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Roadmap for Continuous Professional Development of STEM Lecturers

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Abstract
Despite the ongoing systematic integration under the Bologna Agreement, higher education systems in Europe are still different in different countries and have different focus areas in the professional development of lecturers. At many European universities, professional development is often organised from a pedagogical point of view and the lecturers are left alone to apply the acquired pedagogical knowledge in their own teaching practice. In the Erasmus+ project STEM-CPD@EUni, five European universities and the European Chemistry Thematic Network (ECTN) are collaborating to enable continuous professional development (CPD) in a local university STEM teaching practice. A new concept in CPD is introduced, the CPD ambassador. Three dimensions characterize the activities of the CPD ambassadors in their local context: (1) STEM educational competences, (2) teaching attitudes, and (3) CPD activities. To define the needs for the CPD in these dimensions, a survey was developed with 66 statements evaluated from two different perspectives: their general importance for the quality of teaching and learning and their use in teaching practice. 420 lecturers from 80 universities from 26 countries and 46 education managers from 31 universities from 11 countries in Europe completed the survey from the end of November 2020 to the end of January 2021. The results show similarities and also some differences between the European countries and indicate in which directions the CPD is needed. The survey also showed that the priority list of needs for CPD should not be blindly followed but used in an evidence-based way. It is recommended to repeat the survey after some time. Based on the results of this research, a roadmap for STEM-CPD with guidelines and recommendations was developed in the STEM-CPD@EUni project.

Keywords: higher education, STEM, continuous professional development (CPD), teaching competences, teaching attitudes, CPD activities

Introduction

Despite the ongoing systemic integration under the Bologna process (EUA, https://eua.eu) higher education systems in Europe are still very different in different countries. Many universities today recognize the need for professional development of higher education lecturers. According to the report of European University Association (te Pas, 2019) and based on results of the survey of the ECTNA Working Group "Lecturing qualifications and innovative teaching methods" (ECTN WG, 2020), some professional development is organized at many European universities. In their literature study, Stes et al. (2010) investigated the impact of institutional professional development on lecturers in higher education. In some countries, lecturers can achieve a University Teaching and Learning Certificate or a similar qualification. Yet these programs are often generic and do not focus on subject specific STEM pedagogical aspects that affect how students learn (Walsh, 2017). In general, the professional development courses are currently being developed from a pedagogical point of view and the

lecturers themselves have to apply this pedagogical knowledge in their own educational context.
Teaching doesn't get better by teaching hours alone. It is necessary that lecturers attend some professional development activities. Marsh (2007) followed student evaluations of teaching effectiveness from 195 lecturers who were continuously evaluated over 13 years and found substantial differences between individual teaching effectiveness that were also very stable over time. Educators are more likely to participate in continuous professional development activities (CPD) if they believe such programs are relevant to self-identified needs (Adu, 2017). The literature shows that teachers' beliefs about what constitutes good teaching have a strong influence on how teaching is designed and delivered in practice (Kember, 1994; Prosser, 1999, Norton, 2005). Stes et al. (2010) showed that one-off events are less effective than events that extend over time. Professional development embedded in lecturers' daily practice (Dochy, 2011) more likely has impact on teachers' beliefs (Rienties, 2013). Daumiller et al. (2021) studied the motivation of academics who professionalize and found a positive relationship between performance goals and learning gain.
The use of information and communication technology (ICT) has revolutionized our lives and is also finding its way into higher education. The European Framework for the Digital Competence of Educators (DigCompEdu) has identified 22 competences in different areas (Redecker, 2017). To achieve a relevant use of ICT in education, the professional development of lecturers who use ICT in their teaching should focus on the development of the technological pedagogical content knowledge (TPACK) (Mishra, 2006; Rienties, 2013). The teaching context has an important role in how we teach and what we teach. In STEM professional development, lecturers develop their technological pedagogical content knowledge in the context of their courses and they use digital technology in a relevant way in specific teaching and learning activities. Bottom-up approaches where lecturers collaborate and reflect within the communities of practitioners and in this way supporting each other's development proved to be successful (Cowan, 2006; Goodchild 2014).
Lecturers in CPD are adult learners. When teaching adults, the principles of andragogy should be taken into account (Chametzky, 2014; Knowles, 1980): (a) the self-management of learning, (b) the empowerment of learners leading to increased motivation, (c) the reliance on life experiences of learners to aid with their learning, (d) the objectives of learners for taking the course, and (e) the practical, real-world solutions to problems encountered in the course. The principle of autonomous learning supports learning activities that take place in close connection with one's own workplace, in the case of lecturers their teaching practice (Dochy, 2011). Sustainable CPD activities for lecturers enable lifelong learning educators to continuously improve their teaching skills while supporting continuous improvement in the quality of the courses and curricula in which they teach. Ultimately, it enables to improve the learning process of the students and shape their skills for the future.
In this article, we describe the development and results of a survey aimed at determining the CPD needs of university STEM educators in Europe. The results presented in this article reveal what knowledge and skills the participants of the survey considered important for the university STEM lecturers at the time of completing the survey. The results suggest directions for organization of continuous professional development. Nevertheless, we recommend that new measurements will be conducted every few years.

CPD-Ambassador

Most universities have professional development (PD) policies and organize top-down courses or a PD programme for their lecturers. In every faculty there are also lecturers who have a deeper interest in education and who explore new teaching methods in their courses or new digital tools. They innovate their teaching from intrinsic motivation, bottom-up. There are

university or national funds to support education innovation projects and there are also European funds, like Erasmus+. These bottom-up activities lead to the emergence of networks of lecturers innovators and long-term collaborations. Many lecturers innovators like explaining informally to their fellow lecturers how they use a new teaching method or help colleagues in the workplace using a new teaching tool. Unfortunately, these bottom-up efforts are usually not recognized by faculty management as important teaching duties or as part of the professional development. To the best of our knowledge, there is no known structured bottom-up continuous professionalization approach that is organized by the lecturers themselves. To drive a change, the STEM-CPD@EUni project has introduced a new concept in CPD, the CPD-ambassador (Brouwer, 2020). The role of the CPD-ambassadors is to increase the awareness of fellow lecturers on the importance of the STEM teaching competences and to promote professional development. The CPD-ambassadors organize bottom-up CPD activities for fellow lecturers that exactly match their specific needs so that they can immediately apply the knowledge and solve their educational challenges. This is important for motivation and self-regulated learning. Finding out what lecturers need is thus a fundamental step in organizing bottom-up CPD activities. The CPD-ambassadors from different universities and from different countries are united in a STEM-CPD community where they share their knowledge and exchange experiences. To become CPD-ambassadors at the European level, lecturers can participate in a Summer School for STEM-CPD (https://ectn.eu/work-groups/stem-cpd-o5/).

Method

To map out the needs for the professional development of lecturers in STEM in Europe, a survey was developed (STEM-CPD@EUni, https://ectn.eu/work-groups/stem-cpd/). A clustering method was used to define reliability of the survey scales. Based on the results of this survey, a Roadmap for continuous professional development of STEM lecturers was published with recommendations and guidelines for organizing meaningful CPD activities (Grecea, 2021).

Survey

The survey development team consisted of a core group of four persons: three STEM lecturers, two of whom also had management tasks, and one STEM education consultant, and a feedback group of 16 persons: 15 STEM lecturers, several of whom also had management tasks, and one educational expert. In order to collect feedback on the content and design of the survey, various brainstorming sessions were organized with the core development group and feedback group upon which the individual feedback was given. The final survey resulted in 66 statements, divided into three parts, each measuring a different dimension that the development team defined as relevant to the bottom-up professional development of STEM lecturers (*Figure 5.1*): (1) STEM teaching competence, (2) CPD teaching and learning (CPD) attitudes and (3) CPD activities.

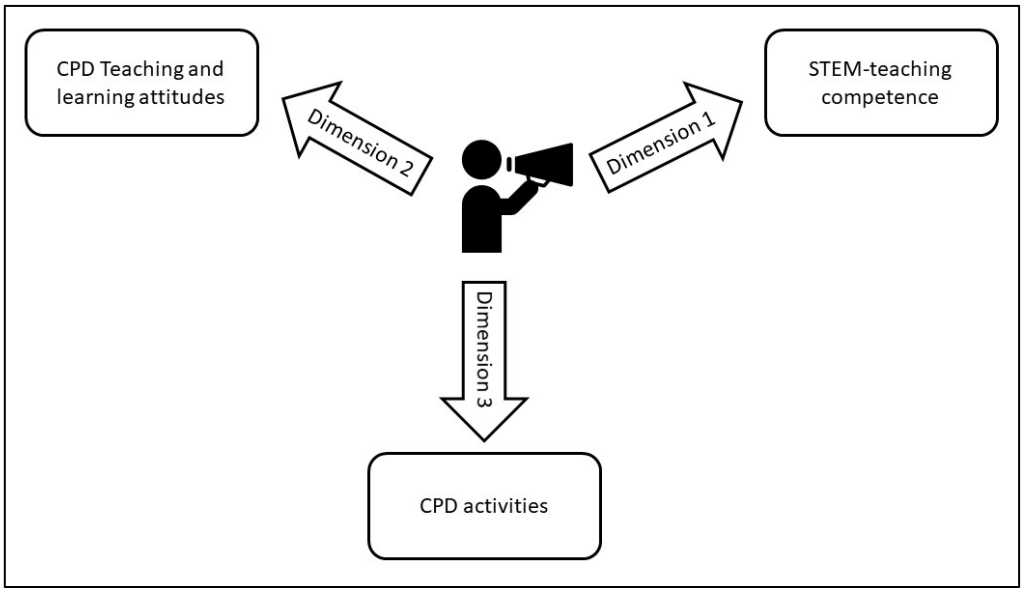

Figure 5.1. Dimensions that characterize a CPD-Ambassador in his/her activities to improve local teaching and learning practice

The survey was anonymous but there were several demographic questions in order to be able to analyze the results. All participants gave consent to use their data for the research and publication purposes. The statements of the survey can be found in different tables.
The participants of the survey were lecturers or educational managers. They evaluated each of the statements on the Likert scale 1 to 5 from two different perspectives.

