Transformative Perceptions of In-service Teachers towards STEM Education:

The Vietnamese Case Study

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Abstract. Science, Technology, Engineering and Mathematics (STEM) education has attracted numerous concerns of scholars and governments. In order to implement the school curriculum on the approach of STEM education, the training of in-service teachers plays an important role. This study conducted the transformative perception of Vietnamese in-service teachers in secondary schools towards STEM education after they had participated in the teacher professional development program (TDP) on engineering designed-based approach hold on by

the Second Upper Secondary Education Development Project 2. Having two separate online and offline phases, the course was designed under the format of TDP developed by Garet et al. In order to assess participants' demographics and their perceptions on STEM education, the instrument was generated on the basis of modification from several previous studies upon engineering design-based learning and to adapt the theme of STEM content knowledge (CK) and STEM pedagogical content knowledge (PCK) for in-service teachers. Full data sets were conducted with 150 participants from 11 provinces of Vietnam who had completed all surveys with the help of Google Form at the beginning and the end of TDP's offline phase. The data were cleaned, then analyzed with SPSS version 20 to assure the validity and reliability. Findings from this study show the positive effectiveness and suitability of the course on the in-service teachers' attitudes towards STEM education, which consequently allow to suggest the future similar courses design.
Keywords: STEM education, perception, attitude, in-service teacher, training, teacher professional development program, TDP.

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1. Introduction

Since it has emerged as a prospective way to foster manpower resource development in the field of Science, Technology, Engineering and Mathematics (STEM), STEM education currently attracts a variety attention of countries. On the dependence of countries' development and local context, strategies, policies and implementation towards STEM education may vary from country to country [Marginson 2013; Tytler 2007]. Nevertheless, common views have been sharing that students' participation with high accomplishment in STEM school subjects will be the basis to pursue work in STEM fields. Not only the competencies of the youth in such fields enhanced, but also technological innovation to spur economic development is designed and created by young people [Bybee 2010; National Research Council 2011; Sadle et al. 2012]. Therefore, stronger economies and more jobs for people will be settled by further innovation that foster STEM educational reform [Banks, Barlex 2014; Williams 2011]. Various approaches to cultivate STEM education have been carried out as curriculum and program redesign, STEM subject integration or changing in methodologies focused on problem-based solving, project-based learning and other active activities [Basham, Israel, Maynard 2010; National Research Council 2012; Honey, Pearson 2014). With the aim of creating a meaningful learning environment, solving practical problems in life, STEM education will increase students' interest in learning, capacity development in the 21st century and encourage them to follow STEM career.

In order to foster STEM education, consequently, to make a good impact on students towards STEM jobs, the role of teachers and their methodologies are important. Though teachers may be good at active learning methods as problem-based solving, project-based learning, they still meet challenges with integrative disciplines of STEM subjects as wells as new procedure as the engineering design process. Many studies have proved that math and science teachers often lack experience in technology and engineering skills, hence, they may face difficulties in managing collaborative problem-based learning and assessment [Asghar 2012; Lesseig et al. 2016; Stohlmann 2012; Wang et al. 2011]. Some investigations argue that technology is not simplistic interpretation as artifacts such as computers, electronics, and Internet or application of science. It should involve the design, engineering, and technological issues related to conceiving, building, maintaining, and disposing of useful objects and/or processes in the human-built world [Yasar et al. 2006]. In addition, many factors as teacher qualifications, teacher attributes and classroom practices may affect the development of teachers' competencies and attitudes [Darling-Hammond, Youngs 2002].

To overcome the difficulties, teacher professional development program has been considered as a solution. Teachers will benefit from program as enriching STEM content knowledge and pedagogical content knowledge in STEM fields, engaging in cooperative learning, and practicing in empirical STEM subjects or topics. They find deeper understandings of disciplinary knowledge of STEM [Brophy 2008], a variety of approaches on integrating content across the disciplines [Moore 2014; Wang et al. 2011]. As a result, their beliefs and understandings related to integrated STEM education are developed [Roehrig 2012; Stohlmann 2012]. Teachers feel more familiar with the engineering content and interested in dealing with engineering activities in classroom [Duncan et al. 2007].

