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Supporting educators to stimulate engineering students' lifelong learning competencies & personal development process

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ABSTRACT

This paper explores the possibilities to develop students' lifelong learning (LLL) competencies via supporting their personal development process (PDP) in engineering education. Despite the recognized importance of LLL, its embedment in learning outcomes remains limited. A survey revealed that both engineering students and educators value LLL competencies but perceive them to be taught and evaluated only to a limited extent. This paper introduces a PDP model to support educators in fostering students' LLL competencies. The model, developed through literature review and educators' input, includes (1) a matrix with various interventions, such as e-portfolios, reflective writing, and student-centred teaching, categorised by different criteria, such as educator and student investment, and (2) a PDP flowchart that aids educators in selecting suitable interventions according to their goals and context. The paper concludes with recommendations for educators to integrate LLL competencies into their teaching practices, emphasising the need for time, tools, and support to effectively implement these interventions.

KEYWORDS

Lifelong learning competencies, Personal development process, Educational interventions

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Introduction

Lifelong learning for (future ready) engineers

In the rapidly changing society, the demand for future-ready engineers has become increasingly urgent. As technology continues to advance, over two-thirds of the skills essential in today's job market are expected to be replaced by new ones that are not yet relevant (Li, 2022). This shift underscores the

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pressing need for engineers who possess not only strong technical competencies but also the ability to adapt to evolving technologies and circumstances. Lifelong learning (LLL) will become essential when dealing with twenty-first century challenges in various domains, like health, mobility, infrastructure or water supply. Engineers have a pivotal role in supporting green growth, cybersecurity, decarbonization, nanotechnologies, etc. (EURES 2021).

In their systematic review, Cruz et al. (2020) define LLL as "the intentional and active personal and professional learning that should take place in all stages of life and in various contexts with the aim of improving knowledge, skills, and attitudes" (Cruz et al., 2020, p.737). If we want to prepare engineering students for LLL they are in need of LLL competencies, i.e. the competencies to be able to act as a lifelong learner. Cruz et al. (2020) identified the following LLL competencies in engineering education: (1) self-reflection, (2) willingness, motivation and curiosity to learn, (3) self-monitoring, (4) locating and scrutinizing information, and (5) creating a learning plan.

A more explicit focus on LLL in the curriculum is needed to increase students' awareness of the importance of LLL competencies (Galanis et al., 2017; Sankaran & Kumar Rath, 2021). However, the extent to which engineering students are currently being prepared for LLL is unclear. On the one hand, a recent study showed that the embedment of LLL competencies in learning outcomes is still limited (Beagon et al., 2022; Dujardin et al., 2023). On the other hand, learning outcomes are not always a perfect representation of what actually happens in the lecture hall and in the minds of students (Armstrong & Niewoehner, 2008; Maher, 2004; Orón Semper & Blasco, 2018). A survey to capture engineering students' and educators' perceptions about LLL competencies indicated that both students and educators consider the different LLL competencies either important or very important (Van den Broeck, Dujardin, et al., 2023). Additionally, the results also showed that students and educators perceived these LLL competencies taught to a limited extent and evaluated even less (Van den Broeck, Dujardin, et al., 2023).

Therefore, it appears that within the realm of education, particularly in engineering education, there is a recognition of the responsibility to cultivate LLL competencies among both students and educators. However, specific, tangible, and effective actions to train these competencies are currently lacking. This paper describes a tool that aids educators to determine appropriate interventions for preparing students for LLL through a personal development process.

Personal development process

The Personal Development Process is a more dynamic and interactive adaptation of the popular Personal Development Plan. The Personal Development Plan can be defined as an assessment tool, used by employees in organizations, that gives an overview of the competencies the employee worked on in the past and the competencies the employee is planning to work on in the future, and how the employee is going to work on them (Beausaert et al., 2011). More broadly, in the concept of personal development, individuals can develop through formal or informal learning, either knowingly or unknowingly, and in a systematic or unsystematic manner. In a Personal Development Process (PDP), the learning is both knowingly and systematic and it enables students to develop a LLL attitude (Zafar, 2020). Patel et al. (2013) distinguishes five steps in this PDP which form the basis of the interventions:

1. Identifying gaps in competencies (skills, knowledge, and attitudes).
2. Prepare for learning by setting a (SMART) goal and identifying resources and opportunities.
3. Act on this plan.
4. Monitor the learning process.
5. Reflect on how the learning process can be improved and what the future learning needs are.

