

## Research Article

Natasa Brouwer\*, Matti Niemelä, Iwona Maciejowska, Ștefania Grecea, Oreste Tarallo and Vincenzo Russo

# Ambassadors of professional development in teaching and learning in STEM higher education

<https://doi.org/10.1515/cti-2024-0026>

Received March 24, 2024; accepted June 29, 2024; published online July 24, 2024

**Abstract:** In STEM higher education, lecturers need to assist learners in constructing understanding of complex scientific concepts by employing relevant teaching methods, tools, and technologies. A continuous professional development (CPD) of academic teaching staff in teaching and learning is indispensable to keep up with the development of STEM. Using a cascade-like approach in continuous professional development in teaching and learning, where lecturers are involved bottom-up as CPD-Ambassadors, makes it possible to address relevant STEM-specific teaching and learning issues and continuously improve teaching practice. At three international STEM-CPD Summer Schools for CPD-Ambassadors, the CPD-Ambassadors developed fifty CPD-User cases about organising professional development in teaching and learning at their own higher education institutions and promoting the importance of CPD in their local context. The analysis of the CPD-User cases shows that the most frequently addressed teaching competencies and attitudes foster student-centred teaching approaches based on constructivist educational views. A relationship is found with previously defined generally important teaching competences and attitudes for higher STEM education. The results indicate that a cascade-like, discipline oriented continuous professional development approach through CPD-Ambassadors is a promising approach in improving university teaching practice.

**Keywords:** continuous professional development (CPD); teaching competences; higher education; STEM

## 1 Introduction

Teaching in Science, Technology, Engineering, and Mathematics (STEM) requires supporting learners in constructing understanding of complex fundamental scientific concepts. The learning process in STEM higher education often involves applying mathematics knowledge and skills as well as developing critical thinking within an interdisciplinary context. Teaching in STEM also requires the development of teaching new concepts within rapid technological changes, transdisciplinary approaches, and the utilisation of specific methods, tools

**\*Corresponding author: Natasa Brouwer**, University of Amsterdam Faculty of Science, Science Park 904, 1090 GE, Amsterdam, The Netherlands, E-mail: n.brouwer-zupancic@uva.nl. <https://orcid.org/0000-0001-6258-5639>

**Matti Niemelä**, University of Oulu Faculty of Science, PO Box 8000, FI-90014, Oulu, Finland, E-mail: matti.niemela@oulu.fi

**Iwona Maciejowska**, Jagiellonian University in Kraków Faculty of Chemistry, Krakow, Małopolskie, Poland, E-mail: iwona.maciejowska@uj.edu.pl

**Ștefania Grecea**, University of Amsterdam Faculty of Science, Science Park 904, 1090 GE, Amsterdam, The Netherlands, E-mail: s.grecea@uva.nl

**Oreste Tarallo**, Dipartimento di Chemical Sciences, University of Naples Federico II, Complesso Universitario di Monte Sant'Angelo, Edificio 5B, via Cinthia, 80126, Napoli, Italy, E-mail: oreste.tarallo@unina.it

**Vincenzo Russo**, University of Naples Federico II Faculty of Mathematics Physics and Natural Sciences, Napoli, Campania, Italy, E-mail: vincenzo.russo@unina.it

and technologies. This is further specific to each STEM discipline. Because of this, STEM and discipline-oriented professional development in teaching and learning are indispensable. The academic teaching staff needs to allocate their time between research and teaching. The university's given priorities influence how much attention may be devoted to continuous professional development (CPD) in teaching and learning. The survey results of Chadha (2021) demonstrate a correlation between educators' interest in CPD and their interest in teaching when CPD is recognized or rewarded. They also confirmed that social interaction is beneficial for CPD. A national university teaching qualification framework increases the priority of CPD and supports academic teachers in integrating professional development in teaching and learning with their research agenda. Brouwer et al. (2022a) have shown that a person-centred, tailor-made, teaching practice-oriented training programme can be effective for the professional development of STEM lecturers and stimulates their participation in CPD afterwards. At almost all universities nowadays, there is some teaching training, and in some countries (e.g. UK, The Netherlands, and Scandinavian countries), there exists a national framework for university teaching certification. There is currently no international agreement for the recognition of university teaching competences. Most professional development programmes are organised at the university level, often at centres for teaching and learning, for lecturers from different disciplines (Henderson et al., 2011). Thus, teacher training at most universities generally has a general pedagogical character, while teaching STEM involves several aspects that are different from teaching in social sciences or languages, and it presents its own specific difficulties (Winberg et al., 2019; Chadha, 2021). Lecturers who complete teaching training should not be left alone in their departments, where they may encounter resistance from fellow lecturers or superiors if they want to make changes to teaching practice (Postareff et al., 2007; Stes et al., 2010). Evidence-based research in STEM motivates educators toward innovation in teaching and can stimulate the use of discipline-specific teaching practices (Singer et al., 2012), hence supporting CPD.

For adult learners, connecting learning to their needs is crucial for motivation and learning success (Knowles et al. 2014, Appleby and Pilkington, 2014). In the case of academic teaching staff, it means acquiring knowledge and skills that they can directly use in their teaching practice. Rienties et al. (2023) explored the effects of online professional development (OPD) across institutions and argued that cross-institutional OPD needs to focus on practical experiences that support the understanding and implementation of innovative teaching practices.

Disciplinary or interdisciplinary professional development activities in teaching and learning are needed to address specific issues in STEM education and to continuously improve teaching practice to prepare students for the challenging future. However, some issues could become too specific to organise a CPD programme for them locally. The creation of interuniversity or international CPD communities could enable the necessary expertise to address specific relevant topics and motivate and stimulate lecturers to sustain their CPD efforts. Universities in Europe collaborate with each other on different levels. In 2019, there existed 17 European alliances (Charret & Chankseliani, 2023). However, these alliances were established particularly for collaboration in research and education policy. Fumasoli and Rossi (2021) reported that transnational networks in education innovation are an emerging phenomenon. They analysed 991 European networks in educational innovation within the Erasmus + programme between 2014 and 2018 and clustered them in 12 clusters. Only four clusters focus on teaching and learning, and none of them specifically address the continuous professional development of lecturers in teaching and learning.

### 1.1 European chemistry thematic network (ECTN) and STEM-CPD@EUni project

The European Chemistry Thematic Network (ECTN, [ectn.eu](http://ectn.eu)) now connects more than 80 European universities and has been active already for over 40 years. In the 1980s, the ECTN had an important role in tuning educational structures and establishing a two-cycle curriculum (bachelor-master) structure (González & Wagenaar, 2000, Pinto, 2010). Through the decades, different ECTN Working groups paid specific attention to the quality of teaching and learning in university chemistry education. From 2020 to 2023, the Erasmus+ Strategic partnership STEM-CPD@EUni project (Maciejowska, 2020), a collaboration of five European universities and the ECTN

association, specifically addressed CPD in teaching and learning in STEM and developed a STEM-CPD framework (Brouwer & Niemelä, 2023), which stimulates the development of technological pedagogical content knowledge (TPACK) (Mishra & Koehler, 2006) of the lecturers at their universities in an international context. This framework also established a new role in CPD, the CPD-Ambassador (Brouwer et al. 2022b). A STEM-CPD Summer School was developed to educate CPD-Ambassadors (Russo et al., 2023). Hendriksen et al. (2016) explored TPACK alongside 21st-century skills and argued for the significant importance of defining what today's students need to know. This has consequences for the teaching competences that university teaching staff need to have and which teaching attitudes are important. TPACK-aligned STEM-CPD can empower lecturers to develop their STEM teaching competences in the context of their discipline, together with a holistic view, and be able to educate students to develop critical, creative, and systems thinking, along with computational thinking, enabling them to judge and make decisions through a creative and innovative mindset (EUA, 2021; OECD, 2019). Sajdak-Burska and Maciejowska (2023) proposed to enrich the practice-based TPACK model with the theoretical concepts of Ingeborg Stahr (2009) and included the description of systemic and social competences related to functioning of a researcher in the role of a lecturer.