Most of in-service teachers in Vietnam are single subject teachers with a degree of a specific subject including Mathematics, Physics, Chemistry, Biology, or Technology and Information Technology. They lack experience in implementing STEM education, thus content knowledge has been emphasized whilst keeping a little connection to real-world problems. Some extra-curricular programs organized by NGOs or institutes as Science Club, STEM Clubs and STEM Ambassador to promote STEM and expose students to real world issues but they were most applied in extra-activities rather than in school curriculum, in some cities and provinces. Therefore, The Second Upper Secondary Education Development Project 2 (SESDP2) hosted by the Ministry of Education and Training (MOET) launched TDP to enrich in-service teachers' knowledge and skills of secondary school in STEM education. They were not only supplied the concept of STEM education but clear benchmarks and outcomes to guide curriculum design and teaching at each educational level. The goal of current program is to make in-service teachers familiar with process of designing and conducting STEM lessons, self-conducting STEM topics/lessons compatible with current curriculum which is oriented to competencies based education. After having enrollment in TDP, in-service teachers will be expected to apply the proper process to develop

STEM topics/lessons which meet the criteria of current curriculum as well as conducting their own school curriculum.

The paper addresses the issues of TDP held by SESDP2 by answering two questions: (1) Do the perceptions of in-service teachers towards STEM education change? And (2) what factors affected to the transition in their attitudes if it had happened?

2. Literature review

Teacher Professional Development Program (TDP) has been studied and widely applied in many countries with explicit contributions to teachers' STEM content knowledge and pedagogical knowledge as well as their skills and perceptions on STEM education [Brophy 2008; Duncan et al. 2007; Roehrig 2012; Stohlmann 2012; Wang et al. 2011]. Though a variety of format and duration has been accessed, TDPs share common sense to develop teachers' STEM literacy and empirical implementation for integration across the STEM disciplines. In training sessions, teachers had absorbed and shared what they learnt to apply into their classrooms. They were equipped direct STEM integration learning experiences by the facilitators to develop a framework for STEM integration. Teachers also experienced sample activities to carry out in their classrooms [Wang et al. 2011]. Plenary lectures, panels, presentations and number hours' content/domain specific strands exploring some theme integrating STEM were combined to give instructions to teachers (e. g., energy, space, the human body, placer mining, mathematical thinking, materials science, and others). The comfort, efficacy, and perceptions of participating teachers on the effectiveness of deep understanding on their subject matter knowledge integrated in STEM, inquiry instruction preparation, and cognitive process of students were increased [Nadelson et al. 2012]. There is a movement trend in TDP from focusing only on inquiry for science teachers and content knowledge for a specific field [Daugherty 2010] to integrate STEM content through science inquiry and engineering design in the context of subjects [Kelley, Knowles 2016; Lesseig et al. 2016]. The duration can be varied as several days, a week or more [Nadelson et al. 2012; Ring et al. 2017; Wang et al. 2011]. The longer activities were aligned with an opportunity for in-depth discussion of content, student conceptions and misconceptions, and pedagogical strategies. Extending activities were reserved to allow teachers to try out new practices in the classroom and obtain feedback on their teaching [Garet et al. 2001].

Depending on the goals and duration of classes in summer or school year, teachers worked in group to explore approaches to teaching integrated STEM subjects as engineering and data analysis, integrating the engineering process within specific areas of science, and developing an integrated STEM curriculum [Nadelson et al. 2012; Ring et al. 2017]. Students were involved in the part of second phase program for working a while with teachers that brought them real experience to successfully complete a STEM design challenge. After students having dismissed, hence, teachers reserved time to reflect on their experiences and explored ideas related to content, ambitious pedagogy, design challenge implementation, and assessment. During these discussions, teachers shared what they discovered about student thinking and reconsidered their role as learning facilitators [Lesseig et al. 2016]. Project-based and problem-based learning were major methodologies approached for teachers' experiences in TDP.

