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Professionalising Science And Engineering Teachers In Guiding And Assessing Reflection

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PROFESSIONALISING SCIENCE AND ENGINEERING TEACHERS IN GUIDING AND ASSESSING REFLECTION (RESEARCH-PRACTICE)

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ABSTRACT

The current knowledge society of the 21st century requires students, among other things, to have the ability to think reflectively. Various studies show however that educational programs and teachers, from engineering programs in particular, experience difficulties in integrating the development of students' reflection skills in their curricula. This gave rise to a multi-year project on improving reflection in engineering educational programs. We worked with teacher teams of 6 programs to improve their curricula and teacher practices regarding reflection. Part of the project were training sessions for teachers focused on guiding and assessing reflection activities of their students.

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This paper presents a study that was conducted in relation to this training to gain insight into: 1) teachers' guidance and assessment skills and 2) the contribution of the training to any changes in these skills. A selection of teachers of the participating teams were interviewed before and after the training (N = 8). To gain insight into teachers' guiding skills, we designed and recorded video's that depict multiple authentic, prototypical situations. Text excerpts of written reflection reports were used to unravel teachers thoughts and approaches regarding assessing students' reflections. The interview protocol aimed to elicit teaching interventions and actions regarding guidance and assessment of students' reflections and teachers rationales and thoughts behind these interventions and actions. Results indicate a shift in teachers' guiding and assessment skills before and after the training; their skill repertoire seems expanded and reflection questions they would ask their students aimed at deeper reflection.

1 INTRODUCTION

1.1 Background

Within the current labor market there is a growing need for technically trained professionals. To function well within this labor market, young professionals should be able to critically react to often fast changing (knowledge) developments (World Economic Forum 2023). More specifically, there is an ongoing demand for technically trained students who are capable of reflective thinking in addition to their domain-specific specialism. Many authors state that reflecting is a basic skill for (future) professionals and therefore for students (Ryan 2013; van Beveren et al. 2018). Reflection is seen as a process of systematic thinking, in which one gains insights based on experiences, looks ahead and gains new experiences, with the aim of developing oneselves (professionally) (van Beveren et al. 2018; Meijers and Mittendorff 2017).

Though reflection as a means to foster students' personal and professional development and the importance of incorporating it as essential part of the curriculum is generally acknowledged (Ryan 2013), schools and teachers experience difficulties regarding effective implementation of reflection in their programs (Hughes et al. 2017). Also, related research has shown that especially technical students not always recognize the added value of reflection and the written format that is often used to incorporate reflection does not fit this technical target group (Mittendorff and Pullen 2019). Teachers of several technical study programs in higher education have indicated that they have little knowledge and skills when it comes to these topics and express a need for further professional development (Mittendorff and Pullen in press).

The project Strengthening reflection in technical higher education programs'addresses these issues. In this project, efforts are made, among other things, to professionalize higher education science and engineering teachers in guiding students in developing their reflection skills and assessing students' reflection activities. Guiding and assessing reflection activities of students appear to be two relevant topics for professionalization. In this paper addresses the way teachers perceive their own skills in relation to these topics and presents a study in which these perceptions were studied before and after training sessions on guiding and assessing students' reflection activities.

1.2 Guiding and assessing reflection

Teachers play a crucial role in guiding students in their learning process and the development of skills such as reflection. For example, in teaching students *how* to reflect by jointly discussing a reflection process, or in guiding a reflective dialogue among students who are collaborating during a project In their role as coaches, teachers are primarily facilitating, activating, diagnosing, challenging and evaluating (Korthagen and Nuijten 2023). Coaching skills that serve as a starting point can be categorized into four categories (Mittendorff and Visscher-Voerman 2019):

- Creating a safe learning environment (atmosphere);
- Asking questions (goal: critical inquiry and reflection so that student is prompted to think);
- Providing feedback;
- Providing (targeted) support.

When it comes to assessing reflection, it is important to understand what reflection actually is, in order to determine the quality of specific reflection processes or activities of students. A reflection process starts with describing a meaningful situation, that an individual examines from both inside and outside. It continues withformulating insights based on that analysis and determining follow-up steps (see Fig. 1; Mittendorff 2014).

