programme showed significant variations in activities on and off the training platform. The variation in the engagement of activities was found to be significantly associated with the change in self-efficacy reported by the participants.

The findings of the study address the need for identifying specific components of a PD programme that make it effective (Desimone & Garet, 2015). This work provided a reliable approach to identify specific activities of participants within a PD programme. It also presents a way to explore the association between the participant activities and outcomes of participating in the PD programme. Such exploration provides actionable inputs for improving the current PD programme and designing future training programmes. In the context of our PD programme for primary school teachers, we find that the subject-specific content and case studies were well received by the participants and found to be effective. These findings are in agreement with the literature which recommends that the content of PD needs to be contextual for higher impact. Also, off-platform activities like Note-taking and Interacting with peers and case-study teachers need to be encouraged, given its significant association with a higher change in self-efficacy.

The importance of off-platform activities extends the work of Veletsianos et al. (2015) by demonstrating that there are variations in off-platform activities and these variations affected the outcomes. It highlights the importance of considering off-platform activities in the context of online learning. Most studies on participant engagement in online learning only consider activities captured on the online platform and ignore off-platform activities. Note-taking activities become essential in the context of limited online infrastructure. Downloading training content as pdfs and videos files enables participants to comfortably engage with the content even with limited internet connectivity. Off-platform interactional activities by the participants like discussing with non-participants, becoming part of a group on a social media platform and contacting case-study teacher cannot be accurately captured online. The significant association of these activities with outcomes make it imperative that future studies of online learner engagement also pay attention to the off-platform actions of the participants. Our findings reinforce the findings made by Kizilcec et al., (2020) to not just ask “what works?” but also to subsequently seek answers to “for whom?” (p .14904).

The analysis of classroom observations showed that participants teaching self-efficacy was associated with their classroom activities and use of materials/techniques. These findings show that teacher’s self-efficacy is one of the critical factors which influence classroom activities and the use of teaching materials and techniques. Most professional development programmes which mainly focus on improving knowledge and teaching techniques also need to ensure that it improves self-efficacy beliefs to perform in a classroom. As education policies in India and around the world aim to make learning more student-centric and also inclusive. Realizing this goal requires not only changes in the curriculum but also how classrooms are conducted. Implementing these changes need effective training programmes on managing classrooms under the new curriculum and guidelines for all teachers. Our findings indicate that higher self-efficacy beliefs are associated with better classroom management. Thus, achieving the goal of student-centric and inclusive classrooms depends on how well the training programmes influence the participants' self-efficacy beliefs.

9 Limitations and Future work

Although the study did provide important findings in the field of online learning and professional development programme, it has two main limitations.

First, the data of online activities was extracted from pageview logs that were captured on an external server. The operational limitations of the programme made use of the readily available external server the only viable option. The use of an external server does result in loss of data, but the design of the platform enabled the removal of user logs that were incomplete. This loss of data could be avoided by enabling the platform to maintain page-request logs which would provide an accurate and complete account of online activities.

Secondly, we used the Stallings Classroom Snapshot Instrument for our classroom observation. During the design of the evaluation, this was one of two classroom observation tools used and recommended by the World Bank in their studies. Stalling Instrument was favoured as being the easier of the two instruments to comprehend and train classroom observers. The drawback of the instrument is that it only captures the frequency of teacher and student actions. It fails to capture the nature and quality of teacher-student interaction which are crucial. This is substantiated by the new classroom observation TEACH tool (Molina et al., 2018) launched by World Bank in 2019. Future evaluation studies of professional development could consider using the TEACH tool.

Apart from the above changes to data collection in future work, the analysis could also explore the on and off-platform activities by interviewing participants. Tseng et al. (2016) expressed the need for interviewing participants to help understand the different factors that influence their engagement and outcomes. Future work could use the identified latent classes and profiles of participants as a sampling criterion to conduct interviews which would explore the underlying reasons for the activities and also highlight why there are corresponding variations in outcomes. The findings of the qualitative study would provide richer insights on designing effective web-based professional development programme for teachers.

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APPENDIX A

Measurement Invariance of self-efficacy constructs

									Model Measurement Invariant	
	Chi. Square	df	CFI	RMSEA	Δ Chi. Square	Δ df	Δ CFI	Δ RMSEA	Chen (2007)	Meade et al.(2008)
									ΔCFI ≤ .005 & ΔRMSEA ≤ .01	ΔCFI ≤ .002
Teaching Self-Efficacy										
Instructional Strategy (IS)										
Non-Invariant Model	1030.636	33	0.987	0.056						
Invariant Model	1416.143	56	0.983	0.05	385.507	23	0.004	0.006	YES	NO
Classroom Management (CM)										
Non-Invariant Model	722.892	33	0.991	0.047						
Invariant Model	616.087	58	0.993	0.032	106.805	25	0.002	0.015	NO	YES
Student Engagement (SE)										
Non-Invariant Model	687.978	33	0.992	0.046						
Invariant Model	653.933	56	0.993	0.033	34.045	23	0.001	0.013	NO	YES
Science Teaching Efficacy Belief Instrument										
Personal Science Teaching Efficacy beliefs (STE)										
Non-Invariant Model	2836.927	374	0.991	0.026						
Invariant Model	3555.201	458	0.988	0.027	718.274	84	0.003	0.001	YES	NO
Science Teaching Outcome Expectancy beliefs (SOE)										
Non-Invariant Model	2641.785	182	0.985	0.038						
Invariant Model	2972.151	242	0.983	0.034	330.366	60	0.002	0.004	YES	YES
Mathematics Teaching Efficacy Belief instrument										
Personal Mathematics Teaching Efficacy beliefs (MTE)										
Non-Invariant Model	3482.487	370	0.989	0.03						
Invariant Model	3911.215	454	0.988	0.028	428.728	84	0.001	0.002	YES	YES
Mathematics Teaching Outcome Expectancy beliefs (MOE)										
Non-Invariant Model	3686.246	190	0.98	0.044						
Invariant Model	4053.014	250	0.979	0.04	366.768	60	0.001	0.004	YES	YES

