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The development of an online STEM teacher professional development package with the DECODE model: An innovative teacher's quality maintenance

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Abstract

Due to the global trend and the international application of STEM education as well as in/post-pandemic COVID-19 condition, this ongoing study aims to elucidate the development progress of an online STEM teachers' professional development (STEM-TPD) package with the DECODE model. In this/post-pandemic era, online STEM education has been gradually emphasized. The researchers sustained the rationale for organizing STEM-TPDs to improve teacher practices by enhancing superior knowledge needed for the betterment of STEM implementations. Indeed, the DECODE model includes three stages: (1) DE: teacher's DEmonstrations, (2) CO: students CO-train the use of cloud classroom, students CO-design an educational technology-integrated course, and (3) DE: students CO-teach, eventually students receive feedbacks and DEbrief what they have learned through the stages mentioned above. Moreover, face and content validity have been deployed to guarantee the quality of the developed packages. The ongoing result from this study is produced to validate the online STEM-TPD package with the DECODE model. Moreover, the package comprises manual training, a set of assessments, and an innovative webpage. Through this online DECODE model with the package, teachers are equipped: to familiarize themselves with various software technology and platforms; enhance their knowledge and abilities in assessment design, instructional design, and practical implementation (TPACK); to effectively teach or guide students in STEM activities, and to effectively improve their STEM literacy.

Keywords: STEM education, teacher professional development, DECODE model, TPACK

INTRODUCTION

The main reason behind the STEM's teacher professional development (STEM-TPD) project research is to increase the quality of teacher practice in teaching activities through knowledge development required to improve the STEM implementation in the classroom during the COVID-19 pandemic or post-pandemic. For expectation, the final result of a TPD program will positively increase students learning outcomes, provided that the activities directly increase the perception and quality of teacher practice in the classroom (Han et al., 2015). Moreover, special professional knowledge possessed by teachers such as pedagogical knowledge (PK), content knowledge (CK), pedagogical content knowledge (PCK), and technological pedagogical content knowledge (TPACK) should be developed for the successful implementation of STEM in the classroom (Awad et al., 2019; Irwanto et al., 2022). Furthermore, the research team in the study analysis also identifies the main features of STEM-TPD that are effective in assessment, teaching, and the global trend in STEM education. Based on a previous research (Irwanto et al., 2022), technological pedagogical and content knowledge aspects are crucial in responding to advances in technological development, such as teaching technology and technology in assessment.

In the COVID-19 pandemic era, especially in Indonesia, the implementation of STEM education is frequently done online. Therefore, another purpose of this two-year research project is to grow the abilities of online TPACK for STEM teachers and strengthen teachers' knowledge and abilities in assessment, teaching, and teaching materials, and equip teachers for

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Contribution to the literature

- This study provides insight into an online STEM teachers' professional development (STEM-TPD) package with DECODE model, which comprises manual training, a set of assessments, and an innovative webpage.
- This study sustains the rationale for organizing STEM-TPD to improve teacher practices by enhancing superior knowledge needed for the betterment of STEM implementations that can facilitate teachers to transform their understanding of innovation actively and reflectively into actual performance.
- Through this online DECODE model with the package, teachers are equipped: to familiarize themselves with various software technology and platforms; enhance their knowledge and abilities in assessment design, instructional design, and practical implementation; to effectively teach or guide students in STEM activities, and to effectively improve their STEM literacy.

comprehensive professional development. In this research project, the STEM-TPD is used to represent the professionality development of STEM teachers. Therefore, this research will develop and test a collaborative training model for STEM teachers in Indonesia, namely the online DECODE model. DECODE is an acronym for demonstrating (DE), collaborating (CO), and debriefing (DE) (Cheng et al., 2022). Instead, the model will expand to users in many countries throughout the world.

