International Journal of Psychosocial Rehabilitation, Vol. 24, Issue 06, 2020
ISSN: 1475-7192

THE IMPACT TEACHER PROFESSIONAL DEVELOPMENT PROGRAM IN INDONESIA ON SCIENCE TEACHERS' KNOWLEDGE AND PRACTICE: A REVIEW AND CRITIQUE

[1]Yohanes Freadyanus Kasi, [2]Achmad Samsudin, [3]Ari Widodo, [4]Riandi Riandi,
[5]Muhammad Nurtanto

Abstract-- *The purpose of this article is to provide a review of empirical studies investigating the impact of teacher professional development (TPD) program in Indonesia on science teachers' knowledge and practices. Across 11 articles that satisfied the definition we embraced, most were devoted to the improve the content knowledge (CoK/CK), general pedagogical knowledge (GPK), pedagogical content knowledge (PCK), and science teaching practices. Although a small number of studies have an implicit focus on variable affective, we set out to examine the studies in science education. Analysis of the related studies resulted in the following the TPD program in Indonesia can help teachers improving their CoK/CK, GPK, PCK, and may facilitate the change in teacher practices, science teachers' activities focusing on student learning in TPD program are more likely to change their practice. However, based on the analysis the TPD program in Indonesia still lacks using a partnership approach, technology, and ethnoscience. The recommendation for further research is still needed to more fully justify the expansion of the TPD program in Indonesia for science teachers using a partnership approach, technology, and ethnoscience to increase knowledge of the TPD program and their role to improve science teaching and learning in class.*

Keywords-- *Teacher Professional Development; science teacher; Indonesia*

I INTRODUCTION

Studies on new methods of teacher professional development program found that the system of teachers that allows to exchange and discuss their involvements are promising traditions for the teaching motivation [1]. Teacher Professional Development (TPD) offers teachers with the knowledge and skills to improve their teaching and to better inform their understandings of student knowledge and is defined differently depending on the context in

[1] *Universitas Pendidikan Indonesia, Bandung, Indonesia and STKIP Nusa Bunga Floresta, NTT, Indonesia, Email: yohaneskasi@upi.edu*
[2] *Universitas Pendidikan Indonesia, Bandung, Indonesia*
[3] *Universitas Pendidikan Indonesia, Bandung, Indonesia*
[4] *Universitas Pendidikan Indonesia, Bandung, Indonesia*
[5] *Universitas Sultan Ageng Tirtayasa, Banten, Indonesia*

Received: 27 Feb 2019 | Revised: 20 Mar 2019 | Accepted: 30 Apr 2020

which it is followed [2]. For instance, organizations and structures for provision science teacher professional development (TPD) are important to accomplishment, student concepts and skills in science need the TPD program which requires science teachers to have dissimilar knowledge and skills. The literature analysis with descriptions of different methods of TPD refers to approaches designed to change the teacher learning and teaching strategies to develop the achievement of their students [3], [3], improve teacher social skill [4], [5], and novice-expert teachers interaction [6], [7].

Several studies show that the TPD program as a means of having a stronger effect of improving teacher knowledge and skills leading to increased teacher efficacy for meeting students' needs [8], [9], [10]. Study designates that after tailored to teacher needs, the TPD program that has the potential involves effective mentoring and collaboration with peers to have a positive impact on their teaching [11]. Although there is no generally acknowledged explanation of initial studies on TPD this providing evidence that strong learning, collaboration of teachers is a vital element to develop the performance of schools. Furthermore, Liepertz & Borowski, (2018) contend that TPD could prove meaningful for effective teaching and also explain the research must investigate the relationship between the TPD program and in-class teacher actions. When teachers collaborate to reflection experiences and experiment with each other's teaching practice, new finding was that the teachers saw their teaching with new eyes after observing their peers. With this in mind, the educational reflections on the classroom were more valuable to teachers when they took the role of researcher and scrutinized another teacher's performance in the classroom [10].

Hereinafter, we used the definition of the TPD program in this paper: in the TPD program science teachers must commit to a shared idea of successful student learning, teachers work collaboratively with discovery explanations to problems of practices, and must improve their knowledge about the student. The purpose of implementing the TPD program on science teacher is both to student outcome. Participants (science teacher) effort together to learning levels of student, classify specific approaches for development strategies teaching. Furthermore, participants use evidence of student learning such as student attitude and test scores heavily in their competence. They use such evidence to make rights about present student understandings and the influence of changes in their teaching practices.

