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Reflections on the Cascade Model for Teacher Professional Development: A Case Study of RSC-Yusuf Hamied Inspirational Chemistry Programme in India

Abstract

The RSC-Yusuf Hamied Inspirational Chemistry Programme was launched in India in 2014 by the Royal Society of Chemistry (RSC, UK). A component of this programme was the professional development of about 8,000 chemistry teachers across India, in five years. This paper reports on an evaluation study conducted in 2018, that reflects on the implementation of the RSC teacher professional development (TPD) programme, via a cascade model. Our analysis of the RSC-TPD programme involved the use of multiple levels of evaluation proposed by Guskey. This study involves data collection from 32 government/ government-aided schools in three states of India. The findings present some evidence of the impact of the programme and highlight the need for sustained interactions with teachers.
Keywords: Teacher professional development, Cascade model, School chemistry education

Introduction

The *RSC-Yusuf Hamied Inspirational Chemistry Programme* was initiated in India by the Royal Society of Chemistry (RSC, UK) in 2014. This programme had a teacher development component referred to as the *RSC-Yusuf Hamied Teacher Development Programme* that was conceptualised for a period of five years (till 2018). It aimed to provide Teacher Professional Development (TPD) for around 8,000 chemistry teachers teaching in secondary schools across India. The TPD implemented by RSC was a cascade model that had three phases of transfer (Figure 1).

The three phases of transfer in this cascade model of RSC-TPD involved transfer of information from (i) primary trainers to secondary trainers/teacher developers (TDs), (ii) TDs to teachers and (iii) teachers to students. As indicated in the figure, five primary trainers from the UK were experienced both in conducting TPD programmes and in the development of instructional materials. Forty-two TDs were trained as part of the programme with almost equal number of males (22) and females (20).

This paper discusses the implementation of the RSC-Yusuf Hamied Inspirational Chemistry Programme and attempts to capture the transfer of the training that occurred in RSC-TPD through different phases. The study is limited to a few government and government-aided schools in three states of India. These three states are located in different regions of India, namely, Karnataka (southwest), Kerala

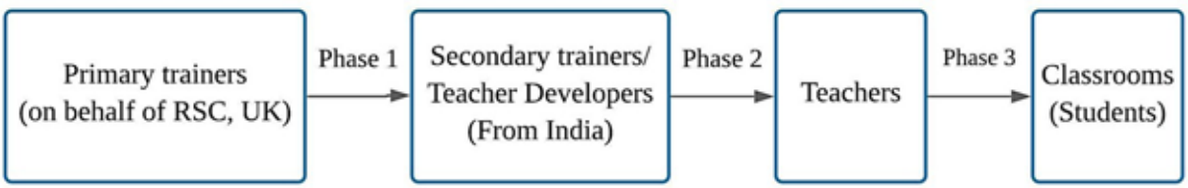

Figure 1. Teacher Professional Development (TPD) model for the RSC-Yusuf HamiedInspirational Chemistry Programme

Table 1. Year-wise Details of the Number of Teacher Participants and Teacher Workshops Conducted in Karnataka, Kerala and Maharashtra[2]

State	Year	No. of teachers (2015)	No. of teachers (2016)	No. of teachers (2017)	Total number of teachers	Total number of work-shops conducted till January 2018
Karnataka		1571	4052	3901	9524	447
Kerala		362	623	21	1006	76
Maharashtra		598	578	203	1379	91
Total		2531	5253	4125	11909	614

(south) and Maharashtra (west), though the TDs conducted RSC-TPD workshops in 24 states of the country. Table 1 presents some relevant data regarding the TPD workshops conducted by the TDs in the states mentioned above. Between January 2015 and January 2018, a total of 614 TPD workshops, were conducted for teachers from various schools in the states of Maharashtra, Karnataka and Kerala.

Table 1 indicates that the maximum numbers of workshops were conducted in Karnataka. Comparatively fewer workshops were conducted in Maharashtra and Kerala, respectively**.** Before we present data on the implementation of the TPD programme, we look at the merits and demerits of the cascade model, used for large scale TPD through some representative studies.

Use of the cascade model for TPD programmes

Introduction

The cascade model is widely used for large scale TPD as it can provide rapid diffusion of ideas in a short period (Suzuki, 2008; Karalis, 2016) and thus can be cost-effective (Thair & Treagust, 2003; Henly, 2005; Shezi, 2008). These reasons have often led to the use of the cascade model in developing countries (Lange, 2014). The cascade model is classified under standardized TPD models by Gaible and Burns (2005) who describe it as a model that follows a 'one size fits all' approach for the transfer of knowledge and skills. Kennedy (2005) has classified TPD models into three main categories, namely, transmission, transitional and transformative, based on the purpose and the increasing capacity of professional autonomy that is provided to teachers.

According to her, a transmission TPD model is similar to the cascade model as it uses a top- down approach for transmission of information, where teachers are often passive participants.