Role of educators

Although educators often acknowledge the importance of LLL competencies they do not necessarily feel adequately prepared to support students' personal development and LLL competencies (Nesterova, 2019). However, to support students and prepare them for LLL, educators need to be more systematically and explicitly engaged in students' PDP. Educators' ability to support students' career development is related to academics' attitudes and beliefs, teaching and learning approaches, as well as the challenges met by the staff (Amiet et al., 2021). Academics also perceive that enhancing students' general skills supports their career development more than focusing on specific careers (Amiet et al., 2011).

Supporting educators is, therefore, indispensable when aiming to increase students' engagement in their PDP. In order to support educators, this study reports about different steps that were taken in the development of a PDP model. The development started with (1) the determination of interventions that can be used to stimulate LLL and PDP and (2) the exploration of educators' understanding of their role in students' PDP and their needs in fulfilling this role.

When investigating interventions and educators roles, the context needs to be recognized. For example, small or large classes, available time, opportunities to integrate interventions, etc. With the context in mind and based on the input of the two earlier described steps, intervention variables were defined. The outcomes allowed to develop a PDP model, consisting of a PDP matrix and a PDP flowchart, integrating different interventions that support the PDP - and by extension LLL -, with clear criteria, preconditions and context variables that are required to implement each intervention. In the next section, the different steps of the PDP model development are explained in-depth.

Development PDP model

The PDP model was developed following different steps: (1) conducting a literature review, (2) gaining insight in the educator's perspective, (3) defining intervention variables, (4) constructing a PDP matrix, (5) combining outcomes of the previous steps into a PDP flowchart for the educators, and (6) piloting the PDP flowchart. This section describes the approach and outcomes of the different steps.

STEP 1 – Literature review

Two literature reviews were conducted to get insight in LLL interventions and PDP practices. A first scoping review gained insight in current practices and effective interventions to support the development of students' LLL competencies (Van den Broeck, Craps, Beagon, et al., 2022). Four types of LLL interventions were identified: (1) interventions focusing on self-regulation, e.g. (e)Portfolios, (2) reflective journals or reflective practice, (3) student-centred teaching methods, e.g., problem-based learning, and (4) peer and self-assessment.

A second literature review explored interventions related to PD (Van den Broeck, Craps, Dujardin, et al., 2022) resulting in five intervention types: (1) e-portfolios, (2) reflective writing, (3) digital storytelling, (4) progress file interviews – tutor or role play, and (5) online resources about PDP, e.g. resources on study strategies and planning.

As expected from theory, PDP and LLL interventions show considerable overlaps. Both literature reviews distinguished interventions with a focus on self-regulation, such as e-portfolios, and on self-reflection, such as reflective journals. LLL interventions can also entail student-centred teaching methods and peer and self-assessment, which were not found in the literature on PDP interventions.

STEP 2 - Perspective of the educator

The second step in the development of the PDP model aimed at exploring the educators' perspective on their role in supporting students' LLL through the PDP. First, general experiences about the use of LLL or PDP interventions and practices were surveyed during a workshop at SEFI 2022 (Naukkarinen et al., 2022). Also, the perceived challenges associated with PDP and the support educators need to engage in PDP processes with students were investigated. Next, an online survey (Van den Broeck, Craps, et al., 2023) was developed in Qualtrics. Educators were invited via email, social networks (LinkedIn), the authors' institutions communication channels (KU Leuven, TU Dublin, and LUT University), and via the SEFI network. A total of 32 educators (N_{male}=21 , N_{female}=11) participated in the survey. Among them, 22 educators had over 10 years of teaching experience, six had between 5 to 10 years of experience, and four had less than 5 years of experience. Their teaching responsibilities were evenly distributed between bachelor's and master's programmes. Participation was voluntary and free of compensation. Ethical permission was granted by KU Leuven's Privacy and Ethics Committee (G-2022-5292-R2(MAR)).