Teaching Self-Efficacy Scale

		Group A		Group B		Group A		Group B	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post
	Range	M (SD)	M (SD)	M (SD)	M (SD)	Std. Loadings	Std. Loadings	Std. Loadings	Std. Loadings
Instructional Strategy						CR = .77 AVE = .46	CR = .87 AVE = .64	CR = .81 AVE = .51	CR = .86 AVE = .60
[IS1] To what extent can you use a variety of assessment strategies?	1 - 5	3.794 (.92)	4.124 (.83)	3.807 (.92)	3.761 (.92)	0.694	0.789	0.707	0.758
[IS2] To what extent can you provide an alternative explanation or example when students are confused?	1 - 5	4.252 (.89)	4.299 (.84)	4.231 (.89)	4.150 (.93)	0.649	0.803	0.711	0.781
[IS3] To what extent can you craft good questions for your students?	1 - 5	4.150 (.86)	4.336 (.82)	4.137 (.88)	4.082 (.90)	0.681	0.813	0.735	0.788
[IS4] How well can you implement alternative strategies in your classroom?	1 - 5	3.773 (.86)	4.120 (.81)	3.810 (.87)	3.804 (.88)	0.686	0.784	0.716	0.773
Correlation Pre vs Post						0.526		0.799	
Classroom Management						CR = .79 AVE = .48	CR = .89 AVE = .66	CR = .82 AVE = .54	CR = .86 AVE = .61
[CM1] How much can you do to control disruptive behaviour in the classroom?	1 - 5	4.144 (.87)	4.263 (.83)	4.148 (.87)	4.109 (.89)	0.670	0.831	0.737	0.772
[CM2] How much can you do to get children to follow classroom rules?	1 - 5	4.181 (.88)	4.299 (.83)	4.176 (.88)	4.152 (.89)	0.685	0.801	0.719	0.777
[CM3] How much can you do to calm a student who is disruptive or noisy?	1 - 5	4.246 (.86)	4.367 (.81)	4.256 (.85)	4.243 (.87)	0.807	0.849	0.821	0.856
[CM4] How well can you establish a classroom management system with each group of students?	1 - 5	4.006 (.86)	4.253 (.82)	4.030 (.86)	4.009 (.86)	0.594	0.777	0.660	0.713
Correlation Pre vs Post						0.457		0.763	
Student Engagement						CR = .76 AVE = .44	CR = .87 AVE = .63	CR = .80 AVE = .50	CR = .83 AVE = .56
[SE1] How much can you do to get students to believe they can do well in schoolwork?	1 - 5	4.293 (.83)	4.388 (.81)	4.272 (.85)	4.235 (.86)	0.712	0.839	0.755	0.788
[SE2] How much can you do to help your students value learning?	1 - 5	4.383 (.83)	4.444 (.78)	4.362 (.84)	4.307 (.88)	0.700	0.846	0.742	0.793
[SE3] How much can you do to motivate students who show low interest in schoolwork?	1 - 5	4.164 (.84)	4.326 (.81)	4.161 (.86)	4.142 (.86)	0.712	0.840	0.763	0.808
[SE4] How much can you assist families in helping their children do well in school?	1 - 5	3.690 (.95)	3.940 (.90)	3.708 (.95)	3.653 (.95)	0.506	0.637	0.554	0.572
Correlation Pre vs Post						0.464		0.764	

Science Teaching Efficacy Belief Instrument

Personal Science Teaching Efficacy Scale

		Group A		Group B		Group A		Group B	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post
	Range	M (SD)	M (SD)	M (SD)	M (SD)	Std. Loadings	Std. Loadings	Std. Loadings	Std. Loadings
Personal Science Teaching Efficacy beliefs						CR = .93 AVE = .57	CR = .94 AVE = .58	CR = .95 AVE = .62	CR = .95 AVE = .63
[STE1] I am continually finding better ways to teach science.	1 - 5	4.469 (.58)	4.578 (.70)	4.461 (.59)	4.433 (.60)	0.657	0.588	0.720	0.723
[STE2] Even when I try very hard, I don't teach science as well as I do most subjects.	1 - 5	2.063 (.88)	2.259 (1.28)	2.125 (.96)	2.153 (1.00)				
[STE3] I know how to teach science concepts effectively.	1 - 5	4.071 (.64)	4.478 (.60)	4.102 (.65)	4.140 (.64)	0.776	0.794	0.791	0.808
[STE4] I am very effective in monitoring science experiments.	1 - 5	4.241 (.62)	4.492 (.61)	4.214 (.65)	4.194 (.65)	0.819	0.816	0.840	0.853
[STE5] I generally teach science effectively.	1 - 5	4.332 (.58)	4.576 (.57)	4.309 (.60)	4.295 (.60)	0.823	0.822	0.862	0.858
[STE6] I understand science concepts well enough to be effective in teaching elementary science.	1 - 5	4.318 (.59)	4.552 (.56)	4.304 (.61)	4.295 (.61)	0.839	0.846	0.870	0.882
[STE7] I find it easy to explain to students why science experiments work.	1 - 5	4.284 (.61)	4.543 (.57)	4.269 (.62)	4.260 (.62)	0.841	0.850	0.883	0.893
[STE8] I am always able to answer students' science questions.	1 - 5	4.086 (.73)	4.346 (.68)	4.088 (.75)	4.065 (.75)	0.754	0.753	0.778	0.780
[STE9] I do not wonder if I have the necessary skills to teach science.	1 - 5	4.057 (.67)	4.344 (.70)	4.058 (.69)	4.061 (.70)				
[STE10] Given a choice, I would invite the principal to evaluate my science teaching.	1 - 5	4.128 (.73)	4.404 (.74)	4.131 (.75)	4.147 (.75)	0.577	0.611	0.611	0.629
[STE11] When a student has difficulty understanding a science concept, I am usually not at a loss about how to help the student understand it better.	1 - 5	4.028 (.77)	4.347 (.79)	4.053 (.79)	4.066 (.78)	0.621	0.652	0.641	0.657
[STE12] When teaching science, I usually welcome student questions.	1 - 5	4.555 (.53)	4.715 (.49)	4.545 (.55)	4.543 (.55)	0.712	0.741	0.763	0.769
[STE13] I know how to motivate students to study science.	1 - 5	4.323 (.58)	4.603 (.54)	4.330 (.58)	4.327 (.59)	0.802	0.821	0.835	0.851
Correlation Pre vs Post						0.569		0.866	