She uses examples of mentoring and communities of practice to explain the transitional models of TPD. Mentoring uses one-to-one interactions between an experienced and a novice teacher, while communities of practice emphasise the role of peer group interactions. The transformative model is similar to action research and requires teachers to act as researchers. In contrast to the models under the transmission category, the transformative model considers the actions of teachers as reflections of their understanding, about classroom situations. Kennedy (2005) and Shezi (2008) further state that the cascade model is closer to a technicist/*'teacher as technician'* view of training which emphasises skills and knowledge over attitudes and values. While discussing the key aspects that need to be considered for designing TPD using a cascade model, Hayes (2000) and Prince & Barrett (2014) suggest that gathering inputs from multiple stakeholders as well as harnessing their potential at various stages of the programme and in the development of instructional materials would result in a reflective and flexible approach

to teacher development as compared to the transmission mode of TPD.

The importance of backward planning for effective use of the cascade model has been highlighted by Guskey (2002) who argues that trainers must be aware of the objectives and desired outcomes of TPD at the preliminary stages itself as also organisational policies and favourable environments available to teachers at their workplace. The short duration of workshops, use of transmission mode by trainers, de-contextualization and adoption of the one- shot approach often reduces the effectiveness of cascade model TPD programmes (Aston, 1988; Shezi, 2008; Hunzicker, 2011; Gathumbi et al., 2013; Chigonga & Mutodi, 2019). An important variable for effective TPD, emphasized by various researchers, such as, Thair & Treagust (2003), Henly (2005), Lewin et al. (2009), Uysal, (2012); Prince & Barrett (2014) and Gemeda & Tynjälä, (2015) is the provision of continual support to the teachers after they participate in the TPD workshop.

The debate about the use of the cascade model for TPD programmes summarised by Suzuki (2008) highlights two kinds of arguments. One argument asserts that there are inherent lacunae in the cascade model, which make this model unsuitable for TPD while the second argument claims that these lacunae are due to the improper implementation of the model and not due to its innate weaknesses. Consequently, for effective implementation, aspects such as defining the purpose of training, identifying the requirements of teachers, resources to be used, recruitment of trainers, the time allotted for each stakeholder to learn new concepts, the scaffolding of training at different levels and modification of the programmes based on the feedback obtained through regular monitoring are crucial parameters (Suzuki, 2008; Lange, 2013; Prince & Barrett, 2014; Karalis, 2016). The cascade model is based on an ideal scenario which assumes that the transfer of training will take place with almost equal efficiency across different layers of the model. However, the distortion of information is most likely to happen if the TDs/secondary trainers do not internalise the keys ideas/concepts covered in the workshops or if they are unable to share the same with the teachers due to limited pedagogical experiences (McDevitt, 1998; Shezi, 2008). Thus, the selection of the secondary trainers will significantly affect the TPD programmes.

Some representative case studies of cascade models of TPD

Gaible & Burns (2005) have presented a case study of the use of the cascade model for a TPD programme involving teachers from 20 secondary schools in Tajikistan. In this study, longitudinal training of teachers, the arrangement of periodical cluster meetings and collaborative projects were some of the significant factors that led to the successful implementation of the programme. Also, in this programme, the teacher trainers' remunerations, were directly linked to two factors: (i) performances of the teachers trained by them and (ii) students' learning. Gaible and Burns also highlighted that the facilities available during the training of a limited number of individuals as expert trainers are different from those that are available at the local level, and this can affect the TPD workshops at local levels. Further, the lack of facilities at the classroom level is likely to affect the implementation of new strategies in the classrooms. Thus, awareness about the facilities at grass-root levels is crucial while designing TPD programmes, especially in developing the instructional materials to be used for the training.

A study of the effectiveness of the cascade model for training of in-service teachers in Nepal, using a four-layered cascade model was conducted by Suzuki (2008). This model led to the professional development of an impressive number of primary teachers. The programme was also cost-effective as it could train more than 90 thousand teachers in six months. However, she highlighted the inadequate transfer of concepts to the teachers through the programme. In her

opinion, the trainers at the topmost layers were highly qualified content experts but lacked teaching experiences for primary schools. The trainers at the lower levels had adequate teaching experiences but could not present enriched discussions about the content. In her opinion, identifying such gaps and working towards bridging them is crucial for the successful implementation of the cascade model for TPD programmes.

A qualitative study involving around a hundred Adult Basic Education and Training (ABET) teachers from the north-west province of South Africa was presented by Mokhele & Dichaba (2012). Their study focused on five key areas: content knowledge of trainers, content delivery, the efficiency of transmission of information, confidence of teachers in cascading the information obtained from the training and finally the implementation of the new strategies in classrooms. They found that the teacher participants reported that their trainers were skilled and knowledgeable but believed that crucial information was distorted and even lost through the layers of the cascade programme. Only 29 per cent of the participants strongly agreed that they were confident about cascading information to their colleagues and more than 50 per cent of teachers were not comfortable using the key ideas from the training in their classrooms. Overall, the researchers did not consider the cascade model to be successful at the classroom implementation level.

