The Value of Participation in Professional Learning Communities (PLCs) for High-School Chemistry Teachers

Subject/Problem. Professional Development (PD) for teachers is recognized as the main tool for supporting teachers in their work, and advancing their knowledge, two aspects that should result in promoting students' learning and achievements (e.g., Desimone, 2009; Dufour, 2004; Hord, 2009; Loucks-Horsley et al., 1996). Therefore, PD programs for teachers are included in the implementation of teaching reforms (Barnea et al., 2010; Blonder, 2018; Bybee & Loucks-Horsley, 2000; Guskey, 2014; Mamlok-Naaman & Taitelbaum, 2019), and embedded in teachers' working routine (e.g., Hamos et al., 2009; Hedger, 2018; Kennedy, 2016; Nadelson et al., 2013; Waldman, 2020). The continuous operation of these programs requires an evaluation of their effectiveness so that they can continue to receive support from stakeholders, be improved, and expand the theoretical knowledge of teachers' professional development (Barnea et al., 2010; Hamos et al., 2009; McComb & Eather, 2017; Nir et al., 2016).

Professional Learning Communities (PLCs) are a platform for teachers' PD, which has become popular in recent years (Avidov-Ungar, 2018; Blitz, 2013; Eylon et al., 2020; Richmond et al., 2017; Vangrieken et al., 2017; Waldman & Blonder, 2020). PLCs are communities where teachers with a common background meet regularly for discussions and collective learning. By sharing knowledge, classroom experiences, and educational views and practices, this platform aims to enrich teachers' knowledge and improve students' learning, and assessment (Orland-Barak, 2020). Personal relationships formed within PLCs differ them from other PD programs by encouraging mutual assistance and improving teachers' well-being (e.g., Hallam et al., 2015; Hamos et al., 2009; Hord, 2009; Wenger et al., 2011). The opportunity for teachers to learn in a community was recognized by Loucks-Horsley et al. (1996) as one of the features of effective PD. Learning within a community differs from learning in a classroom where, usually, knowledge is passed from teacher to student. In PLCs, as in Communities of Practice (CoPs), learning occurs as members discuss problems, debate solutions, or demonstrate work procedures (Lave, 1991; Wenger & Snyder, 2000). Wenger et al. (2011) described two properties of a PLC: "community" - which was defined as a closed group focused on shared identity and interests or goals, and "network" - which was defined by the authors as an open set of connections and relationships among people. From the authors' viewpoint, each PLC is characterized by the balance between these two qualities.

The rising popularity of PLCs as a PD platform raises the need for evaluation of PLCs and their contribution to participating members (e.g., Booth, 2012; Owen, 2014; Vescio et al., 2008). Based on the Value Creation Framework developed by Wenger et al. (2011), this paper examines the value gained from participating in PLCs from the perspective of the participants. In this framework, five categories of value that can be associated with participation in PLC activities are defined (see Table 1 for the description of each value). The use of this framework includes an analysis of teacher reflections on their participation in PLCs collected using a unique format called "Value Stories". The Value Stories consist of teachers' views of their PLC experience. A "toolkit" that includes questions and topics to consider when telling or writing a story was developed by Wenger et al. (2011, p. 1), examples in Table 1. Additionally, the framework contains guidelines for analyzing these stories in conjunction with other data that can be collected to describe community activity, such as attendance data, meeting observation records, and analysis of products developed by the PLC (Wenger et al., 2011). This framework has been used to evaluate various PLCs. For example, Booth & Kellogg (2015) used this framework to study online communities, analyzing Value Stories collected in interviews. Their work demonstrated the advantages of using this framework to describe the professional developments of participants in the online PLCs.