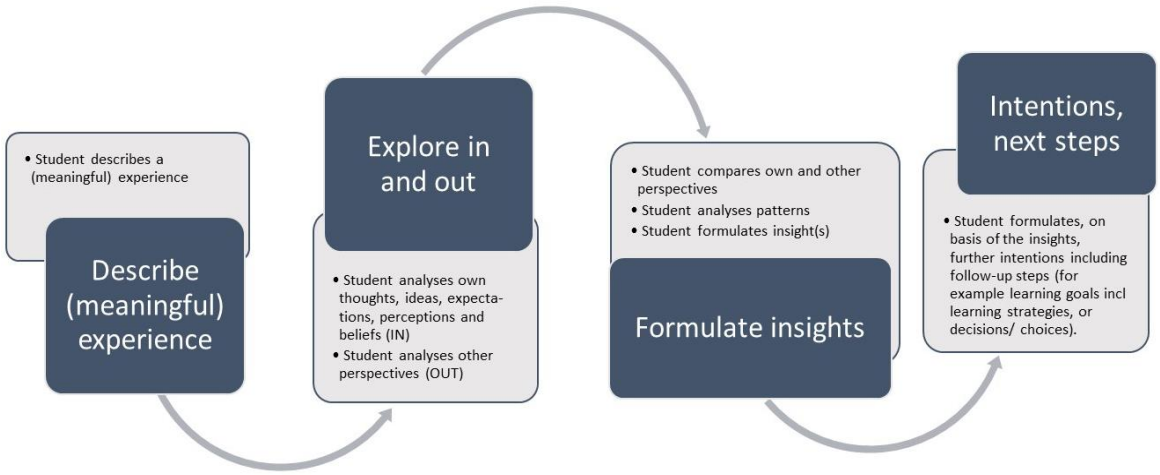

Fig. 1. Reflection Process

Reflection is different from evaluation, because it addresses what is ‘under water’ instead of merely at ‘the surface’; it is aimed at discovering patterns and incorporating perspectives from both inside (e.g., your own thoughts, feelings) and outside (e.g., theory or knowledge, feedback of others) (Kember et al. 2008; Kinkhorst 2010).

When it comes to valuing or assessing students’ reflection activities by teachers, it is important to take into account whether the different aspects or phases of reflection are present: are experiences described, are these experiences analysed (inside and outside), are insights summarized or formulated, and did one look forward to future intentions or actions? (Engelbertink et al. 2021). In addition, it is important to consider whether the various elements of a reflection process are connected or aligned.

This paper presents a study that was conducted in relation to training sessions for science and engineering teachers focusing on guiding and assessing students' reflection activities. It addresses the following research questions:

1) What do science and engineering teachers consider important in guiding and assessing students' reflections, and can we identify differences before and after the training?
2) Can we identify differences in teachers' (perceived) ability in guiding and assessing students' reflection activities, before and after the training?
3) Which elements of the training, according to the teachers, contributed to any increase in (perceived) ability in guiding and assessing students' reflection activities?

2 METHODOLOGY

2.1 Instruments

Interviews

To answer the research questions, a structured interview with science and engineering teachers was conducted both before and after the training (i.e., two weeks before the first and two weeks after the final training). To measure teachers' (perceived) ability, we took a twofold approach: 1) we asked teachers about their perceived ability, and 2) we elicited their reactions to videorecordings of situations in which students reflect and to student reflection reports. The pre- and post-interviews were similar in structure and content (see Table 1).

Table 1. Interview outline

A. Important elements in guiding and assessing students' reflection activities	
What elements do you consider important when guiding and assessing students' reflection activities?	
B. (Perceived) ability in guiding students' reflection activities	
Perceived ability How skilled do you feel regarding guiding students' reflection activities?	*Reaction to video recording (4x)* How would you react to this situation? Can you give specific examples of what you would do, and why?
C. (Perceived) ability in assessing students' reflection activities	
Perceived ability How skilled do you feel regarding assessing students' reflection activities?	*Reaction to reflection report (2x)* How would you characterize the quality of this excerpt, and why? What feedback would you provide to the student?
D. Contribution of training elements (post-interview only)	
To what extent do you notice differences in the way you guide and/or assess students' reflection activities? Which training elements may have contributed to this difference?	

Video vignettes and reflection reports

Video vignettes

To elicit teachers' reactions in real situations, we designed and recorded four videos that represent authentic situations in which teachers guide students' reflections. The video recordings focused on prototypical situations an engeering context and commonly occurring 'issues' regarding students' reflections (for example: a conversation between a project supervisor and a group of students, during which the students reflect on their collaboration; students do not comply with their agreements and hardly communicate about this). To develop the videos the following procedure was followed: 1) based on literature, a selection of prototypical situations and commonly occurring 'issues' was made; 2) engineering teachers were consulted to finetune this selection; 3) based on step 1 and 2 a first draft of the scripts was designed; 4) engineering students were consulted fo finalize the scripts; 5) based on the final scripts, the videos were recorded with the same students.