In 2012, Teacher Educators from a UK University and representatives from the Republic of Kazakhstan while introducing new pedagogical approaches to Kazakhstani teachers, using a three-layered cascade model, incorporated an important component, that is, mentoring of secondary trainers, by the primary trainers, to deal with the dilution effect. The mentors (primary trainers) were expected to analyse their mentees performance, generate reports and provide appropriate feedback. Turner et al. (2017) evaluated this programme, based on the five points listed by Hayes (2000) and in their opinion, the key factor responsible for adequate transfer of content knowledge throughout the different layers was mentoring.

In the Indian context, Ngeze et al. (2018) evaluated the effectiveness of the cascade model used for TPD of around a hundred and fifty in-service instructors belonging to six technical institutions, during a four-week long, three-layered cascade teacher development programme. They collected data from the primary and secondary trainers through interviews and the study recommended that the primary trainers should attend a few of the sessions conducted by the secondary trainers which could be followed by a feedback meeting. Another recommendation of the study was that opportunities must be provided to secondary trainers to share their experiences as these could create a support system for them, during the implementation of the training.

The cascade model thus appears to be an unavoidable option when a large number of teachers need to be trained. As indicated in the above section, appropriate planning, careful selection of individuals at the first level of training and the inclusion of teacher representatives in the planning stage to increase awareness about classroom realities are some of the crucial factors for the implementation of this model. Any evaluation study for TPD programmes conducted using a cascade model needs to look at aspects such as challenges faced by various stakeholders, distortion of key ideas across phases of transfer, the factors responsible for the same and the impact of the training at the grass-root level. Based on the representative studies from literature, we tried to focus on these aspects while evaluating the teacher development component of *RSC- Yusuf Hamied Inspirational Chemistry Programme* in India.

Theoretical framework

Thomas R. Guskey has developed a framework which is widely adopted for

evaluation of TPD programmes (Guskey, 2002). According to this framework, while evaluating TPD programmes, it is essential to gather and examine the information at five levels: (i) participants' reactions (ii) participants' learning (iii) organisation support and change (iv) participants' use of new knowledge and skills and (v) student learning outcomes.

While evaluating *RSC-Yusuf Hamied Inspirational Chemistry Programme* in India, we applied three levels of Guskey's evaluation framework for both the transfer stages of the programme, that is, training of TDs by primary trainers and training of teachers by TDs. To understand the effectiveness of the programme at Level 1 (that is participants' reactions level), we gathered the feedback *post facto* from TDs and teachers using survey questionnaires and a few personal interviews.

The participants' learning level, is about measuring the skills or knowledge gained by participants. The RSC-TPD programme had focused on developing activities/strategies for active learning in the classrooms. Thus, we tried to gather evidence for whether (i) the TDs/teachers prepared activity-based resources for topics other than those covered in the workshops (ii) any modifications were incorporated, by the participants to the original worksheets/activity templates and (iii) any new resources/activities were designed by participants during and after the RSC-TPD workshops. We could not collect data or evidence for Level 3 of Guskey's framework regarding the organisational support and change. However, the school visits and teachers' interviews presented some glimpses about the sociocultural factors in teachers' work environment. Additionally, the teachers' questionnaire had some questions related to the infrastructure of the schools.

Regarding the level 4, participants' use of new knowledge and skills, we observed the RSC-TPD workshops conducted by the TDs and the teaching-learning processes in participant teachers' classrooms *post facto*. We tried to gather evidence for whether the illustrated activities and/or new activities were being used effectively by the teachers in the classrooms. The focus group discussions with students provided more clarity regarding the Active Learning Strategies (ALS) in use.

When we started the evaluation, the TDs had already conducted a significant number of TPD workshops in different states. The schools sampled for data collection were located geographically far apart and were also distant from our location. Thus, we could not visit the schools frequently for classroom observations. Even though some teachers mentioned aspects like students' improvement in learning and enhancement in students' confidence levels, we could not gather much evidence to ascertain the actual impact of the RSC-TPD programme on the students' learning outcomes within the short-stipulated duration of time available for the evaluation study. Thus, for our evaluation study, we focused on levels 1, 2 and 4 of Guskey's framework. Table 2 presents the details of the tools and representative questions used for data collection at different levels of Guskey's framework for TDs and teachers.

Table 2: Data Collection from TDs and Teachers for Different Levels of the Model Provided by Guskey

Levels	Data collection	Representative questions for TDs	Representative Questions for teachers
Level 1: Participants' Reactions	Survey/ Questionnaires, workshop observations and interviews	In your opinion, what was different about RSC training? (Aspects you liked/did not like).	What is your opinion about activities learnt at RSC- TPD workshop?

Level 2: Participants' Learning	Survey/ Questionnaires, workshop observations and interviews	In what way RSC training has equipped you as a teacher developer? Apart from the units provided by RSC, for TPD workshop, have you developed and used any other activities?	Have you prepared new resources? Have you prepared such activities for subjects other than chemistry?
Level 4: Participants' Use of New Knowledge and Skills	Survey/ Questionnaires, workshop observations, classroom observations and interviews	How do you deal with large group of teachers during workshop? How did you handle problems related to content?	Do you use the activities learnt at RSC teacher training workshop? If yes, how frequently?