Nearly half of the participants (n=11) were already implementing PDP practices. Eight educators indicated that they not yet adopted PDP practices. The remaining six educators reported either that they are not using PDP practices (n=4) or that they are not using them anymore (n=2).

Via an open-ended question (n=20, 62% response rate), participants were asked about their responsibility as an educator in supporting the students' personal development process. Almost all educators highlighted their responsibility in coaching and supporting students. Example responses are:

"Give students space to explore, to grow and reflect on these competencies. We all should be coaches in this process."

"At the moment to encourage and guide them to learn to think critically, identify areas where they are unable to answer a question they have and see that a void needs to be filled."

In addition, some lecturers also highlighted the importance of creating the appropriate learning environment, the assessment of competencies, and the role of feedback. Example responses are:

"The role of educators is to create a supportive and challenging learning environment that fosters intellectual, emotional, and social growth, and to provide guidance, mentorship, and feedback to help students achieve their full potential "

"My role is to set up learning activities that will help students develop certain competencies. Providing feedback helps students identify areas for improvement. Generally, I don't explicitly set an individual student's goals and expect them to set their own goals based on the feedback and progress they make with activities"

"Developing forms of assessment which assess the required competencies. Providing timely feedback on assessment to help students identify their strengths and weaknesses. Providing opportunities for reflection on their learning "

When asked, what kind of support they need, the educators indicated that (1) they need tools (n=2), training (n=2), and good practices (n=4) and (2) they need time to take up and fulfil this role (n=6). The need for a student-centred curriculum (n=1) and small class sizes (n=1) were also mentioned. The PDP flowchart is a first step in supporting the educators in choosing an intervention.

STEP 3 - Defining intervention variables

Learning from literature and educators provides the necessary information to determine the various variables that impact the choice for an intervention to foster students' LLL development through PDP.

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To assist educators in deciding which intervention to use, the following inputs from the survey were used to guide the decision tree: (1) time investment for lecturers and students, and (2) implementation in the learning environment. The studies included in the literature reviews were analysed to identify indications of time investments and implementation aspects. Based on the reading, the authors categorised the types of intervention to their best knowledge.

Time investment

Time was indicated to be a significant constraint for educators. Time refers to the time of both the educator (preparation time, contact hours, and time to give feedback) and the student (e.g., amount of contact hours or course time investment).

The educator's time investment is included by approximate time indications ('none', 'low, 'medium', 'high') for (1) time to prepare the intervention, (2) amount of contact hours, and (3) time to provide feedback to students. Time investment is not always related with the quality of interventions. It is possible that an intervention has a low or absent time investment in at least one of the categories but is effective in supporting students LLL development.

The student's time investment has four categories: (1) one time high investment, (2) class time, (3) voluntary time, and (4) multiple times low investment. For illustration, a reflective essay requires students to invest a substantial amount of time to write this essay, but the task is complete upon submission. Alternatively, an e-portfolio requires more frequent efforts with less time per effort. Student-centred teaching is an example of an intervention which requires students to attend class with no additional effort. Finally, online resources are often made available to students without the obligation to use them.

Implementation in the learning environment

The implementation characteristics include four different variables that were identified in the literature on interventions (see earlier section) and the survey on the educator's perspective (see earlier section). The first variable includes professional competencies – besides the LLL competencies – that are developed in the intervention, such as written communication, creativity, and feedback literacy.

The second variable refers to the visibility of the PDP in the intervention ranging from implicit to medium to explicit. An example of implicit implementation of the PDP is student-centred teaching. Students are rarely made aware of the PDP they are going through. In other interventions, the PDP is made explicit through a complete implementation of the PDP (e.g., e-portfolio; explicit) or a strong focus on certain steps of the process (e.g., reflective logs; medium).