Perspective 1: General importance for the quality of teaching and learning in university STEM
Perspective 2: Use / practice in the personal teaching practice (participants lecturers) or in the programme teaching practice (participants managers)
The higher the general importance value of a statement in the survey, the greater its relevance to organizing CPD activities for it. The discrepancy in the value of the two perspectives, the general importance and the personal/program use measures the urgency to organize the CPD activities for that. The urgency is greater when greater the discrepancy between the general importance and the personal/programme use.
The survey was set out first at the partner institutions. Based on the results and gained experiences at this stage, we have decided to keep the survey in the same form and we distributed it further among the lecturers and managers at other universities in Europe.

Results and discussion

The survey was set out between 24th November 2020 and 20th December 2020 at the partner institutions. 94 lecturers and 16 managers completed the survey in this period. Then, the same survey was distributed among lecturers and managers at other universities in Europe. 326 lecturers and 30 managers completed the survey from 21st December 2020 and 30th January 2021.
To examine if the data sets could be pooled, we have executed a quadratic Levene's test on all 66 statements in the survey and found no significant differences between the November-December and December-January sets for both the lecturers data and the managers data. Based on this outcome, we have decided to use the whole set of 420 completed surveys for the analysis

of the survey of lecturers and the whole set of 46 surveys of managers and worked it out together in order to define any difference per country.
In the following paragraphs we define the participants and discuss the results per part of the survey and compare the results of the survey completed by the lecturers and the educational managers.

Participants

A total of 420 lecturers from 26 countries and 46 education managers from 11 countries in Europe (geographically) have completed the survey between 24th November 2020 and 30th January 2021 (*Table 5.1*).

Table 5.1. Countries of participants in the survey.

Country	No. Lecturers	No. Managers
Italy	249	14
Poland	35	9
Netherlands	24	6
Finland	11	1
Spain	11	1
Slovenia	8	2
Belgium	7	6
Cyprus, Hungary, Serbia, Turkey	7	0
United Kingdom	6	0
Greece	5	0
Czech Republic, Latvia	4	1
Austria, Romania, Russia	4	0
Germany	3	4
France, Ireland, Rep. of North Macedonia	3	0
Lithuania	1	1
Croatia, Portugal, Slovakia	1	0
Total	420	46

From 420 lecturers 58% were male, 40% female, 2% did not want to answer this question. The largest group (33%) was between 46-55 years old, 25% were between 36-45 years old, 23% were between 56-65 years old, 9% were older than 65 and 2 persons (0.4%) were younger than 25 years old. 53% of the participants did not have any pedagogical training yet and 26% have obtained some university teaching certificate. For 56% of the participants teaching duties were about 50% of their work tasks and for 25% teaching was a substantial part of their work tasks. 26% of the participants' role was lecturing, 14% laboratory teaching and 12% were teaching in tutorial sessions / working sessions / seminars.
12% of the participating lecturers indicated that they are not yet effective enough and need training, 64% of the participants indicated that they are effective teachers and 46% that they are not always effective. 69% of participants said they are effective lecturers, but they still need training because there is always room for improvement. 9% said they don't have time for training.

Survey Part 1

The set of statements in Part 1 has 30 statements dealing with different educational principles, methods, pedagogical content and technology (*Table 5.2*).

Table 5.2. Statements survey Part 1: Teaching competences.

No	Statement
1	frame the course in the context of the study programme
2	define intended learning outcomes in every course they teach
3	choose an appropriate assessment method for their course
4	engage students and arouse interest for the discipline in the class
5	teach holistically by integrating social and art aspects in teaching and learning complex chemical concepts
6	cope with heterogeneous pre-knowledge of students
7	being able to bring out and correct misconceptions
8	develop critical thinking by students
9	give prompt feedback and support students during learning
10	support students in socializing (specifically e.g. during a pandemic)
11	stimulate discussion
12	design laboratory courses
13	teach about lab safety using digital tools/platform (where appropriate)
14	teach large groups of students
15	teach small groups of students (group's dynamics)
16	design interactive lectures
17	design online exams
18	design problem solving sessions
19	design active learning classes / sessions using digital technology
20	use digital tools in lab courses
21	use design thinking methods
22	use research based teaching methods
23	use project based teaching methods
24	use blended learning approach
25	use interactive online boards for teaching and learning
26	use voting in lectures to activate thinking and understanding of (e.g. chemistry) concepts
27	organize peer-assessment / peer-feedback in their courses
28	organize (online) collaborative learning
29	use advanced tools, based on artificial intelligence, in supporting students in their learning process
30	make/produce short MOOCs

Figure 5.2. shows the results of the survey Part 1 completed by 420 lecturers from 26 different countries about which teaching competences lecturers need to have, evaluated from two perspectives: the general importance and personal use, i.e. how much they apply these competences in their personal practice.

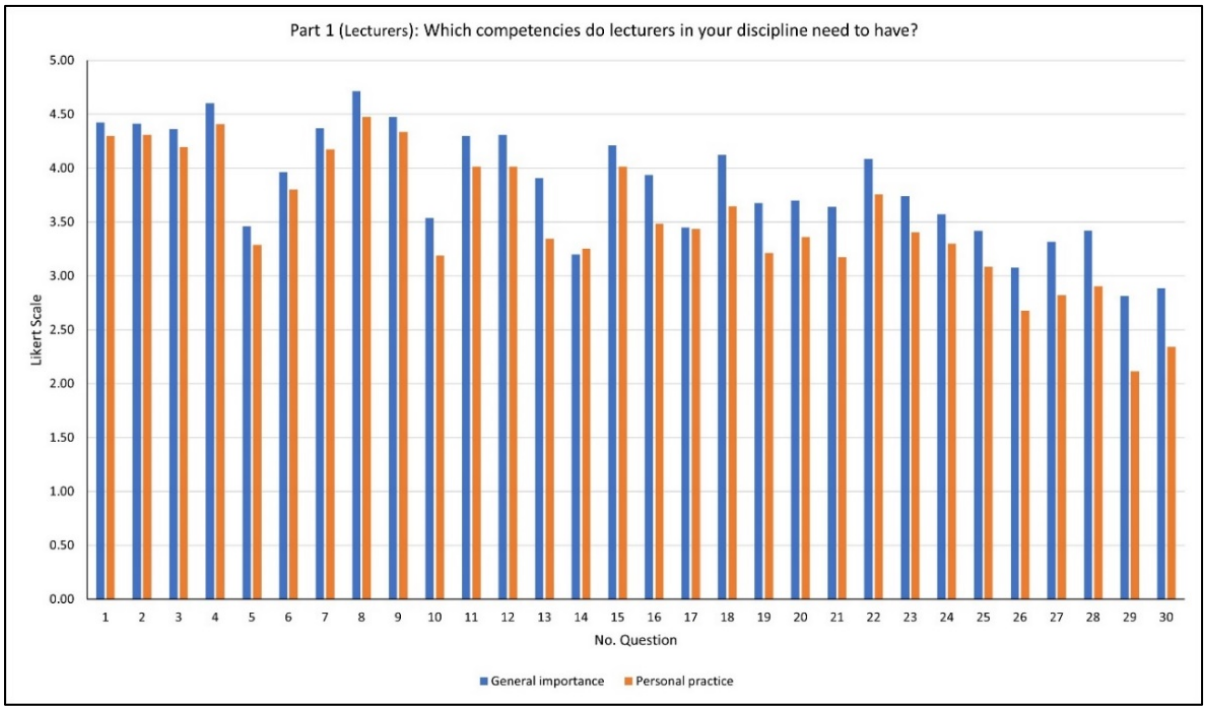

Figure 5.2. Results of the survey Part 1 completed by lecturers from 26 countries regarding the general importance of teaching competences in comparison to their personal practice (evaluated on the Likert scale 1 to 5) - *n*= 420.

In *Figure 5.3* the same results are presented for the group of 46 education managers from 11 countries.