RSC-Yusuf Hamied Inspirational Chemistry Programme in India: Teacher Development Component: A Case study

Introduction to the programme

In this section, we will discuss the salient features of the TPD programme, conducted as part of *RSC-Yusuf Hamied Inspirational Chemistry Programme* in India. Figure 2 indicates the progression of the programme since its pre-launch stage to its evaluation. Before the formal launch of the programme in 2014, the primary trainers from the UK, who were a team of members responsible for content development and training of teacher developers, visited a few schools in India. Additionally, they held workshops with in-service chemistry teachers in 2013, to get first-hand experiences about school chemistry education, in the Indian context.

The main purpose of the school visits and workshops in the pre-launch phase was to acquaint the primary trainers with the Indian school system and to gather baseline information, that would be important for the planning and development of instructional materials for use in the teacher development programme. The instructional modules for the RSC-TPD included topics from the chemistry textbooks produced by National Council of Education, Research and Training, (NCERT) India. The three modules were: (i) towards active learning (ii) chemical reactions and equations and (iii) the particle nature of matter. The focus of the first instructional module was on developing ALS to engage learners. These strategies were adaptable for teaching-learning of any subject/topic. Another key area covered by the instructional module was based on experimental activities that are low-cost, require readily available materials and are micro-scale. The module on the particle nature of matter focused on misconceptions in chemistry, which is an important dimension for teaching-learning of

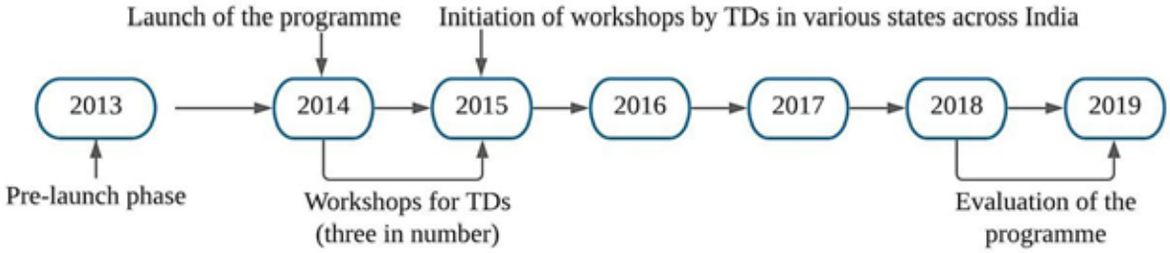

Figure 2. Timeline for the TPD Programme by RSCt

chemistry, at the secondary school level. The topic of chemical reactions and equations is central to the secondary school chemistry syllabus. Thus, the instructional modules developed for the programme addressed the core domains of school chemistry. While designing each module, separate booklets were developed for different layers of the cascade model, namely (a) the primary trainers: experts responsible for the training of teacher developers (b) teacher developers: group of individuals selected for training (TDs) and (c) teachers: participants of the teacher development workshops conducted by TDs.

These booklets differed significantly in terms of complexities and approaches adapted for discussions of the contents, for example, the booklets for teachers tended to be more concrete, simple to understand and contained exemplar worksheets and activity cards for various chemistry topics, which could be used in classrooms directly. Besides, blank templates were available to design similar activities for more chapters. The experimental activities could be performed by teachers as demonstrations or were doable by students. The booklets also included information about useful websites, computer-based simulations and e-resource portals (including RSC website) for the teaching of chemistry at the secondary level. The booklets for TDs incorporated additional discussions about chemistry concepts, experiments and guidelines for using various chemistry softwares useful to generate resources including ICT based resources useful for teacher development workshops. The primary trainers' booklet discussed aspects such as exploring pedagogies in chemistry, development of active learning resources, self/peer-assessment and misconceptions, in addition to the content discussion. Each booklet contained explicitly stated learning objectives and expected learning outcomes. Thus, overall, the instructional booklets covered more reflective and pedagogical aspects for primary trainers and TDs as compared to that for teachers. Overall, these booklets are good examples of designing instructional materials suitable for the different levels of cascade model TPD programmes.

Selection of a group of Teacher Developers

A critical parameter for the cascade model of TPD is the selection of individuals who act as secondary trainers. The selected group of 42 TDs were from diverse backgrounds and differed substantially in terms of age, years of service, regional language and previous experience with teacher education. Most of the TDs were from Karnataka, Kerala or Maharashtra and were conversant with at least two Indian languages, apart from English and were associated with the teaching of chemistry at the school level. The recruitment of a diverse group of TDs can be advantageous as it can lead to rich peer-interactions and/or primary trainers-TDs interactions during capacity building workshops for TDs.

Workshops for TDs

Three workshops, each of five-day duration, were conducted by the primary trainers for the TDs, during 2014–2015. The first development workshop primarily focused on module 1, that is, the ALS along with group work, reflective thinking and introductory sessions about misconceptions in chemistry. After the first workshop, TDs were encouraged to conduct some pilot workshop/s in their local areas so that they could share their experiences and the challenges faced by them in the subsequent workshop.