Although there is an agreement on establishing the good quality of TPD programs [4], [12], nowadays standards-driven education setting needs the extending of science teachers' content knowledge together with the increase of pedagogy knowledge consistent with how students' learn. Therefore, many TPD programs in Indonesia have been criticized for a number of explanations, that the process of the program does not lead to improvement of teachers' abilities and that teachers do not seriously increase their teaching [13]. Additionally, TPD seems detached from the paradigm of professional development for teacher educators on improving science teachers' practice and student learning [14], [15]. Questionably, these efforts have been useless in implementation important improvements in teaching and learning, consequently raising problems for the administrator who manages TPD program to develop science teaching and learning. Teacher Professional Development (TPD) program raises the question of whether participant teachers were really more competent than nonparticipant teachers.

In this research, our orientation to science teacher 'change' as a result of participation in the TPD program comprises 'knowledge and skills'. We consider that teacher knowledge and practices, affective domain, and student learning are fundamental components of teacher change within the environment of TPD. Consequently, the operational definition of this study about teacher change in practice is the combination of the instructional approach, the addition of new materials, and curriculum application in the teaching process. The studies also focus on domains of teacher knowledge, such as Content Knowledge (CoK/CK), General Pedagogical Knowledge (GPK), Pedagogical Content Knowledge (PCK). CoK/CK refers to a knowledge domain that comprises specific subject matter, facts, and concepts within a discipline [3], [16]. GPK refers to knowledge about classroom organization and management, instructional models and strategies, and classroom communication and discourse that also attentive to educational goals and learners as critical contextual features of pedagogical practice [17]. PCK represents the blending of content and pedagogy into an understanding of how particular topics, problems or issues are organized, represented, and adapted to the diverse interests and abilities of learners and presented for instruction [18]. Furthermore, we are using affective domains to refer to further change teachers' knowledge as a result of TPD participation in the form of ethics, beliefs, behaviors, and effect of improving their student learning. Besides, for this study, we critical analysis about how the TPD program in Indonesia effective in improving science teachers and whether teachers retain the experiences.

II RELATED WORK

Given the effectiveness of the TPD program on science teacher improvement, analysis of the consequences TPD program in science education is ascetically important in the related literature. This review and critique, analysis can shed more light on how to effectively devise the TPD program as well as identify their deficiencies. Assumed the prior topics, the current study is special to cover in a significant breach in the related literature. Henceforth, this research would recommend for researchers and the TPD programmed developer to trace the predispositions in studies by decreasing the deficiencies capacities.

This study is expected to analyze the effectiveness of the implementation the TPD program for science teachers in Indonesia. Therefore, it was intended to gather sufficiently the TPD program studies to happen practical results. Conversely, studying numerous disciplines through a thematic analysis could make as an obstacle for an in complexity analysis. Commonly, the existing study is unfinished to professional development studies in science education. To find a characteristic tendency with current studies, the present study has compensated more consideration to the studies available in later years. Predictable at this motive, the researcher's observable to income into description the professional development studies in Indonesia, which may be supposed as an additional limitation of the current research.

III PROPOSED APPROACH

For the cause that the domains mentioned above are dependable through the targets of the students' outcome, a reworking of the TPD program interested in science education research has constantly been preferred. Controlled

the attendance of teacher professional development and educational reform, presenting the past progress of the TPD program in Indonesia is important to understand its general outcome. Therefore, it can be look completed from characteristics in fondness to purposes, methods, sample, data collection, data analysis, results, and recommendations might provide a rounded interpretation of the TPD program. This analysis would deliver understandings of the outcomes of professional development studies in Indonesia completed years and their effectiveness. This researchers expected to review the literature on professional development studies in Indonesia from 2012 to 2020. The design of the study, the succeeding directed the existing research; 1) the purposes 2) methods (data collection), 3) duration, 4) description of the TPD program activities, 5) number of participant/subject, and 6) results of this research.

IV EXPERIMENTAL SETUP

The purpose of this article is to provide a review of empirical studies investigating the impact of the TPD program on science teachers' knowledge, practice and affective characteristics. We examine the studies as they relate to two research questions: how are science teachers impacted by their participation in the TPD program; and effectiveness of the strategy TPD program that has been implemented in Indonesia.