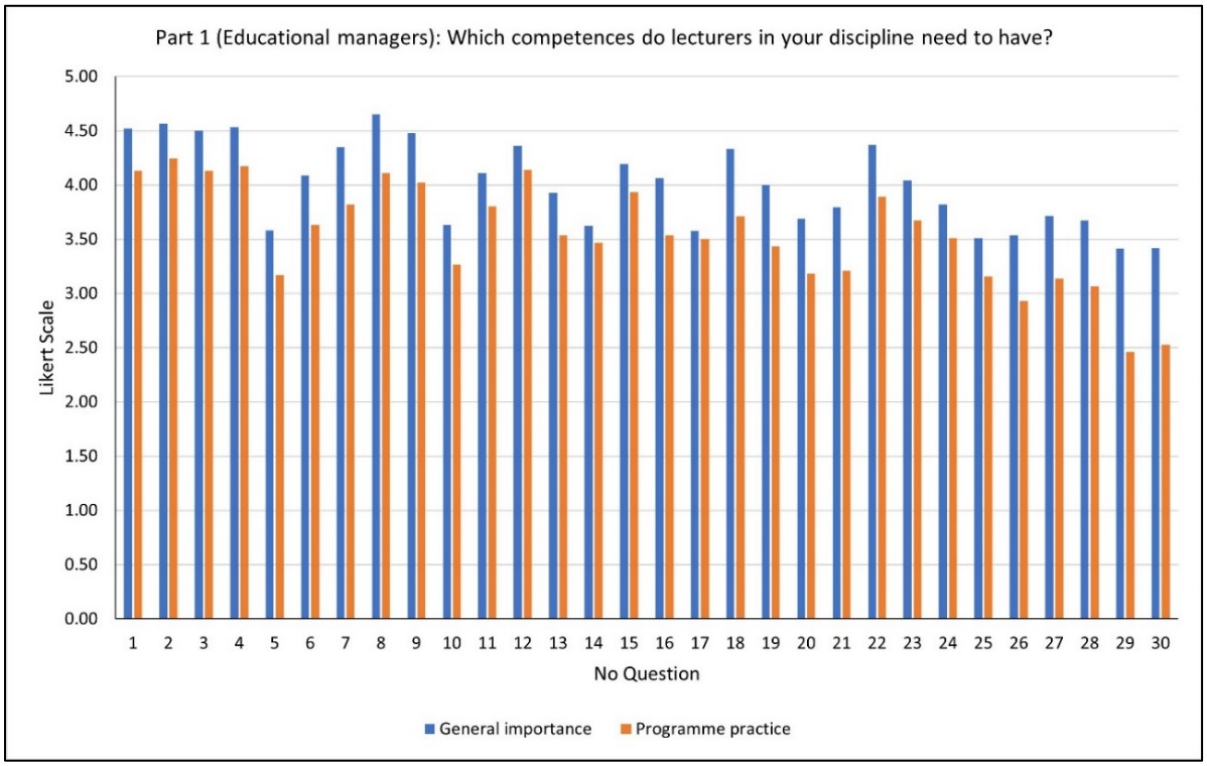

Figure 5.3. Results of the survey Part 1 completed by education managers from 11 countries regarding the general importance of teaching competences in comparison to the practice of their programmes / their lecturers teams (evaluated on the Likert scale 1 to 5) - *n*= 46.

The results show that in all cases the general importance has a higher value than the personal or programme practice use. The education managers find all 30 competences on average important (Likert scale > 3.4). On the other hand the lecturers find the competences 29 (use advanced tools, based on artificial intelligence, in supporting students in their learning process) and 30 (make/produce short MOOCs) on average less important (Likert scale < 3.0)
The results show that the General importance is larger than the Personal/programme practice use in all cases except for question 14 (teach large groups of students) in the survey lecturers, which means that discrepancy, the average general importance - average personal/program use Δ(G – P) is positive (*Figure 5.2 and 5.3*).
Table 5.3 shows the priority list of teaching competences. The four most important teaching competences in the opinion of the lecturers and the education managers are the same, q. 8, q. 4, q. 9 and q. 2 (*Table 5.3*). In addition, Table 5.3 also shows the discrepancy between the general importance and the personal/programme practice use, which is larger in the group of the education managers compared to the group of lecturers in de survey questions no. 8, 4, and 9. This suggests that the experience of the personal situation of the lecturers for those questions is more positive than the experience of the education managers about their programme teams.

Table 5.3. Priority list of competences based on the survey data Part 1.

Lecturers			**Educ. Managers**				
Gen.Imp.	**St. Dev.**	**Δ(G-P)***	**Gen.Imp.**	**St. Dev.**	**Δ(G-P)***	**q. No**	**Statement**
4.71	0.63	0.24	4.65	0.74	0.54	8	develop critical thinking by students
4.60	0.70	0.19	4.53	0.79	0.36	4	engage students and arouse interest for the discipline in the class
4.48	0.73	0.14	4.48	0.86	0.46	9	give prompt feedback and support students during learning
4.42	0.72	0.13	4.52	0.78	0.39	1	frame the course in the context of the study programme
4.41	0.83	0.11	4.57	0.78	0.32	2	define intended learning outcomes in every course they teach
4.37	0.80	0.19	4.35	0.90	0.53	7	being able to bring out and correct misconceptions
4.36	0.79	0.16	4.50	0.81	0.37	3	choose an appropriate assessment method for their course
4.31	0.89	0.30	4.36	0.84	0.22	12	design laboratory courses
4.30	0.84	0.28	4.11	0.99	0.30	11	stimulate discussion
4.21	0.91	0.20	4.20	0.98	0.26	15	teach small groups of students (group's dynamics)
4.12	0.91	0.48	4.33	0.83	0.62	18	design problem solving sessions
4.09	0.94	0.33	4.37	0.93	0.48	22	use research based teaching methods

Table 5.3. continued

3.96	0.91	0.16	4.09	0.89	0.46	6	cope with heterogeneous pre-knowledge of students
3.93	0.98	0.45	4.07	0.90	0.53	16	design interactive lectures
3.91	1.04	0.56	3.93	1.20	0.39	13	teach about lab safety using digital tools/platform (where appropriate)
3.74	1.04	0.33	4.04	1.02	0.37	23	use project based teaching methods
3.70	1.13	0.34	3.69	1.08	0.51	20	use digital tools in lab courses
3.68	1.07	0.46	4.00	0.99	0.57	19	design active learning classes / sessions using digital technology
3.64	1.05	0.46	3.80	1.11	0.59	21	use design thinking methods
3.57	1.13	0.27	3.82	1.07	0.31	24	use blended learning approach
3.54	1.11	0.35	3.63	1.10	0.36	10	support students in socializing (specifically e.g. during a pandemic)
3.46	1.14	0.17	3.58	1.05	0.41	5	teach holistically by integrating social and art aspects in teaching and learning complex chemical concepts
3.45	1.16	0.01	3.58	1.22	0.08	17	design online exams
3.42	1.18	0.51	3.67	1.12	0.61	28	organize (online) collaborative learning
3.42	1.18	0.33	3.51	0.99	0.36	25	use interactive online boards for teaching and learning
3.31	1.13	0.50	3.72	1.17	0.58	27	organize peer-assessment / peer-feedback in their courses
3.20	1.19	-0.05	3.62	1.19	0.16	14	teach large groups of students
3.08	1.22	0.40	3.53	1.06	0.60	26	use voting in lectures to activate thinking and understanding of (e.g. chemistry) concepts
2.88	1.18	0.54	3.42	1.02	0.89	30	make/produce short MOOCs
2.81	1.30	0.70	3.41	1.26	0.95	29	use advanced tools, based on artificial intelligence, in supporting students in their learning process

*(G-P) = average general importance - average personal/program use

In *Figure 5.4*, the general importance of the five project partner countries of the STEM-CPD@EUni project (the Netherlands, Poland, Italy, Finland and Slovenia) are compared to the average general importance of all the countries that have contributed to the survey.
In general, the Figure 5.4 shows many similarities and some differences between the countries. First, when we exclude the largest group (Italy) the competence "Develop critical thinking by students" (q. 8) remains the competence with the highest general importance. The figure shows that in Poland, the competence "Teaching small groups of students (group dynamics)" (q. 15) is the second most important competence, which is different from other countries. Furthermore,

in Poland the third place shows two competences having the same score (4.6, St. Dev. 0.6 and 0.7 respectively): “Engage students and arouse interest for the discipline in the class” (q. 4) and “Define intended learning outcomes in every course they teach” (q. 2). The education managers in Poland also ranked the competence “Teaching small groups of students (group dynamics)” (q. 15) second most important. and on the third place there are two competences having the same score (4.6, St. Dev. 0.6 and 0.7 respectively) “Engage students and arouse interest for the discipline in the class” (q. 4) and “Define intended learning outcomes in every course they teach” (q. 2). The education managers in Poland also put q.15 on the second place. The lecturers and the education managers in Poland assigned the competence “Teach holistically by integrating social and art aspects in teaching and learning complex chemical concepts” (q.5) a higher general importance value than average in all countries (Lecturers: 3.97, St. Dev. 0.95, all countries 3.46 St. Dev. 1.14; Managers: 4.25, St. Dev. 0.71, all countries 3.58, St. Dev. 1.05).