Science Teaching Outcome Expectancy Scale

		Group A		Group B		Group A		Group B	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post
	Range	M (SD)	M (SD)	M (SD)	M (SD)	Std. Loadings	Std. Loadings	Std. Loadings	Std. Loadings
Science Teaching Outcome Expectancy beliefs						CR = .88 AVE = .48	CR = .91 AVE = .55	CR = .89 AVE = .52	CR = .90 AVE = .54
[SOE1] When a student does better than usual in science, it is often because the teacher exerted a little extra effort.	1 - 5	4.219 (.65)	4.472 (.64)	4.233 (.65)	4.217 (.67)	0.625	0.717	0.697	0.722
[SOE2] When the science grades of students improve, it is most often due to their teacher having found a more effective teaching approach.	1 - 5	4.120 (.70)	4.404 (.69)	4.112 (.72)	4.103 (.72)	0.689	0.759	0.741	0.778
[SOE3] If students are underachieving in science, it is most likely due to ineffective science teaching.	1 - 5	3.154 (.99)	3.343 (1.15)	3.162 (1.01)	3.084 (1.03)				
[SOE4] The inadequacy of a student's science background can be overcome by good teaching.	1 - 5	3.832 (.78)	4.160 (.80)	3.864 (.79)	3.875 (.79)	0.504	0.582	0.517	0.534
[SOE5] The low science achievement of some students can generally be blamed on their teachers.	1 - 5	2.448 (.94)	2.624 (1.17)	2.475 (.98)	2.436 (1.00)				
[SOE6] When a low achieving child progresses in science, it is usually due to extra attention given by the teacher.	1 - 5	3.924 (.70)	4.195 (.75)	3.922 (.73)	3.921 (.75)	0.723	0.767	0.753	0.767
[SOE7] Increased effort in science teaching produces a lot of change in some students' science achievement.	1 - 5	4.270 (.53)	4.532 (.56)	4.272 (.56)	4.280 (.57)	0.689	0.723	0.702	0.720
[SOE8] The teacher is generally responsible for the achievement of students in science.	1 - 5	3.823 (.73)	4.117 (.76)	3.838 (.74)	3.845 (.76)	0.764	0.780	0.773	0.793
[SOE9] Students' achievement in science is directly related to their teacher's effectiveness in science teaching.	1 - 5	4.119 (.62)	4.373 (.66)	4.115 (.65)	4.109 (.66)	0.802	0.814	0.801	0.810
[SOE10] If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child's teacher.	1 - 5	4.148 (.65)	4.400 (.67)	4.153 (.66)	4.141 (.67)	0.720	0.746	0.729	0.740
[SOE11] Effectiveness in science teaching has a lot of influence on the achievement of students with low motivation.	1 - 5	3.812 (.69)	4.085 (.75)	3.818 (.70)	3.831 (.72)				
[SOE12] Even teachers with good science teaching abilities cannot help some kids learn science.	1 - 5	3.305 (.94)	3.345 (1.10)	3.335 (.95)	3.358 (.97)				
Correlation Pre vs Post						0.565		0.845	

Mathematics Teaching Efficacy Belief Instrument

Personal Mathematics Teaching Efficacy Scale

		Group A		Group B		Group A		Group B	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post
	Range	M (SD)	M (SD)	M (SD)	M (SD)	Std. Loadings	Std. Loadings	Std. Loadings	Std. Loadings
Personal Mathematics Teaching Efficacy beliefs						CR = .94 AVE = .60	CR = .94 AVE = .58	CR = .95 AVE = .64	CR = .95 AVE = .63
[MTE1] I am continually finding better ways to teach mathematics.	1 - 5	4.398 (.57)	4.486 (.71)	4.378 (.60)	4.354 (.62)	0.683	0.607	0.720	0.703
[MTE2] Even when I try very hard, I don't teach mathematics as well as I do most subjects.	1 - 5	2.153 (.93)	2.273 (1.20)	2.202 (.98)	2.226 (1.00)				
[MTE3] I know how to teach mathematical concepts effectively.	1 - 5	4.154 (.59)	4.360 (.64)	4.132 (.63)	4.113 (.64)	0.817	0.792	0.823	0.808
[MTE4] I am very effective in monitoring mathematics experiments.	1 - 5	4.156 (.62)	4.433 (.60)	4.159 (.63)	4.154 (.63)	0.861	0.835	0.877	0.865
[MTE5] I generally teach maths effectively.	1 - 5	4.309 (.58)	4.511 (.57)	4.301 (.60)	4.277 (.60)	0.862	0.837	0.884	0.884
[MTE6] I understand mathematical concepts well enough to be effective in teaching elementary maths.	1 - 5	4.331 (.59)	4.526 (.56)	4.326 (.61)	4.305 (.62)	0.858	0.846	0.890	0.878
[MTE7] I find it easy to explain to students why mathematics works.	1 - 5	4.258 (.59)	4.520 (.57)	4.253 (.61)	4.232 (.62)	0.758	0.788	0.787	0.799
[MTE8] I am always able to answer students' questions.	1 - 5	4.223 (.72)	4.386 (.69)	4.208 (.73)	4.154 (.75)	0.771	0.759	0.794	0.779
[MTE9] I do not wonder if I have the necessary skills to teach mathematics.	1 - 5	4.113 (.68)	4.332 (.69)	4.102 (.70)	4.093 (.71)				
[MTE10] Given a choice, I would invite the principal to evaluate my mathematics teaching.	1 - 5	4.181 (.74)	4.400 (.75)	4.178 (.75)	4.183 (.76)	0.617	0.633	0.662	0.665
[MTE11] When a student has difficulty understanding a mathematics concept, I am usually not at a loss about how to help the student understand it better.	1 - 5	4.096 (.74)	4.333 (.78)	4.090 (.76)	4.089 (.77)	0.651	0.665	0.680	0.690
[MTE12] When teaching mathematics, I usually welcome student questions.	1 - 5	4.532 (.52)	4.683 (.49)	4.513 (.54)	4.505 (.55)	0.777	0.774	0.808	0.801
[MTE13] I know how to motivate students to study mathematics.	1 - 5	4.293 (.59)	4.550 (.55)	4.301 (.60)	4.295 (.61)	0.832	0.824	0.847	0.853
Correlation Pre vs Post						0.577		0.881	

Mathematics Teaching Outcome Expectancy Scale

		Group A		Group B		Group A		Group B	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post
	Range	M (SD)	M (SD)	M (SD)	M (SD)	Std. Loadings	Std. Loadings	Std. Loadings	Std. Loadings
Mathematics Teaching Outcome Expectancy beliefs						CR = .90 AVE = .54	CR = .93 AVE = .62	CR = .92 AVE = .59	CR = .93 AVE = .62
[MOE1] When a student does better than usual in mathematics, it is often because the teacher exerted a little extra effort.	1 - 5	4.202 (.60)	4.427 (.63)	4.210 (.62)	4.197 (.65)	0.835	0.820	0.862	0.851
[MOE2] When the mathematics grades of students improve, it is most often due to their teacher having found a more effective teaching approach.	1 - 5	4.147 (.64)	4.414 (.66)	4.148 (.66)	4.141 (.67)	0.840	0.855	0.872	0.870
[MOE3] If students are underachieving in mathematics, it is most likely due to ineffective mathematics teaching.	1 - 5	3.060 (.99)	3.265 (1.16)	3.061 (1.00)	3.017 (1.01)				
[MOE4] The inadequacy of a student's mathematics background can be overcome by good teaching.	1 - 5	3.714 (.88)	4.042 (.90)	3.740 (.88)	3.758 (.88)				
[MOE5] The low mathematics achievement of some students can generally be blamed on their teachers.	1 - 5	2.495 (.95)	2.638 (1.17)	2.531 (.99)	2.477 (1.00)				
[MOE6] When a low achieving child progresses in maths, it is usually due to extra attention given by the teacher.	1 - 5	4.200 (.53)	4.461 (.59)	4.205 (.56)	4.204 (.57)	0.694	0.747	0.716	0.724
[MOE7] Increased effort in maths teaching produces a lot of change in some students' mathematical achievement.	1 - 5	4.090 (.62)	4.361 (.67)	4.094 (.63)	4.103 (.65)	0.809	0.828	0.832	0.828
[MOE8] The teacher is generally responsible for the achievement of students in mathematics.	1 - 5	3.910 (.70)	4.177 (.75)	3.918 (.72)	3.919 (.74)	0.765	0.796	0.793	0.791
[MOE9] Students' achievement in mathematics is directly related to their teacher's effectiveness in mathematics teaching.	1 - 5	3.852 (.80)	4.410 (.64)	3.942 (.78)	4.151 (.64)	0.571	0.831	0.672	0.822
[MOE10] If parents comment that their child is showing more interest in maths at school, it is probably due to the performance of the child's teacher.	1 - 5	4.148 (.61)	4.401 (.65)	4.139 (.64)	4.147 (.65)	0.766	0.795	0.779	0.795
[MOE11] Effectiveness in mathematics teaching has a lot of influence on the achievement of students with low motivation.	1 - 5	3.868 (.68)	4.130 (.74)	3.878 (.70)	3.890 (.71)	0.524	0.575	0.567	0.578
[MOE12] Even teachers with good mathematics teaching abilities cannot help some kids learn maths.	1 - 5	3.311 (.97)	3.350 (1.13)	3.360 (.98)	3.374 (.98)				
Correlation Pre vs Post						0.545		0.838	