Data Collection

This research explored famous international records to verve finished the professional development studies in Indonesia. To begin our study, a comprehensive search was conducted of the following peer-reviewed educational databases to files were considered for correspondingly; Taylor & Francis, Web of Science, DOAJ, Microsoft Academic Search, BASE (Bielefeld Academic Search Engine), Copernicus International, Google Scholar, IOP Publishing, ERIC, and Elsevier to collect associated research in general issued. The reason for choosing databases is to cover as many educational research of sources as possible and not to miss any TPD manuscripts. Studies relating to science education and including the term 'teacher professional development' were identified in the initial search. Nevertheless, because teacher professional development can be connected to other topics and locations, we selected our exploration terms 'teacher professional development in Indonesia' (both singular and plural) as 'teachers, professional communities', 'teachers collaboration program', 'teachers learning communities', '*Lesson Study*', 'in-service training', 'developing science learning', and MGMP. We also added science, physics, chemistry, biology, and Indonesia. Besides, we focused on individual exploration terms and all the pertinent combinations of these terms on the topics of the articles within the databases that served as the primary sources for the relevant literature. After a search, we excluded articles that did not contain relevant empirical results about teacher knowledge and practice. Although there were an excess of articles connecting professional development programs and science teachers, not much research about the TPD program implemented in Indonesia.

Hereinafter, we analysis all the abstracts of the articles, noted their definition of the professional development program, and individually made a judgment of the research article. Furthermore, our standards for article collection comprise; science teachers were clearly engaged and in attendance in the TPD program. We eliminated articles

Received: 27 Feb 2019 | Revised: 20 Mar 2019 | Accepted: 30 Apr 2020

that did not follow to the definition we embraced and the process resulted in 11 articles that met the criteria for presence in this review.

Data Analysis

These examples of data analysis parameters parameters were: purpose, method, part of larger the TPD program, description of the TPD program activities, the number of teachers/ subject/level, and results of this research. An example of data analysis is obtainable in Table 1.

Table 1. An example of data analysis

Purpose	Investigates the implementation and enactment of a climate change professional development (PD) model for science teachers and its impact on student learning
Method	Mixed-methods (interview, audio-video record, test)
Duration	2 weeks, 1 month
Description of the TPD program activities	Design instruction, review best practices, discuss experiences, content and pedagogy
Number of participant/subject	20/biology
Results of this research	Enhances the science teachers' PCK

Similar research was categorized and coded distinctly and the limitations as mentioned overhead equally recognized the subjects determined by the codes in the content investigation. Discussion and results were obtainable regarding these subjects and codes.

V RESULTS

Consistent with our view of the TPD program as an instrument for science teachers' professional development, we explained results according to two research questions. The articles providing particular details about a context research question are highlighted further in the following sections. Appropriate details about each article are explained for a clear understanding of the studies and the role that the TPD program played in every context.

The impacts of teacher professional development on science teachers

We believe in understanding the degree to which the TPD program allows science teachers in improving their knowledge, improve their science teaching approach, and develop other important affective variables. This section speeches our main research question: how are science teachers impacted by their participation in the TPD program? The results expose, though they are not reliable crosswise all studies under review, that there are obvious improvements in science teachers' knowledge and practices as well as affective variables.

Received: 27 Feb 2019 | Revised: 20 Mar 2019 | Accepted: 30 Apr 2020

Table 2: Descriptive analysis related to the reviewed articles

References	Purpose	Methods	Duration	Description of the TPD program activities	The number of teachers/ subject	Results of this research
Harjanto *et al*. (2017)	To identify how the Tanoto Foundation has designed and implemented it Teacher quality improvement program for in-service teachers in Remote schools in Indonesia	Mixed-methods (questionnaires, test, interview, observation)	1 year	Design instruction, workshop, sharing ideas, plan and implement action research,	193/science	Enhance teachers' knowledge of student active learning, and improve their teaching practices.
Sari & Lim, 2012	Discusses contextual application of design-based research (DBR) in an Online Learning Community for Teacher Professional Development (OLC4TPD) study in Indonesia for improving teaching and learning teachers.	Design-based research	1 year	Online discussion, mentoring	26	DBR process is presented to provide insights for those interested in enacting similar education, innovation In their local contexts
Anif *et al.* (2019)	To describe the mechanism of pedagogical competence development activities for biology teachers in a post-certification program through MGMP forum and to identify the characteristics of the activities of biology MGMP.	Survey (polling and a questionnaire)	5 years (2011 - 2016)	Sharing ideas and strategies, discuss experiences, discussion about learning and teaching concepts, evaluation of teaching practice, design instruction	332/biology	The results of this study revealed that the mechanisms and the procedures of activities to develop the pedagogical competence of biology teachers
Purwoko *et al*. (2017)	To improve high school chemistry teacher's competency in terms of	Survey (Likert-scale questionnaire)	5 months	Sharing ideas and strategies, discuss experiences, discussion	524/chemistry	The partnership program between MGMP (the teacher program) and LPTK (Pre-service Teacher Training Institution) is able to improve