The research showed the transformative perception of teachers about the important role of conducting content knowledge via inquiry rather than the formality of funning design. They found the necessity of supporting students to use various methods of problem solving to develop students capacity by implementing their own research with some ideas on their own. Because of having worked with students during the TDP, teachers realized that students were both motivated and empowered by the complex, open-ended design challenges. They felt motivated to manage their goal by solving a real problem with a tangible product or outcome even they did not sure about the process or idea failed. Their confidence, hence, was increased for most students [Lesseig et al. 2016]. Teachers from the same school, department, or grade level working in groups had advantages in sharing curriculum materials, course offerings, and assessment requirements to develop their curriculum or topics to meet their school context. Activities involved in active learning during TDP as observing and being observed teaching; planning for classroom implementation; reviewing student work; and presenting, leading, and writing were shown to contribute to the positive accomplishments of teachers [Garet et al. 2001].

Nonetheless, the challenges had been reported as pedagogical, curricular, and structural in implementation. Teachers faced the pedagogical challenges in working as facilitators to guide students solving ill-defined problems that provoked students' own ideas and solutions. The components of a real-world STEM problem coincided with the suitable content standards at level grade requirements were curricular challenges. The structure challenges came from the lack of flexibility in the sequence of instructional units to the confines of class scheduling; the difference in structures and student set of isolated subject courses in traditional schools that was hard implementation across subjects. The study proposed four key supports in TDP context as: providing a vision of integrated, project-based STEM learning; motivating teachers to implement design challenges (DCs) in their classrooms; providing pedagogical tools; and supporting the planning and implementation processes in an ongoing manner [Lesseig et al. 2016].

In order to evaluate the effectiveness of TDP, some instruments were developed on the purpose of studies. Daugherty accessed the hands-on activities, teacher collaboration, and instructor credibility contributed to effective professional development experiences on inquiry for science teachers and content knowledge for a specific field [Daugherty 2010]. The participants' professional characteristics, and other latent variables presented the perceptions and practices of STEM teaching, the pedagogical discontentment, the inquiry implementation, and the efficacy for teaching STEM, with the modification of content and number items based on the previous studies [Nadelson et al. 2012]. Nonetheless, Ring et al. developed the STEM Reflection Protocol to access 8 distinct conceptions by teachers' drawn models that shifted in usage over the course of the 3 weeks [Ring et al. 2017]. Lesseig et al. exploited the codecs based on the set of survey responses to analyze on each teachers' comments. They addressed the teachers' perceptions of the values of the DCs, the scientific, mathematical and engineering practices and 21st century skills, the motivating and empowering all students, the difficulties and issues in the implementation of STEM DCs, and other variables [Lesseig et al. 2016]. A series of questions addressed teachers' perceptions about the meaning of STEM integration and their classroom practices for STEM integration, which were transcribed verbatim to produce fruitful data [Wang et al. 2011]. Thibau et al., on the other hand, developed a questionnaire with 75 items with a five-point Likert-scale (1 = totally disagree, 5 = totally agree) for the distinguished STEM principles: integration of STEM content, problem-centered learning, inquiry-based learning, design-based learning, and cooperative learning. The study accessed the correlation of the background characteristics and teachers' attitudes, and the school context and teachers' attitudes [Thibaut et al. 2018].

3. Methodology

3.1. Participants

The four-day TDP was held in Danang province and Haiphong province in March, 2019. Participants took part in 4 learning stages in sequence: listening to the talk and having a discussion with expert, playing a role as students in studying a STEM topic, analyzing STEM teaching clips, developing a STEM topic and lesson plan in group. Data analysis was conducted on the 150 participants who completed all surveys and provided us with full data sets. Of the 150 valid responses, approximately 18.7% were male and 81.3% were female. The greater number of women than men in the sample was representative of the gender distribution found in the field of education in Vietnam [OEDC2018]. About 91.3% of the sample played the role of teacher and the remaining worked as principals and vice-principals. Their ages varied in groups as 10% under 30 years old, 60.7% in the period from 30–39 years old, 25.3% in the period from 40–49 years old, and 4% over 50 years old. The number rate of in-service teachers in junior high schools was 46.6%, whilst 51.4% working in high schools, and 2.0% working in secondary schools. Above half of them (59.3%) had 10–19 years of teaching experiences, 27.3% less than 10 years, 12% in the period from 20–29 years' experience, and 1.3% over than 30 years of teaching. Participated teachers in Danang came from provinces in the Central region of Vietnam, while participants in Haiphong came from the Northern provinces. The total provinces of attendees were eleven. The rate of major subject-specific were descending in order as science (42%), mathematics (24%), information technology (17.3%), technology (10%), other subjects (0.7%), combined two subjects (as chemistry-biology; biology-technology; mathematics-information technology; mathematics-physics; physics-technology) holding 6.1%. Most participants instructing two subjects were teachers in junior school who were well-educated for combined subjects in the local pedagogy colleges.