Response to Off-Platform Activity Survey

Note Taking Activities

How many PDF files did you download?	**None**	**About 25%**	**About 50%**	**About 75%**	**All**
	5.86 % (457)	30.05 % (2342)	27.24 % (2123)	22.18 % (1729)	14.67 % (1143)
How many Videos did you download?	**None**	**About 25%**	**About 50%**	**About 75%**	**All**
	11.97 % (933)	31.70 % (2471)	29.05 % (2264)	17.73 % (1382)	9.55 % (744)
Did you take/maintain notes related to the course offline?	**No**	**Yes**			
	25.44 % (1983)	74.56 % (5811)			

Interactional Activities

Did you share your notes, PDFs or video with other participants?	**No**	**Yes**			
	68.26 % (5320)	31.74 % (2474)			
Did you discuss the content of the programme with other participant teachers?	**No**	**Yes with < 5**	**Yes with 5 - 10**	**Yes with 11 - 20**	**Yes with > 20**
	18.80 % (1465)	47.59 % (3709)	19.46 % (1517)	7.75 % (604)	6.40 % (499)
Did you discuss the content of the programme with other teachers who were not participating?	**No**	**Yes**	**Missing**		
	58.74 % (4578)	41.25 % (3215)	0.01 % (1)		
Did you join any Whatsapp or Facebook group for discussing the course content?	**No**	**Yes**	**Missing**		
	67.27 % (5243)	32.68 % (2547)	0.05 % (4)		
Did you contact any of the teachers whose case-study was presented in the course?	**No**	**Yes**			
	85.82 % (6689)	14.18 % (1105)			

Online Activities of Participants

Online Content	Time (in Minutes)				Time (as % of total time)			
	Range	Mean	STD	Median	Range	Mean	STD	Median
Science Expert Content	3 - 810	126.895	79.6	110	0.77 - 38.95	11.795	4.44	11.526
Science Case Study	3 - 456	76.843	49.64	65	0.43 - 23.41	7.163	2.84	6.86
Math Expert Content	2 - 546	83.344	65.06	64	0.37 - 24.11	7.39	3.34	6.932
Math Case Study	0 - 445	66.761	45.32	55	0 - 21.71	6.115	2.31	5.888
Classroom Management Expert Content	0 - 357	46.289	31.26	39	0 - 18.49	4.459	2.19	4.073
Classroom Management Case Study	6 - 1131	181.636	105.83	161	2.14 - 43.49	17.011	4.98	16.957
SCE Expert Content	0 - 141	13.483	13.71	8	0 - 10.08	1.239	1.07	0.914
SCE Case Study	0 - 179	25.94	19.38	20	0 - 15.39	2.418	1.22	2.18
ICT Use Expert Content	0 - 149	17.626	16.84	11	0 - 13.01	1.618	1.25	1.253
ICT Use Case Study	1 - 342	46.607	32.2	39	0.15 - 17.83	4.337	1.9	4.104
Grade Peer Projects	0 - 191	18.572	16.63	13	0 - 17.80	1.787	1.35	1.413
View Peer Feedback on Project	0 - 311	9.586	12.78	6	0 - 13.52	0.951	1.15	0.589

APPENDIX B

The English version of the Classroom Observation Manual which was translated to Gujarati for actual training. The Gujarati version also included the additional examples. The following text (in quotes) was also included at the bottom of every page of the manual

"The android application and parts of this manual have been derived from:
World Bank Group. 2017. Conducting Classroom Observations: Stallings 'Classroom Snapshot' Observation System for an Electronic Tablet. World Bank, Washington, DC. © World Bank. https://openknowledge.worldbank.org/handle/10986/28339 License: CC BY 3.0 IGO.
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SAMARTH

Manual for using the Classroom Observation Application (Android)

Ketan S Deshmukh
27 May 2018

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Introduction

As part of SAMARTH, 500 Cluster Resource Centre Coordinators (CRCCs) will assist in conducting classroom observation. Each CRCC will observe two schools in their own cluster. Classroom Observation would be conducted three times in one month for three months. During classroom observation, data will be collected on teacher activities, materials used and the number of students engaged with the teacher and in other activities. The data collected would be analysed by IIMA to provide feedback to teachers through CRCCs.

The data collected would be in digital format on an Android application installed on the CRCs mobile/ tablet device. The format is based on "Stallings Classroom Snapshot" instrument which helps in recording and analysing reliable data.

This manual provides instructions on

- Installation of the application to your device
- Process of making the observation
- Filling data from classroom observations.

Application Installation Instructions

Step 1. Navigate to www.inshodh.org
Step 2. Click on the link for **SAMARTH: Observing the Classroom**
Step 3. Log into the website with your credentials (Sent by SMS to your Mobile phone)
Step 4. Download application file and then install it on your android mobile device

Conducting Observations

- All participating CRCCs will receive the names of two schools, School 1 and School 2, and names of corresponding teachers who they have observe.
- CRCCs must observe both teachers when they are teaching 7^{th} Standard. (In rare cases where 7^{th} Standard is not possible, we will guide you.) Once the Standard is selected, for three months you will follow only that Standard. That is, all nine observations (3 times a month, for 3 months) will be of that Standard only.
- In School 1 subject to be observed is Mathematics and in School 2 it is Science.
- Kindly schedule your observation schedule for the week at least a week before.
- Please ensure that: -
    - No teacher is observed twice on the same day.
    - All three observations for the month of the teacher are conducted preferably within a week; if not possible spread over two weeks.
- Please check that your device has sufficient battery and set to **DO NOT DISTURB** mode for the duration of the observation
- Kindly fill the data on the application as you make your observations
- Please save the data collected after the end of each classroom observation before proceeding to the next observation
- Before sending the collected data kindly check if the device has good data connection.