References	Purpose	Methods	Duration	Description of the TPD program activities	The number of teachers/ subject	Results of this research
	classroom instruction.			about learning and teaching concepts, evaluation of teaching practice, design instruction, teacher observation of students		the professional competence and pedagogical competence of chemistry teachers
Rochintaniawati *et al.* (2019)	To analyze the development of biology teachers' Technological Pedagogical Content Knowledge (TPACK) in lesson study and to describe the role of the observer in developing teacher's TPACK during the activity.	Descriptive analysis	6 months	Lesson Study, discussion, design instruction	6/biology	The study revealed that the teachers' TPACK in school-based lesson study was more in the aspect of pedagogical knowledge, meanwhile teacher TPACK in the biology, association lesson study improved their TPACK in pedagogical knowledge, content knowledge, and technological knowledge.
Winarsih & Mulyani, (2012)	To improve the science teacher professionally by conducting lesson study activity, in order to create an effective and qualified learning process	Research and Development / R & D (observation and test)	2 months	Lesson Study, discussion, design instruction	5/science	This research is successful to improve the professionalism of science teacher, develop learning an instrument, improve students' learning result, and improve students' activity.
Rahman *et al.* (2015)	Report the evaluation of a professional development program to improve content knowledge Indonesian teachers	Experiment (test)	10 days	Choosing and using methods and materials, facilitator/leadership, learning activities	147	All three models led to improvement in the teachers' content knowledge
Anif *et al.* (2020)	Identifying the problems faced by Social and natural science teachers of Indonesia in the	Qualitative (documentation, questionnaire,	1 years	Lesson Study, discussion, design instruction, mentoring	30/science	The study found out the problems faced by Social and natural science teachers in the implementation of the National Curriculum consist of internal and external

References	Purpose	Methods	Duration	Description of the TPD program activities	The number of teachers/ subject	Results of this research
	Implementation of National Curriculum, a suitable model For Social and natural science teacher development in the implementation of National Curriculum, and lesson study Validation as a model for Social and natural science teacher Development in the implementation of National Curriculum	observation, test, and interview				issues, model for Social and Natural Science teacher development in the implementation of the National Curriculum incorporates a lesson study approach and collaborative approach, i.e., Workshops, laboratory training, and teacher mentoring, lesson study validation as a model for Social and Natural Science teacher development in the implementation of the National Curriculum involves validation of theory and practice.
Soko *et al.* (2016)	Development of a culturally-based education and training module of high school physics teachers	Research and Development / R & D (test)	1 day	*Peer teaching*, develop teaching material (module), discussion	20/physic	The research findings showed that (1) the developed module conforms the validity criterion (excellent category), (2) there was an increasing of teachers' *PCK*, and (3) hypothesis testing using one sample t-test proved that there is a significant increase of teachers' content and pedagogical knowledge.
Misnasanti *et al.* (2017)	To describe Lesson Study (LS) activity and its roles in the development of mathematics learning instruments based on Learning Trajectory (LT)	Narrative studies (observation, documentations, and deep interview)	2 months	Lesson Study, discussion, design instruction, mentoring	2	The study result shows that through LS activity, teachers know more about how students think. Teachers also can revise their learning instrument in the form of a lesson plan.
Sari (2012)	Investigates the concept of online learning community (OLC) to address the issues of teacher professional	Development / R & D	2 months	Online discussion, planned the online learning activities, online seminar	1198	This paper presents key results of the introduction and trialling of OLC with Indonesian teachers and teacher educators between 2009 and 2010 and aims to explore the feasibility of this model to support

References	Purpose	Methods	Duration	Description of the TPD program activities	The number of teachers/ subject	Results of this research
	development practice in twenty-first century Indonesia.			and discussion		professional development of teachers in this era.

Change science teacher knowledge (CoK/CK, GPK, PCK)

Based on the studies, we found vicissitudes in teacher knowledge to include improvements in both their *Content Knowledge* (CoK/CK), *General Pedagogical Knowledge* (GPK), *Pedagogical Content Knowledge* (PCK) subsequently involved in TPD program. In our analysis, we found that four articles described increases in both CoK/Ck, GPK and PCK of teachers participating in the TPD program. One article described an increase only in CoK/CK knowledge [19], one article described increases only in PCK (TPACK) knowledge [20], and other two articles described increases only in GPK knowledge [21], [22]. Nevertheless, three of the 11 articles did not examine either CoK/CK, GPK, and PCK [23], [24], [25]. One article particularly provided indication that teachers increased their CK, GPK, and PCK knowledge through participation in the TPD program. The research aimed to develop teachers' science content knowledge, pedagogical knowledge, and PCK through TPD program based ethnoscience in East Nusa Tenggara. The researcher described that 20 physic teachers reported that participating in the TPD program caused them to increase their CK, GPK, and PCK.

