

The role of professional learning communities (PLCs) in supporting chemistry teachers during the COVID-19 crisis.

Subject/Problem. In the beginning of 2020, lockdowns were imposed due to COVID-19 pandemic and schools were compelled to divert to Emergency Distance Learning (ERT) (Hodges et al., 2021). This change required simultaneous adaptations in all aspects of the teachers' work e.g., pedagogy, assessment, use of technological tools, and communication with students (Hodges, et al., 2021). Since ERT was adopted globally, this crisis offered a unique opportunity to study the transition to ERT. Adapting to the new reality led teachers to seek support (Rap et al., 2020). One channel providing support were Professional Learning Communities (PLCs). In a PLC, teachers with a common background meet regularly for discussions and joint learning; knowledge is built by sharing classroom experiences and practices, and participation in activities and discussions within the group (Booth, 2012; Orland-Barak, 2020). Relationships form among teachers promote collaboration unique to communities (Wenger et al., 2011). The Refined Consensus Model (RCM) for PCK (Carlson & Daehler, 2019), is the framework used to analyze the aspects of chemistry teaching during ERT. We focus on three aspects of the RCM model: the models' basis, i.e., pedagogical knowledge management, use of technology, assessment, and knowledge of students; the common knowledge (cPCK) shared by PLC members; and the contribution of the PLC to the formation of personal knowledge and skills (pPCK). Since PLCs operate continuously, our research goals are to understand changes in teachers' work compared with the routine before the pandemic and learn about the support aspects PLCs provided. Specifically, this work aims to answer the following research questions: (1) From what sources do chemistry teachers seek support? (2) In what aspects the PLCs support member teachers? (3) How does teacher diversity affect the support discussed? Questions are examined from the perspective of PLC members and includes a comparison to non-member teachers. The study considers ethnic differences among chemistry teachers in Israel. The inclusion of all these perspectives enhances the understanding of PLCs' contribution to teachers during the crisis and leads to practical recommendations to improve community's support and introduction of educational changes to teachers.

Design. Research Setting – This research was conducted in the setting of a PLC network in Israel that operates from the Technion – Israel Institute of Technology and seeks to support the development of chemistry teachers. A Teacher Leaders Community (TLC) which includes senior teachers is the basis of network; TLC members lead Chemistry Teacher Communities (CTC) close to their home, as described by to the “fan model” (Levy et al., 2020). These communities met continuously since 2018 face-to-face or by Zoom.

Research Participants – Two PLCs included in this research: one is Northern Israel's TLC that includes 21 members, most with more than seven years of teaching experience. The community joins members from various factions of the Israeli society, a third of them Arabic speakers. Three coordinators who are experienced chemistry teachers who also work in academia or as teacher supervisors in the Ministry of Education run activities. The second is Haifa's CTC which includes 23 members, 2 of them Arabic speakers; their teaching experience ranges from three to over 31 years of teaching. We also show results of a questionnaire answered by 122 Israeli chemistry teachers. Most responses, 67.2%, were from PLC members. The other responses were of teachers who are not PLC members. Teachers from the Jewish community, “Hebrew speakers”, comprised 57.4% of responders; Arab and Druze teachers “Arabic speakers”, were 44.6% of respondents. Teachers' experience was in a range between two to over 40 years of experience.

Research Tools and Methodology – In this mixed methods study, qualitative and quantitative data collection were carried out separately, and analyzed together to provide an in-depth interpretation

of the data (Creswell et al., 2003). Semi-structured interviews were conducted with coordinators of the TLC, TLC members, CTC members, and chemistry teachers not participating in a PLC. The interviewees' group was selected based on availability and reflects upon the diversity of communities' members. Interview goals of the were to characterize the teaching process in class vs. ERT mode, identify teachers' challenges, and examine the PLCs' role during ERT. Although the questions were planned, we maintained flexibility and enabled personalization of the interview protocol (Barriball & While, 1994). All interviews were audio-recorded, transcribed, and qualitatively analyzed.