3.2. Instrument

To assess our participants' professional characteristics, we developed a demographics instrument based on the information we determined to be salient to our research questions. Included were standard items such as age and gender. In addition, we included the items necessary to determine the grade level our participants teaching, their teaching subject majors, their work (teacher or administrator), and teaching experiences.

To address the perceptions of in-service teachers towards STEM education, the concept, goals, and characteristics of STEM education were asked in the open questions. They also were required to self-evaluate their understanding on STEM education assigned with 5-likert scale coded from 0 to 4 value, as "Level 1: Don't understand", "Level 2: Know but not understand", "Level 3: Understand basically", "Level 4: Understand clearly", "Level 5: Understand very well". To assess their content knowledge and pedagogical content knowledge to implement STEM education on engineering design-based learning, a set of Likert scale questions from "0" representing "unnecessary" to "4" representing "very necessary" was delivered to in-service-teachers. Thirty-seven Likert scale questions assigned to six categories related to content knowledge and pedagogical knowledge. In addition, the questions in the sense of teacher professional development were involved to associate with the scenario training plan. The format of survey was the same in the pre-test and post-test to assess the transformative perceptions of in-service teachers in the TDP. The pre-test was carried out at the beginning of the offline session, while the post-test was done at the end of program. Participants filled their name and their school name to track their responses. Though there were modifications of the instrument in comparison with other studies (Daugherty, 2010; Nadelson et al., 2012; Ring et al., 2017; Thibaut et al., 2018), it still aligned with the theme of STEM content knowledge and STEM pedagogical content knowledge for in-service teachers (Shulman, 1986). The instrument presented in Table 1 as follows:

The instrument was carried out by using the Google-Form with extra questions included closed-ended questions, multiple choice questions, Likert-type scale questions and open questions. The data were cleaned, then analyzed with SPSS version 20 to assure the validity

Table 1. **Instrument to assess perceptions in implementing STEM teaching script on the engineering design-based approach**

Category (latent variables)	Items (measured variables)
Building topics and lesson plans	1. Teachers find out the needs and practical applications of the knowledge mentioned in the lesson content 2. Teachers search for materials and information from reference sources (Internet, teacher books, magazines ...) to develop content and teaching plan 3. Teachers discuss with colleagues who teach the same subject to select the appropriate topic and content 4. Teachers discuss with colleagues who teach different subjects to choose the appropriate topic and content 5. Teachers need to determine the goals for each teaching activity 6. Teachers need to identify specific requirements and criteria for self-learning activities and self-understanding of students' knowledge 7. Teachers need to define specific requirements and criteria for products (if products required) 8. Teachers perform the tasks, exercises, activities and products in advance, which are expected to be handed over to students for completion
Studying background knowledge for students	1. Students learn knowledge related to content / learning tasks 2. Students conduct experiments and experiments based on relevant theoretical knowledge 3. Students explain the usage of relevant knowledge in product creation process
Designing and producing products	1. Students develop their own plans and solutions to create products 2. Students work in group to create products by clearly assigning work to each member 3. Students proactively propose solutions and collaborate with others in the group to select solutions to design and develop products 4. Students pay attention to the principles of safety and hygiene in the process of product implementation 5. Students use appropriate and saving costs materials 6. Students calculate costs to create economically beneficial products
Sharing and evaluating products	1. Students report and display products designed 2. Students report plans and solutions, protect ideas to create products in class before starting to build real products 3. Students self-vote and evaluating within the group during the process of performing tasks 4. Student groups are evaluated by other groups of students 5. Students are assessed by teachers with their products 6. Students are assessed by teachers of related subjects (if the product uses interdisciplinary knowledge) 7. Students are encouraged to improve their plans, solutions and products 8. Students need to explain the adjustments and improvements in the process of creating products 9. Students are encouraged when failure and see the failure as a lesson, a driving force for success
Pedagogical content knowledge	1. Teacher determines proper implementation to meet the goal of each learning activity 2. Teacher needs to assign tasks and sources of necessary learning materials for students to self-study 3. Teacher readily facilitates if students have difficulties in self-study 4. Teacher asks other specific subject colleagues to support if students have difficulties in carrying out the tasks related to those specific subjects 5. Teacher performs the summation and finalization of key knowledge after the students have completed and reported the groups' accomplishment 6. Teacher needs to distribute the overall time and reasonable time for each activity to ensure the feasibility for students' self-studying
Professional development	1. Teacher participates in training classes to be trained on how to build and organize teaching activities 2. Teacher participates in practice / experience practical activities to have experience in building topics and organizing teaching activities 3. Teacher participates in training for colleagues to have experience in building topics and organizing teaching activities 4. Teacher participates in observing and assessing lesson of colleagues to have experience 5. Teacher needs to pay attention to actions taken by students to make sure whether that meet the learning objectives in observing lesson of colleagues