During the second workshop, the primary trainers provided the TDs sufficient time for sharing their experiences from the pilot workshops conducted by them. This workshop covered activities and experiments that can be used while teaching various chemical reactions and equations in secondary level chemistry classes. Moreover, TDs were encouraged to develop resources that could be used by them in the workshops they would conduct. The third

workshop, conducted after a gap of a year, focused on content enrichment about some of the core topics in chemistry syllabi at the secondary/higher secondary levels. Also, the focus on generating resources using ICT continued. This workshop included more detailed discussions about misconceptions in chemistry as requested by the TDs. Thus, across these three training workshops, progressively, the TDs were empowered to conduct TPD workshops and reduce their dependence on the primary trainers.

Results

Impressions through interactions with TDs

As part of the evaluation study, we interacted with TDs to understand their impressions about the programme. Through a questionnaire and personal interviews with TDs, we gathered information regarding their capacity building, the number of workshops conducted by them, resources developed, challenges faced and the strategies adopted by them to overcome challenges, etc. Additionally, we observed TPD workshops by seven TDs to understand how they conducted the workshops and what was being transferred in the process to teachers.

Overall, we found that the TDs were highly positive about their capacity building. In our survey, we obtained responses from 20 TDs who were actively conducting TPD workshops and the consensus opinion among these TDs was that the RSC training not only equipped and empowered them for conducting the RSC-TPD workshops but also helped them to mature as facilitators. While evaluating the programme in 2018, we observed that only half the initial number of the TDs were actively conducting TPD workshops. The TDs who could not conduct the workshops were primarily in-service teachers. Informal interactions with a few of these in- service teachers (TDs) indicated that their inability to get leave from their schools/institutions was the primary reason for non-conduct of TPD workshops. This situation also reduced opportunities for them to visit other schools in order to organise workshops.

We observed seven RSC-TPD workshops conducted by different TDs in the states of Karnataka, Kerala, Maharashtra, Gujarat and Madhya Pradesh. The duration of each workshop was generally two days. The number of teacher participants ranged from thirty to forty. The discussions during the workshops revolved around the RSC booklets for teachers and often the sessions were successful in actively engaging the participants. During these workshops, we observed that the TDs had extended the inventory of resources to other subjects and local languages. The workshops were highly interactive and significant efforts were made by TDs to exemplify the idea of active learning to teachers. Often, the TDs communicated both in English and the local languages.

We also observed that teachers from other disciplines (biology, physics, mathematics etc.) often participated in the workshops originally designed for chemistry teachers. In such cases, experiments from physics and biology, in addition to chemistry, using low cost, easily available materials were demonstrated and discussed by TDs. For a few workshops, the teacher participants also performed the experimental activities on their own. The RSC chemistry experiments were modified by TDs using the materials available at the local level; making these more accessible to teacher participants. Some TDs also ensured that towards the end of the workshops, the teacher participants collaboratively designed lesson plans for any topic from their discipline, using various ALS. All these efforts by TDs demonstrate that they had not only internalized the key ideas introduced to them but were also able to customise them as per the needs at the local levels.

The TDs faced several challenges in organizing the workshops. The list of common challenges faced by TDs is presented in Table 3 along with how TDs dealt with these challenges. One of the main hurdles faced in the initial phase of the programme was to

gain permissions from schools to conduct the workshops. Often, TDs managed to obtain the permissions through personal contacts or by collaborating with NGOs or other Government bodies. When TDs had to curtail the duration of the workshops due to various constraints, the session on misconceptions tended to be compromised. The module on student misconceptions, due to its abstract nature, was generally conducted after the introduction of the ALS and the module on chemical reactions (including experimental activities). As mentioned before sensitization of teachers to student misconceptions, especially about the particulate model of matter, a central explanatory framework in chemistry, is crucial in the adoption of teaching strategies in the chemistry classrooms. However, in some cases, TDs did not have much control over the time allocated to them for the conduct of TPD workshops and thus even though they were keen on conducting the misconception sessions; they were unable to do so.

The teacher participants were positive during the feedback sessions at these workshops and appreciated (i) the active engagements (ii) the concrete activities done by TDs and given in the booklets which according to them would be useful in classrooms and (iii) the conduct of the sessions. Overall, teachers mentioned that these workshops helped to understand the philosophy of ALS.

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Impressions through interactions with teachers and classroom observations

To understand the percolation of ideas to the chemistry classrooms, we visited several schools and observed classes. Our sample comprised of 32 Government/Government aided schools, located in urban, semi-urban and rural areas of Maharashtra, Karnataka and Kerala. We kept in mind the time gap between the RSC-TPD workshops and our visits, and this gap varied from a few months to 2 years.

Table 3: Challenges Faced by TDs and the Strategies Adopted by them to Overcome these Challenges[3]

Challenges faced by TDs	Strategies adopted by the TDs
Organising workshops	Using personal contacts/Public-Private partnerships
Non-availability of proper infra-structure and materials	Carrying essential chemicals, laptops, projectors, UPS and other requirements with them. Substituting glass-wares and apparatus with easily available low-cost materials.
Dealing with a large group of teachers (more than 100)	Increasing the number of TDs per workshop and dividing the teachers into smaller groups.
Teachers who speak regional languages	Using a combination of both English and the regional language whenever possible. Requesting participant teachers to translate some of the technical terms Including games and activity cards in regional languages.
Dealing with a mixed group of teachers (Physics, Biology, Mathematics etc.)	Including a few games and activities related to non-chemistry subjects.