In this article, a discipline-oriented bottom-up approach of CPD in teaching and learning within an international community, which introduced the CPD-Ambassador as a new role in CPD, is briefly described. Next, an analysis of the CPD-User cases that were developed by the CPD-Ambassadors during three STEM-CPD Summer Schools is presented. The aim is to create awareness about the CPD and to stimulate the development of teaching competences and attitudes in higher STEM education at their local universities.

The research questions are:

- What teaching competences and attitudes do the CPD-User cases address? How relevant are these teaching competences and attitudes for higher STEM education in general?
- What CPD activities are utilised in the CPD-User cases? How engaging might these CPD activities be for STEM faculties in general?
- What is the pedagogical potential of CPD-User cases developed by CPD-Ambassadors for addressing pedagogical challenges?

## 2 Methods

This section has three parts. First, the participants who developed the CPD-User cases are introduced. Next, the instruments used for collecting data are presented. Finally, the research design is described. As part of the research design, the STEM-CPD framework, which forms the foundation of this research (Brouwer & Niemelä, 2023), is summarized.

### 2.1 Participants

The data for this research were collected in the context of three international STEM-CPD Summer Schools that were organised in 2021, 2022, and 2023. Fifty participants attended the STEM-CPD Summer schools and obtained a CPD-Ambassador certificate (25, 12, and 13 respectively). The participants of the summer schools were lecturers or programme directors in Chemistry or STEM at university or professionals who were involved in CPD of STEM lecturers at the university. The participants of the three summer schools came from 12 European countries: Italy 11, Netherlands 8, Poland 7, Spain 3, Portugal 4, Slovenia 4, Austria 2, Finland 3, Hungary 2, Latvia 1, Sweden 1, United Kingdom 1, and there were two participants were from South Africa and one from Australia.

## 2.2 Instruments

In the period from October 2021 to October 2023, the 50 CPD-User cases described in this paper were developed and published on the open platform Starfish ([starfish-education.eu](https://starfish-education.eu)). Several CPD-Ambassadors developed additional CPD-User cases after returning home from the STEM-CPD Summer School. They sometimes collaborated with their fellow lecturers at their home institutions. Starfish is a free, open source knowledge network social platform that is based on the TPACK model (Mishra & Koehler, 2006) (<https://starfish-education.eu/>). Starfish connects educators and knowledge about teaching and learning through the TPACK tags. In the STEM-CPD@EUni project (Maciejowska, 2020), an online template was developed specifically to develop CPD-User cases and the tool that automatically generates a CPD-Scenario for each published CPD-User case on Starfish. A Handbook for CPD Ambassadors (Brouwer & Niemelä, 2023) is available on Starfish to support users on how to create and publish CPD-User cases.

## 2.3 Research design

First, the elements of the STEM-CPD framework (Brouwer & Niemelä, 2023) are briefly introduced, and next, it is explained how the CPD-User cases were analysed.

The STEM-CPD framework (Brouwer & Niemelä, 2023) which is based on the constructivist philosophy and the following pedagogical concepts: constructive alignment (Biggs & Tang, 2011), the TPACK model (Mishra & Koehler, 2006), the Community of Inquiry model (Garrison et al., 2000), and it serves adult learners' needs (Knowles, Holton & Swanson, 2014) forms the foundation of this research (Brouwer & Niemelä, 2023). The STEM-CPD framework consists of the following four elements: CPD-Ambassador, CPD-User case, CPD-Scenario, and STEM-CPD Summer school for educating CPD-Ambassadors.

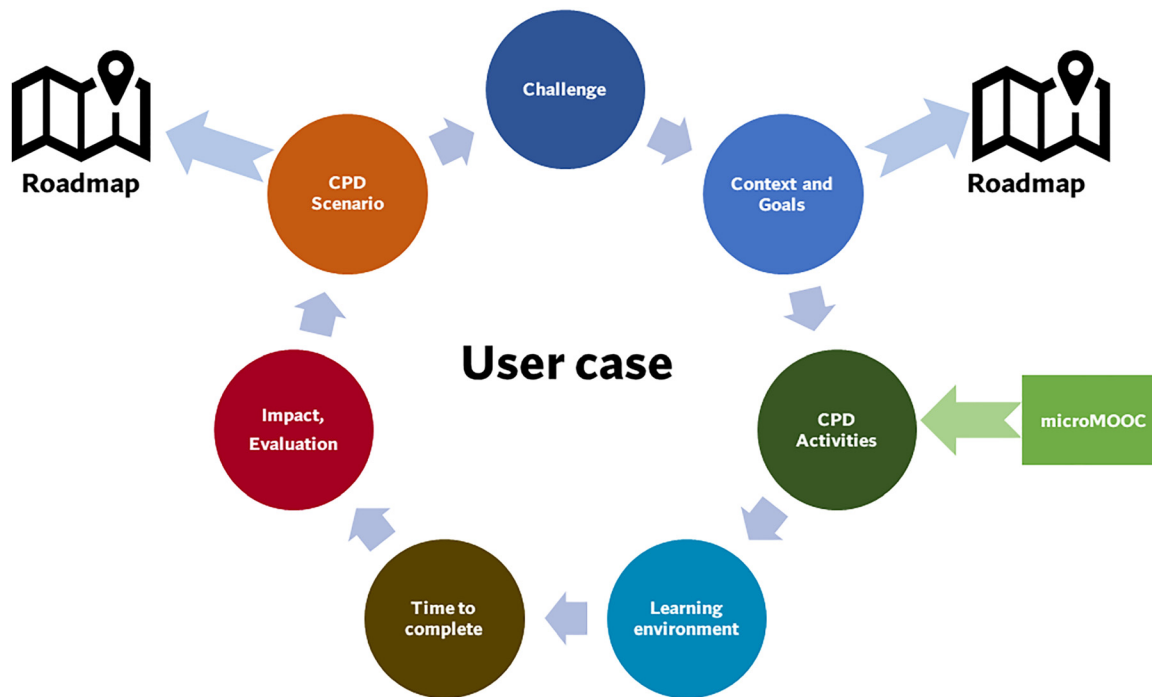
### 2.3.1 CPD-ambassador

The CPD-Ambassador is a new role in CPD (Brouwer et al. 2022b). The principle of the ambassador's approach ensures a cascade effect: a small number of CPD-Ambassadors from different institutions are educated and trained using a needs-oriented, co-creative learning approach to organise CPD activities at their local institutions. This process multiplies the number of lecturers who receive discipline-oriented continuous professional development in teaching and learning.

A CPD-Ambassador is typically a lecturer or individual engaged in higher education teaching and learning, with a keen interest in teaching innovation and a strong belief in the importance of CPD in higher education. CPD-Ambassadors work according to the STEM-CPD framework (Brouwer & Niemelä, 2023), sharing their knowledge and assisting fellow lecturers in improving teaching practice. Their role is to raise awareness among their peers about the importance of professional development in teaching and learning. They organise CPD activities tailored to the specific needs of lecturers at their local universities, addressing specific yet locally relevant educational challenges, which ensure the direct application of the gained knowledge and skills in teaching practice. A fundamental task of CPD-Ambassadors, when organising bottom-up CPD activities, is to inquire about the teaching and associated problems that fellow lecturers encounter. CPD-Ambassadors from different universities and countries are united in a STEM-CPD community, where they share knowledge and exchange experiences.