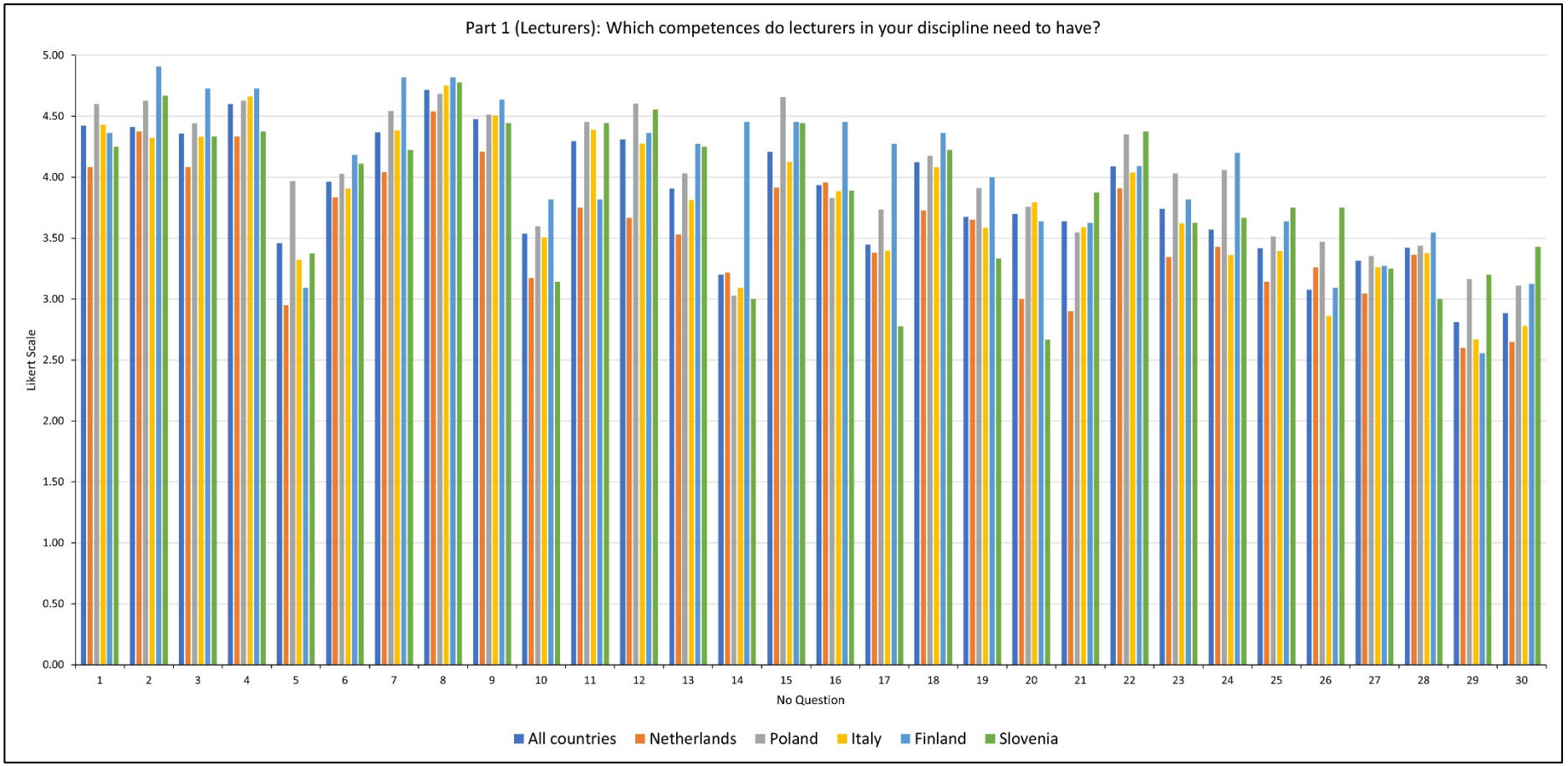

Figure 5.4. Results of the survey Part 1 completed by lecturers from 5 partner countries involved in the STEM-CPD@EUni project regarding the general importance of teaching competences (evaluated on the Likert scale 1 to 5) - n= 327.

The lecturers who completed the survey in Finland were mostly from the University Oulu and teach courses with large groups of students. They assigned the highest score for the competence q.2 (4.91, St. Dev. 0.30) and for the competence "Teach large groups of students" (q.14) a much higher general importance score (4.45, St. Dev. 0.82) than lecturers in other countries (3.20, St. Dev. 1.19). The general importance scores for the competences "Design interactive lectures" (q.16) (4.45, St. Dev. 0.82, average all countries 3.93 St. Dev. 0.98) and "Design online exams" (q.17) (4.27, St. Dev. 0.79, average all countries 3.45, St. Dev. 1.16) are on average also higher in Finland than in other countries.
The results from specific countries are likely to be related to the organizational culture of their higher education institutions, traditions, and legal regulations. Indication of teaching in large student groups as a less important competence in higher education, may be related to education organisation in that country (Maciejowska, 2022). For example in Poland, courses are organized for each department separately, and therefore with a limited number of students from a few (astronomy) to approx. 200 (computer science) and there are no join lectures on basic STEM courses for really large groups of students (e.g. general chemistry for chemistry, biology, pharmacy, forestry study programmes). Another reason may be the common, traditional, also expected by students, way of lecturing without interaction with the audience.

We have combined the competence statements in Part 1 in four larger education competences and sub-competences considering general pedagogical principles, constructive alignment and TPACK model (Biggs, 2011; Mishra, 2006). We have statistically evaluated these competence scales and subscales by using a statistical clustering method.

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)

Table 5.4 gives the values of the scales and subscales calculated from the average score values of the statements in the survey answered by both lecturers and education managers. The reliability of the scales and sub-scales is given by the Cronbach's Alpha. The reliability Cronbach's Alpha for the whole Part 1 (30 items) of the survey is 0.951 for General importance and 0.945 for Personal/programme use. The cluster analysis supports the sets of statements in the education competences. An exception is "Teach large groups of students" (q.14). Excluding the question q.14 from the subscale Competence Teaching (P1-2 Pedagogy- Interactive teaching) increases the value of this subscale from 3.86 to 4.07 in the lecturers group and from 3.98 to 4.10 in the managers group. The reliability Cronbach's Alpha increases when q.14 is excluded from the subscale from 0.558 to 0.648 in general importance part and from 0.473 to 0.577 in the personal/programme part. The reason why q.14 doesn't fit well in the subscale may be the usual traditional way of teaching large groups of students without interaction. More research is needed to prove this.

Table 5.4. Values of the scales / subscales that measure the importance of four general education competences for the lecturers in STEM, in the opinion of the lecturers and the education managers.

Scales	**Lecturers General**	**Lecturers Δ(G-P)[a)]**	**Managers General**	**Managers Δ(G-P)[b)]**	**Cronbach's Alpha**
P1-1 Constructive alignment (q. 1, 2, 3, 6)	4.29	0.14	4.42	0.38	G: 0.752 P: 0.718
P1-2 Pedagogy - Interactive teaching					
P1-2a Competence Teaching (q. 9, 10, 14, 15	3.86	0.12	3.98	0.31	G: 0.558 P: 0.473
P1-2b Competence Design interactive teaching (q.16, 19)	3.81	0.46	4.03	0.55	G: 0.746 P: 0.735
P1-3 Pedagogy - Learning facilitation					
P1-3a Problem solving (design and teaching) (q. 18, 21, 22, 23)	3.90	0.40	4.14	0.51	G: 0.783 P: 0.753
P1-3b Engagement and motivation, facilitation discipline specific learning (q. 4, 12, 13)	4.27	0.35	4.28	0.33	G: 0.646 P: 0.569
P1-3c Deep learning[c)] (q. 5, 7, 8, 11)	4.21	0.22	4.17	0.45	G: 0.705 P: 0.709
P1-3d Organize peer-feedback, collaborative learning (q. 27, 28)	3.37	0.50	3.70	0.59	G: 0.724 P: 0.754
P1-4 Technology in facilitative teaching					
P1-4a Use of digital tools for a pedagogical goal (q. 17, 25, 26, 29, 30)	3.13	0.40	3.49	0.58	G: 0.820 P: 0.788
P1-4b Blended learning 20, 24	3.63	0.30	3.76	0.41	G: 0.572 P: 0.581

[a)]The difference between the general importance for the lecturer and the use in the personal teaching practice

[b)]The difference between the general importance for the education managers and the use in the programme teaching practice

[c)]According to the definition of Biggs (2011).

The scales P1-1 (Constructive alignment) 4.29 (group lecturers) and 4.42 (group education managers) clearly show that both groups are aware of the importance of the Constructive alignment (Biggs, 2011) in the course design. Both subscales of P1-2 (Pedagogy - Interactive teaching), Competence teaching and Competence Design interactive teaching in the lecturers' survey are under 4.00 (agree on Likert scale). In the group of education managers this is only slightly higher. Only the subscales P1-3b and P1-3c (*Table 5.4*) of the scale P1-3 Pedagogy - Learning facilitation is higher than 4.00 in both groups.
These results show that, at the moment of the survey the interactive activating teaching methods were not perceived as relevant for the higher education lecturers by both the majority of participating lecturers and education managers. This is in sharp contrast with the extensive research in this field (Freeman, 2014) that recommends omitting traditional lecturing because interactive activating teaching works better.
The value of both subscales of P1-4 (Technology in facilitative teaching) are for both groups lower than 4.00. This indicates that the majority of the lecturers and education managers did not find the use of digital technology in enabling education relevant for higher education lecturers at the time of the survey, which was before the outbreak of COVID19 in Europe. It is possible that a repeat of the study now turns out differently.