Cowan and Menchaca (2014) examined a graduate program in educational technology involving CoPs. They used network analysis based on questionnaires and focus groups and analyzed qualitative data using the Value Creation Framework. Using this framework, the authors gave a holistic view of the program. The need for PLC evaluation was expressed while teachers collaborated to incorporate design principles into STEM instruction as part of implementation of a new Dutch science curriculum, that addressed 'technical design skills'. (Stammes et al., 2020; Vossen et al., 2020). Reflecting on projects of teacher PD using PLCs, Martinovic and Milner-Bolotin (2020) discussed the relation between knowledge and practice in PLCs and emphasized the need for further research directed at understanding teacher learning. In this study, the framework for evaluation of PLCs presented by Wenger et al. (2011) was used to study the value of participation in PLC for high-school chemistry teachers. Therefore, we asked the following research question: As a result of participating in the PLC network, what value was gained and how it was described?

Table 1. The Five Value Cycles and Short Descriptions, Following Wenger et al. (2011)

Value Cycle	Description	Example
Immediate value: Activities and interactions	Benefit from the sharing of materials and interactions during meetings and related conversations with other members.	Can you describe the meaningful activities you participated in?
Potential value: Knowledge capital	Skills, knowledge, materials, and relationships that became available to members and may be used in the future if necessary.	What specific insights, information or materials did you gain?
Applied value: Changes in practice	Class implementation of ideas that originated in the community, and the adoption of new materials and procedures to be used in class.	What impact did activities and community connections have on your classroom teaching?
Realized value: Performance improvement	Changes in teaching practices which resulted from reflection on community experience.	In what ways did the PLC help you achieve your personal and professional goals?
Reframing value: Redefining success	Rethinking of goals, pedagogy, and success definitions, as well as sharing community benefits with others.	Have your views on teaching topics and approaches changed? Did you influence your colleagues' or the principal's opinions?

Design. Research Setting – This research was conducted in the setting of a PLC network in Israel that seeks to support the development of chemistry teachers. A Leading Teacher Community (LTC) which includes senior teachers is the basis of the network; LTC members lead Chemistry Teacher Communities (CTC) close to their homes, as described by the "fan model" (Levy et al., 2020). Since 2018, these communities have met continuously, face-to-face or by zoom. Members

of the network represent various factions of the Israeli society, both Hebrew and Arabic speakers, and discussions are held in Hebrew.

Research Participants –Three PLCs participated in this study: The first is Northern Israel's LTC which includes 16 members, most of whom have teaching experience of over seven years. Three coordinators lead the Northern country's LTC, who have experienced chemistry teachers that also work in academia or in education ministry supervisory roles. The second community includes 20 members, mostly teachers who speak Hebrew as their mother tongue, some immigrants from eastern Europe, and three Arab-speaking teachers who speak Hebrew as a second language. The third community is a CTC which includes 20 Arabic-speaking teachers, who speak Hebrew as a second language. This community is centered in an Arabic town in northern Israel. Members of the CTCs have teaching experience ranging from one to over 31 years.

Research Tools and Methodology – This qualitative study was based on the reflections of PLC members. Teachers are required to write end-of-year reflections as part of their PLC participation. Teachers were asked to write their value stories at the end of the 2021-22 school year; this task was based on guidelines from Wenger et al. (2011). The questions were translated into Hebrew, and examples are included in Table 1. In addition, teachers were asked about activities they adopted in their classes following their involvement in PLCs. They were also asked to reflect on the unique qualities of their PLC and to share other thoughts. Teachers who agreed to participate contributed 31 reflections. After reading all reflections, we selected nine for further analysis, three from each PLC. First, reflections were chosen to reflect network diversity. Second, reflections mentioning specific PLC activities were preferred over general impressions. Thematic analysis was used to analyze the texts. Our work followed the steps detailed by Braun and Clarke, (2006). According to the conceptual framework, codes were created for various categories of value. Coded segments were also categorized by other aspects, such as activity, contacts, or PLC description during coding. Since the data was complex, we used negotiating agreement, where the first researcher independently coded and the final codes were discussed and agreed upon in various meetings. (Watts & Finkenstaedt-Quinn, 2021).