### 2.3.2 CPD-user case

The aim of the CPD-User case is to tackle a specific local university teaching and learning challenge and to support the lecturers in solving that challenge. Thus, the first step in developing a CPD-User case is to define what the challenge is. Through a bottom-up approach described in the CPD-User case, lecturers develop their teaching and learning competences, as well as teaching attitudes necessary to improve their own teaching practice and solve



**Figure 1:** Attributes of the CPD user case (Brouwer & Niemelä, 2023).

the challenge. The Roadmap (Brouwer et al., 2022c) defined 19 different types of CPD activities that could be used for this purpose.

The attributes of the CPD User case are presented on Figure 1 (Brouwer & Niemelä, 2023).

The CPD-Ambassadors share their CPD-User cases on the Starfish platform. To publish a CPD User case they use a specific CPD-User case template which includes all attributes given in Figure 1. An example of a CPD-User case on Starfish is presented in Figure 2.

### 2.3.3 CPD-scenario

The CPD-Scenario of the CPD-User case is determined by the teaching competences and teaching attitudes that the CPD-User case addresses, the learning environment of the CPD-User case, and by the time needed to complete it (Brouwer & Niemelä, 2023). The CPD-scenario is automatically created by Starfish when the author of the CPD-User case, the CPD-Ambassador selects the parameters on Starfish, i.e. the teaching competences and teaching attitudes that need to be addressed by the CPD-User case and that are listed in the Roadmap survey list (Brouwer et al., 2022c). Each CPD-User case can have only one CPD-scenario, while one CPD-scenario can describe multiple CPD-User cases. The scales of teaching competences (Table 1) that are addressed in the CPD-User case define the type of the CPD-Scenario. This way there are 15 possible types of CPD-Scenarios. When a CPD-User case addresses only teaching attitudes and no teaching competences are addressed, the type of CPD-Scenario follows the teaching attitudes scales (Table 1). In that case, there are 25 types of CPD-Scenario possible.

### 2.3.4 STEM-CPD summer school

To become CPD-ambassadors, lecturers can participate in an STEM-CPD Summer School (Russo et al., 2023). Participants in the STEM-CPD Summer School develop their competences in an international context. The STEM-CPD Summer School utilises an intensive active learning approach based on co-creation. To obtain the

## Continuous Online Assessments

Posted by [Natasja Brouwer](#), [Matti Niemelä](#), [Johanna Kärkkäinen](#), on Oct. 8, 2021, 4:39 p.m.

Chemistry

None

Explore

MScChemistry

Explore Visit...

STEM-CPD@EUn

STEM-CPD is continuous professional development of lecturers in Science, Technology, Engineering and Mathematics (STEM). In the project STEM-CPD@EUn ( <https://ectn.eu/work->

Explore Read more...

Pedagogy [FormativeAssessment](#) [SummativeAssessment](#)

Technology [AssessmentTools](#) [DigitalAssessment](#)

Content [Chemistry](#)

Context/Topic [MScChemistry](#) [STEM-CPD@EUn](#)

**Matti Niemelä, Johanna Kärkkäinen**  
University of Oulu / Faculty of Technology / Chemistry degree programme

### Challenge and goal

Assessment is a crucial part of both traditional and online education. However, creating continuous online assessment for large student groups is still a challenge. Teachers often have concerns that may limit the use of online assessment (students cheating, plagiarism, academic misconduct, isolation of students, correct tools, instructors workload e.g. how to assess a large student group online etc.). In addition to teachers, students have their own concerns about online assessments as well. For example, fairness, technical issues and abilities, and the possibility to clarify assignment guidelines are things that students may worry about.



### Topic of the user case

Motivating change toward authentic and continuous assessment.

Context and Goals

CPD Activities

Evaluation

CPD Scenario

### Local context (specific)

Assessment is a crucial part of both face-to-face and online education. Learning outcomes, as well as assessment criteria defined in the curricula, are key factors in the planning of assessment and selection of assessment type(s). In general, the aim of evaluation of student's study attainments is to:

- monitor the progress of studies
- collect information on the learning process

### See also

- [P](#) Matti Niemelä
- [R](#) STEM-CPD@EUn

**Figure 2:** A print screen of a CPD user case continuous online assessments on starfish, <https://starfish-education.eu/usercase/1076/>.

CPD-Ambassador certificate, participants are required to develop their own CPD-User case to be implemented in their own local university and to share the CPD-User case open on the Starfish platform in the international community.

A lecturer/professional awarded a title of CPD-Ambassador, is able to:

- explain to peer lecturers different approaches toward students, and different active learning teaching methods
- propose activities to motivate learners
- describe and explain peers and faculty authorities the necessity of CPD for lecturers

A lecturer/professional awarded a title of CPD Ambassador, commits to be willing to:

- share knowledge, experience, and good practices with peer lecturers
- consider to introduce inclusive teaching
- organise CPD activities for lecturers at home university
- continuously develop own skills and technological pedagogical content knowledge

In this research, 50 CPD-User cases developed until October 2023 were analysed, which are openly available on Starfish. The classification of teaching competences and attitudes addressed in the CPD-User cases utilised the



STEM-CPD Roadmap survey classification (Brouwer et al., 2022c). The roadmap survey contained 30 statements (P1; q1–q30) addressing educational principles, methods, pedagogical content, and technology, 17 statements (P2; q1–q17) concerning attitudes toward teaching, and 19 statements (P3; q1–q19) regarding preferred types of professional development activities. Furthermore, the roadmap survey led to the classification of 30 STEM teaching competences into four pedagogical scales with several subscales, 17 teaching attitudes into five scales, and 19 CPD activities into six scales (Table 1, Brouwer et al., 2022c).

**Table 1:** Classification of teaching competences, teaching attitudes and CPD activities.

---

|   |                                                                                             |
|---|---------------------------------------------------------------------------------------------|
| – | P1-1 Constructive alignment (q. 1, 2, 3, 6)                                                 |
| – | P1-2 Pedagogy, Interactive teaching                                                         |
| – | – P1-2a Competence teaching (q. 9, 10, 14, 15)                                              |
| – | – P1-2b Competence design interactive teaching (q. 16, 19)                                  |
| – | P1-3 Pedagogy, Learning facilitation                                                        |
| – | – P1-3a Problem solving (design and teaching) (q. 18, 21, 22, 23)                           |
| – | – P1-3b Engagement and motivation, facilitation discipline specific learning (q. 4, 12, 13) |
| – | – P1-3c Deep learning (q. 5, 7, 8, 11)                                                      |
| – | – P1-3d Organize peer-feedback, collaborative learning (q. 27, 28)                          |
| – | P1-4 Technology in facilitative teaching:                                                   |
| – | – P1-4a Use of digital tools for a pedagogical goal (q. 17, 25, 26, 29, 30)                 |
| – | – P1-4b Blended learning (q. 20, 24)                                                        |
| – | P2-1 Motivation and self-regulation for CPD (q. 2, 14, 15, 16)                              |
| – | P2-2 Pastoral interest (q. 3, 4, 5)                                                         |
| – | P2-3 Reflection (q. 1, 10, 11)                                                              |
| – | P2-4 Evidence informed approach (q. 6, 7, 13)                                               |
| – | P2-5 Knowledge sharing (q. 8, 9, 12, 17)                                                    |
| – | P3-1 Imparting information (trainer-centered) (q. 1, 2, 3)                                  |
| – | P3-2 Learning facilitation person-centered) (q. 4, 5, 7, 8, 9, 10)                          |
| – | P3-3 Collaboration (q. 11, 13)                                                              |
| – | P3-4 Mentor-mentee support (q. 12, 15, 17)                                                  |
| – | P3-5 (Personal/individual) expert support (q. 14, 16)                                       |
| – | P3-6 Knowledge sharing (q. 6, 18, 19)                                                       |

---

### 3 Results

#### 3.1 Analysis of the CPD-user cases

The CPD-User cases developed by the CPD-Ambassadors from 2021 to 2023 and published on Starfish were studied to identify which teaching competences and teaching attitudes they addressed to tackle the challenges, as well as which types of CPD activities were used for this purpose. The results obtained were compared with the results published from the Roadmap survey (Brouwer et al., 2022c), particularly focusing on the general importance of the teaching competences and teaching attitudes for higher education STEM as defined in the Roadmap survey.