Due to the global trends and situations, this research project aims to develop an online DECODE model platform, a workshop manual package, and a series of assessment packages to evaluate the online teaching knowledge and skills of STEM teachers. With these online DECODE packages and models, teachers will be equipped to familiarize themselves with various technologies and software platforms; improve their knowledge and skills in assessment design, instructional design, and practical implementation; effectively teach or guide students in STEM activities; and effectively improve the STEM literacy of teacher participants. Moreover, the research team will survey the characteristics of STEM education in Indonesia. Then, the team will compare it with several other countries in the next project stage to adapt the online DECODE model and its instruments so that it can be applied and tested internationally. Furthermore, the current research project targets teacher candidates and in-service teachers in Indonesia for planned training services. Finally, the findings targeted in this research phase will contribute to the achievement of the 2017-2045 National Research Master Plan and the priority research topics determined, namely those specifically related to research in the social humanities, arts and culture, and education with the themes of educational research, on the topics of educational and learning technology in Indonesia, and the wider world.

Professionality Development for Improving the TPACK Expertise of STEM Teachers

STEM education contributes to a match between design thinking and professional development by increasing teacher capacity to foster student motivation. As a research field, professionality development can be approached from several aspects such as teacher beliefs, CK, technological knowledge (TK) and skills, new teaching methods, and curriculum design (Bautista & Ortega-Ruíz, 2015; Irwanto et al., 2022). In addition, the dimensions of teacher support can relate to

a. learning process based on autonomy, structure, and teacher involvement,
b. teacher capacity building to support student needs, and
c. generate many opportunities for feedback and reflection.

To foster student motivation, teachers must practice strategies that can support teacher autonomy to reflect on choices, explanations, demands, stress, language, and other factors involved in the course of an educational interaction (Chiu et al., 2021).

According to Philipsen et al. (2019), online teacher professional development (TPD) and online-based learning (OBL) consider the following aspects: design and development of TPD that supports OBL programs and the environment, acknowledgment of the existing context for OBL, handling teacher change adjustments related to the transition to OBL, setting general goals and relevance of TPD for OBL, recognition of TPD strategies related to changes to OBL, evaluation of TPD and dissemination of knowledge, skills, and attitudes. Therefore, this viewpoint emphasizes two important factors, namely, firstly, the importance of planning and implementation, training time, and a well-structured program to align workload, duration/time, objectives, and methods. Secondly, the need to carry out TPD in terms of changes in practice and its impact on the identity and beliefs of teachers (Niemi, 2015). So, these two aspects require a reflection on the role of students and teachers.

Professional development facilitators (PDFs) define TPD as alignment between PDFs' epistemology, content, and objectives of professionality development activity. Perry and Booth (2021) state that this approach integrates three areas:

1. content, which is composed of ideas, theories, pedagogy, curriculum design, training, and feedback activities,
2. pedagogy, related to engagement strategies to increase CK and student interaction, and
3. embodiment, that is, based on social and relational interactions, along with emotions, types of knowledge, and judgments.

In addition, this approach highlights engagement with research to support pedagogical decisions, content choices, and comparative evidence on teacher practices and processes in learning activities (Perry & Booth, 2021). Therefore, the development of an online professionality development model platform equipped with a workshop manual package and a series of assessment packages to evaluate online teaching knowledge and skills is a must.

In the same field, professionality learning networks (PLNs) are defined as a group of educators (e.g., teachers, school leaders, possibly in collaboration with researchers, and/or policymakers) who work together with others outside their everyday community for the purpose to engage in collaborative learning and improve student outcomes (Poortman et al., 2021). PLN distinguishes student learning outcomes from student achievement outcomes, linking TPD to various social issues and curriculum goals. Finally, from the research perspective, PLN promotes a research-based approach, detailed background, objectives, methods, result validation criteria, and limitations.