Classroom Information

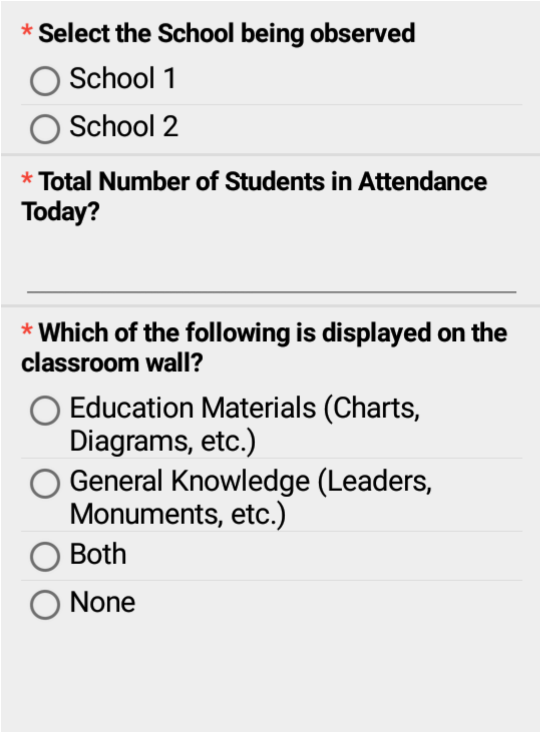


Image 1: Classroom Information

Kindly record the following classroom information at the start of the observation

School
Select the school which you are observing at that moment. Please pay attention to this selection as it linked to the standard, the subject and the teacher of the class being observed.

Number of students
Kindly note the number of students sitting in the classroom at the start of the classroom period. If the number of students changes during the period i.e. students come late or leave early, mention the changed number of students at the end in the Additional Observation Notes section

Materials on Classroom Walls
Please observe the classroom walls and indicate if they display educational content or general knowledge material.
Educational Materials are charts, diagrams, posters based on the curriculum of the classroom. E.g. Parts of tree, Graph of data collected in current student's project, etc.
General Knowledge information would be content which is not included in the syllabus of the class. E.g. Leaders, Pictures of monuments, etc.

After recording the classroom information, you need to record **10 observations (referred to as Snapshots) at 3-minute intervals** to complete the classroom observation.

Process of Recording Snapshots

Observation no.	1	2	3	4	5	6	7	8	9	10
Time (min.)	1	4	7	10	13	16	19	22	25	28

Table 1: Timeline in minutes for making a snapshot observation

Note: We are assuming that a class period is of 35 to 40 minutes. Observations need to be taken at intervals indicated in the table above. E.g. 1^{st} observation would be taken 1 minute from start time of the class period, 7^{th} observation will be recorded at 19^{th} minute from start time of the class period. In case you start at minute 2 for any reason, then the 10^{th} observation will be at minute 29. Note that getting 10 OBSERVATIONS is important.

At the time of the observation **scan the classroom for 15 seconds** and record the following

- What activity is the teacher doing? (See TEACHER ACTIVITY section below.)
- What materials is the teacher using? (See MATERIALS & STUDENTS INVOLVED WITH THE TEACHER section below)
- How many students are involved in the teacher's activity? (See MATERIALS & STUDENTS INVOLVED WITH THE TEACHER section below)
- If there is no teacher or students are unengaged with the teacher, what are the uninvolved students doing? (See STUDENTS UNINVOLVED WITH THE TEACHER section below.)

After recording all the above in the app wait for the next observation time to repeat the snapshot.

Teacher Activity

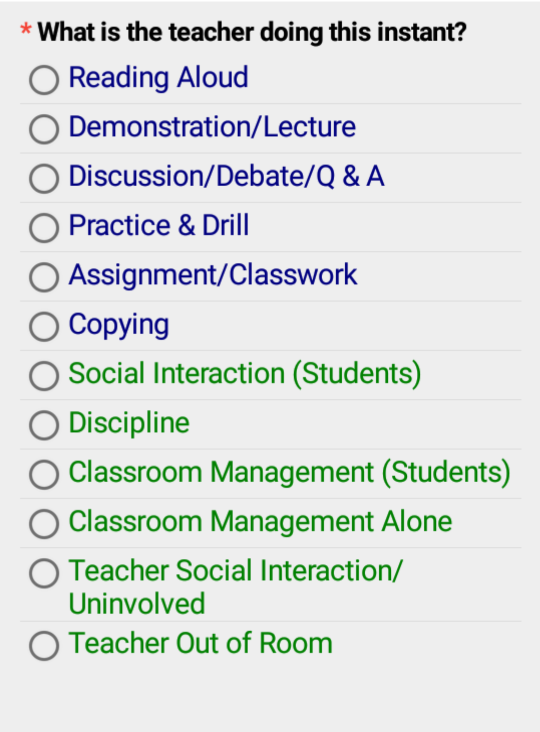


Image 2: Teacher Activity

Teacher Activity in the classroom can be grouped into two sets of activities: Learning Activities **(Blue)** & Classroom Management Activities **(Green)**

Reading Aloud

The teacher or one or more students are reading aloud from a textbook, the blackboard, their own writing, or a handout.

Choose this option if:

- The teacher or a student is reading out loud
- A group of students is reading in unison
- ALL the students are reading in unison
- Students are reading along with the teacher

Demonstration/Lecture

The teacher, radio, television or some form of media is informing, explaining or demonstrating academic content to the students. Generally, the activity involves presenting new content to the class by the teacher or students

Choose this option if:

- The teacher is lecturing or demonstrating something – an experiment, a math problem, etc. to the class
- The teacher is reviewing material that was taught in a previous class
- A student or group of students is making a presentation and the teacher is supervising

Discussion/Debate/Question & Answer

The teacher is asking or answering questions or exchanging ideas with the students about an academic topic.

Choose this option if:

- The teacher is asking or answering student's questions or vice versa.
- The students are debating a topic suggested by the teacher
- The teacher is exchanging ideas/opinions with the students
- Students are solving mathematics problem posed by teacher

Practice & Drill

These are activities which involve repetition with the main goal being to memorize the information.

Choose this option if:

- The teacher is leading practice – calling out math problems or vocabulary and having the students repeat it
- Students are practicing math facts, spellings words, the alphabet, or any rote learning activity
- The students are repeating after the teacher
- Students are simply memorizing and repeating multiplication tables

Assignment/Classwork

Activities involves making students to write papers, solve problems, read silently at their desks, or work on a test or a quiz.

Code this option if:

- The teacher has assigned the students to work on a textbook exercise or solve math problems on the blackboard
- The teacher is monitoring the students as they write an essay
- The students are taking a test or quiz.

Copying

Activity involves students to transfer lesson-related text in to their notebooks or paper.