Each video had a length of approximately 2 minutes and started with a sort description of the situation. The video's were played one-by-one during the interview.

Reflection reports

To gain insight into how teachers would assess students' reflections, examples of real reflection reports were requested from engineering teachers. From these reports, a selection of two text excerpts was made and anonymized.

2.2 Participants

Participants came from three study programs (Building & Infrastructure, Information Technology/Electrical Engineering, and Fashion Textile & Technology) of two universities of applied sciences in the Netherlands. The team lead of each participating teacher team was instructed to select 4 teachers (based on their availability and their intention to participate in the training) to be interviewed, teachers were then asked to participate in the interview, and all teachers were willing to do so. Initially, 11 teachers participated in the pre-training interview. Three of them were absent during more than one (out of three) training sessions and therefore not interviewed after the training. The remaining 8 teachers (6 males, 2 females), who were all interviewed before and after the training, were used as respondents in the analysis. All teachers were experienced in guiding and assessing students' reflections. The level of experience and the role(s) they have (e.g., study coach, project supervisor) varied.

2.3 Training

The training was developed and provided to the whole teacher team of the participating study programs. The training consisted of three sessions on the following topics: 1) guiding reflection activities of individual students; 2) guiding reflection activities of a group of students; 3) assessing/ valuing students' reflection activities. Each training session included a mix of information, hands-on activities and concrete tools to support teachers in guiding and assessing students' reflection activities. The sessions took about three hours each.

2.4 Data-analysis

All interviews were recorded and transcribed. A within-case analysis was performed to create an overview of answers to the interview questions per teacher. Therefore, transcripts of each interview question were summarized per case. To gain insight

into which guidance strategies teachers would employ and how they would approach assessment of students' reflections, their reactions to the video recordings and reflection reports were categorized by adopting a deductive coding approach. Teachers' reactions to the video recordings were coded as one or more sub-categories as presented in Table 1. Regarding teachers' reactions to the reflection reports, it was determined whether attention was paid to the different aspects or phases of reflection and their interconnectedness (Engelbertink et al. 2021).

The following procedure was adopted to categorize the reactions (which was done by two coders). First, a small selection of answers was discussed together. Second, both coders coded a selection of answers independently of each other and discussed differences and similarities of this selection afterwards. Third, descriptions of the codes were further refined based on the discussion. Fourth, the second and third step were repeated, afther which the full dataset was analyzed.

Finally, a cross-case analysis was conducted to gain insight into the similarities and differences accross the eight cases, both on the pre- and post interview.

Table 1. Overview of codes to characterize guiding behaviour, based on Mittendorff and Visscher-Voerman 2019

Codes	**Sub-codes**
Creating a safe learning environment	• Creating space for students to ask questions and/or share ideas • Demonstrating genuine interest (by demonstrating curiosity and/or by listening actively)
Asking questions	• Aimed to elicit evaluation • Aimed to elicit reflection • Directed to one or more reflection steps (and their interconnectedness)
Providing feedback	• Mirroring students' behaviour • Sharing opion about the situation • Providing a frame of reference for behaviour • Helping students to gain self-awareness
Offering (targeted) support	• Scaffolding by providing tailored help • Modeling behaviour

3 RESULTS

The results below present the main findings of the cross-case analysis for the pre- and post- interview in relation to the research questions.

3.1 Important elements in guiding and assessing students' reflection activities

Overall, answers among teachers differed, during both the pre- and post-interview.

Guiding reflection activities

During the pre-interview teachers noticed, for example, the importance that students *become aware* of their own behaviour and that they *look back* to see what could have been done differently. Regarding important guidance elements teachers mentioned, among other things, to *ask questions* instead of merely forwarding information to their students. An aspect mentioned more than once, is to allow students '*to think by themselves'*.

During the post-interview, teachers noticed aspects such as helping students to *recognize patterns* in their behaviour, trigger students to *increase awareness* regarding their behaviour, and having students *practice reflection* by means of a model. Similar to the pre-interview, the importance to allow students *'to think by themselves'* was mentioned more than once. What stands out is that five out of eight teachers during the post-interview noticed the importance of *facilitating a safe environment and stimulating mutual trust*, whereas this was not mentioned during the pre-interview.