Analyses and Findings. All reflections mentioned the first four value categories: Immediate, Potential, Applied, and Realized value; Reframing value was mentioned in only seven of them.

Immediate value was demonstrated by teachers describing their contact with colleagues, including meeting them and forming personal relationships. In all analyzed reflections, this was cited as being the most significant factor for creating immediate value. Teachers described the discussions as fruitful, productive, and encouraging. One teacher wrote: "*There were group discussions and communal work... Everyone shared their challenges and experiences, collaborating, discussing, and learning from one another to find practical solutions. [Faiz 9].* Teachers described PLCs as safe places and as promoting unity, as one teacher summarized: "*My highest value is not a specific activity or a significant person, ... [but] the feeling of unity and safety in every meeting." [Lilach 7].* In seven out of nine reflections, teachers described interesting and enriching activities. One teacher reflected on suggested opening lesson activities: *"PLC members discussed the activities for the opening lesson, allowing the teacher to get to know students in contexts not related to instructional materials." [Anna 92].*

Potential value – Six reflections discussed future implementation of presented activities. Plans for future lessons were mentioned, as well as activities that would require planning. Following PLC activity, an experienced teacher outlined what she would teach ninth-grade students: *"In one meeting, leaders provided Lego blocks and we discussed how to use them in lesson [on materials' structure]. At the time, it didn't fit my needs... [but] now... I'm planning a syllabus for the 9th grade*

that will join next year... I plan to use Lego... I ordered the necessary blocks. [A detailed plan for 9th grade followed]" [Ilana 38].

Applied value – All reflections listed PLC activities teachers used in their classes. Community members offered teachers new instructional materials and ideas that enhanced their knowledge. The most frequently mentioned activity was writing questions together for a matriculation-style test, as one teacher detailed: *"My PLC helped me create a matriculation-style exam for my students, a yearly challenge. The exams shared by community members helped me choose questions that best prepared my students [for the final matriculation exam]." [Lilach 16]*

Realized value – The fourth value focused on performance improvement. Two aspects of teachers' realized value were impacted by the PLC: personal sense of ability and satisfaction, and their pedagogical progress. A CTC member reflected on her sense of ability: *"I solve problems differently because of the PLC. Today, I'm calm and believe more in my students' potential, in collective learning, and I use various assessment methods" [Farida 45].* A teacher described how sharing one's own experience and beliefs contributed: *"I felt my voice was heard [in the community] ... I assisted those who asked by sharing worksheets and tests, and mediating the topics discussed." [Amira, 22].* Teachers' positive feelings were mostly due to relationships with other members. Community support was evident during the COVID lockdowns. During remote teaching, zoom meetings were held and groups communicated through WhatsApp. As one teacher wrote: *"... [during lockdown] a lot of uncertainty existed, ... I felt I wasn't alone, and others faced similar situations. It was very comforting... We always discussed challenges most teachers face, and everyone shared experience and knowledge." [Faiz 38].* Likewise, the sense of community was appreciated in routine, as a single chemistry teacher in her school wrote: *"...after all, I have limited interactions with adults at work... mostly with youth ... Being a member of the community relieves loneliness." [Anna 34].* Additionally, teachers with colleagues in their school valued the PLC's sense of community: *"I value the possibility of consulting with [other coordinators] who deal with issues relating to the Ministry of Education." [Ilana 27].* One of the PLC's strengths was its diversity. Building relationships with colleagues of varying experience, languages, and schools was welcomed. Five reflections discussed contacts between experienced and novice teachers. One experienced teacher, who is a CTC leader, wrote: *"Despite my seniority ... I feel contributed in every meeting from both experienced and novice teachers. It is reflected in new experiments and ones I perform differently ... it makes me think of the new method vs mine." [Jonathan, 26].* The second CTC in this study is the most diverse. It brings together Hebrew- and Arabic-speaking teachers who work in schools with various orientations and serve students from diverse backgrounds. As one member wrote: *"One unique aspect ... is the heterogeneous community: Moslems, Druze, Jews; secular and religious; urban and rural area [schools]; young and old; seniors and ones in the beginning [of their career]. This creates interest, ... spices the [PLC] experience, and creates openness. We all have different pedagogical conceptions and can learn from each other." [Ilana 21].*