STEM Education in Indonesia

STEM education is a very broad term; a simple definition refers to teaching and learning about STEM subjects in various ways (Bybee, 2013; Chesky & Wolfmeyer, 2015). More complex definition refers to an interdisciplinary teaching approach or method that integrates some or all of science, technology, engineering, mathematics, and other knowledge, skills, and beliefs particular to these disciplines (Baran et al., 2016; Chesky & Wolfmeyer, 2015). Another STEM education refers to teaching and learning in a STEM subject, which emphasizes problem solving with real-world problems involving many disciplines and other skills such as science, technology, mathematics, and engineering by an integrated way (Martín-Páez et al., 2019; Wahono et al., 2021). In this current study, STEM teachers refer to teachers who teach in the field of STEM studies (in Indonesia context generally for science and math teachers).

Based on a study, science teachers in Indonesia have a very good attitude, moderate application level, and poor knowledge level about STEM education. The knowledge level classified as the low and moderate category for application in the field of science teachers on STEM education shows that many things must be managed and changed to increase the usefulness of STEM education in Indonesia (Wahono & Chang, 2019; Wahono et al., 2021). Furthermore, based on the model from the quality STEM program pathway (CAN, 2018), the conditions in Indonesia show that we remain in an initiation position (from four positions: not ready, initiation, improvement, and expansion) (Wahono & Chang, 2019). Therefore, structured and massive professional development programs may be one way to improve this condition, particularly if it faces the current state of the COVID-19 pandemic and its variants.

The comprehensive research also studied professionalism and teacher professionality development programs in Indonesia (Kola, 2013). The research results indicate that the low quality and quantity of the conditions relate to teacher professionality development programs in Indonesia. The research findings reveal that correction to problem roots does not make professionality performance or teacher professionality development practices in Indonesia better (Kola, 2013; Utomo et al., 2018). Moreover, Wahono and Chang (2019) mention some crucial findings from their research that although most teachers in Indonesia do not know what STEM is, more than 75% of teachers have a very good attitude toward STEM. This condition also becomes the reason why most teachers in Indonesia have implemented STEM without knowing the term before. However, the STEM application level has not been deeply confirmed in the research. However, the research findings on the condition of attitudes and knowledge indicate that these two domains are crucial for the basis for better implementation and sustainability of STEM education in Indonesia.

RESEARCH METHOD AND PROCEDURE

The DECODE model is the acronym for "DEmo-CO-design/teach-feedback-DEbriefing." It is a model of professionality development to improve teachers' online TPACK. The DECODE model integrates teacher-student experiences, teaching-learning processes, and technology-based systems to promote collaborative and active learning, information and resource sharing, and creative communication (Cheng et al., 2022). The use of technology is crucial in responding to the problems due to the COVID-19 pandemic, strengthening resilience, and increasing the pedagogical and technological competencies of online educators (Dhawan, 2020). The latest educational challenges that have emerged in the pandemic and post-pandemic era require appropriate steps to ensure that education rights are still achievable through a platform that supports access to learning resources (Zhu & Liu, 2020). The DECODE model will facilitate efforts to determine teachers' critical abilities regarding their affordability to innovative technologies in their teaching practices, especially in subject matter selection, motivational empowerment, information

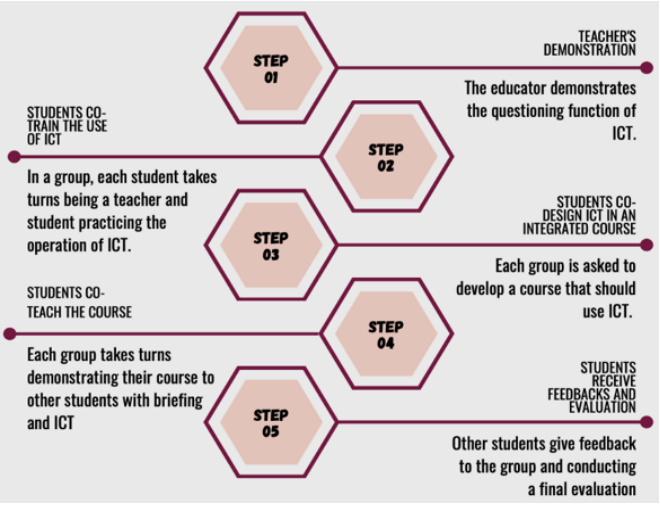

Figure 1. DECODE model (adopted from Cheng et al., 2022)

presentation, activity design, and transitions in teaching. Finally, the DECODE model can facilitate teachers' TPACK capabilities towards a connected model responsible for accessing technology, pedagogy, and subject matter together.