and reliability. Questions were designed in groups to investigate the understandings and attitudes of in-service teachers to STEM education as methods for creating subjects, teaching activities following the engineering design-based approach, and assessment.

4. Result and Discussion

4.1. The reliability and validity of the instrument developed

The reliability of observed variables is assessed by Cronbach's Alpha coefficient. The requirement to accept the scale is to remove variables with the total correlation coefficient less than 0.3 and Cronbach's Alpha coefficient less than 0.6 [Bland, Altman 1997]. The reliability of the instrument was established to have a 0.984 Cronbach's alpha with the subscales Cronbach's alphas ranging from 0.931 to 0.977 for the pre-test, and a 0.981 Cronbach's alpha with the subscales Cronbach's alphas ranging from 0.899 to 0.963 for the post-test which indicates a high level of instrument reliability.

The validity of the scale is assessed by the method of exploratory Factor Analysis (EFA). In each test, the variables had factor loadings (from 0.762 to 0.951, and 0.766 to 0.928 for Pre and Post test correspondingly) greater than the standard (with sample size 150, the required factor loading is greater than 0.45) (Table 2, page 116, [Hair et al. 2010]). The values of KMO were satisfied the condition 0.5 <KMO <1, showing that EFA explores factor analysis in accordance with actual data. Barlett's tests had a Sig significance level less than 0.05, so the observed variables were linearly correlated with representative factors. All of the average variance values extracted (corresponding to Eigenvalues values greater than 1) were greater than 62%, indicating that more than 62% of the variation of the factors were explained by the observed variables.

4.2. The impact of TDP towards in-service teachers' perceptions

To find out the relation between the groups of variants and self-assessment on STEM education of in-service teachers, the correlation analysis was dealt with Pearson Correlation tool in SPSS. Results in Table 2 shows the significant relationships between variants of STEM implementation assessment in the pre-test. However, there was no link between such variants with self-assessment on STEM perception of in-service teachers. Lack of experience in conducting STEM topics coherently with engineering design-based learning and format of TDP may account for the reason.

Nonetheless, after having experienced in TDP, the transformative perceptions of in-service teachers had a strong connection with two categories of variants that they spent more time for absorbing lectures from experts and dealing with tasks that focused on building STEM topics and lesson plans (Table 3). Because of being involved in the professional development activities as playing a role as students, observing and evaluating a sample teaching session, training and to be trained, in-service teachers benefit from TDP, so the changing in their perceptions related to this variant category ($p < 0.01$). A less signif-