Based on the survey results, significant numbers of teachers reported that participation in the TPD program positively impacted their understanding of developing learning instrument, knowledge about students, improve students' learning result, and improve students' activity [26]. Likewise, the specific of analysis by Rochintaniawati *et al.* (2019) studies using *Lesson Study* to improving biology teachers TPACK. Science teachers acknowledged that they refined their ideas about teaching approaches and how it can be applied successfully with the help of their peers in the TPD program. Six biology teachers in the *Lesson Study* project further stated that participation in the TPD program helped them to become mindful of the important appearances of teaching approach using technology

Change science teachers' practice

Increase in teacher performs indicate that as a result of participation in the TPD program, improving their procedure of reform-based science teaching practices, with shifting to a more student-centered approach through facilitation and support of student activities [27]. In this study, 8 of the 11 articles indirectly inspected teachers' performing of inquiry-based teaching approach and decided that teachers participating in the TPD program experienced obvious changes in their practices. Nevertheless, the researcher of these 8 articles differed in how they attributed the role of the TPD program to specific variable in teaching practices and student learning.

Four of these 11 articles used Lesson Study as a model of teacher professional development that included a formal project that involves groups of teachers meeting regularly over a period of time ranging from several months to a year (6 months and 1-2 year) to work on the design and implementation [20], [28], [23], [29]. Teachers believe

that phase spent studying their lessons will subsequently increase their teaching. Additionally, they believe that the most effective place to improve their teaching is in the context of a classroom lesson. Furthermore, four of these 11 studies used the TPD program as a component of comprehensive PD efforts that also included teacher workshops/trainings [30], [22], [26], [19], [31]. The researcher of these studies attempts to assert that changes in teacher practices stemmed excluded from participation in the TPD program. Furthermore, [23] explain the effect of the TPD program in similar comprehensive program efforts nevertheless did declare that the changes in teacher practices were attributable to their participation in the TPD program. Sari & Lim, (2012) and Sari (2012) documented significant using technology in the TPD program to improve teacher practice. Collaboration teachers in program such as online discussion, planned the online learning activities, online seminar and discussion can help teachers improve their instructional methods in the classroom. Nevertheless, the researcher did not provide specific empirical evidence to support this result.

Effectiveness of the strategy TPD program in Indonesia

The model of Teacher Professional Development (TPD) usually includes workshops or training in a long and short time [32], [33], [34], formal university coursework [5], [9], Lesson Study [35], collaborative work in professional learning community [10], and mentoring from experts or teachers experienced [16], [36]. The special features of a teacher professional development programs are defined in order to bring about change on teachers' attitudes and perceptions, to scale up their classroom practices so as to enhance students' learning. In the context of teacher professional development, there are alternative interpretations of the notion 'teacher change' which can be associated with different characteristics and goals in the development of in-service programs [37]. In this study, our analysis to confirm these insights as we inspected science teachers' engagement in the TPD program and emphasis on student learning. The collection process was consequently guided by detailed inclusion criteria and a deliberate focus on empirical studies of the TPD program involving science teachers. Current research shows that effective TPD focuses on developing a *Community of Learners* (CoL) in which teachers' collaboration with lecture and other teachers in discussing about teaching practices can improve their knowledge and self-confident [4], [37]. A collaboration aspect added to TPD offers a shift in thinking about teaching and learning. The findings in this review provide some support for the claim that explained the increase teachers' quality of inquiry teaching increased after the professional development programme.

Based on an analysis (11 articles), shows that a TPD program in Indonesia still lacks a collaboration strategy between a teacher and another experienced teacher, using technology as a means to preserve program sustainability and ethnoscience approach which links cultural activity in a region to the concept of science. Several studies explain that when teachers in a professional development program collaborate with experienced experts to together design learning, teach classes, learning evaluations and reflect the learning indicate increased knowledge of PCK [36], [38], [38], [39], [40], curriculum knowledge [9], content knowledge [16], pedagogy knowledge [38], and knowledge of learners [42]. Next, to be able to maintain a sustainable program requires technological involvement. The use of strategy involves technology in the TPD program gives the teacher an advantage. Research shows that the TPD program using technology can increase teacher knowledge over time, the teacher's pedagogy belief in

scientific inquiry and the teacher's keen interest in the TPD program [43], [2]. Other studies also explain the effectiveness of the TPD program's ethnoscience approach. Szelei *et al.* (2019) explains the context-based professional development for diverse cultures in Portuguese schools suggests that the need for professional framed devloteachers to be redirected to some other cultural diversity. An alternative approach to the study of a professional development program that may move the field forward calls for a shift of researchers' attention from effective features of the TPD program in Indonesia to processes and mechanisms that positively impact teacher learning and more specifically teacher change. In addition, there should be a model of Indonesia's teacher's professional development program using a partnership approach between teachers, technology and materials integrated into local cultures.