The DECODE model includes three stages (**Figure 1**):

1. DE: teacher's DEmonstration (trainer demonstrations),
2. CO: students CO-train (participants practice together) with the use of CloudClassRoom (CCR), participants CO-design a classroom integrated closely with educational technology, and
3. DE: participants CO-teach, participants receive feedback from each other and DEbrief (summarize) what they have learned through the stages mentioned above (Cheng et al., 2022).

For each learning technology type used, it will run once through DECODE. The length of time to run the DECODE model will base on each technology type and characteristic. In each implementation of the DECODE model, at least two rounds of DE-CO-DE-CO-DE will be carried out to grow and strengthen teachers' mastery and familiarity with the technology used in STEM education.

The online DECODE model will be carried out via virtual and combined mode with a hardcopy (manual book) which unitedly form a mixed-mode training model. The delivery of material packages and manuals to participants aims to maximize the goal achievement and interaction of distance teaching. This research project targets prospective teachers and in-service teachers in Indonesia. Moreover, this research project will develop an online teacher TPACK assessment that can be used in Indonesia and other countries.

In particular, the package development consists of an innovative website homepage, STEM workshop module package, and assessment. It is a systematic and planned process with several development stages through a model of ADDIE development. ADDIE stands for analyze, design, develop, implement, and evaluate (Smith, 2018). This sequence, however, does not impose a strictly linear progression through the steps. Educators, instructional designers, and training developers find this approach very useful because the defined stages facilitate the implementation of training tools effectively. Therefore, the ADDIE model is selected because it fits the characteristics of the target product developed, namely a workshop package that is widely needed and is in the process of being introduced by the user community. In the development process, we carry out internal and external validity. It will maintain the quality of the developed package. Face and content validity from experts and self-reflected judgment from the research team is also an integral part of the development process through this ADDIE model.

DEVELOPMENT AND VALIDATION PROGRESS OF ONLINE STEM TPD's PACKAGES WITH THE DECODE MODEL

This project targets three main goals, namely the development of a communication and information platform through an innovative website homepage, the development of a STEM workshop package, and the development of an assessment to access the TPACK capabilities of the participants of the online DECODE collaborative workshop model. This research is an early stage, and it is a large part of TPD's online STEM project with the decode model in Indonesia. It is a two-year collaborative project between two major educational institutions in Indonesia, namely the Faculty of Teacher Training and Education, University of Jember, and the Faculty of Mathematics and Natural Sciences, Yogyakarta State University. The two institutions are also responsible for the preparation and development of human resources toward a Golden Indonesia in 2045 (one hundred years of Indonesia's independence).

Face and content validity by experts of the Online STEM TPD's Packages with the DECODE model has been done in this initial project. There were three experts involved in this validation process, each of whom has an academic doctoral qualification and teaching experience of more than 10 years. The validation results from the experts showed that the online STEM TPD's packages with DECODE model is valid and can be used for workshops in Indonesia. In addition, professional judgment from the research team has been taken as an integral part of maintaining the quality and validity of the package. However, a limited-scale trial in the field through a workshop must see the practicality and the construction of the package validation directly. The researchers test it as a further part of this research project, including translating all related workshop packages into English so that they can be used not only in Indonesia but also in other countries in the world.

Figure 2. The structure of the online STEM TPD's with DECODE model platform page (Source: Designed by authors using www.canva.com)

In this current study, we show various progress and advance in achieving the results of this initial project. **Figure 2** is a structure of the platform page used as a vehicle for communication and information between workshop participants and developers/instructors. This page can be accessed and explored at the following link: https://stem.fkip.unej.ac.id

On the platform page, there are many features. Candidates and trainees (in-service teachers) can obtain information about the online STEM-TPD packages with the DECODE model. The home section displays the main description of the online STEM-TPD packages with the DECODE model. In addition, the homepage provides information about the facilities obtained by participants when participating in this workshop, including beneficial knowledge, electronic certificates, and workshop packages both online and in printed form. More specifically, the printed file is in the form of a module as a manual book will be send to all participants of this workshop.