Choose this option if:
- The teacher is copying lesson-content onto the blackboard that the students are copying or are expected to copy
- The teacher is dictating a passage and the students are copying what they hear
- The teacher is monitoring students while they are copying

Social Interaction (Students)
Activities involves that the teacher is interacting socially with the students.
Choose this option if:
- The teacher is chatting with the students about non-academic topics
- The teacher is listening to the students chat about non-academic topics

Discipline
Activities involve teacher take remedial action against students for their unacceptable classroom behaviour.
Choose this option if:
- The teacher is reprimanding one or more students or the whole class
- The teacher is punishing the errant students for their behaviour

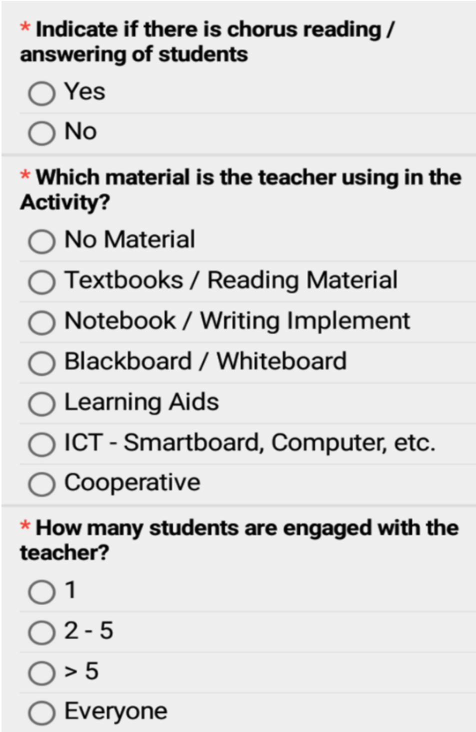
Classroom Management (Students)
The teacher and students are engaged in activities of an organizational or management nature.
Choose this option if:
- The teacher and one or more students are engaged in activities like taking attendance, passing out papers, etc.
- The teacher is giving instructions on homework assignment, timetable etc.
- The teacher asks students in arranging classroom materials

Classroom Management Alone
The teacher alone performs the all above activities without help from students
Choose this option if:
- Teacher is sitting at a desk grading papers.
- Teacher is setting up a learning aid or ICT system for the next lesson in class

Teacher Social Interaction/Uninvolved
The teacher is in the classroom but not involved in any academic activity and is not engaged with the students.
Choose this option if:
- The teacher is not engaged in any classroom management activities.
- The teacher is looking out the window, using a cell phone or reading from a book.
- The teacher is talking to a visitor at the door of the classroom

Teacher Out of Room
The teacher is not present in the room at the moment of your observation.
Choose this option if:
- The teacher has not yet arrived or left the room to go get materials (or talk to the principal or a parent).
- The teacher has dismissed the class early and left the room before the class time is over

Materials & Students involved with the Teacher



* **Indicate if there is chorus reading / answering of students**

- Yes
- No

* **Which material is the teacher using in the Activity?**

- No Material
- Textbooks / Reading Material
- Notebook / Writing Implement
- Blackboard / Whiteboard
- Learning Aids
- ICT - Smartboard, Computer, etc.
- Cooperative

* **How many students are engaged with the teacher?**

- 1
- 2 - 5
- > 5
- Everyone

Image 3: Materials & Students

<u>Chorus reading or answering</u>

This question requires response only if the teacher and students are engaged in reading aloud. If the reading or answering of questions happens in unison then it needs indicated by selecting “Yes”.

<u>Material used by the teacher in the activity</u>

This question is only required if the teacher and students are engaged in Learning activities. Always select the material used by the teacher to teach the lesson. Following are the options

No Material:
No material of any kind is being used in the classroom at that moment.

Textbook / Reading Materials:
This category refers to any printed materials that students do not write in directly. This category includes textbooks, story books, magazines or newspapers.

Notebook / Writing implements:
This category refers to any materials that students work with and write in. e.g. notebooks, workbooks, worksheets, journals, slates, or blank sheets of paper

Blackboard/ Whiteboard:
Blackboard, Chalkboard or whiteboard.

Learning Aids:
This category includes all kinds of visual aids and manipulatives that teachers use to help students understand. Learning aids include maps, charts, photos, posters, flipcharts, materials used in science experiments, rulers, compasses, currency, calculators (electronic too), blocks, flash cards, sticks or human bodies.

ICT:
This category includes electronic learning aids such as digital whiteboards, projectors, radios, televisions, videos, computers, laptops, tablets and smart phones being used for instructional purposes.

Cooperative:
A cooperative activity is one where a pair of students or a group of students is working together, and there is only one product of their work – a group product.
Note: if students are sitting in groups, but they are each working on individual worksheets, it is not considered a cooperative activity.

Number of Students engaged with the teacher
This question requires response for all learning activities and those classroom management activities which involve students. Select the appropriate number of students involved in the teacher activity

Students Uninvolved with the Teacher

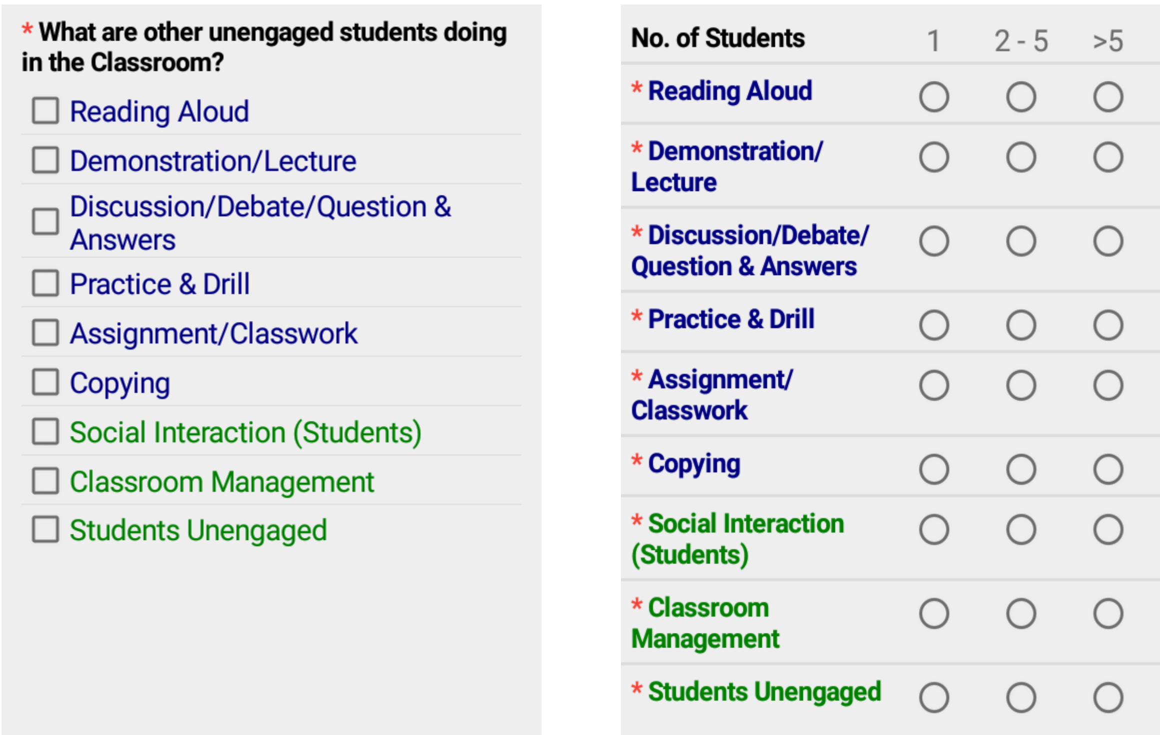


Image 4: Activities of Uninvolved Students & Number of Students in each selected activity

Response to this question is required unless the entire classroom is engaged by the teacher or the teacher is out of the room or is uninvolved.