VI CONCLUSION

The conclusion of the studies we have explained a review of empirical studies that described the impact of the TPD program for science teachers in Indonesia. We statement that provided specific settings a emphasis on student learning the TPD program in Indonesia strength have the potential to improve teachers' knowledge and practice to improve student learning. The most essential condition for the effect of the TPD program in Indonesia is the focus on student outcome. However, many questions still remain unanswered: what are best practices for engaging science teachers in the TPD program and whether participating teachers in TPD program were really more competent than nonparticipant teachers. Furthermore, based on the analysis the TPD program in Indonesia still lack using partnership approach, technology and ethnoscience. We recommended that further research is still needed to more fully justify the expansion of the TPD program in Indonesia for science teachers using a partnership approach, technology, and ethnoscience to increase knowledge of the TPD program and their role to improve science teaching and learning in class.

ACKNOWLEDGEMENTS

I sincerely thank Lembaga Pengelola Dana Pendidikan (LPDP), Departemen Keuangan Indonesia, for providing me with the financial support during my study at Indonesia University of Education.

REFERENCES

1. M. L. L. Gaikhorst, L., Beishuizen, J.J., Zijlstra, B.J.H. & Volman, 'Contribution of a professional development programme to the quality and retention of teachers in an urban environment', *Eur. J. Teach. Educ.*, vol. 38, no. 1, pp. 41–57, 2015.
2. T. Lee, H., Longhurst, M. & Campbell, 'Teacher learning in technology professional development and its impact on student achievement in science', *Int. J. Sci. Educ.*, vol. 0693, no. June, 2017, doi: 10.1080/09500693.2017.1327733.

3. B. J. Förtsch, C., Werner, S., Kotzebue, L. V. & Neuhaus, 'Effects of biology teachers ' professional knowledge and cognitive activation on students ' achievement cognitive activation on students ' achievement', *Int. J. Sci. Educ.*, vol. 0, no. 0, pp. 1–25, 2016.
4. Z. Trabona, K., Taylor, M., Klein, E. J., Munakata, M. & Rahman, 'Professional Development in Education Collaborative professional learning : cultivating science teacher leaders through vertical communities of practice leaders through vertical communities of practice', *Prof. Dev. Educ.*, vol. 00, no. 00, pp. 1–16, 2019.
5. V. L. Ufnar, J.A., & Shepherd, 'The Scientist in the Classroom Partnership program: an innovative teacher professional development model', *Prof. Dev. Educ.*, vol. 45, no. 4, pp. 642–658, 2018.
6. W. Jin, X., Li, T., Meirink, J., Van des Want, A. & Admiraal, 'Learning from novice–expert interaction in teachers' continuing professional development', *Prof. Dev. Educ.*, pp. 1–18, 2019.
7. D. Geeraerts, K., Tynjälä, P., Heikkinen, H. L. T., Markkanen, I., Pennanen, M. & Gijbels, 'European Journal of Teacher Education Peer-group mentoring as a tool for teacher development', *Eur. J. Teach. Educ.*, pp. 37–41, 2015.
8. M. Nurtanto, P. Pardjono, Widarto -, and S. D. Ramdani, 'The Effect of STEM-EDP in Professional Learning on Automotive Engineering Competence in Vocational High School', *J. Educ. Gift. Young Sci.*, vol. 8, no. 2, pp. 633–656, Jun. 2020, Accessed: Mar. 18, 2020. [Online]. Available: https://dergipark.org.tr/en/pub/jegys/645047.
9. H. Snoek, M., Knezic, D., Van Den Berg, E., Emmelot, Y., Heyma, A. & Sligte, Sligte, 'Impact of in-service Master of Education programmes on teachers and their working environment', *Eur. J. Teach. Educ.*, vol. 41, no. 5, pp. 620–637, 2018.
10. L. Lund, 'Improving Schools When school-based , in-service teacher training sharpens pedagogical awareness', *Improv. Sch.*, pp. 1–15, 2018.
11. S. Kilpatrick, S. & Fraser, 'Using the STEM framework collegially for mentoring , peer learning and planning learning and planning', *Prof. Dev. Educ.*, vol. 5257, pp. 1–13, 2018.
12. B. F. Desimone, L. M., Porter, A. C., Garet, M. S., Yoon, K. S. & Birman, 'Effects of Professional Development on Teachers ' Instruction : Results from a Three-year Longitudinal Study', vol. 24, no. 2, pp. 81–112, 2015.
13. J. Correia, C., Dinis, L.T., Pinheiro, R., Fraga, H., Ferreira, H., Goncalves, I., Costa, J., Oliveira, A., Malheiro, A. & Mountinho-Pereira, 'Climate change and adaptation strategies for human health', *J. Int. Sci. Publ. Agric. Food Vol.*, vol. 2, no. June, pp. 1314–8591, 2014.
14. O. Avidov-ungar, O. & Herscu, 'Professional Development in Education Formal professional development as perceived by teachers in different professional life periods', *Prof. Dev. Educ.*, vol. 00, no. 00, pp. 1–12, 2019.
15. T. Swennen, A. & Bates, 'The professional development of teacher educators', *Prof. Dev. Educ.*, vol. 36, pp. 1–7, 2010.
16. C. Shein, P. P. & Tsai, 'International Journal of Science Impact of a Scientist – Teacher Collaborative Model on Students , Teachers , and Scientists', *Int. J. Sci. Educ.*, vol. 37, no. 13, 2015, doi: 10.1080/09500693.2015.1068465.