Table 2. **Correlation between measures in pre-test**

Items	Self-assessment on STEM perception	Building topics and lesson plans	Studying background knowledge for students	Designing and producing products	Sharing and evaluating products	Pedagogical content knowledge	Professional development
Self-assessment on STEM perception	1	−0.023 0.776*	0.000 0.997*	−0.005 0.949*	−0.024 0.769*	−0.003 0.968*	0.34 0.683*
Building topics and lesson plans	—	1	0.607**	0.615**	0.635**	0.943**	0.881**
Studying background knowledge for students	—	—	1	0.941**	0.946**	0.599**	0.577**
Designing and producing products	—	—	—	1	0.952**	0.604**	0.588**
Sharing and evaluating products	—	—	—	—	1	0.610**	0.587**
Pedagogical content knowledge	—	—	—	—	—	1	0.911**
Professional development	—	—	—	—	—	—	1

Pearson Correlation; Sig. (2-tailed), **p = .000 < .01, *p > 0.1; N = 150

icant correlation (0.01<p<0.1) is the relationship between teachers' perception and the variant on pedagogical content knowledge (PCK). Because the integration in teaching a STEM topic is new to the participant, so some components of PCK were not considered important. For example, the component 4th in PCK referred to the support from other specific subject colleagues when student met difficulties in dealing with tasks related to the specific subject. In-service teachers may think it was not comprehensive due to their current specific subject teaching. Additionally, the duration of TDP and/or the practices may not be long enough and frequently enough to impact on their

Table 3. **Correlation between measures in post-test**

Items	Self-assessment on STEM perception	Building topics and lesson plans	Studying background knowledge for students	Designing and producing products	Sharing and evaluating products	Pedagogical content knowledge	Professional develop-ment
Self-assessment on STEM perception	1	0,224** 0,006	0,009 0,909*	−0,042 0,612*	−0,053 0,520*	−0,195* 0,017	0,212** 0,009
Building topics and lesson plans	—	1	0,741**	0,719**	0,708**	0,918**	0,899**
Studying background knowledge for students	—	—	1	0,918**	0,882**	0,710**	0,654**
Designing and producing products	—	—	—	1	0,926**	0,690**	0,648**
Sharing and evaluating products	—	—	—	—	1	0,684**	0,635**
Pedagogical content knowledge	—	—	—	—	—	1	0,885**
Professional development	—	—	—	—	—	—	1

Pearson Correlation; Sig. (2-tailed), **p = <0 .01, *p > 0.1; N = 150

perceptions. The significant relationships between variants of STEM implementation assessment of the post-test were similar to the pre-test's results.

In sum, the means and deviations of study measures in comparison between the pre-test and post-test are shown in Table 4.

Note that the scale for the first item range from 0 to 4 aligned with no awareness of STEM conception to comprehensiveness, while other items have scale from "0" representing "unnecessary" to "4" representing "very necessary". Thus, each scale has a value of 0.8. All items from the second to the seventh of Table 4 were standardized

Table 4. **Comparison between measures in pre-test and post-test**

No	Items	Pre-test		Post-test	
		M	SD	M	SD
1	Self-assessment on STEM perception	1.43	0.680	2.21	0.535
2	Building topics and lesson plans	3.00	0.776	3.20	0.562
3	Studying background knowledge for students	3.10	0.827	3.30	0.672
4	Designing and producing products	3.02	0.788	3.24	0.633
5	Sharing and evaluating products	3.01	0.794	3.14	0.633
6	Pedagogical content knowledge	3.01	0.795	3.20	0.589
7	Professional development	3.05	0.827	3.19	0.589

to the original scale by averaging its' sum-up components. Table 4 reveals that in-service teachers changed their self-assessment on STEM perception at the level "know but not understand" at the beginning of TDP to the upper level "basically understand" at the end of the training course.

For the items related to the content knowledge and pedagogical content knowledge as well as the professional development, the participants accessed as "necessary" for all items at the beginning and changed to "very necessary" for three items at the end of the course. They regarded the critical importance of activities "Studying background knowledge for students", "Designing and producing products", "Building topics and lesson plans" and the last "Pedagogical content knowledge" after having experienced in the course. In spite of the results, surprisingly, there is no correlation between the two first items and their self-assessment, and even negative correlation between the last item and their self-evaluation.