In Table 2, the teaching areas where the CPD-User cases focus are presented, along with the number of CPD-User cases and the number of different universities and countries having such CPD-User cases. Table 2 shows that there are CPD-User cases that address teaching areas very specific to the STEM disciplines, such as laboratory teaching (11 CPD-User cases) and specifically assessment in laboratory courses (2 CPD-User cases). Additionally, there are CPD-User cases that, within a specific STEM context, address more general aspects of teaching and learning in higher education, such as activating students for learning (8 CPD-User cases from eight universities across four different countries), communication with students (3 CPD-User cases from two countries), and inclusive teaching (3 CPD-User cases from two different countries).

**Table 2:** Teaching and learning field of the CPD-user cases.

| Teaching domain of the CPD-user cases         | Number of CPD-User cases ( <i>N</i> = 50) | Number universities (number countries) |
|-----------------------------------------------|-------------------------------------------|----------------------------------------|
| Laboratory teaching                           | 11                                        | 8 (7)                                  |
| Activating students for learning              | 8                                         | 8 (4)                                  |
| Assessment                                    | 5                                         | 5 (5)                                  |
| Assessment in laboratory courses              | 2                                         | 2 (2)                                  |
| Prior knowledge/knowledge gaps                | 3                                         | 2 (2)                                  |
| Communication with students                   | 3                                         | 2 (2)                                  |
| Inclusive teaching                            | 3                                         | 3 (2)                                  |
| Use of 3D models and visualizations           | 2                                         | 1 (1)                                  |
| Teaching using AI                             | 2                                         | 2 (2)                                  |
| Teaching chemistry for non-chemistry students | 2                                         | 2 (2)                                  |
| Organizing excursions to industry             | 2                                         | 1 (1)                                  |
| Curriculum perspectives                       | 2                                         | 2 (2)                                  |
| Teaching soft skills/academic writing         | 2                                         | 2 (2)                                  |
| Sustainable goals in education                | 1                                         | 1 (1)                                  |
| Support/organizing tutoring                   | 1                                         | 1 (1)                                  |
| Mentoring newly appointed lecturers           | 1                                         | 1 (1)                                  |
| Transition from secondary school to bachelor  | 1                                         | 1 (1)                                  |

The needs for improvement of the assessment are recognized in 5 (10 %) CPD-User cases from five different countries, and additionally in two CPD-User cases the assessment is addressed specifically in written reports in laboratory courses. Three CPD-User cases focus on the heterogeneous background of students and address the gaps in their prior-knowledge, while two specifically address transition problems from secondary school to university bachelor programs. There are two CPD-User cases from two different countries that focus on curriculum development. Most user cases address additional aspects of using digital technology and the skills lecturers need for specific purposes described in the CPD-User case.

Table 3 shows how CPD-User cases on Starfish correspond to the pedagogical scales defined in the Roadmap survey (Brouwer et al., 2022c).

Table 3 shows that the three teaching competence (sub)scales that are highlighted in the STEM-CPD Roadmap (Brouwer et al., 2022c) as having the highest general importance are also the first three most addressed in the CPD-User cases. The distribution of CPD-User cases that address at least one teaching competence, at least one teaching attitude, or at least one CPD-activity from a specific STEM-CPD Roadmap pedagogical scale are presented in Table 3.

In Figure 3 the frequency of the addressed teaching competences (Roadmap items, Brouwer et al., 2022c) in the CPD-User cases is presented for each of the four teaching competences pedagogical scales. The teaching competences belonging to the scale “Learning facilitation” are most often (92 times) addressed in the CPD-User cases.

The number of CPD-User cases that address a specific teaching competence, teaching attitude or CPD activity as defined in the Roadmap (Brouwer et al., 2022c) is presented in Table 4.

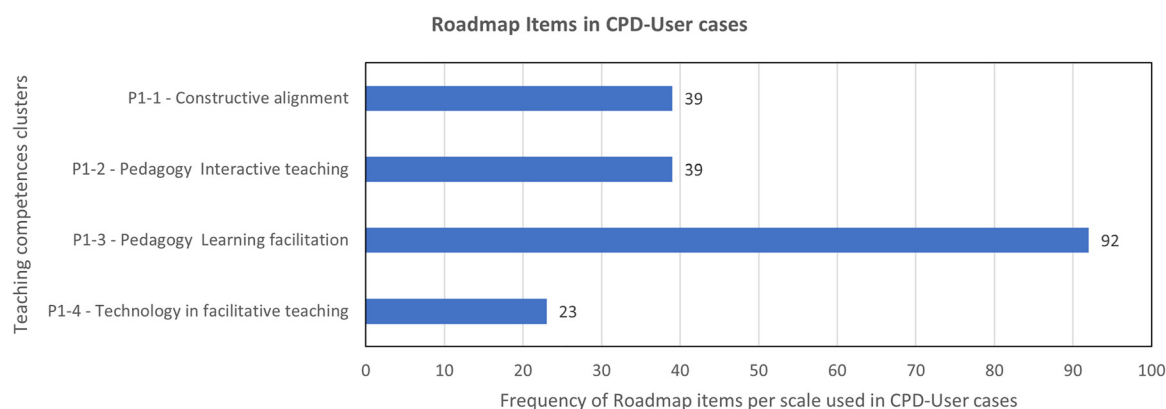
In the CPD-User cases most frequently addressed teaching competence is “Engage students and arouse interest for the discipline in the class” addressed in 17 CPD-User cases (34 %). In the STEM-CPD Roadmap survey (Brouwer et al., 2022c) this competence was recognized as the second most important teaching competence (score 4.60 on the Likert scale 5), after “Develop critical thinking by students” (Table 4, P1 q08, Roadmap score 4.71). This teaching competence is classified in the subscale “Engagement and motivation, facilitation discipline specific learning” (Table 3: P1-3b) which is the most represented one in the CPD-User cases (Figure 3). This teaching competence is one of the four items in the scale “Deep learning” (P1-3c). “Develop Critical thinking” is addressed in 13 CPD-User cases. 16 CPD-User cases address the competence “Stimulate discussion” (Roadmap score 4.30), which is also part of the pedagogical subscale “Deep learning” (Table 3: P1-3c) and is an important teaching competence in stimulating Critical thinking of students.