Received: 27 Feb 2019 | Revised: 20 Mar 2019 | Accepted: 30 Apr 2020

17. G. Morine-Dershimer and T. Kent, 'The Complex Nature and Sources of Teachers' Pedagogical Knowledge', *Examining Pedagog. Content Knowl.*, pp. 21–50, 1999.
18. L. Shulman, 'Knowledge and Teaching: Foundations of the New Reform', *Harv. Educ. Rev.*, vol. 57, no. 1, pp. 1–23, 1987.
19. A. Rahman, B., Abdurrahman and N. E. Kadaryanto, B. & Rusminto, 'Teacher-based scaffolding as a teacher professional development program in Indonesia', *Aust. J. Teach. Educ.*, vol. 40, no. 11, pp. 66–78, 2015.
20. Y. Rochintaniawati, D., Riandi, R., Kestianty, J., Kindy, N. & Rukayadi, 'The analysis of biology teachers' technological pedagogical content knowledge development in lesson study in West Java Indonesia', *J. Pendidik. IPA Indones.*, vol. 8, no. 2, pp. 201–210, 2019.
21. H. J. Anif, S., Sutopo, A. & Prayitno, 'Lesson Study Validation : Model for Social and Natural Sciences Teacher Development in the Implementation of National Curriculum in Muhammadiyah Schools , Indonesia', vol. 8, no. 1, pp. 253–259, 2020.
22. I. N. Purwoko, A. A., Andayani, Y., Muntar, M. & Diartha, 'Efforts in improving teachers' competencies through collaboration between teacher forum on subject matter (MGMP) and pre-service teacher training institution (LPTK)', *J. Pendidik. IPA Indones.*, vol. 6, no. 1, pp. 11–15, 2017.
23. F. Misnasanti., Dien, C. A. & Azizah, 'The roles of lesson study in the development of mathematics learning instrument based on learning trajectory', *J. Phys. Conf. Ser.*, vol. 983, no. 1, 2018.
24. C. P. Sari, E. & Lim, 'Design-based Research: Understanding its application in a teacher professional development study in Indonesia', *Asia-Pac. Educ. Res.*, vol. 21, no. 1, pp. 28–38, 2012.
25. E. R. Sari, 'Online learning community: A case study of teacher professional development in Indonesia', *Intercult. Educ.*, vol. 23, no. 1, pp. 63–72, 2012.
26. M. Harjanto, I., Lie, A., Wihardini, D., Pryor, L. & Wilson, 'Community-based teacher professional development in remote areas in Indonesia', *J. Educ. Teach.*, vol. 7476, no. December, pp. 1–20, 2017.
27. NRC, *National Science Education Standards*. 1996.
28. N. B. M. Anif, S., Sutama., Prayitno, H. J. & Idrus, 'Effectiveness of pedagogical competence: A development model through association of biology teachers' forum', *J. Pendidik. IPA Indones.*, vol. 8, no. 1, pp. 22–31, 2019.
29. S. Winarsih, A. & Mulyani, 'Peningkatan profesionalisme guru IPA melalui lesson study dalam pengembangan model pembelajaran PBI', *J. Pendidik. IPA Indones.*, vol. 1, no. 1, pp. 43–50, 2012.
30. M. Nurtanto, H. Sofyan, P. Pardjono, and S. Suyitno, 'Development model for competency improvement and national vocational qualification support frames in automotive technology', *Int. J. Eval. Res. Educ. IJERE*, vol. 9, no. 1, Mar. 2020, doi: 10.11591/ijere.v9i1.20447.
31. A. Soko, I. P., Setiawan, A. & Widodo, 'Development of a Cultural-based Physics Learning Module for Teacher Education and Training Program to Enhance Teacher Pedagogical Content Knowledge', *4th ICRIEMS Proc. Publ. Fac. Math. Nat. Sci.*, pp. 29–36, 2015.
32. R. Weitzel, H. & Blank, 'Pedagogical Content Knowledge in Peer Dialogues between Pre-Service Biology Teachers in the Planning of Science Lessons . Results of an Intervention Study Pedagogical Content Knowledge in Peer Dialogues between Pre-Service Biology Teachers in the Planning', *J. Sci. Teach. Educ.*, vol. 00, no. 00, pp. 1–19, 2019.