The questionnaire was developed to understand teachers' strategies for coping with ERT, and the challenges they faced during 2019-20 school year. It included questions concerning pedagogical aspects e.g., assessment and maintaining personal relationships with students; inquired on technological challenges, changes in teachers' work environment; participants' demographic and personal data were collected anonymously. Experts were consulted on the items in the questionnaire before it was administered electronically to chemistry teachers in Israel. Thematic analysis was used to analyze the texts of transcribed interviews and answers to open-ended questions in the questionnaire. Our work followed the steps detailed by Braun and Clarke, (2006). A set of codes was formed after initial review of the data. The set included the various types of teacher's knowledge, according to the conceptual framework, and aspects typical to chemistry teaching, e.g., hands-on learning. Additional codes were defined during coding, to categorizes all topics in the texts. For reliability, sample texts were coded separately by different researchers; differences were discussed, and codes were clarified by a negotiated agreement approach (Watts & Finkenstaedt-Quinn, 2021). Finally, codes were grouped into themes, considering the theoretical framework and the comparison with the results obtained from the quantitative analysis.

In the multiple answer questions, teachers were allowed to mark more than one answer, responses were coded using thematic analysis and given the same weight. Exploratory factor analysis was used to explore factors of the questionnaire's Likert type items. Four factors were found: (1) Teaching high order thinking skills; (2) Assessment of learning; (3) Teacher's knowledge of students learning characteristics; and (4) Teacher-Student relationships in the learning environment. Cronbach's α values were larger than 0.74 for all factors.

Analyses and Findings. Source of Support - To identify sources support chemistry teachers working in ERT Mode leaned on, the questionnaire included the multiple answer question: "How

did you cope with the technological challenges during ERT?". List of answers included: prior knowledge, independent learning, support of family and acquaintances, chemistry teachers support, PLC meetings, school support, etc. A total of 541 responses were collected, 73% of then from teachers in PLCs. Sources of support were divided into three categories. One was personal sources, i.e., family, friends, teacher's previous knowledge, and abilities; the others were support from chemistry teachers, and support of schools and the Ministry of Education. Comparison of preferred support source revealed that non-members were self-reliant, while PLC members preferred to receive support from other chemistry teachers

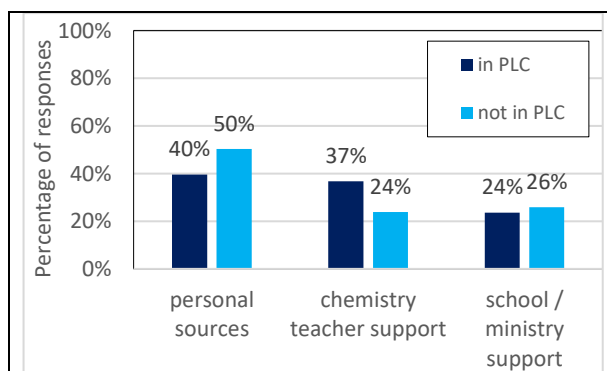


Figure 1: Support aspects preferred sources of support by PLC members (N=394) and teachers non-members (N=147)

reliant, while PLC members preferred to receive support from other chemistry teachers (**Error! R**

eference source not found.); this result was significant ($p < .05$, $\chi^2(2) = 8.563$). On a professional level, ideas and teaching materials shared in the community, were the basis for planning lessons and class activities, for example: *“The community took us a step forward, sharing ideas and [activities] ... Suddenly [teachers] became professional and shared a variety of things they created. Then they communicated it, building a process with us, like we were pupils; it was excellent”*. The rapid transition to ERT was an emotional task. Sharing within the community reduced the feeling of isolation and supported teachers, as one teacher wrote: *“The community was where we shared our fears. I realized I was not the only one facing difficulties”*. Among chemistry teachers in Israel, the diversity in spoken language is a central issue. Hebrew speakers are the majority; Arabic speakers are bilingual. Therefore, inclusion of teachers who speak and teach in different languages in a PLC deserves attention. Comparison of preferred support sources between Hebrew and Arabic speaking teachers showed similarity: 42% and 44% of responses, respectively, were related to reliance on personal ability; 33% and 43%, respectively, noted receiving help from other chemistry teachers; and 25% and 22%, respectively, mentioned assistance given by schools and Ministry of Education. In the PLCs described in this research, the spoken language is Hebrew. Thus, Arabic speakers faced an extra challenge of translating teaching materials. One Druze teacher explained: *“In every assignment I make adjustments.... I always change something or adapte it to the people I’m teaching.”* Translation is a time-consuming task; working in a community enables teachers to share translations. In CTC with a majority of Arabic speaking teachers, materials were developed in Arabic, as a member said: *“I [usually] translate... because there was a majority of Arab teachers, we asked the [PLC] leaders to do the work in Arabic, so we will have a collection of activities, and they allowed it.”* The relationships among PLC members inspired feeling of unity in spite of diversity. One Arabic speaking teacher who independently found solutions to difficulties, still valued the support of the group: *“...I think that only sharing within the community, with teachers, felt better, because we are all the same, all share the same challenges, and this is OK. I did not use tools suggested in the community to connect with my students”*. Other personal issues, such as working from home, the need for family support, or challenges parents of young children, were described by teachers belonging to all parts of society.