To determine the characteristics of variants in the instrument, the normal test utility of SPSS was used. The Sig. value of the Shapiro-Wilk Test is less than 0.05 for all items, the data is abnormal distribution. Therefore, the Wilcoxon signed-rank test has been used and it revealed that p-value was less than 0.05 for the case of "Self-assessment on STEM education", "Overall assessment", "Designing and producing products". The results confirmed that the difference of in-service teachers' perceptions between two points of the training course is meaningful. Recalling the inspections in Table 4, we found that the transformative perceptions of in-service teachers towards such kinds of STEM knowledge were significant.

In addition, data collected from open questions revealed that participants highly appreciated the benefits gained from TDP. Many views confirmed useful and practical experiences as resources and experts' enthusiasm and guidance. Some of them would like to participate in the summer course that less affected to their current work. Others needed more time to study documents and sample teaching scripts and sample videos. They expected the next course would give more empirical examples for the core subjects as mathematics and other science subjects rather than a limitation in physics and chemistry. The critical analysis for product's criteria also needed to be given further. Some participants confessed the ambiguity in the engineering design process that reminded them concerning products only rather than the background knowledge students needed to study to explain the way they follow to create a product. In another way, the product was considered as a shell for students conducting new knowledge or applying the old that they ever learned. By that way, students invoked general knowledge and skills to perform assigned tasks including collaboration and other skill of the 21st century [Bybee 2010; National Research Council 2011; 2012].

Some in-service teachers felt difficult to create an integrated topics and designing activities. Thinking about a specific subject without linking to a real world problem as participants' habit in teaching caused the barrier in creativity. Because most of them were not educated to teach integrated subject and experienced in engineering process, thus, designing and producing were strange to many body [Brophy 2008; Wang et al. 2011]. Though they were experienced such tasks in TDP, they needed more time to practice with their colleagues in their school that was not occurred in the training course. That was the trend for longer course, for example, in summer [Garet et al. 2001; Lesseig et al. 2016].

To examine what other factors affected to the self-assessment on STEM perception and overall assessment latent variables, the correlation test was carried out based on the survey data. At the end of the training course, in-service teachers were asked to assess on documents, facilities, lecture, duration and time for the training course followed 5 Likert scales from "0" indicated "Poor/Not suitable" to "3" indicated "Good/Very suitable". The results revealed that lecturer at the top of evaluation (M = 2.07, SD = 1.12), document assessment following (M = 1.82, SD = 0.925), then during assessment (M = 1.72, SD = 0.922), facilities assessment (M = 1.66, SD = 0.934), and finally time assessment (M = 1.34, SD = 1.07). With p-value was less than 0.01 and 0.05, the inspections show that lecturers and experts contributed majorly to the high appreciation of in-service teachers on overall assessment and self-assessment on STEM perception (Table 5). Other conditions of TDP also impacted on the high self-assessment on STEM perception of participants but not explicit contribution to overall assessment. The data reflected frankly the conditions of TDP. In-service teachers were impressed by the enthusiasm of lecturers and associated lecturers who built up sample teaching scripts. They were willing to share their experiences, even difficulties in implementing a

Table 5. **Correlation between measures and assessments in post-test**

Items	Self-assessment on STEM perception	Overall assessment	Document assessment	Facilities assessment	Lecturer assessment	Duration assessment	Time assessment
Self-assessment on STEM perception	1	0.094 0.252	0.270** 0.001	0.275** 0.001	0.236** 0.004	0.289** 0.000	0.255** 0.002
Overall assessment	—	1	0.012 0.885	0.154 0.061	0.209* 0.11	0.028 0.738	–0.050 0.544
Document assessment	—	—	1	0.455** 0.000	0.304** 0.000	0.477** 0.000	0.346** 0.000
Facilities assessment	—	—	—	1	0.269** 0.001	0.515** 0.000	0.536** 0.000
Lecturer assessment	—	—	—	—	1	0.288** 0.000	0.309** 0.000
Duration assessment	—	—	—	—	—	1	0.505** 0.000
Time assessment	—	—	—	—	—	—	1

Pearson Correlation;**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed)

STEM topic and solutions, whereby the route was more convinced to participants. Working in groups with colleagues from the same school, in-service teachers had a lot of opportunities to think over the solutions to carry out a STEM topic into their school program. However, at the first step, they were required to design a sketch and create a prototype as a sample part of the groups' teaching script. The product should be produced properly to the local materials and context, usually by hands-on. It was an intentional request for the flexibility and creativity in proposing an integrated STEM topic that brought a good example for participants to develop their own subject matter and teaching plan. Nonetheless, not many participated teachers realized the intention of the organizer, thus, they complained about the facilities as well as other factors.