Second, pedagogical changes emerged from the reflections. A teacher with a few years' experience wrote PLC participation influenced her teaching routine: *"The community gave me the confidence to use my imagination and include activities not directly related to the matriculation syllabus.... For a while, I wanted to experiment with crystal formation [as was shown in a PLC meeting]. I hesitated [because] it is [only] loosely related to the teaching material." [Anna 55].* An additional teacher stressed the importance of experiencing a variety of teaching strategies, activities, and practices. She prioritized reflection over implementing additional activities: *"My participation helped me to focus on my work and rethink my teaching methods ... During the year [of PLC*

participation], I became familiar with different activities ... I'm not sure if I'll use them, but the exposure [to new activities] alone raised thoughts that led to changes in my teaching." [Lilach 16]. Another teacher discussed the importance of sharing activities and discussing them: *"We all benefited from participants sharing their [classroom] activities. Participants' confidence grew as they shared and received feedback on improving activities to suit a variety of goals and schools."* [Moona 10].

<u>Reframing value</u> was the least described category. It refers to value added to schools and wider communities around teachers. Seven reflections referenced it, and three teachers wrote it was not noticed. When described, teachers wrote schools gained indirect benefits from improved teaching and atmosphere in chemistry class, for example, one teacher wrote: *"Ultimately, a teacher's professional success is a school's success... adding to students' enthusiasm may contribute to the entire school [having] curious, happy, and motivated students."* [Anna 76]. Two teachers noted social contributions. One teacher suggested forming a PLC to her biology colleague; another took her students to a senior citizen's home to demonstrate: *"We choose to visit an old-age home in our village... We made delicious ice cream using equipment from school. ...A real treat for the elderly. They learned that chemistry is relevant to everyday life ... [inspiring] hope ... their son or grandson will become a scientist."* [Farida 17].

Discussion and Contribution to the Teaching and Learning of Science. In this study, the Value Story framework (Wenger et al., 2011) was used to assess the value gained by high school chemistry teachers in the PLC network. From the perspective of teachers, Immediate, Potential, and Realized value were the most important value cycles. Developing social relationships with teachers was a key component of the PLC contribution to teachers. It was directly related to the description of networking by Wenger et al. (2011). The network description highlights how diversity enhanced pedagogical knowledge and teachers' well-being within a PLC. Working with chemistry teachers from other schools was especially beneficial for teachers working as single chemistry teachers in their school, although the benefits were also noted by teachers working in chemistry teacher groups. Solving everyday problems together matches Wenger's description of CoPs (Wenger, 2011). However, PLCs differ from CoPs described by Lave (1991). Lave described apprenticeship methods, where novice members learned from older members, then mastered their skills and passed them on. In this study, teachers reported learning from all members of the community, with experienced teachers interested in ideas from younger members. Results showed the importance of reflection as a tool of professional development. Since PLCs emerged in education (e. g., Hord, 1997; Stoll et al., 2006; Vangrieken et al., 2017), reflection has become a key part of participation. Participants gained value from participation by reflecting on their work and receiving feedback. Providing teachers with novel ideas and teaching methods had significance even if they were not used in the classroom. It helped teachers develop activities and tools tailored to their students' needs, as well as reconsider their teaching methods.

This study could benefit the NARST community both theoretically and practically. Firstly, it was linked to theoretical frameworks, including CoPs and PLCs, which describe how teachers learn collectively. Using "Value Stories," we showed how social learning helped teachers make a difference in their classrooms. We recommend PLC coordinators and leaders devote more time to discussions and reflection, even if that means fewer presentations. When evaluating PLCs as platforms for PD, it is important to consider both the collective reflection process and individual members' reflections.

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