Another crucial part of this website is the courses page. On this page, participants can attend workshop classes by registering on the login menu for free. After registration, participants can access the stages of this online DECODE workshop. These stages include teacher demonstration, student co-train the use of the ICT, student co-design the ICT in an integrated course, student co-teach the course, and finally, students receive feedback and evaluation.

The manual book received by all participants contains all the information related to the training. According to UNECE (2015), a manual book or training manual is needed in implementing training or workshops. The manual book will be a guide for participants in terms of the organization of time and the material they will learn and get. The information in the manual book becomes material for participants to strengthen their understanding before, during, and after the training is conducted. Furthermore, the manual book or training manual helps trainers to prepare for their sessions, shows them how to structure the training, and gives pedagogical and didactical guidelines for achieving the participants' learning objectives (UNECE, 2015). Therefore, it can be said that one of the keys to the success of online training with this decoding model is very dependent on the quality of the manual book owned by the participants.

Figure 3 shows some descriptions of the developed manual book.

The developed package or manual book comprises several main components such as introduction, content, and closing. The introductory section contains complementary items such as a preface, table of contents, list of pictures, objectives, and guidelines for using this package. The core section covers some of the main things related to online training with the DECODE model. These sections cover what and how of the DECODE models, online learning platforms, TPACK, and general concepts about STEM education.

In general, DECODE is a training model, namely DEmo-CO-design/teach-feedback-DEbriefing. Online DECODE allows teachers to familiarize themselves with various technologies and software platforms that increase teachers' knowledge and skills in assessment design, instructional design, and practical implementation (Cheng et al., 2022). The expectation is that this online DECODE model will effectively improve the ability of STEM teachers during and after the COVID-19 pandemic. Furthermore, this package illustrates the crucial role of online learning platforms that STEM teachers may find beneficial when teaching in the classroom. One of the online learning platforms shows that the main key in this project package is CCR. The CCR platform enables active interaction between teachers and students on an online platform. The features contained in the CCR are very suitable for use by teachers to maintain motivation, activeness, and student learning outcomes, including for less active students (passive students) in direct learning activities.

Education in the COVID-19 pandemic and post-pandemic also requires online TPACK capabilities, namely an approach that combines aspects of knowledge (Knowledge/K), how to teach (Pedagogy/P), the mastery of learning materials according to the field (Content/C) with ICT (Technology/T). In addition to using technology as a learning medium, in the TPACK framework, pedagogy is a crucial aspect to be considered in learning activities (Irwanto et al., 2022). Moreover, this manual contains the general concepts of STEM education with examples of practical applications in everyday learning. Finally, this two-year research project is to foster online TPACK capabilities for STEM teachers, as well as to strengthen teachers' knowledge and abilities in assessment,