Assessing reflection activities

During the pre-interview teachers mainly noticed the extent to which students provide *concrete descriptions* (e.g., whether they describe their role/contribution during a project, how the process evolved, or whether they provide concrete examples).

During the post-interview two elements stand out. First, teachers indicated the importance of *coherence during students' reflections* (i.e., whether they go through the full reflection process and whether there is a connection between the various steps; for example, a connection between insights regarding the current situation and future actions). Second, some teachers noticed the extent to which students provide an *in-depth reflection* (e.g., beyond merely an evaluation of the situation, willing to take into account their emotions, recognizing behavioural patters and deriving insights form these).

3.2 (Perceived) ability in guiding and assessing students' reflection activities

Guiding reflection activities

Perceived ability

During the pre-interview teaches indicated to feel rather skilled. Two of them indicated to act merely on intuition. Teachers' perceived ability during the post-interviews seems very similar to the pre-interview. However, two of them indicated to feel more skilled, whereas one teacher declared to feel somewhat less competent after the training, because of all the information provided and lessons learned.

Reactions on video recordings

The analysis of teachers' reactions and provided examples of what they would do in certain situations (as portrayed in the video recordings), showed that teachers demonstrate different guidance strategies when comparing their answers on the pre- and post-interviews. Although the answers between teachers differed, an obvious finding is that teachers demonstrate a more extensive skill repetoire during the post-interview compared to the pre-interview. The strategies described below became more often apparent in the post-interview, compared to the pre-interview.

The main difference was found in *providing feedback*; teachers showed or indicated to provide more feedback. More specifically, they would more often mirror students' behaviour and help them to gain self-awareness. Also, teachers were more concerned about *facilitating a safe environment* when guiding students' reflections. Their reactions were more often categorized as 'creating space for students to ask questions and/or share ideas' and 'demonstrating genuine interest' (for example by demonstrating curiosity and/or by listening actively). Finally, teachers would *ask questions* more often and provide more examples of questions they would ask. Also, these questions seem to aim for more in-depth reflection (i.e., more focused on feelings, underlying assumptions, understanding of patterns in students' behaviour,

and future actions). For example, during the pre-interview a teacher would ask ‘what is going well?’ and ‘what can be improved?’, whereas during the post-interview, this teacher would ask more nuanced questions, such as ‘what makes you dislike this course?’, ‘what would you like to learn?’, ‘taking into account next academic year; what would make you happy?’, ‘what motivates you?’.

Assessing reflection activities

Perceived ability

During the pre-interview, half of the teachers indicated to feel rather skilled, whereas the other half indicated to feel not (very) skilled. During the post-interview half of the teachers pointed out to feel more skillful compared to how they felt before the training. Two teachers noticed to feel less skillful, because of the gained insights during the training. Others found it difficult to indicate how skillful they are.

Reactions to reflection reports

Considering how teachers would characterize the quality of students’ reflections and their reasoning behind it, teachers’ assessments during the pre- and post-interviews can be labelled rather similar. However, it is noteworthy that during the post-interviews, teachers more often payed attention to particular reflection steps; whether students would *look ahead* and provide *concrete future actions*. Also, teachers put more emphasis on whether students’ reflections are personal and whether students are making connections between reflection steps (e.g., whether they link the current to a previous situation in order to discover patterns).

3.3 Contribution of training elements

Although not all teachers specifically indicated whether the training contributed to their ability level, most teachers indicated that they have received concrete tools that would help them in guiding and assessing students’ reflection activities. Examples of tools that are found to be helpful are a provided reflection model (with reflection steps), reflection cards (with example reflection questions that teachers could ask to guide students’ reflections), and a reflection rubric (with an indication of various reflection levels). Teachers recognized the importance to practice their teaching skills regarding guiding and assessing reflection with the help of these tools. However, they also indicated that they would appreciate more time to practice these skills and to discuss examples of students’ reflections with colleagues.