All activities undertaken by the students who are not involved with the teacher need to be selected. On the next screen the number of students in the selected activity have to be indicated. Unengaged students can be involved in activities explained earlier.
E.g.
Demonstration/Lecture:
- A student or group of students is making a presentation and taking the role of the teacher, but the teacher is not present

Discussion/Debate/Question & Answer:
- Students are discussing a class assignment among themselves

Classroom Management:
- The teacher is out of the classroom, but the students are passing out papers or collecting books.

Social Interaction (Students):
- Two or more students are talking or laughing about non-academic activities.
- Students involved in disruptive activities such as moving around, shouting, shoving, etc.

Students Unengaged
When one or more students are visibly not engaged in activity with the teacher and with other students they are categorised as "unengaged".
Choose this option if:
- Student is staring out the window, resting his/her head on the desk, sleeping, or doodling on a piece of paper, etc.
- Students are sitting quietly and waiting for the teacher to begin the lesson, or waiting for instructions about what to do next
- Students who are walking in or out of the classroom for reasons that are unclear

Additional observation notes

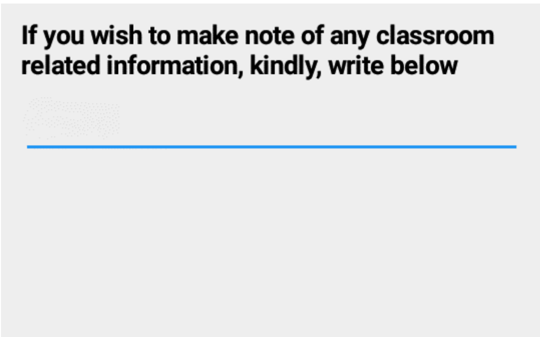


Image 6: Additional Observation Note

This field is to record any additional observations, after completing the 10 snapshot observations, that you will make during the classroom session.
Use the space to mention
- If the number of students changes from the one recorded at the start.
- If a test or quiz was administered.
- Describe any kind of punishment awarded to students

APPENDIX C

Summary of Classroom Observation

	Overall			Group A			Group B		
Rounds	1	2	3	1	2	3	1	2	3
No. of. Teachers	663	544	286	328	273	145	335	271	141
Teacher Activities									
Learning Activities	94.71 % (10.71)	95.31 % (11.26)	96.18 % (11.26)	94.5 % (11.06)	95.16 % (11.11)	95.52 % (13)	94.92 % (10.36)	95.47 % (11.43)	96.86 % (9.13)
	[0 - 100]	[0 - 100]	[0 - 100]	[0 - 100]	[0 - 100]	[0 - 100]	[0 - 100]	[0 - 100]	[10 - 100]
Reading Aloud	8.94 % (12.86)	8.22 % (13.1)	7.63 % (13.29)	8.6 % (12.73)	8.84 % (13.97)	8.72 % (15.28)	9.26 % (13)	7.6 % (12.15)	6.5 % (10.82)
	[0 - 100]	[0 - 90]	[0 - 95]	[0 - 100]	[0 - 90]	[0 - 95]	[0 - 85]	[0 - 70]	[0 - 50]
Demonstration / Lecture	21.71 % (15.83)	23.01 % (18.62)	24.22 % (19.32)	21.55 % (15.79)	23.13 % (18.04)	23.45 % (18.75)	21.87 % (15.88)	22.9 % (19.23)	25.02 % (19.93)
	[0 - 90]	[0 - 100]	[0 - 100]	[0 - 73.33]	[0 - 100]	[0 - 90]	[0 - 90]	[0 - 100]	[0 - 100]
Discussion / Q&A	32.79 % (17.86)	31.86 % (18.54)	32.9 % (20.87)	32.85 % (18.38)	32.22 % (19.29)	32.97 % (22.48)	32.73 % (17.37)	31.49 % (17.79)	32.83 % (19.15)
	[0 - 100]	[0 - 100]	[0 - 100]	[0 - 100]	[0 - 93.33]	[0 - 100]	[0 - 90]	[0 - 100]	[0 - 100]
Practice & Drill	15.52 % (14.36)	16.08 % (15.21)	15.19 % (15.79)	14.85 % (14.31)	14.95 % (15.08)	14.79 % (16.36)	16.17 % (14.39)	17.2 % (15.29)	15.59 % (15.22)
	[0 - 95]	[0 - 95]	[0 - 90]	[0 - 95]	[0 - 95]	[0 - 90]	[0 - 86.67]	[0 - 93.33]	[0 - 65]
Assignment / Classwork	10.21 % (11.79)	11.38 % (12.82)	11.79 % (13.09)	10.55 % (12.45)	10.87 % (13.09)	10.77 % (13)	9.87 % (11.11)	11.9 % (12.53)	12.84 % (13.15)
	[0 - 70]	[0 - 80]	[0 - 60]	[0 - 70]	[0 - 80]	[0 - 60]	[0 - 60]	[0 - 80]	[0 - 60]
Copying	5.55 % (8.48)	4.77 % (8.45)	4.45 % (7.86)	6.1 % (9.42)	5.15 % (9.38)	4.82 % (8.19)	5.01 % (7.41)	4.39 % (7.39)	4.08 % (7.51)
	[0 - 50]	[0 - 70]	[0 - 50]	[0 - 50]	[0 - 70]	[0 - 40]	[0 - 40]	[0 - 40]	[0 - 50]
Classroom Mgmt. Activities	3.04 % (8.22)	2.93 % (8.25)	2.48 % (9.33)	3.24 % (7.75)	3.01 % (8.28)	3.25 % (11.78)	2.84 % (8.67)	2.84 % (8.24)	1.68 % (5.75)
	[0 - 100]	[0 - 80]	[0 - 100]	[0 - 95]	[0 - 80]	[0 - 100]	[0 - 100]	[0 - 80]	[0 - 50]
Discipline	0.56 % (2.58)	0.52 % (2.83)	0.76 % (4.26)	0.56 % (2.25)	0.6 % (3.54)	1.18 % (5.73)	0.56 % (2.88)	0.44 % (1.87)	0.33 % (1.7)
	[0 - 40]	[0 - 50]	[0 - 50]	[0 - 20]	[0 - 50]	[0 - 50]	[0 - 40]	[0 - 16.67]	[0 - 10]
Classroom Mgmt. (w Student)	2.05 % (5.7)	2.13 % (5.84)	1.4 % (4.87)	2.3 % (6.1)	2.23 % (6.18)	1.7 % (5.48)	1.8 % (5.27)	2.04 % (5.49)	1.1 % (4.15)
	[0 - 75]	[0 - 60]	[0 - 50]	[0 - 75]	[0 - 60]	[0 - 50]	[0 - 50]	[0 - 43.33]	[0 - 40]
Classroom Mgmt. Alone	0.43 % (2.24)	0.28 % (1.82)	0.31 % (1.88)	0.38 % (1.99)	0.19 % (1.2)	0.37 % (1.85)	0.48 % (2.46)	0.36 % (2.28)	0.25 % (1.92)
	[0 - 25]	[0 - 25]	[0 - 20]	[0 - 25]	[0 - 10]	[0 - 10]	[0 - 20]	[0 - 25]	[0 - 20]