The data collection, from the selected schools, commenced in July 2018 and lasted until January 2019. The states mentioned above exhibited considerable linguistic diversity reflected in the media of instruction, especially at the school level. Regional language and semi-English (that is only science/mathematics taught in English) schools are common in these states in addition to the English language schools. For these three states, we selected a few schools from 3 to 4 districts. Owing to the torrential rainfall and resultant deluge in 2018, we confined the data collection in Kerala to five schools.

In this paper, we are presenting our observations for schools in the states of Karnataka (10 schools), Maharashtra (17 schools) and Kerala (5 schools) where the medium of instruction was either regional language or semi-English. Apart from classroom observations, we conducted semi-structured interviews with teachers and held focus group discussions with students in schools where activities from RSC modules were being implemented in the classrooms. The purpose of the focus group discussion was to understand the acquaintance of students with the activities as an indirect measure of implementation of ALS in the classrooms.

Due to time constraints and geographical locations of the schools, we visited these schools only once post the teacher development workshops. More frequent visits to these schools would have been useful in gaining in-depth insights about the classroom scenarios. This is a limitation of the study.

For Karnataka schools, the gap between our visit and the RSC-TPD workshops was at least one year or sometimes two years. Despite the considerable gap, teachers from schools in Karnataka were able to remember their TPD workshops and were highly positive about them. They were appreciative about both the content and pedagogical expertise of the TDs and the RSC modules. These impressions reinforce the proactive roles played by TDs for the TPD programme.

In most of our sample schools in Karnataka, teachers were using ALS and other activities from RSC modules in science classrooms. We witnessed the development of resources in both English and regional languages, by teachers for different science topics and their usage in classrooms. However, the teachers used these resources primarily as revision tools or evaluation tools rather than for teaching of new concepts. The activities were implemented as group activities and were engaging for students. In the case of the experimental activities, the demonstration mode was the predominant method used by teachers. During interviews, teachers expressed concerns regarding the safe handling of chemicals by students and stated that monitoring all students in the classrooms (or in laboratory space) is not easy. Thus, teachers perceived the demonstration model to be the 'safe' mode for chemistry experimental activities. The micro-scale model of experimentation was also not considered to be suitable for classroom demonstration purposes by the teachers hence they refrained from using it.

An intriguing development that we noticed in Hejamadi, (from Udupi district on the west coast of Karnataka), was that a group of teachers formed a practice of exchanging the resources developed by them. This collaboration played a vital role in the generation of resources and their continual use. These teachers opined that continual interactions and discussions with the TDs helped them be more confident in integrating the ALS based approach with their classroom teaching practices. During focus group discussions, we observed that most of the students were familiar with the ALS, indicating that these activities were being used in the classrooms fairly regularly. In most of these schools, the number of students in the classrooms was about 40 (or less) and thus the class could be managed by a single teacher using group work. Besides, the teachers had autonomy to execute ALS and other activities in the classroom.

Overall, for the schools visited by us in Karnataka, the presence of motivated teachers, the optimal number of students in the classroom and the positive attitude of the school authorities acted as a catalyst in integrating ALS with the classroom teaching-learning process. However, it is possible that if the cascade model would have included opportunities for sustained interactions between TDs and teachers, the impact of the RSC-TPD programme on the classroom practices would have been better since other favourable conditions were existing.

In Maharashtra, we also collected the post-development workshop data from 17 schools. For these schools, the gap between the RSC-TPD workshops and our data collection varied from two years to a few months. Besides, we also collected baseline data from 9 schools before the occurrence of teacher development workshops. We observed classes of a few teacher participants from Jalgaon district (a district in the northern part of Maharashtra) who had participated in RSC-TPD workshop. These teachers were using the ALS and these schools were more diverse in terms of the students' population and infrastructure as compared to the schools we observed in Karnataka. The number of students per classroom was about 50 to 60 per teacher, in the schools in Maharashtra and with such a student-to-instructor ratio, adapting and using ALS was not easy for teachers.

Of the 5 schools in Jalgaon district, one was a well-established school; the second was a rural school with fairly good infrastructure and facilities, whereas the remaining 3 were residential schools catering to tribal populations and located in tribal-dominated areas. In one of the tribal schools, we observed a few activities being used even at the primary school for teaching environmental studies. This was evidence that the ALS and other activities in RSC modules were adaptable even at primary level. This example also indicated that highly motivated teachers were successful in efficiently adapting the key ideas introduced through the RSC-TPD workshop for their classes. However, the situation in chemistry classrooms at the secondary level was not as rosy. We observed that even though the activities were being used in secondary classrooms, teachers often did not play the role of facilitators effectively. We saw that often opportunities for appropriate questioning were missed by the teachers and thus, students did not gain much from the activities. At times the activities were performed in a perfunctory manner.