Survey Part 2

The survey Part 2 includes 17 statements about the attitudes considering different educational principles, pedagogies, content and technology. The list of statements used in the Survey Part 2 can be found in *Table 5.5.*

Table 5.5. Statements survey Part 2: Teaching and learning attitudes/characteristics.

No	Statement
1	be reflective teachers and reflect about their courses / lectures.
2	have high expectations for the students and themselves.
3	inspire a positive attitude in their class.
4	make students feel special, included, safe and secure.
5	be interested in their students' progress.
6	use students evaluations and the feedback of students to improve courses.
7	read literature about teaching and learning in higher education.
8	discuss teaching with their colleagues.
9	observe (some) lectures / teaching sessions of colleagues and give feedback.
10	record (some) own lectures / teaching sessions on the video to reflect on.
11	organize / attend meetings of their own teaching team to discuss / reflect on the teaching methods and on the effect of those on studentsâ€™ learning.
12	share experience and knowledge gained through continuous professional development (CPD) with lecturers from other institutions.
13	analyse the effect of teaching and introduce changes in an evidence based way.
14	set their own goals for professional development.
15	attend training for lecturers at the university.
16	apply for specific professional development programmes to obtain certificate(s) in teaching. (If this doesn't exist in your country, please indicate in General importance what is your personal opinion about it and choose in Personal practice not applicable)
17	participate in conferences about teaching in higher education.

Figure 5.5 shows the results of the survey Part 2 completed by 420 lecturers from 26 countries regarding which attitudes (characteristics) lecturers should have evaluated from two perspectives: the general importance and how much they experience a specific attitude in their personal practice. *Figure 5.6* shows these results collected from 46 education managers from 11 countries and compares their two perspectives: general importance and presence in their programme practice. The results also show that in all cases the general importance is evaluated higher than the real situation in practice. This means that there is urgency for the professionalization of lecturers in the dimension of teaching and learning attitudes (*Figure 5.1*).

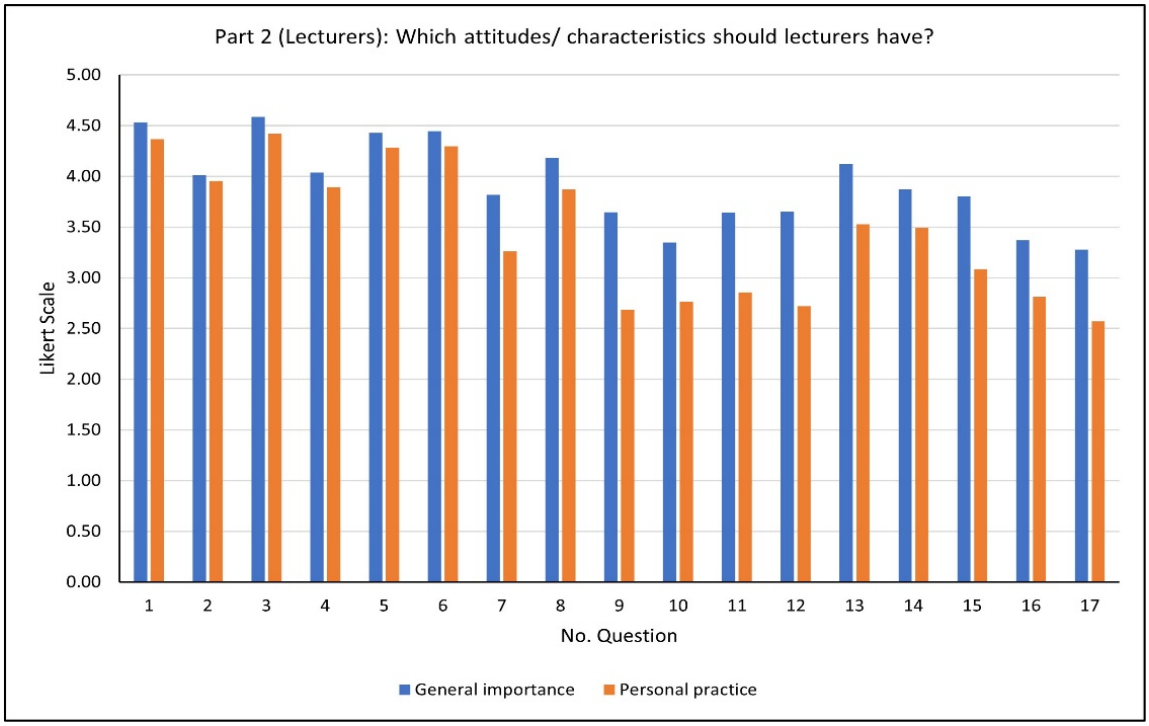

Figure 5.5. Results of the survey Part 2 completed by lecturers from 26 countries regarding the general importance of teaching and learning attitudes in comparison to their personal practice (evaluated on the Likert scale 1 to 5) - n= 420.

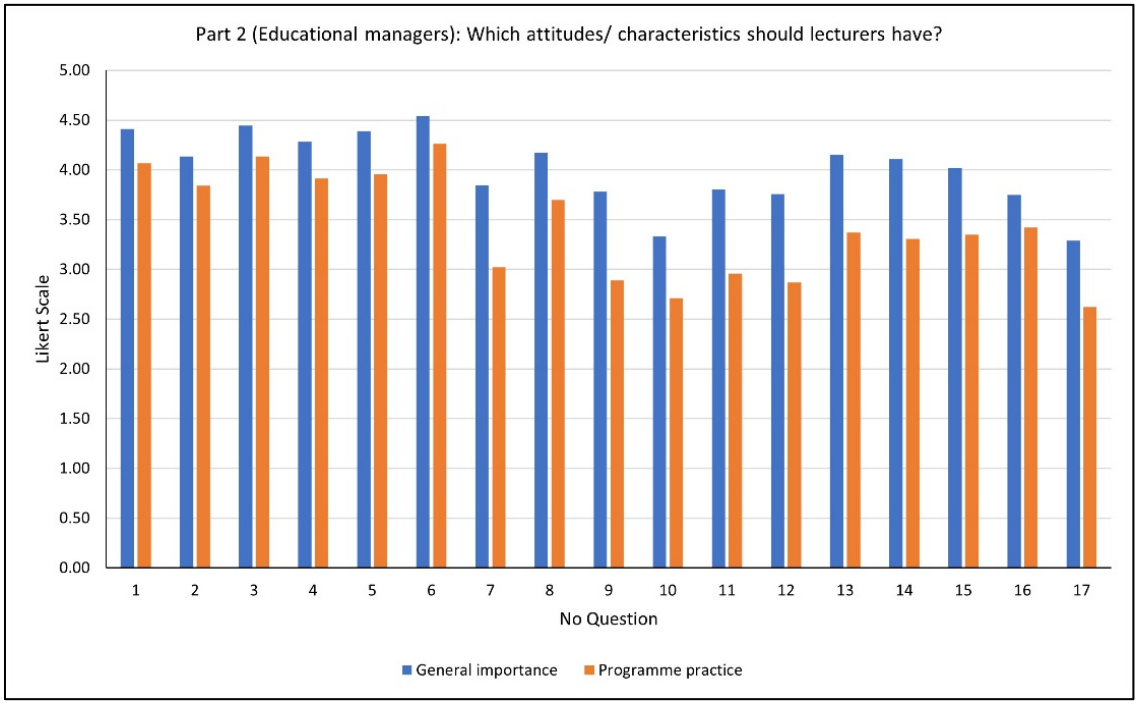

Figure 5.6. Results of the survey Part 2 completed by education managers from 11 countries regarding the general importance of teaching and learning attitudes in comparison to the practice of their programmes / their lecturers teams (evaluated on the Likert scale 1 to 5) - n= 46.

Figure 5.7 shows the results for 5 countries of the project partner universities.