33. A. Nilsson, P. & Elm, 'Capturing and Developing Early Childhood Teachers ' Science Pedagogical Content Knowledge Through CoRes Capturing and Developing Early Childhood Teachers ' Science', *J. Sci. Teach. Educ.*, vol. 00, no. 00, pp. 1–19, 2017.
34. H. Bravo, P. & Cofré, 'Developing biology teachers ' pedagogical content knowledge through learning study : the case of teaching human evolution', *Int. J. Sci. Educ.*, vol. 0, no. 0, pp. 1–28, 2016.
35. N. Coenders, F. Verhoef, 'Professional Development in Education Lesson Study : professional development (PD) for beginning and experienced teachers', *Prof. Dev. Educ.*, vol. 5257, pp. 1–14, 2018.
36. P. J. Barnett, E. & Friedrichsen, 'Educative Mentoring : How a Mentor Supported a Preservice Biology Teacher ' s Pedagogical Content Knowledge Development', *J. Sci. Teach. Educ.*, vol. 26, no. 7, pp. 647–668, 2015.
37. D. Sgouros, G. & Stavrou, 'Teachers' professional development in Nanoscience and nanotechnology in the context of a Community of Learners', *Int. J. Sci. Educ.*, vol. 41, no. 15, pp. 2070–2093, 2019.
38. C. Coenders, F. & Terlouw, 'A Model for In-service Teacher Learning in the Context of an Innovation', *J. Sci. Teach. Educ.*, vol. 26, no. 5, pp. 451–470, 2015.
39. G. Kadji-beltran, C., Zachariou, A. & Liarakou, 'Professional Development in Education Mentoring as a strategy for empowering Education for Sustainable Development in schools', *Prof. Dev. Educ.*, vol. 40, no. 5, pp. 37–41, 2014, doi: 10.1080/19415257.2013.835276.
40. Z. Arifin, M. Nurtanto, W. Warju, R. Rabiman, and N. Kholifah, 'The TAWOCK Conceptual Model for Content Knowledge for Professional Teaching in Vocational Education', *Int. J. Eval. Res. Educ. IJERE*, vol. 9, no. 3, Apr. 2020, doi: 10.11591/ijere.v9i3.20561.
41. Z. Arifin, M. Nurtanto, M. Fawaid, and R. Rabiman, 'The TAWOCK Framework: A Professional Innovation Teaching and Learning on Vocational Education', *J. Educ. Learn. EduLearn*, vol. 14, no. 3, Aug. 2020, doi: 10.11591/edulearn.v14i3.15946.
42. M. G. Juhler, 'The Use of Lesson Study Combined with Content Representation in the Planning of Physics Lessons During Field Practice to Develop Pedagogical Content Knowledge', *J. Sci. Teach. Educ.*, no. 1, 2016.
43. F. E. Terrazas-arellanes, L. A. Strycker, E. D. Walden, L. A. Strycker, E. D. Walden, and E. D. Walden, 'Web-Based Professional Development Model to Enhance Teaching of Strategies for Online Academic Research in Middle School', *J. Res. Technol. Educ.*, vol. 0, no. 0, pp. 1–24, 2019, doi: 10.1080/15391523.2018.1564637.

Received: 27 Feb 2019 | Revised: 20 Mar 2019 | Accepted: 30 Apr 2020