Type of support – The results presented above were also analyzed considering the type of support teachers preferred. Responses were classified into three categories: for teachers who preferred to rely on their personal abilities, receive support in a group setting, or accept help individually from colleagues. A higher percentage of PLC members favored group support compared to non-members, who relied on their personal abilities (Figure 2); this tendency was not significant ($p > .05$, $\chi^2(2) = 4.155$). Comparison between Hebrew and Arabic speaking teachers also showed similarity

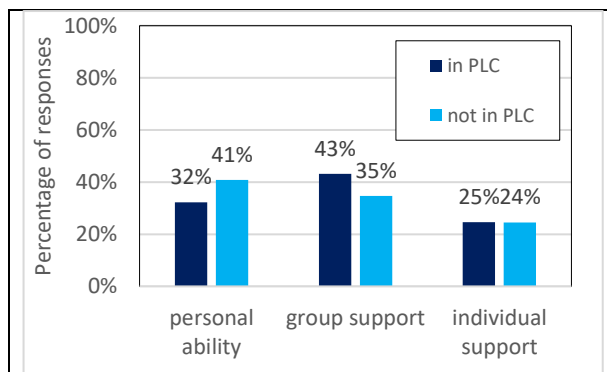


Figure 2: Type of support preferred by PLC members (N=394) and teachers non-members (N=147).

in this aspect: responses referring to personal ability were 34% and 36% respectively, responses indicating preference to group support were 41% and 40%, respectively, were, and 25% and 24% of responses referred to individual support.

Aspects of PLC support - Teachers were asked to compare their teaching experience during ERT vs. their usual routine, in the aspects of teaching, assessment, and maintaining relationships with students. Responses to 18 items were collected using a 5 level Likert scale ranging from 1 “almost impossible during COVID-19 crisis” to 5 “significant improvement due to COVID-19 crisis”. Four factors were identified: (1) Teaching high order thinking skills,

(2) Assessment of learning, (3) Teacher’s knowledge of students’ learning characteristics, and (4) Teacher-Student relationships in the learning environment. Figure 3 shows that assessment was the most difficult aspect of teaching in ERT mode, as claimed by teachers (mean score =

1.89). On the contrary, Teacher-Students personal relationships, in class or on-line, was rated a little above 3 (mean score = 3.1), meaning that teachers felt there was almost no difference between teaching during ERT vs. their usual routine. Significant differences were not found comparing factors’ mean scores between PLC members and non-member teachers, and between

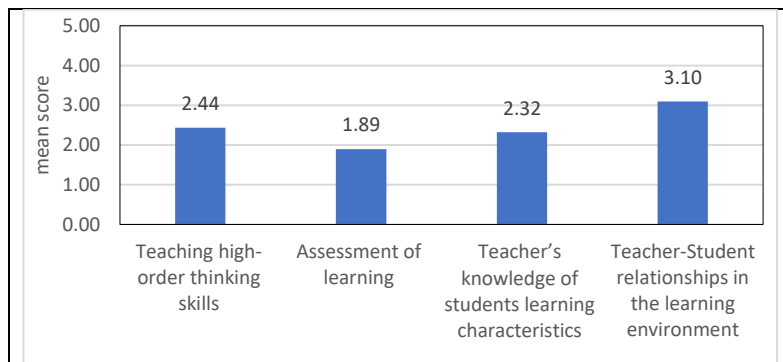


Figure 3. Mean score for factors dealing with pedagogical aspects during ERT (N=122)