The third variable, the content section, makes a distinction between course-specific interventions (the content of the course is part of the intervention) and interventions with a pure focus on PDP. For some interventions, both course-specific and PDP focused implementations were found in the literature. Finally, the fourth variable is the type of feedback that is classified as (1) written, (2) verbal, and (3) none.

STEP 4 – Analysing interventions according to variables

In a next step, the different interventions were examined according to the identified variables. This categorisation facilitated the development of a comprehensive PDP matrix, which is detailed in **Error! Reference source not found.**. This matrix showcases the wide variety of interventions where all interventions differ in at least one context variable.

Table 1 : PDP Matrix

	Educator Investment			Student Investment	Implementation Characteristics			
	Preparation	Contact	Feedback		Development Professional competencies	PDP	Content	Feedback
Reflective essays	Low	Low	High	One time high	Written communication	Medium	PDP/course-specific	Written
Digital storytelling	Low	Low	Medium	One time high	Creativity, multimedia	Medium	PDP/course-specific	Written
Individual guidance	Low	High	Low	One time high	Verbal communication	High	PDP	Verbal
Role-playing	Low	Medium	Low	One time high	Verbal communication	High	PDP	Verbal
Lecture or seminar	High	Medium	Low	Class time	None	High	PDP	None
Online resources	High	Low	Low	Voluntary	None	High	PDP	None
E-portfolio	Medium	Low	Medium	Multiple times low	None	High	PDP/course-specific	Written
Journals/logs	Medium	Low	Medium	Multiple times low	Written communication	Medium	PDP/course-specific	Written
Student-centred teaching	High	Medium	None	Class time	Verbal communication	Implicit	Course-specific	None
Peer- and self-assessment	Medium	Low	None	One time high	Feedback literacy	Implicit	Course-specific	None

STEP 5 – Constructing a PDP flowchart for educators

To create a user-friendly tool for educators, the information from the PDP matrix (**Error! Reference source not found.**) has been utilised to construct a PDP flowchart (see Figure 1). This flowchart is composed of relevant questions, derived from the contextual variables described earlier, that assist educators in choosing suitable interventions.

STEP 6 - Piloting the PDP flowchart

The PDP flowchart was piloted in a workshop at the 2023 SEFI conference (Beagon et al., 2023). During the workshop, participants individually reflected on their own teaching and chose a module suitable for introducing an intervention. The PDP flowchart was circulated, and participants used it to choose an appropriate intervention based on their context. Facilitators and participants co-created an intervention, gathering best practices and views from participants, including any constraints. The input from the workshop assisted in developing intervention sheets, which include: (1) descriptions of the interventions, along with their respective advantages and disadvantages, (2) the LLL competencies targeted, and (3) how the PDP process can be included in the intervention. These details are provided in Appendix A.