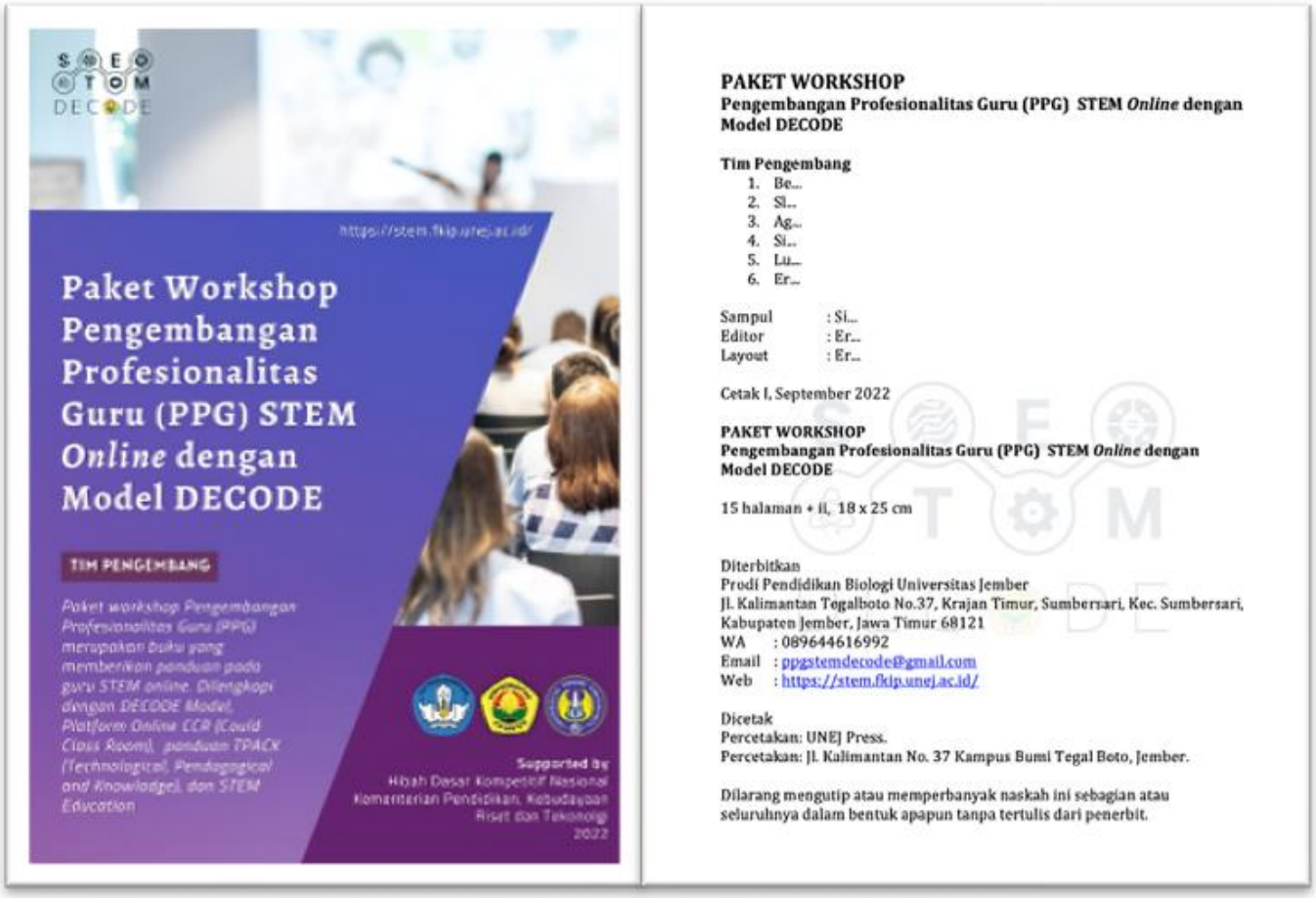

Figure 3. Manual book of the online STEM TPD's packages with the decode model (Source: Designed by authors using www.canva.com)

teaching, and teaching materials, as well as to equip teachers for comprehensive professional development.

In addition to the workshop module package, this project also develops a set of assessments that participants can use when they connect online STEM-TPD instruments with the DECODE model. When training with the DECODE Online model, TPACK teachers need an assessment used as valuable input for the sustainability of this program in the future. An assessment instrument is also a powerful tool that will measure the success of this program. **Figure 4** is the cover and cover page of the instruments developed in the online STEM-TPD instruments with the DECODE model.