**Table 3:** CPD-User cases on Starfish ( $n = 50$ ) and pedagogical scale importance in STEM-CPD roadmap.

| Scales teaching competences, teaching attitudes and CPD activities <sup>a</sup>            | No. CPD-user cases/roadmap (sub)scale | Roadmap score <sup>b</sup> |
|--------------------------------------------------------------------------------------------|---------------------------------------|----------------------------|
| <b>Teaching competences</b>                                                                |                                       |                            |
| P1-3b: Engagement and motivation, facilitation discipline specific learning (q. 4, 12, 13) | 27                                    | 4.27                       |
| P1-1: Constructive alignment (q. 1, 2, 3, 6)                                               | 26                                    | 4.29                       |
| P1-3c: Deep learning (q. 5, 7, 8, 11)                                                      | 25                                    | 4.21                       |
| P1-2a: Competence teaching (q. 9, 10, 14, 15)                                              | 17                                    | 3.86                       |
| P1-3a: Problem solving (design and teaching) (q. 18, 21, 22, 23)                           | 14                                    | 3.90                       |
| P1-4b: Blended learning (q. 20, 24)                                                        | 13                                    | 3.63                       |
| P1-2b: Competence design interactive teaching (q. 16, 19)                                  | 11                                    | 3.81                       |
| P1-3d: Organize peer-feedback, collaborative learning (q. 27, 28)                          | 10                                    | 3.37                       |
| P1-4a: Use of digital tools for a pedagogical goal (q. 17, 25, 26, 29, 30)                 | 9                                     | 3.13                       |
| <b>Teaching attitudes</b>                                                                  |                                       |                            |
| P2-2: Pastoral interest (q. 3, 4, 5)                                                       | 26                                    | 4.35                       |
| P2-5: Knowledge sharing (q. 8, 9, 12, 17)                                                  | 23                                    | 3.69                       |
| P2-4: Evidence informed approach (q. 6, 7, 13)                                             | 18                                    | 4.13                       |
| P2-3: Reflection (q. 1, 10, 11)                                                            | 17                                    | 3.84                       |
| P2-1: Motivation and self regulation (CPD) (q. 2, 14, 15, 16)                              | 8                                     | 3.95                       |
| <b>CPD activities</b>                                                                      |                                       |                            |
| P3-2: Learning facilitation (q. 4, 5, 7, 8, 9, 10)                                         | 30                                    | 3.25                       |
| P3-1: Imparting information (q. 1, 2, 3)                                                   | 22                                    | 3.59                       |
| P3-3: Collaboration (q. 11, 13)                                                            | 18                                    | 3.59                       |
| P3-6: Knowledge sharing (q. 6, 18, 19)                                                     | 11                                    | 3.23                       |
| P3-4: Peer-mentor – mentee support (q. 12, 15, 17)                                         | 9                                     | 3.75                       |
| P3-5: Personal/individual expert support (q. 14, 16)                                       | 4                                     | 3.28                       |

<sup>a</sup>Classification from STEM-CPD Roadmap (Brouwer et al., 2022c). <sup>b</sup>Data from STEM-CPD Roadmap (Brouwer et al., 2022c). List of all items in the Roadmap questionnaire Part 1 (Teaching competences), Part 2 (Teaching Attitudes) and Part 3 (CPD activities) (Brouwer et al., 2022c) is also accessible on Starfish at: [https://starfish-education.eu/static/pdf/cpd\\_questions\\_overview.pdf](https://starfish-education.eu/static/pdf/cpd_questions_overview.pdf).

**Figure 3:** Frequency of roadmap items in the CPD-User cases per teaching competences scale.

The majority of CPD-User cases (26) developed one or more teaching attitudes from the attitude scale Pastoral interest (Table 3), including attitudes “Inspire a positive attitude in their class” (13), “Make students feel special, included, and safe” (7), and “Be interested in their students’ progress” (17). This teaching attitudes scale is also recognized in the Roadmap survey as the most generally important teaching attitude scale (4.35, Table 3). The order of the rest of the scales differs from the one in the STEM-CPD Roadmap. The second most frequently addressed teaching attitude scale in the CPD-User cases is Knowledge sharing, with 23 CPD-User cases addressing this scale (Table 3), out of which 21 develop the teaching attitude “Discuss teaching with their

**Table 4:** Number of CPD-user cases that address a specific teaching competence, attitude or use specific CPD activity.

| Item roadmap <sup>a</sup>                                                                                                                               | Number<br>CPD-user cases |
|---------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| <b>Competences</b>                                                                                                                                      |                          |
| P1 q 04 engage students and arouse interest for the discipline in the class                                                                             | 17                       |
| P1 q 11 stimulate discussion                                                                                                                            | 16                       |
| P1 q 08 develop critical thinking by students                                                                                                           | 13                       |
| P1 q 01 frame the course in the context of the study programme                                                                                          | 11                       |
| P1 q 03 choose an appropriate assessment method for their course                                                                                        | 11                       |
| P1 q 02 define intended learning outcomes in every course they teach                                                                                    | 10                       |
| P1 q 09 give prompt feedback and support students during learning                                                                                       | 10                       |
| P1 q 12 design laboratory courses                                                                                                                       | 9                        |
| P1 q 22 use research based teaching methods                                                                                                             | 9                        |
| P1 q 14 teach large groups of students                                                                                                                  | 8                        |
| P1 q 19 design active learning classes/sessions using digital technology                                                                                | 8                        |
| P1 q 06 cope with heterogeneous pre-knowledge of students                                                                                               | 7                        |
| P1 q 27 organise peer-assessment/peer-feedback in their courses                                                                                         | 7                        |
| P1 q 24 use blended learning approach                                                                                                                   | 7                        |
| P1 q 20 use digital tools in lab courses                                                                                                                | 6                        |
| P1 q 10 support students in socialising (specifically e.g. during a pandemic)                                                                           | 5                        |
| P1 q 16 design interactive lectures                                                                                                                     | 5                        |
| P1 q 18 design problem solving sessions                                                                                                                 | 5                        |
| P1 q 30 make/produce short MOOCs                                                                                                                        | 5                        |
| P1 q 07 being able to bring out and correct misconceptions                                                                                              | 4                        |
| P1 q 13 teach about lab safety using digital tools/platform (where appropriate)                                                                         | 4                        |
| P1 q 15 teach small groups of students (group's dynamics)                                                                                               | 3                        |
| P1 q 28 organise (online) collaborative learning                                                                                                        | 3                        |
| P1 q 17 design online exams                                                                                                                             | 2                        |
| P1 q 21 use design thinking methods                                                                                                                     | 2                        |
| P1 q 23 use project based teaching methods                                                                                                              | 2                        |
| P1 q 25 use interactive online boards for teaching and learning                                                                                         | 2                        |
| P1 q 05 teach holistically by integrating social and art aspects in teaching and learning complex chemical concepts                                     | 1                        |
| P1 q 29 use advanced tools based on artificial intelligence in supporting students in their learning process                                            | 2                        |
| P1 q 26 use voting in lectures to activate thinking and understanding of (e.g. chemistry) concepts                                                      | 0                        |
| <b>Attitudes</b>                                                                                                                                        |                          |
| P2 q 08 discuss teaching with their colleagues                                                                                                          | 21                       |
| P2 q 05 be interested in their students' progress                                                                                                       | 17                       |
| P2 q 01 be reflective teachers and reflect about their courses/lectures                                                                                 | 13                       |
| P2 q 03 inspire a positive attitude in their class                                                                                                      | 13                       |
| P2 q 11 organise/attend meetings of their own teaching team to discuss/reflect on the teaching methods and on the effect of those on students' learning | 9                        |
| P2 q 13 analyse the effect of teaching and introduce changes in an evidence based way                                                                   | 9                        |
| P2 q 06 use students evaluations and the feedback of students to improve courses                                                                        | 8                        |
| P2 q 04 make students feel special, included, safe and secure                                                                                           | 7                        |
| P2 q 07 read literature about teaching and learning in higher education                                                                                 | 5                        |
| P2 q 12 share experience and knowledge gained through continuous professional development (CPD) with lecturers from other institutions                  | 5                        |
| P2 q 15 attend training for lecturers at the university                                                                                                 | 4                        |
| P2 q 02 have high expectations for the students and themselves                                                                                          | 3                        |
| P2 q 09 observe (some) lectures/teaching sessions of colleagues and give feedback                                                                       | 1                        |
| P2 q 14 set their own goals for professional development                                                                                                | 1                        |
| P2 q 16 apply for specific professional development programmes to obtain certificate(s) in teaching                                                     | 1                        |
| P2 q 17 participate in conferences about teaching in higher education                                                                                   | 1                        |
| P2 q 10 record (some) own lectures/teaching sessions on the video to reflect on                                                                         | 0                        |
| <b>CPD-activities</b>                                                                                                                                   |                          |
| P3 q 02 attending presentations about teaching approaches                                                                                               | 16                       |
| P3 q 05 following online courses/MOOC about teaching and learning                                                                                       | 16                       |