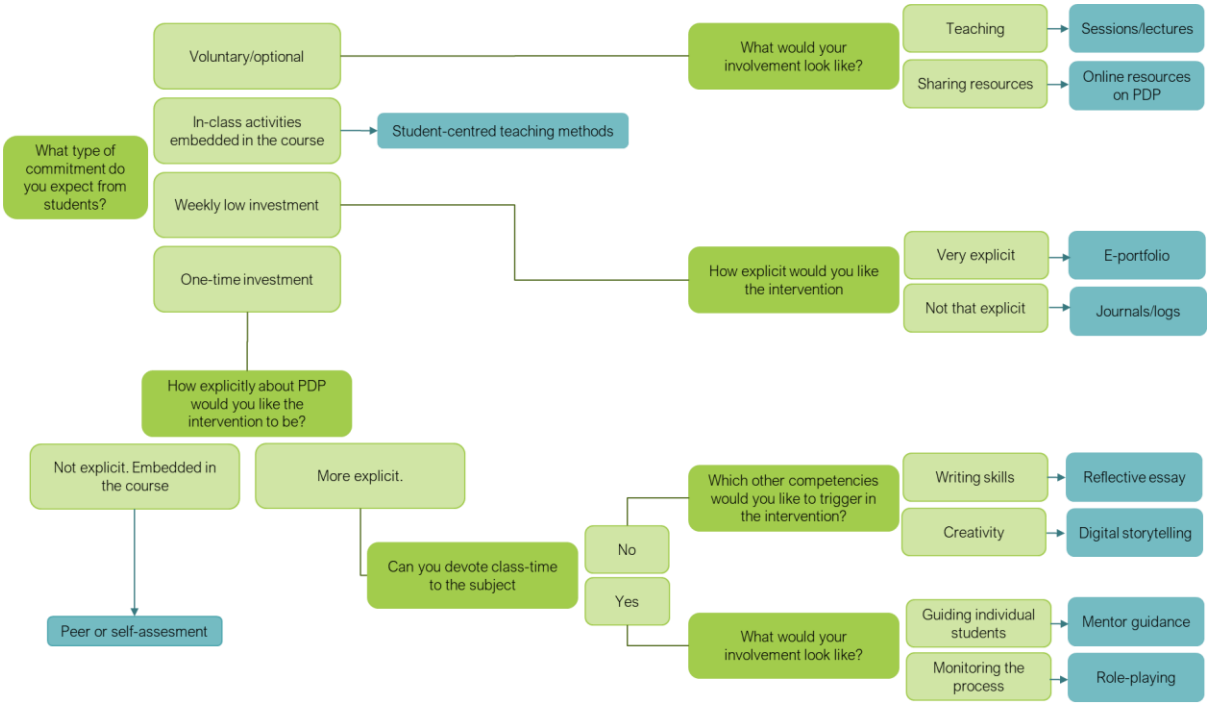

Figure 1. PDP flowchart

Concluding recommendations for educators

The PDP model presents a comprehensive overview of the different LLL and PDP interventions in relation to the criteria and preconditions, which are necessary to implement each intervention. It consists of a matrix with interventions coupled with estimates of the required resources as well as other characteristics related to the intervention and how the interventions focus on the personal development process. In addition to the matrix, the model includes a flowchart designed to serve as an easy decision-making tool for educators, helping them select appropriate interventions.

The PDP matrix shows the diversity in interventions from the PDP and LLL literature, allowing for possible implementations in many contexts. When looking at the investment of the educator, it is notable that many combinations of time investment are possible in preparation, contact hours, and feedback. Reflective essays, for example, require a minimum amount of preparation and contact hours, but a significant amount of time to provide feedback. Meanwhile, providing individual guidance to students requires a large amount of contact hours, but a minimum amount of preparation and feedback. It was concluded that time was the main concern of educators in implementing these interventions. By outlining the necessary time investment during the different phases of an intervention and defining the variables related to the implementation in the learning environment, an informed choice can be made.

Educators often face the challenge of limited time, which can make implementing new strategies daunting. However, starting with small, manageable steps is a practical approach to overcoming this obstacle. It is essential for educators to select methods and tools that resonate with their teaching style and context. While individual educators have the power to make a difference, collaboration and support within the educational community can amplify these efforts. LLL and LLL competencies are not just buzzwords, they are crucial competencies that are needed in students' further (study)career.

Therefore, educators are encouraged to explicitly integrate LLL competencies into their teaching practices and include them in the learning outcomes.

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Declaration of Interest

No conflict of interest.

Notes on Contributors

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Dr Una Beagon is Head of Civil Engineering at the Technological University, Dublin and a Fellow of the Institution of Structural Engineers. Her research in Engineering Education centres around using pedagogical initiatives to improve professional skills in engineering students, shaped by her previous industry experience as a consulting engineer in Ireland and abroad. Her interests also include phenomenography as a research method, problem-based learning and the first-year experience. Una is the lead for the Education Training and Skills research pillar of the Built Environment Research and Innovation Centre (BERIC) research centre and she is also a member of the CREATE Research Group in TU Dublin.