The assessment instrument package developed comprises several parts covering a STEM-TPD DECODE observation sheet with a scoring rubric, a questionnaire sheet, and a reflection sheet for the activity participants. Generally, we can classify the three parts into two main instrument categories according to Fiser et al. (2015), namely the self-assessment surveys and the performance-based assessments. The self-assessment surveys instrument in this project is a questionnaire sheet and an activity reflection sheet. Meanwhile, the performance-based assessments are STEM-TPD DECODE's observation sheets. Furthermore, this assessment instrument package aims to evaluate trainee ability in the professional development of online STEM teachers with the DECODE model. This instrument focuses on abilities in six TPACK areas, namely TK, PK, CK, PCK, Technological Pedagogical Knowledge (TPK), and TPACK. In addition, the assessment and module aim to improve teacher and trainee ability to utilize technology through learning activities in the COVID-19 pandemic and post-pandemic era. In the digital era and the post-pandemic period, STEM teachers need online TPACK capabilities because they will strengthen their teacher knowledge and ability in assessment, teaching, teaching materials, and learning technology, and equip teachers in comprehensive professional development (Murtafiah et al., 2022).

IMPACTS OF THE CURRENT STUDIES

The advantage of the DECODE model as the framework and the development of teacher professionality programs in this research is that the DECODE model understands that the ability development process–including teacher competence–needs to build learning or training situations. These can facilitate teachers to transform their understanding of innovation actively and reflectively into actual performance. Specifically, the online STEM-TPD