Table 4: (continued)

| Item roadmap <sup>a</sup>                                                                                           | Number<br>CPD-user cases |
|---------------------------------------------------------------------------------------------------------------------|--------------------------|
| P3 q 11 collaborating with a peer-lecturer on a redesign of a course                                                | 13                       |
| P3 q 04 attending hands-on workshops on specific continuous professional development (CPD) topics                   | 11                       |
| P3 q 13 collaborating on a teaching innovation project                                                              | 8                        |
| P3 q 18 giving workshops to other lecturers                                                                         | 8                        |
| P3 q 01 reading books/journal articles on teaching and learning in HE                                               | 7                        |
| P3 q 12 getting peer-feedback on own teaching practice from a colleague                                             | 7                        |
| P3 q 15 getting mentoring from an experienced colleague                                                             | 4                        |
| P3 q 09 attending workshops that are organised specifically for STEM lecturers                                      | 3                        |
| P3 q 10 attending workshops that are organised generally for lecturers from different disciplines                   | 3                        |
| P3 q 16 getting just-in-time support on a specific teaching and learning issue                                      | 3                        |
| P3 q 19 participating in a teaching and learning network or a special interest group on teaching and learning in HE | 3                        |
| P3 q 17 giving mentoring to a junior lecturer                                                                       | 2                        |
| P3 q 03 attending webinars about teaching and learning                                                              | 1                        |
| P3 q 06 attending conferences on teaching and learning in HE                                                        | 1                        |
| P3 q 07 attending a summer school on teaching and learning                                                          | 1                        |
| P3 q 08 attending a professional development programme to get a teaching certificate in higher education            | 1                        |
| P3 q 14 getting personal coaching/support by a pedagogical expert                                                   | 1                        |

<sup>a</sup>See list items on Starfish: [https://starfish-education.eu/static/pdf/cpd\\_questions\\_overview.pdf](https://starfish-education.eu/static/pdf/cpd_questions_overview.pdf).

colleagues” (P2 q 08, Table 4). The teaching attitude scale “Knowledge sharing” is recognized in the STEM-CPD Roadmap survey only as the fifth most important attitude in CPD for teaching and learning (score 3.69, Table 3).

The most frequently used CPD activities follow a learner-centred, learning facilitation approach, observed in 30 CPD-User cases (Table 3). In 22 CPD-User cases, some imparting of information occurs, such as presentations about teaching approaches (12 cases). Additionally, 16 CPD-User cases include an active learning microMOOC, allowing participants to gain knowledge about specific concepts at their own pace, while 11 CPD-User cases organise hands-on workshops. Peer Mentor-Mentee approach, recognized in the STEM-CPD Roadmap survey as the most effective CPD approach, is applied in 9 CPD-User cases.

### 3.2 CPD-scenarios

Each CPD-User case has a specific CPD-Scenario. The CPD-Scenarios can be clustered in types regarding the teaching competences scales. Out of 15 theoretically possible CPD-Scenario types (Table 5), 11 are found in the set of analysed CPD-User cases. Additionally, one CPD-Scenario was developed that didn’t focus on any teaching competence but only on teaching attitudes. Table 5 presents the number of CPD-User cases that correspond to each specific CPD-Scenario type.

Table 5: Number of CPD-User cases that correspond to specific CPD-scenario type.

| Addressed roadmap scales              | CPD-scenario type                                                                                                                                                                                               | Number CPD-user cases |
|---------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| Teaching competences                  |                                                                                                                                                                                                                 |                       |
| – Constructive alignment              | P1-1, P1-2, P1-3, P1-4                                                                                                                                                                                          | 5                     |
| – Interactive teaching                | This type of CPD scenario describes a user case in which lecturers develop their competence in sound course design, interactive teaching, learning facilitation, and use of technology in facilitative teaching |                       |
| – Learning facilitation               |                                                                                                                                                                                                                 |                       |
| – Technology in facilitative teaching |                                                                                                                                                                                                                 |                       |
| – Interactive teaching                | P1-2, P1-3, P1-4                                                                                                                                                                                                | 8                     |
| – Learning facilitation               | This type of CPD scenario describes a user case in which lecturers develop their competence in interactive teaching, learning facilitation, and use of technology in facilitative teaching                      |                       |
| – Technology in facilitative teaching |                                                                                                                                                                                                                 |                       |

Table 5: (continued)

| Addressed roadmap scales              | CPD-scenario type                                                                                                                                                                                               | Number CPD-user cases |
|---------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| – Constructive alignment              | P1-1, P1-2, P1-3                                                                                                                                                                                                | 6                     |
| – Interactive teaching                | This type of CPD scenario describes a user case in which lecturers develop their competence in sound course design, interactive teaching, and learning facilitation                                             |                       |
| – Learning facilitation               |                                                                                                                                                                                                                 |                       |
| – Constructive alignment              | P1-1, P1-3, P 1-4                                                                                                                                                                                               | 3                     |
| – Learning facilitation               | This type of CPD scenario describes a user case in which lecturers develop their competence in sound course design, interactive teaching, learning facilitation, and use of technology in facilitative teaching |                       |
| – Technology in facilitative teaching |                                                                                                                                                                                                                 |                       |
| – Constructive alignment              | P1-1, P1-2, P1-4                                                                                                                                                                                                | 0                     |
| – Interactive teaching                | This type of CPD scenario describes a user case in which lecturers develop their competence in sound course design, interactive teaching, and use of technology in facilitative teaching                        |                       |
| – Technology in facilitative teaching |                                                                                                                                                                                                                 |                       |
| – Constructive alignment              | P1-1, P1-3                                                                                                                                                                                                      | 11                    |
| – Learning facilitation               | This type of CPD scenario describes a user case in which lecturers develop their competence in sound course design, and learning facilitation                                                                   |                       |
| – Interactive teaching                | P1-2, P1-3                                                                                                                                                                                                      | 5                     |
| – Learning facilitation               | This type of CPD scenario describes a user case in which lecturers develop their competence in interactive teaching, and learning facilitation                                                                  |                       |
| – Constructive alignment              | P1-1, P1-4                                                                                                                                                                                                      | 1                     |
| – Technology in facilitative teaching | This type of CPD scenario describes a user case in which lecturers develop their competence in sound course design, and use of technology in facilitative teaching                                              |                       |
| – Constructive alignment              | P1-1, P1-2                                                                                                                                                                                                      | 0                     |
| – Interactive teaching                | This type of CPD scenario describes a user case in which lecturers develop their competence in sound course design, and interactive teaching                                                                    |                       |
| – Interactive teaching                | P1-2, P 1-4                                                                                                                                                                                                     | 1                     |
| – Technology in facilitative teaching | This type of CPD scenario describes a user case in which lecturers develop their competence in interactive teaching, and use of technology in facilitative teaching                                             |                       |
| – Learning facilitation               | P1-3, P 1-4                                                                                                                                                                                                     | 0                     |
| – Technology in facilitative teaching | This type of CPD scenario describes a user case in which lecturers develop their competence in learning facilitation, and use of technology in facilitative teaching                                            |                       |
| – Technology in facilitative teaching | P1-4                                                                                                                                                                                                            | 2                     |
|                                       | This type of CPD scenario describes a user case in which lecturers develop their competence in use of technology in facilitative teaching                                                                       |                       |
| – Learning facilitation               | P1-3                                                                                                                                                                                                            | 5                     |
|                                       | This type of CPD scenario describes a user case in which lecturers develop their competence in learning facilitation                                                                                            |                       |
| – Interactive teaching                | P1-2                                                                                                                                                                                                            | 1                     |
|                                       | This type of CPD scenario describes a user case in which lecturers develop their competence in interactive teaching                                                                                             |                       |
| – Constructive alignment              | P1-1                                                                                                                                                                                                            | 0                     |
|                                       | This type of CPD scenario describes a user case in which lecturers develop their competence in sound course design                                                                                              |                       |
| <b>Teaching attitudes</b>             |                                                                                                                                                                                                                 |                       |
| – Reflection                          | P2-3, P2-5                                                                                                                                                                                                      | 1                     |
| – Knowledge sharing                   | This type of CPD scenario describes a user case in which teaching competences are not specifically addressed In this scenario lecturers develop their attitudes in reflection and knowledge sharing             |                       |

One CPD-User has only a goal to inform and enthuse about a tool and address no teaching competences or attitudes and this way was not assigned a CPD-Scenario type. The CPD-User cases and CPD-Scenarios are accessible on Starfish at <https://starfish-education.eu/browse/?community=2&ftype=usercase>.