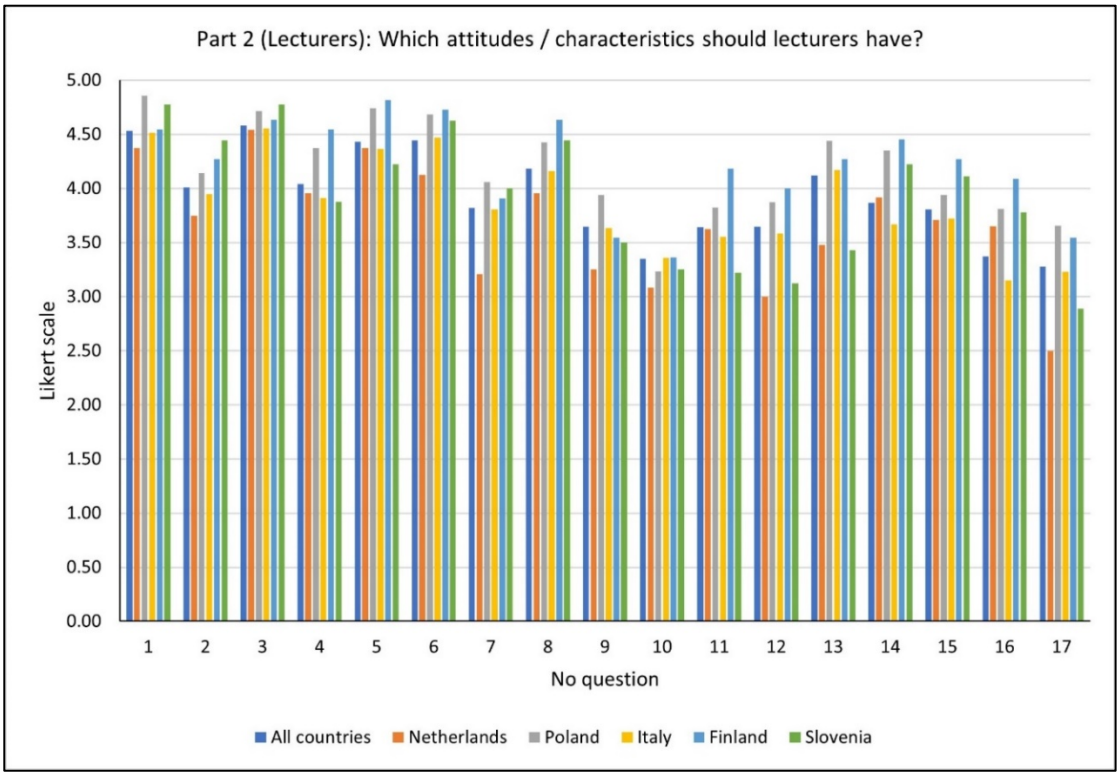

Figure 5.7. Results of the survey Part 2 completed by lecturers from 5 partner countries involved in the STEM-CPD@EUni project regarding the general importance of teaching and learning attitudes (evaluated on the Likert scale 1 to 5) - n= 327.

Table 5.6 shows the priority list of attitudes (personal characteristics). The four most important teaching and learning attitudes in the opinion of the lecturers and the education managers, measured on the Likert scale 1 to 5 are q. 3., q. 1, q. 6, and q. 5 (*Table 5.6*). Similarly to Part 1 the participants of the survey (lecturers or education managers) evaluated each statement from two perspectives: general importance and use in personal or programme practice.

Table 5.6. Priority list of attitudes (personal characteristics) based on the survey data Part 2.

Lecturers			**Educ. managers**				
Gen.Imp.	**St. Dev.**	**Δ(G-P)***	**Gen.Imp.**	**St. Dev.**	**Δ(G-P)***	**q. No**	**Statement**
4.58	0.71	0.16	4.44	0.87	0.31	3	inspire a positive attitude in their class.
4.53	0.75	0.17	4.41	0.91	0.35	1	be reflective teachers and reflect about their courses / lectures.
4.45	0.85	0.15	4.54	0.91	0.28	6	use students evaluations and the feedback of students to improve courses.
4.43	0.80	0.15	4.39	0.88	0.43	5	be interested in their students' progress.
4.18	0.86	0.31	4.17	0.95	0.48	8	discuss teaching with their colleagues.
4.12	1.00	0.60	4.15	0.94	0.78	13	analyse the effect of teaching and introduce changes in an evidence based way.
4.04	1.07	0.15	4.28	0.96	0.37	4	make students feel special, included, safe and secure.
4.01	0.93	0.06	4.13	1.04	0.29	2	have high expectations for the students and themselves.
3.87	1.04	0.37	4.11	0.97	0.80	14	set their own goals for professional development.
3.82	1.03	0.56	3.85	1.03	0.83	7	read literature about teaching and learning in higher education.
3.81	1.12	0.72	4.02	0.91	0.67	15	attend training for lecturers at the university.
3.65	1.11	0.93	3.76	1.03	0.89	12	share experience and knowledge gained through continuous professional development (CPD) with lecturers from other institutions.
3.65	1.02	0.97	3.78	1.01	0.89	9	observe (some) lectures / teaching sessions of colleagues and give feedback.

Table 5.6. continued

3.64	1.09	0.78	3.80	1.07	0.85	11	organize / attend meetings of their own teaching team to discuss / reflect on the teaching methods and on the effect of those on students' learning.
3.37	1.30	0.56	3.75	1.08	0.33	16	apply for specific professional development programmes to obtain certificate(s) in teaching. (If this doesn't exist in your country, please indicate in General importance what is your personal opinion about it and choose in Personal practice not applicable)
3.35	1.18	0.59	3.33	1.13	0.62	10	record (some) own lectures / teaching sessions on the video to reflect on.
3.28	1.25	0.71	3.29	1.14	0.67	17	participate in conferences about teaching in higher education.

*difference between general importance G and personal use (lecturers) / programme use (managers) P

We have combined the teaching and learning attitudes statements in Part 2 (Table 5.5) and assigned five larger educational attitudes that are based on general pedagogical principles about learning and motivation, teachers' beliefs, adult learning and CPD:

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)

In *Table 5.7*, the scales are calculated based on the survey results of lecturers and education managers.

Table 5.7. Values of the scales that measure the importance of teaching and learning attitude of the STEM lecturers, in the opinion of the lecturers and the education managers.

Scales	Lecturers General	Lecturers Δ(G-P)	Managers General	Managers Δ(G-P)	Cronbach's Alpha
P2-1 Motivation and Self-regulation (CPD) (q. 2, 14, 15, 16)	3.95	0.43	4.00	0.52	G: 0.771 P: 0.752
P2-2 Pastoral interest (q. 3, 4, 5)	4.35	0.15	4.37	0.37	G: 0.829 P: 0.812

Table 5.7. continued

P2-3 Reflection (q. 1, 10, 11)	3.84	0.51	3.85	0.61	G: 0.688 P: 0.572
P2-4 Evidence informed approach (q. 6, 7, 13)	4.13	0.43	4.18	0.63	G: 0.710 P: 0.657
P2-5 Knowledge sharing (q. 8, 9, 12, 17)	3.69	0.73	3.75	0.73	G: 0.801 P: 0.801

Table 5.7 shows similar values of the scales given by the lecturers and managers. The discrepancy Δ(G-P) in the score for general importance and personal / programme use of these scales is larger in the group of managers than in the group of lecturers. It can be concluded that the education managers are less positive about the situation of teaching practice in their programme than the lecturers. It is remarkable that the scales P2-3 Reflection and P2-5 Knowledge sharing in both groups are lower than 4.00 and are thus, perceived by the majority of lecturers and education managers as not important elements in continuous professional development of lecturers.

Survey Part 3

Part 3 of the survey includes 19 statements dealing with the type of preferred professional development activities. The list of statements in the survey Part 3 can be found in *Table 5.8.*

Table 5.8. Statements survey Part 3: Professional development activities.

No	Statements
1	reading books / journal articles on teaching and learning in HE.
2	attending presentations about teaching approaches.
3	attending webinars about teaching and learning.
4	attending hands-on workshops on specific continuous professional development (CPD) topics.
5	following online courses / MOOC about teaching and learning.
6	attending conferences on teaching and learning in HE.
7	attending a summer school on teaching and learning.
8	attending a professional development programme to get a teaching certificate in higher education*
9	attending workshops that are organized specifically for STEM lecturers.
10	attending workshops that are organized generally for lecturers from different disciplines.
11	collaborating with a peer-lecturer on a redesign of a course.
12	getting peer-feedback on own teaching practice from a colleague.
13	collaborating on a teaching innovation project.
14	getting personal coaching / support by a pedagogical expert.
15	getting mentoring from an experienced colleague.
16	getting just-in-time support on a specific teaching and learning issue.
17	giving mentoring to a junior lecturer.
18	giving workshops to other lecturers.
19	participating in a teaching and learning network or a special interest group on teaching and learning in HE.

*if there existed no progamme to achieve a teaching certificate in higher education in the country, the participants were requested to only indicate their opinion about the General importance and to choose not applicable in the Personal practice perspective.

Figure 5.8 shows the results of the survey Part 3 completed by 420 lecturers from 26 different countries (*Table 5.1*) about which professional development activities generally work well (general importance) and which activities they experience in their personal practice. *Figure 5.9* shows these results collected from 46 education managers from 11 countries and compares their two perspectives: general importance and experience in their programme practice.