	Overall			Group A			Group B		
Rounds	1	2	3	1	2	3	1	2	3
<u>Teacher Off Task Activities</u>	2.25 % (5.07)	1.76 % (4.78)	1.35 % (4.03)	2.26 % (5.56)	1.83 % (4.87)	1.23 % (3.08)	2.24 % (4.54)	1.69 % (4.69)	1.47 % (4.82)
	[0 - 55]	[0 - 35]	[0 - 40]	[0 - 55]	[0 - 30]	[0 - 16.67]	[0 - 33.33]	[0 - 35]	[0 - 40]
Social Interaction (w Students)	1.78 % (4.03)	1.41 % (3.95)	1.13 % (3.81)	1.91 % (4.54)	1.58 % (4.15)	1.03 % (3)	1.66 % (3.46)	1.25 % (3.74)	1.23 % (4.5)
	[0 - 30]	[0 - 30]	[0 - 40]	[0 - 30]	[0 - 30]	[0 - 16.67]	[0 - 20]	[0 - 30]	[0 - 40]
Social Interaction (w Others)	0.22 % (1.6)	0.22 % (1.68)	0.13 % (1.3)	0.21 % (1.79)	0.12 % (1.3)	0.13 % (0.76)	0.24 % (1.39)	0.33 % (1.99)	0.14 % (1.68)
	[0 - 30]	[0 - 20]	[0 - 20]	[0 - 30]	[0 - 20]	[0 - 5]	[0 - 13.33]	[0 - 20]	[0 - 20]
Out of Room	0.24 % (1.89)	0.12 % (1.14)	0.08 % (0.75)	0.14 % (1.18)	0.13 % (1.38)	0.07 % (0.59)	0.34 % (2.38)	0.11 % (0.82)	0.09 % (0.89)
	[0 - 33.33]	[0 - 20]	[0 - 10]	[0 - 15]	[0 - 20]	[0 - 5]	[0 - 33.33]	[0 - 10]	[0 - 10]
Materials Used									
No Material Used	4.39 % (9.14)	4.14 % (8.54)	4.34 % (9.25)	4.7 % (10.34)	4.55 % (9.76)	4.05 % (8.96)	4.1 % (7.81)	3.72 % (7.1)	4.63 % (9.56)
	[0 - 80]	[0 - 70]	[0 - 63.33]	[0 - 80]	[0 - 70]	[0 - 50]	[0 - 55]	[0 - 50]	[0 - 63.33]
Text-Book	21.23 % (19.45)	21.15 % (19.93)	19.71 % (19.49)	20.04 % (18.9)	21.21 % (19.85)	21.11 % (20.08)	22.4 % (19.93)	21.09 % (20.05)	18.26 % (18.82)
	[0 - 90]	[0 - 100]	[0 - 90]	[0 - 80]	[0 - 100]	[0 - 90]	[0 - 90]	[0 - 100]	[0 - 90]
Note-Book	14.48 % (13.43)	14.45 % (13.33)	14.84 % (14.6)	14.54 % (14.01)	14.15 % (13.07)	15.55 % (14.76)	14.43 % (12.85)	14.75 % (13.6)	14.11 % (14.46)
	[0 - 70]	[0 - 80]	[0 - 60]	[0 - 70]	[0 - 60]	[0 - 60]	[0 - 70]	[0 - 80]	[0 - 60]
Black-Board / White-Board	39.49 % (23.11)	37.18 % (24.08)	36.38 % (24.49)	39.41 % (22.81)	37.85 % (23.82)	35.68 % (25.21)	39.57 % (23.43)	36.5 % (24.36)	37.1 % (23.8)
	[0 - 100]	[0 - 100]	[0 - 100]	[0 - 100]	[0 - 100]	[0 - 100]	[0 - 100]	[0 - 100]	[0 - 93.33]
Learning Aids	7.82 % (11.12)	10.81 % (14.51)	12.54 % (16.97)	8.2 % (11.31)	10.08 % (14.08)	11.01 % (16.21)	7.46 % (10.94)	11.54 % (14.92)	14.11 % (17.63)
	[0 - 85]	[0 - 90]	[0 - 100]	[0 - 85]	[0 - 90]	[0 - 100]	[0 - 70]	[0 - 80]	[0 - 80]
ICT (PC / Smart-Board)	4.33 % (13.89)	4.25 % (13.51)	4.32 % (13.6)	4.58 % (12.41)	4.31 % (12.12)	4.22 % (11.36)	4.09 % (15.22)	4.19 % (14.81)	4.42 % (15.62)
	[0 - 100]	[0 - 100]	[0 - 100]	[0 - 74]	[0 - 70]	[0 - 65]	[0 - 100]	[0 - 100]	[0 - 100]
Co-operative	2.96 % (6.46)	3.34 % (7)	4.05 % (8.83)	3.04 % (6.62)	2.99 % (6.47)	3.9 % (9.1)	2.87 % (6.3)	3.69 % (7.49)	4.21 % (8.58)
	[0 - 60]	[0 - 40]	[0 - 50]	[0 - 40]	[0 - 40]	[0 - 50]	[0 - 60]	[0 - 40]	[0 - 50]
Avg. Class Size	19.92 (11.22)	19.29 (9.27)	18.81 (9.15)	18.83 (9.37)	18.8 (9.05)	18.37 (9.35)	20.98 (12.71)	19.8 (9.48)	19.26 (8.94)
	[2 - 151.3]	[2 - 68]	[2 - 63]	[2 - 74]	[2.33 - 68]	[5 - 63]	[2 - 151.3]	[2 - 53.75]	[2 - 53]