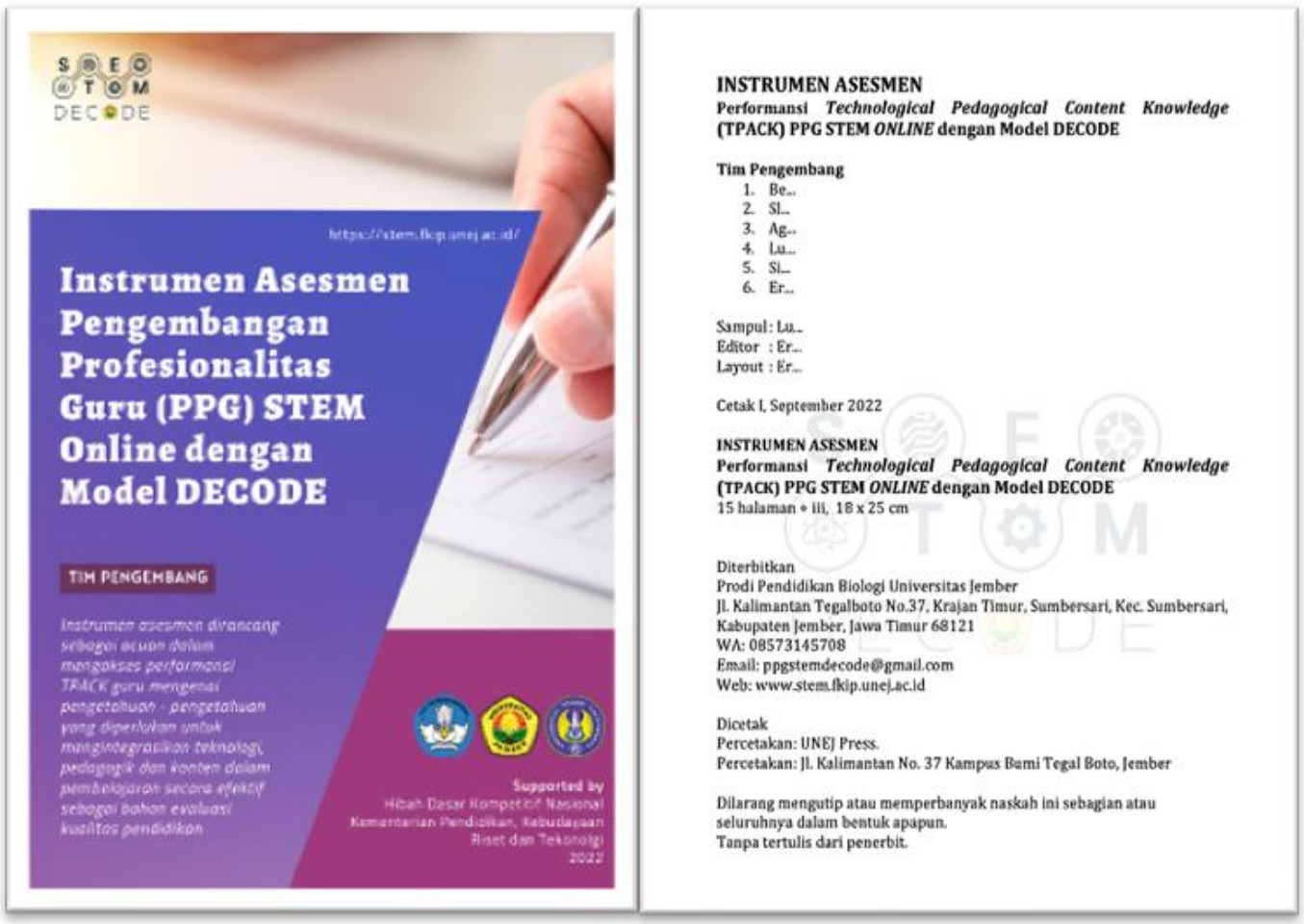

Figure 4. Assessment package of the online STEM-TPD's packages with the decode model (Source: Designed by authors using www.canva.com)

package with the DECODE model is a sort of an innovative teacher's quality maintenance during the COVID-19 pandemic or post-pandemic.

Indeed, at the beginning of the model, the demonstration phase (DE) will provide imitable performance examples and challenge to adapt them to new situations by redesigning activities in different circumstances and trying them out in the CO phase. Understanding the performance principles through critical demonstrations needs to be transformed into the context of actual design adaptation with co-design and co-training.

In the final phase, debriefing (DE) will establish a complete 'space' of reflection for teachers to measure and evaluate the learning process and its adaptability in adopting the innovation studied, namely STEM-based biology learning with information technology. Discussion activities in debriefing facilitate teachers to improve awareness and understand the positive aspects that must be corrected and eliminate the negative ones that are shown or found in the learning process to create a meaningful process from the learning experience. One thing to note, the debriefing process designed does not only involve instructors (mentors) and participants (menti) but also between participants. It has the potential to provide psychological reinforcement through the fairness of the process.

Based on the model framework above, this research implements the DECODE model for training to increase and maintenance the competence or professionalism of science teachers in implementing STEM-based biology learning by strengthening the use of information and communication technology in a web-based platform. The use of the web-based platform has some reasons. The fundamental consideration of the web platform application is an accessibility orientation widely. It can reach the target users of science teachers without any limits. The researchers expect that the web platform for developing and implementing STEM-based science learning training with the DECODE model will become a tested training package to support the expansion of the positive impact of STEM implementation in learning while strengthening the professionalism of science teachers in Indonesia.

Therefore, several big-scale impacts could have appeared through the lasting results from this project produced by the online STEM-TPD packages with the DECODE model. Firstly, the teachers (participants) are equipped to familiarize themselves with various software technology and platforms. In the manual book

package, we provide teachers with a pivotal foundation to initiate using many technological education platforms. It will lead the teacher to become a well-prepared 21st century teacher. Moreover, the online STEM-TPD's Packages with the DECODE model enhance their knowledge and abilities in assessment design, instructional design, and practical implementation (TPACK). Through these three skills, STEM teachers are trained to organize and manage the online class, and then, in turn, they will master any circumstances of classroom teaching and learning. In addition, this current project result effectively affects teachers to teach or guide students in STEM activities and improve their STEM literacy. Finally, this current project has served as a framework for the future design of innovative online TPD-enhanced learning environments to enhance more efficient and effective teaching and learning in any situation, both nationally and internationally.

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Ethical statement: The authors stated that the University of Jember did not have specific protocols for this type of study when this research was carried out. Informed consents were obtained from the participants. The data was treated as confidential information used exclusively for research purposes. It is impossible to identify the participants from the data.

Declaration of interest: No conflict of interest is declared by authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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