## 4 Discussion

Disciplinary-based research has shown that teaching in higher education STEM requires specific teaching and learning approaches (Singer, 2012). Discipline oriented professional development programmes proved to be beneficial and motivating in this respect (Brouwer et al. 2022a; Henderson et al., 2011). However, a lifelong professional development in teaching and learning is necessary to keep improving oneself and to cope with new developments in the discipline and coming educational challenges. Thus, in order to efficiently support students in their learning, academic teachers need continuous development of specific STEM teaching competences and attitudes (Brouwer et al., 2022c) to effectively support students in their learning.

The three research questions are discussed one by one.

What teaching competences and attitudes do the CPD-User cases address? How relevant are these teaching competences and attitudes for higher STEM education in general?

In the development of CPD-User cases, defining the educational challenge is a crucial first step. This ensures that the CPD-User cases address exactly what lecturers at the local university experience as relevant teaching and learning problems. This common ground among users supports motivation to learn (Knowles et al., 2014; Appleby & Pilkington, 2014). In 50 analysed CPD-User cases developed for the author's own teaching practice within an STEM (mostly chemistry) context, two distinct categories can be identified: CPD-User cases specific to teaching and learning in Chemistry, such as Laboratory teaching or Teaching chemistry for non-chemists, and CPD-User cases addressing general pedagogical issues or situations elaborated within a specific STEM faculty context, such as formative assessment, collaborative learning, and use of digital learning platforms. This way, aside from laboratory teaching and two user cases that specifically address teaching chemistry for non-chemists, all CPD-User cases in the analysed set have general relevance for any discipline, and they can be used as an inspiration to develop a specific new CPD-User cases in the context of other disciplines. The three teaching competence scales that are most often addressed in the analysed CPD-User cases: "Engagement and motivation, facilitation discipline specific learning" (P1-3b), "Constructive alignment" (P1-1), and "Deep learning" (P1-3c), are recognised also in the Roadmap survey taken in 2020 as the most important teaching competences in STEM (Brouwer et al., 2022c). It can be argued that this makes these CPD-User cases very relevant for any other STEM institution to tailor-make them and use them for their own local teaching practice.

The analysis also reveals the current situation in teaching and learning in higher education. Fifty-four percent of developed CPD-User cases address one or more competences related to "Engagement and motivation, facilitation discipline specific learning" (Brouwer et al., 2022c), implying that a lack of motivation among STEM students is experienced at many universities in different countries. Fifty-two percent of CPD-User cases develop one or more competences necessary to implement constructive alignment (Biggs & Tang, 2011), and half of the CPD-User cases address competences needed to stimulate "Deep learning". This indicates that CPD-Ambassadors recognize challenges in teaching and learning caused by persistent traditional teaching practices (Freeman et al., 2014) and intend to help their fellow lecturers improve their student-centred teaching competences and feel more comfortable in using them.

In the STEM-CPD Roadmap survey (Brouwer et al., 2022c), the competence to "Develop critical thinking by students" is recognised as the most important STEM teaching competence. This teaching competence is addressed in 26 % of CPD-User cases, which might not seem like a high percentage. However, in the 50 CPD-User cases that were analysed, competences from the scale "Learning facilitation" are addressed 92 times. Together, with the development of lecturers' competencies in this scale, such as "stimulate discussion" and "problem solving" this can guarantee the development of powerful learning situations. It is worth mentioning that "Stimulate discussion" is recognized in the Roadmap survey as a generally important teaching competence, ranking only ninth. This indicates that the CPD-Ambassadors who developed the CPD-User cases were more aware of the importance of the discussion in learning and in developing critical thinking skills than the participants in the survey in 2020.

Regarding the attitudes that are addressed in the CPD-User cases, attitudes from the scale Pastoral interest are addressed by more than half of the CPD-User cases, followed by the attitudes from the scale Knowledge sharing (46 %), particularly the attitude "discuss teaching with colleagues". The scale Pastoral interest is also recognized in

the 2020 Roadmap survey as generally the most important teaching attitude scale. However, the average importance values found in the STEM-CPD Roadmap survey for knowledge sharing were generally low (under 4.0 on the Likert scale of 5). This is an indication that CPD-Ambassadors find reflective teaching practice and peer feedback much more important than the average participant of the Roadmap survey in 2020 (Brouwer et al., 2022c). The high frequency of the competence “Knowledge sharing” in the CPD-User cases shows a strong commitment of the CPD-Ambassadors to sharing knowledge, experience, and good practices in teaching and learning with peer lecturers and in CPD, which they also commit to when achieving the CPD-Ambassadors’ certificate.

What CPD activities are utilised in the CPD-User cases? How engaging might these CPD activities be for STEM faculties in general?

In the analysed CPD-User cases, all 19 CPD activities defined in the Roadmap in 2020 are used. In a majority of the CPD-User cases (30), the activities are learner-centred, while in 22 CPD-User cases, one or more CPD activities with a more or less teacher-centred approach are used. Thirty-two percent of CPD-User cases include a self-paced microMOOC, and 22 % of the CPD-User cases organise hands-on workshops. It is remarkable that the peer mentor-mentee approach, recognized in the Roadmap survey as the most effective CPD approach, is applied only in nine CPD-User cases. Nevertheless, it is necessary to mention that the importance values from the Roadmap survey for the part with the CPD activities were all under 4.0 and scattered.

What is the pedagogical potential of CPD-User cases developed by CPD-Ambassadors for addressing pedagogical challenges?

The CPD-Ambassadors developed the CPD-User cases during or after attending an STEM-CPD Summer school. The analysis of the CPD-User cases shows that CPD-Ambassadors strongly promote active learning and the learner-centred approach (Biggs & Tang, 2011) in university teaching and in CPD in teaching and learning. Ninety percent of CPD-User cases (45) address at least one teaching competence from the scale P1-3 Learning facilitation. All analysed CPD-User cases are specifically developed for a local teaching practice and thus have huge potential to motivate adult learners (Knowles, Holton & Swanson, 2014) to improve teaching practice at the universities for which they are developed. From the results regarding the CPD-Scenarios, it can be argued that similar educational challenges could obviously be addressed by developing different teaching competences and different teaching attitudes depending on the context of the pedagogical challenge.

## 5 Conclusions

The CPD-User cases available on Starfish platform show that the issues they address are of high importance at various universities and in different countries. A review of this topic may be inspiring for STEM faculties authorities designing CPD activities. The teaching competences addressed in the CPD-User cases indicate that CPD-Ambassadors share a student-centred teaching and learning (SCL) vision, which they aim to foster in their local teaching practice and share knowledge and good practice about. This is very encouraging, because the process of introducing SCL into higher education in Europe has not yet been completed, and CPD-User cases can help with this. CPD-Ambassadors share their expected impact on Starfish in the Evaluation section. The limitation of this study is the limited number of CPD-User cases that were developed so far and only a qualitative approach was used. A second limitation is that the actual impact of the CPD-User cases on local teaching practices has not yet been determined. This should be investigated in follow-up research, as implementing changes takes time and additional efforts. Recognition and support for CPD-Ambassadors at their local universities are needed and can be stimulated through international cooperation. The European Chemistry Thematic Network organises STEM-CPD Summer Schools, and various meetings for CPD-Ambassadors to enable them to share their experiences in a more informal way, highlighting the need for more recognition and support for the CPD-Ambassadors. Taking the Roadmap survey again is strongly recommended. This will provide insights into the current CPD needs in higher education and how they change over time, and guidance for collaboration. Establishing the Eurolecturer



Academy (Brouwer et al., 2022b) could play an important role in making STEM-CPD in an international context sustainable. Constant support of the authorities of STEM faculties for the systematic development of their lecturers, e.g. as part of the Eurolecturer Academy or other international initiatives, is highly recommended.