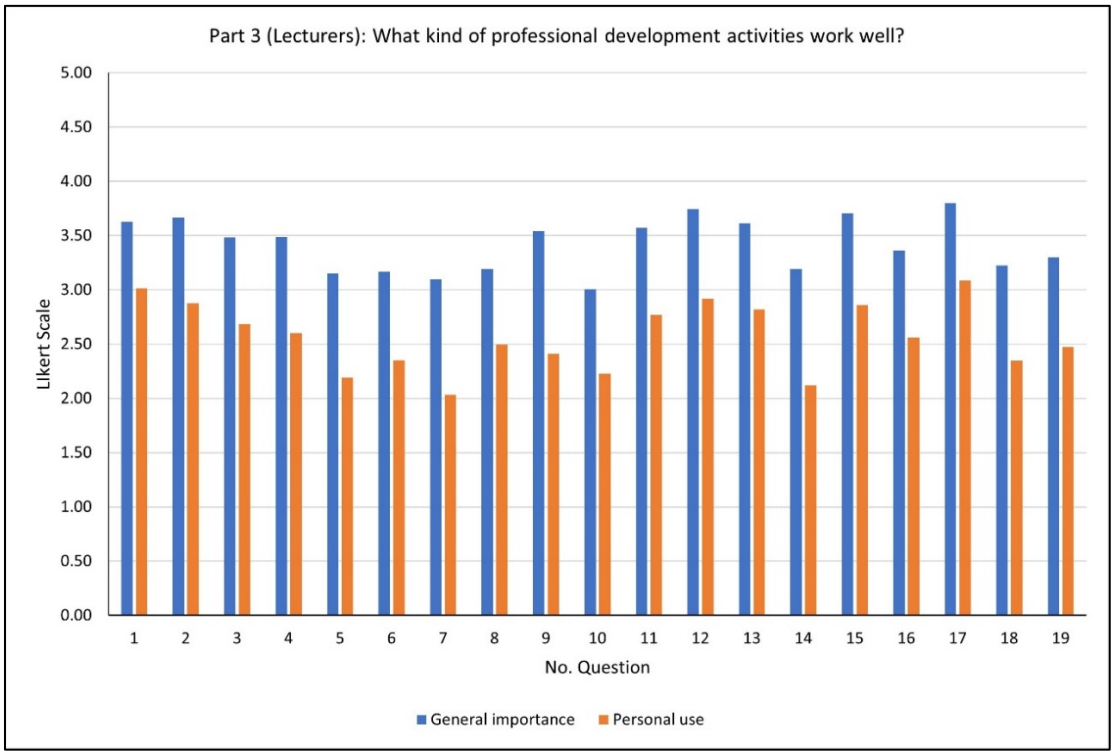

Figure 5.8. Results of the survey Part 3 completed by lecturers from 26 countries regarding the general importance of CPD activities in comparison to their personal experience with these CPD activities (evaluated on the Likert scale 1 to 5) - n= 420.

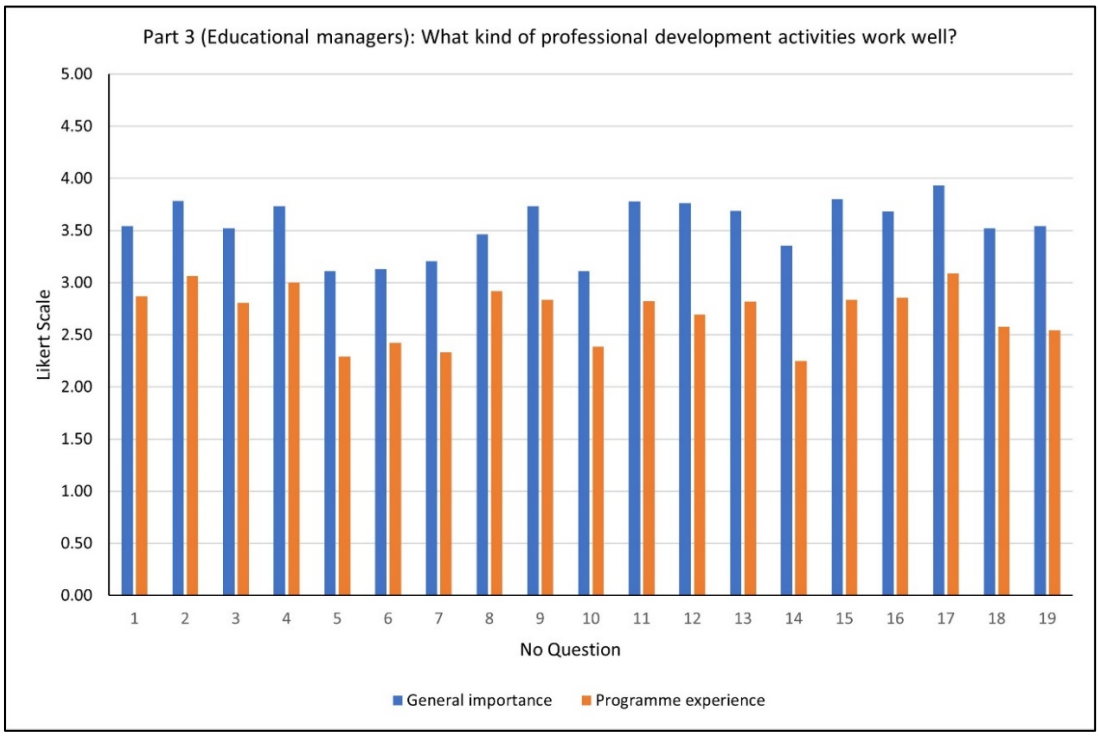

Figure 5.9. Results of the survey Part 3 completed by education managers from 11 countries regarding the general importance of CPD activities in comparison to the experience in the practice of their programmes / their lecturers teams (evaluated on the Likert scale 1 to 5) - n= 46.

Figure 5.10 shows the data from the survey Part 3 from the five countries of the universities that are partners in the STEM-CPD@EUni project.

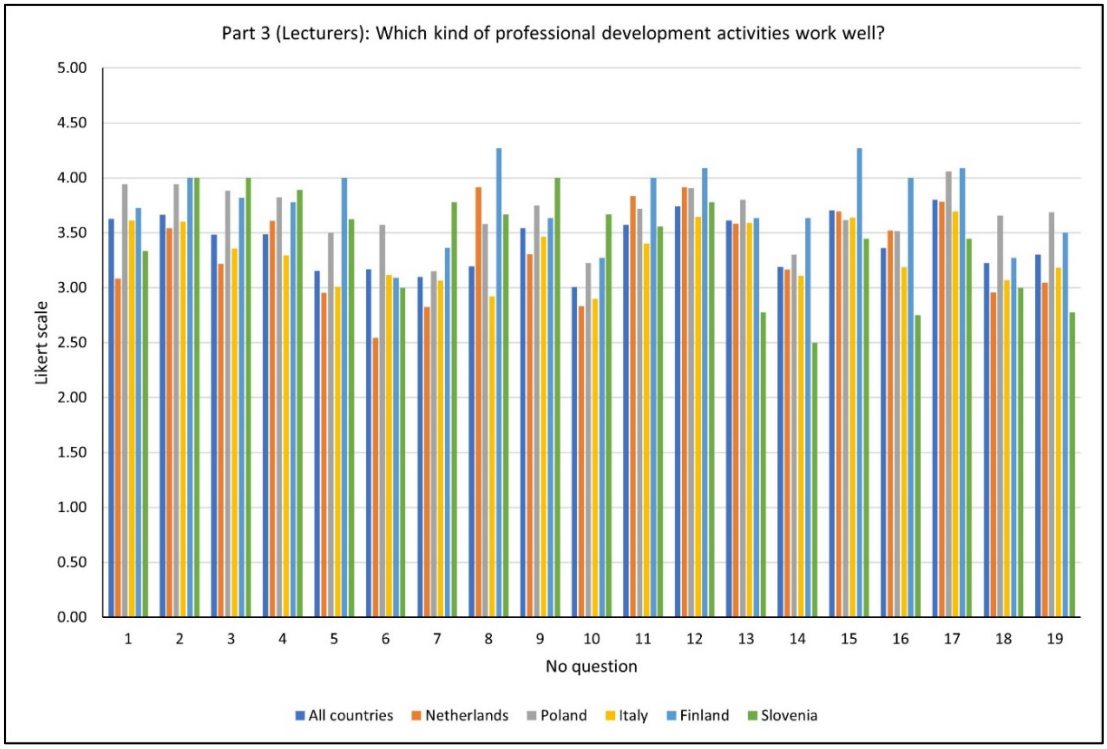

Figure 5.10. Results of the survey Part 3 completed by lecturers from 5 partner countries involved in the STEM-CPD@EUni project regarding the general importance of professional development activities (evaluated on the Likert scale 1 to 5) - n= 327.

Table 5.9 summarizes the CPD activities, that on average are recognized to work best, measured on the Likert scale 1 to 5 according to their relevance for the lecturers.

Table 5.9. Priority list of professional development activities that work best according to lecturers and education managers based on survey data Part 3.

Lecturers			**Educ. Managers**				
Gen.Imp.	**St. Dev.**	**Δ(G-P)***	**Gen.Imp.**	**St. Dev.**	**Δ(G-P)***	**q. No**	**Statement**
3.80	1.04	0.72	3.93	1.21	0.84	17	giving mentoring to a junior lecturer.
3.74	1.04	0.82	3.76	1.14	1.07	12	getting peer-feedback on own teaching practice from a colleague.
3.71	1.10	0.85	3.80	1.18	0.96	15	getting mentoring from an experienced colleague.
3.67	1.04	0.79	3.78	0.99	0.72	2	attending presentations about teaching approaches.
3.63	1.14	0.61	3.54	0.96	0.68	1	reading books / journal articles on teaching and learning in HE.
3.61	1.17	0.79	3.69	1.08	0.87	13	collaborating on a teaching innovation project.