3.4 Conclusions

The results showed that the science and engineering teachers that participated in this study differ in terms of how they perceive their own ability to guide and assess students’ reflection activities, both before and after training. This shows that, as with students, it is crucial to scaffold teachers’ learning (and their reflection) (Coulson and Harvey 2013). Overall, teachers do not explicitly express an increase in their guidance or assessing skills. However, when they are asked what they would actually do in real situations (as portrayed in the video recordings and reflection reports) a shift in their reactions can be observed. Their answers regarding guidance strategies are more nuanced and profound. For example, before the training their focus would be on having students ‘look back and realize what could have been improved’ (i.e. merely focusing on evaluation), whereas after the training more emphasis on ‘gaining insight into patterns’ and ‘emotions or underlying certain behaviour’ (i.e. more focusing on in-depth reflection) can be observed. Also, teachers mention the aspect of creating a safe environment more often. Another

topic that teachers focused more on after the training, appeared to be learning students how to reflect and providing them with feedback.

Considering teachers' assessing strategies we can conclude that teachers stressed the importance of consistency in reflection steps (or answers) when students describe their reflection processes more often after the training. Also, teachers tend to be focusing more on whether students would look forward (as reflection is not only gaining insights from a past situation, but also describing future steps or actions).

The results also indicate that the aspects in the training that contributed most, were the concrete tools that were provided. For example, the rubric to assess reflection, the reflection cards with specific reflection questions, or examples of reflection exercises that can be used for science and engineering students. As indicated too by Mittendorff and Pullen (2019), it seems crucial to provide teachers – and science and engineering teachers in particular - with very clear examples, pictures, or models that show them what can be done (for example, which steps to undertake) or which questions to ask.

4 SUMMARY AND ACKNOWLEDGMENTS

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REFERENCES

Coulson, D., and Harvey, D. 2013. "Scaffolding Student Reflection for Experience-Based Learning: A framework." *Teaching in Higher Education* 18, no 4: 401-413.

Engelbertink, M. M., Colomer, J., Woudt-Mittendorff, K. M., Alsina, Á., Kelders, S. M., Ayllón, S., and Westerhof, G. J. 2021. "The Reflection Level and the Construction of Professional Identity of University Students." *Reflective Practice* 22, no. 1: 73-85. https://doi.org/10.1080/14623943.2020.1835632

Hughes, D., Law, B., and Meijers, F. 2017. "New School for the Old School: Career Guidance and Counselling in Education." *British Journal of Guidance and Counselling* 45, no. 2: 133-137. https://doi.org/10.1080/03069885.2017.1294863

Kember, D., McKay, J., Sinclair, K., and Wong, F. K. Y. 2008. "A Four-Category Scheme for Coding and Assessing the Level of Reflection in Written Work." *Assessment & Evaluation in Higher Education* 33, no. 4: 369-379. https://doi.org/10.1080/02602930701293355

Kinkhorst, G. 2010. *Didactische Ontwerpregels voor Reflectieonderwijs.* Onderwijsinnovatie.

Korthagen, F. and Nuijten, E. 2023. *De Kracht van Reflectie: Een Sleutel voor de Ontwikkeling van Leraren.* 2nd Edition. Amsterdam: Boom.

Meijers, F., and Mittendorff, K. 2017. *Zelfreflectie in het hoger onderwijs.* Apeldoorn: Garant

Mittendorff, K. 2014. "Leren Reflecteren". In *Het Onzekere voor het Zekere. Kwetsbaarheid als Kracht in Loopbaandialogen*. Antwerpen/ Apeldoorn: Garant.

Mittendorff, K. and Pullen. A. 2019. *Succesfactoren voor een Verbeteraanpak Gericht op Reflectie bij Technische hbo-opleidingen*. Enschede: TechYourFuture.

Mittendorff, K. & Pullen, A. (in press). Reflectie binnen technische hbo-opleidingen: Ervaringen en behoeften van studenten en docenten. *Tijdschrift voor Hoger Onderwijs.*

Mittendorff, K. and Visscher-Voerman, I. 2019. *Docent als Coach van het Leerproces*. Onderwijsinnovatie.

Ryan, M. 2013. "The Pedagogical Balancing Act: Teaching Reflection in Higher Education." *Teaching in Higher Education* 18, no. 2 (Spring): 144-155. https://doi.org/10.1080/13562517.2012.694104

Van Beveren, L., Roets, G., Buysse, A., and Rutten, K. 2018. "We All Reflect, But Why? A Systematic Review of the Purposes of Reflection in Higher Education in Social and Behavioral sciences." *Educational Research Review* 24: 1-9. https://doi.org/10.1016/j.edurev.2018.01.002

World Economic Forum. 2023. *Future of Jobs Report 2023*. Geneva: World Economic Forum.