In personal interviews, some of the teachers from the tribal schools stated that they could not internalize the key ideas of the RSC-TPD workshop due to a language barrier. They felt that more TPD workshops and particularly activities/resources in regional languages would have

helped them, to adapt and use these activities in their classrooms. Another fact that emerged through the discussions was that the schools shifted the medium of instruction for science and mathematics from regional to the English language. Thus, teaching-learning in 'English' was a huge challenge, both for the teachers and students and was the central concern for these schools. In such a scenario, innovating with the conventional teaching-learning practices took a back seat. This exemplifies what other researchers such as Thair & Treagust (2003), Wedell (2005), Avalos (2011), Shezi (2008), Gathumbi et al. (2013), Prince & Barrett (2014) and Gemeda & Tynjälä (2015) have indicated with respect to the need for individuals at the topmost layers of the cascade to be cognisant of the sociocultural factors in the teachers' work environment as these could impede the implementation of new strategies in classrooms.

Moreover, since the RSC-TPD workshops were being planned for some of the areas of Maharashtra, we collected baseline data from 5 schools of Ratnagiri (a coastal district in the western part of Maharashtra) and 4 schools of Bhor (a town in Pune district towards the western part of Maharashtra).

In these schools, teachers primarily used chalk and talk or the lecture method, in the chemistry classrooms that we observed. In a few of these schools, teachers demonstrated simple experiments while teaching some of the chemistry concepts.

On our visit to these schools, post RSC-TPD workshops (with a gap of 1 to 2 months); we did not witness any significant changes in the chemistry classrooms. Teachers were not implementing ALS and other activities in the classrooms, so we tried to understand the reasons for the same. In the Bhor region, where the class size often ranged between 60-80 students per division, teachers expressed their inability to handle group work. One of the teachers who did make efforts to implement the activities expressed a dilemma about the ideal group size for the activities. He wanted to be able to monitor each group and thus made groups with 10-12 students per group. However, such a large number of members in a group led to the fragmentation of the group into smaller groups and then class control became an issue. Despite this situation, the teacher did not want to make groups with few members (3 to 4 students/group) as monitoring the class would have been a challenging task. Thus, the teacher decided not to use ALS as he did know how to resolve this problem of group size. Also, the generation of an adequate number of resources for large class sizes demands time; which teachers were unable to allocate with their existing workload in the schools. These are representative examples of how certain factors in the teachers' work environment can hamper the implementation of key ideas covered in TPD. The problems raised by teachers are genuine and need solutions if ALS have to be integrated into classroom teaching. Without sustained interactions between TDs and teachers and no rectifying measures to enhance the student-to-instructor ratio, it was difficult for the TDs to fathom the intensity, at which various factors in the classrooms of the participating teachers were likely to affect the implementation of the programme. For TDs to understand the various vital factors relevant for the participating teachers and schools, there is a need for them to visit at least a few representative schools, especially before conducting the RSC-TPD workshops and also after.

In Ratnagiri region, apart from time constraints and the perceived infeasibility of ALS for large classrooms, teachers mentioned the vastness of syllabus, content overload and the conventional mode of assessment as additional factors that hampered the implementation of ALS and other activities. Teachers also opined that such strategies are more suitable for teaching science at lower classes rather than at the secondary level. Overall teachers need support if they are to make a shift from conventional teaching to activity-based learning.

As compared to Karnataka and Maharashtra, the sample from Kerala was limited. During the period of evaluation, Kerala was hit by torrential rains and recurrent flooding due to which the school schedules were affected substantially. We were able to visit five schools, located in three districts of Kerala, that is Idukki (a district in the central part of Kerala), Calicut and Malappuram (districts in the northern parts of Kerala). However, the school scenario in this state was significantly different from Karnataka & Maharashtra.

During our visits, we observed the government school classrooms in Kerala, equipped with laptops and projection facilities. In 2017, the Kerala government initiated the *Pothu Vidyabyasa Samrakshana Yajnam* (Mission to Protect Public Education) to improve the quality of education in public schools. As a result, numerous government and government-aided schools had substantial development of infrastructure including laptops and projectors facilities (Varma, 2018).

In addition to this, an e-resource portal called *Samagra* was also launched for school education by the state government.

Through interaction with teachers, we learned that the portal provides them with e-resources and lesson plans that are linked directly to their syllabus. Most importantly, these resources are in regional languages. Teachers frequently used these resources and were satisfied with them, primarily because of the direct connect to the syllabus. Additionally, the content could be edited as per need by the teachers who were also responsible for maintaining records of the usage of e-resources.

The teacher participants from the sample schools in Kerala had attended the RSC-TPD workshops during the year 2015–2016. Even with such a large time gap, we observed that a few ALS activities introduced by the RSC-TPD were being used in classrooms. Similar to teachers from Maharashtra, some of the teachers from Kerala, in the interviews, mentioned the vastness of the syllabus, classroom management and time constraints as the primary factors for non-implementation of activities. In our sample schools from Kerala, the number of students in the classrooms on an average was around 40. This class size is comparable to that in schools of Karnataka where teachers used ALS more frequently. Nevertheless, a few teachers in Kerala mentioned the number of students in the classrooms as one of the factors for non-implementation of ALS.