Table 5.9. continued

3.57	1.12	0.80	3.78	1.04	0.96	11	collaborating with a peer-lecturer on a redesign of a course.
3.54	1.13	1.13	3.73	1.23	0.90	9	attending workshops that are organized specifically for STEM lecturers.
3.49	1.17	0.89	3.73	0.99	0.73	4	attending hands-on workshops on specific continuous professional development (CPD) topics.
3.48	1.09	0.80	3.52	1.01	0.72	3	attending webinars about teaching and learning.
3.36	1.17	0.80	3.68	1.25	0.82	16	getting just-in-time support on a specific teaching and learning issue.
3.30	1.22	0.83	3.54	1.13	1.00	19	participating in a teaching and learning network or a special interest group on teaching and learning in HE.
3.23	1.22	0.88	3.52	1.22	0.94	18	giving workshops to other lecturers.
3.19	1.31	0.70	3.47	1.30	0.55	8	attending a professional development programme to get a teaching certificate in higher education (if it doesn't exist in your country, please indicate in General importance what is your personal opinion about it and choose in Personal practice not applicable).
3.19	1.25	1.07	3.36	1.23	1.11	14	getting personal coaching / support by a pedagogical expert.
3.17	1.19	0.82	3.13	1.20	0.71	6	attending conferences on teaching and learning in HE.
3.15	1.19	0.96	3.11	1.02	0.82	5	following online courses / MOOC about teaching and learning.
3.10	1.20	1.06	3.20	1.25	0.87	7	attending a summer school on teaching and learning.
3.01	1.17	0.78	3.11	1.32	0.72	10	attending workshops that are organized generally for lecturers from different disciplines.

*difference between general importance G and personal use (lecturers) / programme use P (managers)

Table 5.9 shows that the average values of general importance of CPD activities are all lower than 4.0 (agree) on the Likert scale and this is lower than the highest obtained average values in Part 1 and Part 2 of this survey. The scattering of the answers (standard deviations) in Part 3

is high and it is higher than in Part 1 and 2. The discrepancies Δ(G-P) in scores for general importance and personal / programme practice are larger than in Parts 1 and 2.
Moreover, some interesting observations on the level of the countries can be discussed. First, part of the statements in some countries were evaluated with 4.0 (agree) or higher. For example the statement "Giving mentoring to a junior lecturer" (q.17) in Poland and in Finland scores higher than 4.0 (Finland: 4.09, St. Dev. 0.83; Poland: 4.06, St. Dev. 0.81). In Finland, q.17 is not the activity with the highest score but there are two other statements in Part 3 that score in Finland higher than q.17. Q.15: "Getting mentoring from an experienced colleague" score with the score 4.27 (St. Dev. 0.79) and q.8: "Attending a professional development programme to get a teaching certificate in higher education" with the score 4.27 (St. Dev. 0.90). In the Netherlands q.8 has the highest score of all statements (3.92, St. Dev. 1.10, average all countries 3.19, St. Dev. 1.31). Finland and the Netherlands are two countries where lecturers can get the University teaching certificate. In the Netherlands there is also a national framework for University teaching qualification (de Groot, 2018). "Following online courses / MOOCs about teaching and learning" (q.5) is most appreciated in Finland, Slovenia and Poland (Figure 5.10). From the perspective of the personal practice and the programme practice and taking into account all countries in the survey only q.1 (3.01, St. Dev. 1.37) and q.17 (3.08, St. Dev. 1.36) are larger than 3.00. On the other hand, there are substantial differences between the countries. For example in Italy, in personal experience, all scores are below 2.9, in Poland only q.1 (reading books / journal articles on teaching and learning in HE) scores higher than 3.5 (3.56, St. Dev. 1.19), in Slovenia two statements, q.2 and q.3 score higher than 3.5 (3.56, St. Dev. 1.01 and 3.78, St. Dev. 1.20 respectively) while in the Netherlands these are the statements q.8 and q.11 (3.77, St. Dev. 1.45 and 3.68, St. Dev. 1.25). Last but not least in Finland 6 statements have a higher score than 3.5 among which the statement q.8 has the score 4.10 (St. Dev. 1.29). As suggested before, the differences are likely to be related to the legal regulations, traditions, and organizational culture of their higher education institutions. Polish lecturers indicated creating MOOC courses as a minor competence, probably because in Poland a legal regulation of the status of such courses in study programs is unclear (Maciejowska, 2022).
We believe that this means that the frequency of professional development activities is currently not very high on average, nor may there be much variation in the types of professional development activities. Low values in personal / program experience and large discrepancies between general importance and personal/programme experience Δ(G-P) recommend urgent actions in the dimension of CPD activities (Figure 5.1) and suggest development of a broad range of CPD activities.

In Part 3, we have combined the 19 statements (*Table 5.8*) that describe professional development activities in six groups and assigned six scales of the survey.

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)

Scales P3-1 and P3-2 measure the importance of the pedagogical character of the CPD activities, namely the activities person-centered or trainer-centered. The other scales focus on the importance of the type of the interaction that takes place in activities. P3-3 includes collaboration and peer-feedback between the participants, P3-4 individual support by a more

experienced lecturer, P3-5 individual support by experts (not lecturers) and P3-6 activities relevant to knowledge sharing.

Table 5.10 presents the values of the six scales in the dimension of the professional development activities, calculated from the results of the survey taken by 420 lecturers from 26 countries and by 46 education managers from 11 countries in the survey Part 3 of the survey.

Table 5.10. Values of the scales that measure the importance of the type of professional development activities organized for the lecturers, in the opinion of the lecturers and the education managers.

Scales	Lecturers General	Lecturers Δ(G-P)	Managers General	Managers Δ(G-P)	Cronbach's Alpha
P3-1 Imparting information (q. 1, 2, 3)	3.59	0.73	3.62	0.70	G: 0.840 P: 0.846
P3-2 Learning facilitation (q. 4, 5, 7, 8, 9, 10)	3.25	0.92	3.39	0.77	G: 0.917 P: 0.929
P3-3 Collaboration (q. 11, 13)	3.59	0.80	3.73	0.91	G: 0.714 P: 0.775
P3-4 Peer-Mentor – mentee support (q. 12, 15, 17)	3.75	0.80	3.83	0.96	G: 0.843 P: 0.831
P3-5 Personal / individual Expert support (q. 14, 16)	3.28	0.94	3.52	0.97	G: 0.725 P: 0.733
P3-6 Knowledge sharing (q. 6, 18, 19)	3.23	0.84	3.40	0.88	G: 0.868 P: 0.901

The results in *Table 5.10* show that the values in all scales lower than 4.00. This means that organizing professional development activities for the university lecturers, in the opinion of the lecturers and education managers who have participated in the survey was not considered as something very important and that knowledge sharing was seen as the least important activity (3.23 by lecturers and 3.40 by education managers). It is remarkable that the scale Imparting information in both groups has a higher value than learning facilitation. This is in contradiction with the general knowledge and extensive research (Freeman, 2014) about how learning works and how to make teaching effective (Biggs, 2011). Besides, the discrepancy Δ(G-P) between the scales that measure the general importance of activities and experiences in personal or programme practice are higher in comparison to the values obtained in the other two parts of this survey. This illustrates the high urgency for organising a broad variety of CPD that also might increase the motivation among lecturers.

Conclusions

This paper discusses the survey developed within the framework of the Erasmus+ project STEM-CPD@EUni which was conducted in the period from November 2020 to January 2021 with the goal to create a roadmap for continuous professional development (CPD) of STEM lecturers. The survey has 66 statements distributed in three parts and could be used in the future as an instrument to measure the professional development needs of STEM lecturers. The participants evaluate the statements in the survey from two perspectives: general importance

and the use in personal/programme teaching practice. We have defined three CPD dimensions (*Figure 5.1*): teaching and learning competences, teaching and learning (CPD) attitudes and CPD activities. Using the results, we have defined priority lists for the teaching and learning competences, teaching and learning (CPD) attitudes and CPD activities that work best according to the opinion of 420 lecturers from 26 countries and 46 managers from 11 countries who have completed the survey at that moment. The limitation of this research is the small number of participants coming from most of the countries. We have clustered the 66 statements of the survey in the three parts according to educational principles in larger educational concepts considering competences, attitudes and CPD activities. The results show that both lecturers and education managers find the concept Constructive alignment very important and also several concepts connected to active learning. The results also show that some concepts are not yet seen as important for lecturers and their professional development such as the use of digital technology. Moreover, some conceptions regarding what is needed for professional development of lecturers refer to teacher-centered views. The CPD-ambassadors who organize the CPD activities need to do more than blindly follow the priority list defined in this survey but operate evidence based. We therefore recommend that CPD-ambassadors innovate teaching themselves to provide inspiring new examples and user cases and share their knowledge and experience in the community of CPD-ambassadors. We expect that the CPD activities that are organized at the local university will influence the needs for the CPD of lecturers. We also recommend that this survey is taken again after some time to measure the change in needs and to gain insight on the impact of CPD-ambassadors.

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