The controversy and ambiguity also appeared during the TDP. In-service teachers concerned about the role of their subject in developing an integrated STEM topic or lesson. Some found inconvenient to connect the content knowledge in the textbook to a real world problem. Some others thought the collaboration only occurred to teachers teaching the same subject. In the case, lecturers had to arrange groups for mixing subject-specific participants. Collaboration between teachers with different subjects proved the positively influenced implementation [Stohlmann 2012; Thibaut et al. 2018]. Nevertheless, such an idea has not often met the fact due to the imbalance of the subject quantity of in-service teachers to be assigned to participate in TDP. Other challenges were the quarrel about the implementation of a STEM topic focused on science subjects. Some attendees argued that inquiry learning was more relevant to teaching science than engineering design learning. Lecturers, in the case, had to understand the theme of STEM implementation and relevance, thus, to point out the reasonable conditions for applying the engineering design-based process or the inquiry-based process or the combination of two processes in carrying out a STEM topic.

4.3. Limitations and perspective for further research

The study has responded to the two research questions on transformative perceptions of Vietnamese in-service teachers in secondary schools and the causes after they participated in TDP held by SESDP2. Nonetheless, the current design has some limitations. Self-reported for all measures is one of limitation. This may be affected by the local context and emotion of attendees and could have contributed to artifactual covariation among measures. Other objective measures as observing activities and products or accomplishments of participants should be used in further research.

Moreover, some characteristics of participants did not reflect the correlation of variants as their age, teaching experiences, subject teaching etc., though several factors were reported to influence on their belief and practices [Southerland et al. 2012; Thibaut et al. 2018; Wang et al. 2011]. The explanation may have resulted in the size of items and samples studied (for example, this study conducted 37 items for 150 attendees in comparison with 75 items and 254 participants in the other research [Thibaut et al. 2018]). To further examine the transformative perceptions and the implementation of integrated STEM education of in-service teachers, the more details of characteristics of other factors as classroom variants including outcomes of students, instructional methodologies, a collaboration between colleagues in local school etc. should be involved to study.

5. Conclusion

The research aimed to find out the examination for the transformative perceptions of Vietnamese in-service teachers in secondary schools and the explanation. Six latent variants assigned to align with categories in the teaching script based on the engineering design-based process and the professional development. Self-assessment of participants on STEM perception revealed strong positive correlation with thorough instructions and activities in the offline phase of TDP as "Building topics and lesson plans" and "Professional development", after they had experienced. For other latent variants, self-assessment on perception did not elicit coherently with such variants which raised questions on the exact of self-assessment that needed to further study. However, their perceptions on STEM education showed a positive transition on both components and total indicators of content knowledge, pedagogical content knowledge and knowledge of professional development. The results were caused by the effectiveness and suitability of the course, whilst the impact of lecturer and methodologies as well as the supports for participants during the course were important. Though some suggestions were gathered in the survey showing the necessity of sample videos and sample teaching scripts, other study proved the attendees' attitudes could be improved through attitude-concentrated during the teacher professional program, whereby assignments and experiences were used increasingly [Aalderen-Smeets, Walma van der Molen, 2015].

The accomplishment of study also proposed extended support for in-services teachers at their home town, whereby, they could communicate conveniently with colleagues and students to develop and implement their STEM topics as well as teaching script related to the local context which are more meaningful and benefited for their students. The extent courses could be organized in the school context to foster and empower teachers due to the comfort and advantages in their familiar environment which are proved by other studies [Garet et al. 2001; Nadelson et al. 2012; Thibaut et al. 2018].

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