A crucial factor that affected the implementation of ALS and other activities in Kerala schools was the availability of e-resources through *Samagra*. The ALS and other activities introduced by RSC-TPD were not ICT based and were not linked to school chemistry syllabus directly. Teachers in Kerala had shifted to using technology in classroom teaching and were primarily interested in ICT based resources. With easy access e-resources in regional languages, adapting them for classrooms was a convenient option for teachers. Teachers also mentioned peer group interactions through routine cluster meetings as a valuable support system.

Thus, the evaluation study for the RSC-TPD programme indicates the following: (i) the programme was successful at level 1 of Guskey's model for both TDs and teachers as they were highly appreciative about their development (ii) we witnessed strong evidence, both for TDs and teachers regarding the development of new resources and appropriate adaption of the illustrated resources, indicating the transfer of the key ideas (iii) however, for level 4, the usage of illustrated/new resources and the pedagogical skills by teachers varied substantially across the states and was primarily influenced by the classroom realities, especially, by the number of students in the class (iv) the programme was affected at level 4 due to absence of sustained support to teachers in terms of follow-up/feedback mechanism and (v) awareness about the sociocultural factors at the school level is important for planning and implementation of TPD programmes.

Discussion

For the cascade model implemented by RSC-TPD in India, there was evidence that the capacity- building workshops and the instructional resources helped TDs to develop as facilitators and also build their confidence to conduct workshops independently. Teachers were found to be highly appreciative of the content knowledge of TDs and the manner in which the TPD workshops were conducted. We found the implementation of the ALS by the teachers in chemistry classrooms to be better in Karnataka where maximum workshops had been conducted as compared to other states.

However, we observed that even in Karnataka, the ALS did not take a central position in chemistry (science) classrooms. A critical factor that appeared to hamper the transition of ideas to the classrooms was the lack of a sustained support system for the teachers. The post-workshop interactions between the teachers and Teacher Educators are important as these can help teachers receive appropriate feedback while

planning and implementing new techniques. According to Turner et al. (2017), the mentoring of teachers is vital for the success of the cascade model of TPD programmes. Providing opportunities for the active involvement of teachers in their professional development through action research and peer interactions in the form of collaboration, co-learning, cluster meetings, mentoring of novice teachers by senior teachers etc. are also effective approaches that can enhance positive changes in the classroom teaching-learning process (Guskey, 2002; Thair & Treagust, 2003; Henly, 2005; Shezi, 2008; Lewin et al., 2009; Mokhele & Jita, 2010; Avalos, 2011; Hunzicker, 2011; Ramnarain & Ramaila, 2012; Gathumbi et al., 2013; Bett, 2016).

The RSC-TPD focused primarily on the transfer and propagation of ideas to a pre-set target population of teachers. However, there was no emphasis on post-workshop interactions with teachers. During the initial stages of the programme, the TDs bore the sole responsibility of seeking permission for arranging and conducting RSC-TPD workshops. With limited access to school systems, it was difficult for TDs to learn about the socio-cultural factors and the challenges faced by teachers in the classrooms. Such an understanding would be useful for secondary trainers (TDs in this case) to arrive at plausible solutions.

Some of the positive aspects of the RSC-TPD programme regarding its implementation by the cascade model were: (i) efforts for mapping of instructional material on the National level chemistry syllabus (NCERT) in the Indian context (ii) identification of some of the key areas/concepts in Indian chemistry school syllabus/textbooks (iii) development of instructional modules for different stakeholders (primary trainers, TDs and teachers) and (iv) structure and progression in the development workshops conducted for TDs.

Conclusion

The knowledge gained from the evaluation of TPD programmes can strengthen various aspects of the same or similar programmes, such as its design, content, delivery/ execution, organizational support and feedback systems (Guskey 2002). In our opinion, measures like producing resources in regional (Indian) languages, initiating periodic follow-up with at least some teachers, mentoring teachers through on-line mode are important in making TPD programmes effective in terms of their impact on the conventional teaching-learning practices in schools. Another possible measure suggested by Gaible and Burns (2005) and Wedell (2005) is the collaborations between teachers from different schools in the same geographical area through structured meetings. Such interactions can act as a catalyst for the actual implementation of teaching strategies. Such meetings did take place in the state of Kerala and teachers acknowledged their significance in arriving at solutions for the teaching (and other) challenges in the classrooms. Initially, TDs can take a central role as facilitators in these meetings, and this role over a period can be shifted to competent teachers to empower them, a process similar to the one that took place in capacity building of TDs by primary trainers.

We hope that the observations from this study would help in better planning and implementation of TPD programmes based on the cascade model. Awareness about diverse scenarios in the classrooms among the experts as well as secondary trainers is important in the implementation of large scale TPD programmes. Furthermore, a sustained support system for teachers through interactions with secondary trainers needs to be an integral part of the cascade model for better percolation of ideas to the classroom.

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