**Acknowledgments:** The authors wish to acknowledge Max Marshall and Steven Lageveen, both students at Faculty of Science, University of Amsterdam, for their contributions to the development on the Starfish platform, and for their work on the CPD-User case and CPD-Scenario templates. Erasmus+ project STEM-CPD@EUni, 2020-1-PL01-KA203-081802 <https://ectn.eu/work-groups/stem-cpd/> is acknowledged for their support in making this research possible. The project played no role in the study design; in the collection; analysis, and interpretation of data; in the writing of the report; or in the decision to submit the report for publication.

**Research ethics:** Not applicable.

**Informed consent:** Not applicable.

**Author contributions:** The authors have accepted responsibility for the entire content of this manuscript and approved its submission.

**Competing interests:** The authors state no conflict of interest.

**Research funding:** None declared.

**Data availability:** The raw data can be obtained on request from the corresponding author. All data are openly and freely available on Starfish in Creative Commons <https://starfish-education.eu/>. The data on Starfish reflect the current situation of CPD-User cases.

## References

- Appleby, Y., & Pilkington, R. (2014). *Developing critical professional practice in education*. Niace.
- Biggs, J., & Tang, C. (2011). *Teaching for quality learning at university* (4th ed.). Open University Press.
- Brouwer, N., Joling, E., & Kaper, W. (2022a). Effect of a person-centred, tailor-made, teaching practice-oriented training programme on continuous professional development of STEM lecturers. *Teaching and Teacher Education*, 119, 103848.
- Brouwer, N., Maciejowska, I., McDonnell, C., Niemelä, M. E., Pirok, B., Grecea, Ş., Femoni, C., Ortiz-Bustos, J., Byers, W., & Wasser, I. (2022b). Creating a common ground for professional development of university chemistry (STEM) lecturers in Europe. *Education Policy, Management and Quality*, 14(1), 45–57.
- Brouwer, N., Grecea, Ş., Kärkkäinen, J., Maciejowska, I., Niemelä, M., & Schreuders, L. (2022c). Roadmap for continuous professional development of STEM lecturers. In I. Devetak (Ed.), *University chemistry teaching in the 21st century*. University of Ljubljana, Faculty of Education (p. 85–111). <https://zalozba.pef.uni-lj.si/index.php/zalozba/catalog/book/198>
- Brouwer, N., & Niemelä M., (Eds.) (2023). Handbook for STEM-CPD Ambassadors, STEM-CPD@EUni, 2020-1-PL01-KA203-081802. Download: <https://starfish-education.eu/information/1393/> (Accessed on March 2024).
- Chadha, D. (2021). Continual professional development for science lecturers: Using professional capital to explore lessons for academic development. *Professional Development in Education*, 1, 1–16.
- Charret, A., & Chankseliani, M. (2023). The process of building European university alliances: A rhizomatic analysis of the European universities initiative. *Higher Education*, 86(1), 21–44.
- EUA (European University Association) (2021). *Universities without walls. A vision for 2030*. <https://eua.eu/downloads/publications/universities%20without%20walls%20a%20vision%20for%202030.pdf> (accessed on March 2024).
- Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences*, 111, 8410–8415.
- Fumasoli, T., & Rossi, F. (2021). The role of higher education institutions in transnational networks for teaching and learning innovation: The case of the Erasmus+ programme. *European Journal of Education*, 56(2), 200–218.
- Garrison, D. R., Anderson, T., & Archer, W. (2000). Critical inquiry in a text-based environment: Computer conferencing in higher education. *The Internet and Higher Education*, 2(2–3), 87–105.
- González, J., & Wagenaar, R. (Co-ordinators) (2000). *Tuning educational structures*. European Commission <http://unideusto.org/tuning/> (Accessed on March 2024).
- Henderson, C., Beach, A., & Finkelstein, N. (2011). Facilitating change in undergraduate STEM instructional practices: An analytic review of the literature. *Journal of Research in Science Teaching*, 48(8), 952–984.
- Henriksen, D., Mishra, P., & Fisser, P. (2016). Infusing creativity and technology in 21st century education: A systemic view for change. *Journal of Educational Technology & Society*, 19(3), 27–37.

- Knowles, M. S., Holton III, E. F., & Swanson, R. A. (2014). *The adult learner: The definitive classic in adult education and human resource development*. Routledge.
- Maciejowska, I. (Co-ordinator) (2020). STEM-CPD@EUni, Erasmus+, 2020-1-PL01-KA203-081802. <https://ectn.eu/work-groups/stem-cpd/> (Accessed on March 2024).
- Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for integrating technology in teacher knowledge. *Teachers College Record*, 108(6), 1017–1054.
- OECD. (2019). OECD future of education and skills 2030 conceptual learning framework: Core foundations for 2030. [https://www.oecd.org/education/2030-project/teaching-and-learning/learning/core-foundations/Core\\_Foundations\\_for\\_2030\\_concept\\_note.pdf](https://www.oecd.org/education/2030-project/teaching-and-learning/learning/core-foundations/Core_Foundations_for_2030_concept_note.pdf) (Accessed on March 2024).
- Pinto, G. (2010). The Bologna process and its impact on university-level chemical education in Europe. *Journal of Chemical Education*, 87(11), 1176–1182.
- Postareff, L., Lindblom-Ylänne, S., & Nevgi, A. (2007). The effect of pedagogical training on teaching in higher education. *Teaching and Teacher Education*, 23(5), 557e571.
- Rienties, B., Divjak, B., Eichhorn, M., Iniesto, F., Saunders-Smiths, G., Svetec, B., Tillmann, A. & Zizak, M. (2023). Online professional development across institutions and borders. *International Journal of Educational Technology in Higher Education*, 20(1), 30.
- Russo, V., Tarallo, O., Brouwer, N., Lis, A., Maciejowska, I., & Prashar, S. (2023). Summer schools for STEM CPD ambassadors. Handbook for organisers, STEM-CPD@EUni, 2020-1-PL01-KA203-081802. Download: [https://ectn.eu/wp-content/uploads/2023/10/Summer-school\\_-Handbook-1.pdf](https://ectn.eu/wp-content/uploads/2023/10/Summer-school_-Handbook-1.pdf) (Accessed on March 2024).
- Sajdak-Burska, A., & Maciejowska, I. (2023). Systemowe działanie vs projektowy supermarket? *Forum Akademickie*, 30(2), 48–50.
- Singer, S. R., Nielsen, N. R., & Schweingruber, H. A. (2012). *Discipline-based education research*. The National Academies.
- Stahr, I. (2009). Academic staff development: Entwicklung von Lehrkompetenz. In J. Wildt, U. Welbers, B. Szczyrba & R. Schneider (Eds.), *Wandel der Lehr-und Lernkulturen*. Vol. 120 (pp. 70–87). wbv Media GmbH & Company KG.
- Stes, A., Min-Leliveld, M., Gijbels, D., & Van Petegem, P. (2010). The impact of instructional development in higher education: The state-of-the-art of the research. *Educational Research Review*, 5(1), 25–49.
- Winberg, C., Adendorff, H., Bozalek, V., Conana, H., Pallitt, N., Wolff, K., & Roxå, T., Roxå, T. (2019). Learning to teach STEM disciplines in higher education: A critical review of the literature. *Teaching in Higher Education*, 24(8), 930–947.