Hebrew and Arabic speakers. In response to open ended questions in the questionnaire, teachers described the challenges they faced. On assessment statements indicated that teachers struggled with comprehending whether students understood the topics presented during class, monitoring the process of problem solving by students, the reliability of exams, and adapting exams to digital format. An experienced teacher explained during her interview: “[In Zoom] they learned and solved well; the average grade was over 85. When we returned to class, I noticed they had figured out how to work with online worksheets, probably together, to turn in for good grades. But it was far from representing their true knowledge”. Other challenges detailed concern teaching high order thinking skills. The inability to work in the lab was mentioned by many teachers. Other statements were related to instruction of scientific skills, two examples are: “[When teaching] Scientific topics, students acquire skills, which are difficult to pass on in remote teaching”; and “[topics of] stoichiometry and energy [were difficult], students have difficulties with complex calculations”. Advantages of the shift to ERT were attributed to students who worked independently, practicing problem solving. For example: “The improved aspect of teaching was practice of multiple-choice questions. Each student gets their own time without interruptions from others.”. The factor “Teacher’s knowledge of students’ learning characteristics” included two aspects: Self-Regulated Learning (SRL) and responding to individual students. SRL, attributed to individual work of students, was mentioned by many teachers. One teacher wrote: “There is a significant shift of responsibility for learning to the student.... A student can choose to be more, or less, attentive and involved in the learning process”. Working with small groups or individual students was assisted by technological tools. Zoom breakout rooms were described as more effective compared to groups in a traditional classroom: “The good thing I found was working in groups on assignments or lab reports. Moving among breakout rooms enables giving attention to every team without

interruptions, making it possible to push them forward as a group.” Opportunities inherent to remote teaching, which benefit individual students even without direct interaction with a teacher, were noted: *“Some students thrive on-line: those with ADHD, Autism Spectrum Disorder, behavior problems, or a preference to learn alone and manage time independently”*. The last factor, ‘Teacher-Student relationships in the learning environment, included issues of class management. Teacher reported that coping with behavior problems was simpler in on-line mode.

Discussion and Contribution to the Teaching and Learning of Science. Teaching in ERT mode presented diverse challenges to teachers. Answering the first research question about the support teachers seek, results showed that PLC members preferred the setting of group support. Thus, we concluded that chemistry teachers’ PLCs had an important role in support and fulfilling teachers’ needs during ERT. Regarding the second question, two knowledge gaps were mapped with respect to the RCM (Carlson & Daehler, 2019). One is the basis of teachers’ knowledge i.e., assessment knowledge, technical knowledge, and knowledge of students; the second is the pool of class activities and teaching techniques, included in cPCK. Collaboration advanced PLC members towards filling these gaps. Sharing information, guidance, and useful tips about technological tools strengthened their technological knowledge. Sharing teaching activities, developed especially for online use, enriched cPCK; some teachers reported this was essential for their teaching online. This exposure to a variety of novel tools and activities is a direct contribution to both aspects of PCK. PLCs were not the only source of know-how in these fields. Teachers reported that they were able to acquire the needed skills individually and in private consultations with colleagues. These skills and knowledge add to the basis of knowledge of specific teachers. In our opinion, the independent work of teachers has a smaller contribution to cPCK, compared to PLC activity. According to PLCs’ framework (Hord, 2009; Wenger et al., 2011), the relationships formed among community members are the basis for joint learning and professional development. Views of teachers included in the results describe cooperation and the importance of sharing of professional assets in communities for teachers during COVID-19 crisis. The significance of relationships in the community found here, is also identified by other researchers as summarized by Vangrieken et al., (2017). Review of diversity within PLCs considered the diversity in speaking and teaching language among chemistry teachers in Israel. Teachers’ statements revealed that the PLCs that included a variety of teachers with respect to speaking and teaching language provided significant support to all. Although Arabic speaking teachers have needs which differ from their Hebrew speaking colleagues, they found the community to be an important and useful source of support and materials during ERT. The relationships within the communities with diverse members were regarded in higher importance compared to the work related to adoption of teaching materials written in Hebrew. Connections between Arabic speaking teachers enabled sharing of materials written in Arabic. Both Hebrew and Arabic speakers reflected in their statements the emotional support given in PLCs and its importance. The similarity among members of diverse communities is also supported by qualitative results, indicating similarity in all issues considered here: emotional, and professional. As PLCs were supportive in times of crisis and were found to be a platform for developing professional knowledge among teachers, we recommend expanding the network of chemistry teachers’ PLCs and making the communities accessible to more teachers. The support PLCs provided teachers from diverse backgrounds, both professional and emotional aspects, shows the advantages and potential of communities in promoting inclusion of variety chemistry teachers in communities, extending cooperation outside school boundaries to regional and national levels and beyond.

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