Dr. Sofie Craps holds a PhD in Engineering Technology and in Social Sciences. Her research interests focus on professional identity and career development, professional competencies, and diversity in engineering. She is a member of the Leuven Engineering & Science Education Centre (LESEC) and has been actively participating in the steering committee of the SEFI Special Interest Groups Attractiveness (as co-chair), and Diversity, Equity, and Inclusion. She is also a steering member of KU Leuven Diversity Council. As a BSc in Political and Social Sciences and a MSc in Communication Sciences, she has been teaching communication skills to engineers. Since 2021, she is the chair of the faculty's Teacher's Team Professional Competencies.MSc in Communication Sciences and a doctor in Social Sciences and in Engineering Technology at KU Leuven. She is currently working as a researcher focusing on professional identity and career development, professional competencies and diversity

Rani Dujardin is a PhD researcher and holds a MSc in Theoretical and Experimental Psychology. After graduating in 2022, she started as a PhD student at KU Leuven in the research group ETHER (Engineering Technology Education Research) as part of the TRAINeng-PDP project on the subject of lifelong learning and personal development of engineering students. Currently, she is the Director of Engineering Education at European Young Engineers.

Dr Aimee Byrne is a Sustainability Education Lead at TU Dublin who has been working in research, lecturing and module development since 2009. Her current research interests include Engineering Education, Lifelong Learning, Circularity in the Built Environment, and Sustainable Materials and Practices for which she has received both Irish and EU funding and supervised 4 PhD students. She has extensive experience in developing educational events, training, and support materials through her current work, and through National and International Committees. This includes 2 EU COST Actions, Engineers Ireland Academic Society, Enterprise Ireland, National Standards Authority of Ireland, and the pan-European Network for dynamic building performance 'DYNASTEE'.

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Dr Johanna Naukkarinen is currently working as an Associate Professor at the School of Energy Systems at Lappeenranta-Lahti University of Technology LUT. Her main research interests relate to engineering pedagogy, technology education, diversity and inclusion in engineering, and the philosophy of engineering science. Johanna has over twenty years of experience in the pedagogical training of engineering teachers in three different universities and she has been active in national and international networks and projects for university pedagogy and teaching development.

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Appendix A

Student-centred teaching

Description

Student-centered teaching shifts the focus from the teacher to the student. Students actively participate in decisions about what, when, and how they learn. SCL aligns learning experiences with students' interests, and uses assessment to guide students' progress.

Advantages	Challenges
• Embedded into a course • Trains many different competencies • Aligns with employability skills • Already present in many programmes	• Usually a setting with already a lot of different elements, competencies and assignments • Implicit personal development process • Student attendance/engagement can remain weak (only the bare minimum)

Personal development process

Ways to use the intervention to support the different phases of the students' PDP process:

Identify strengths and weaknesses	• Use appropriate tests and/or self-assessment (subject matter, teamwork, personality etc.) to identify the starting level of the students • Use learning outcomes to help students identify gaps in their knowledge
Prepare a plan for learning	• Make students set their own learning goals • Co-create learning materials list (books, podcasts etc.) • Make students think how they learn the best and how to use that knowledge during the course
Act by executing the learning plan	• Follow and encourage student attendance and activity • Have students report on the use of different learning materials
Monitor the learning process	• Milestone avaluations on goal achievement • Use peer-assessment to provide feedback • Re-do the assessments in the identify-part
Reflect on the process and what is next	• Make students describe and explain their progress towards the goals • Have students create learning material for new students (what would you focus on, why and how)

Good support for LLL competencies:

- ☑ Locating and scrutinizing information
- ☐ Self-monitoring
- ☑ Creating a learning plan
- ☑ Willingness, motivation and curiosity to learn
- ☐ Self-reflection

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ePortfolio

Description

An ePortfolio is an evolving electronic/online collection of artifacts of learning and reflection for an individual learner with which the learner can showcase personal and/or professional growth over time.

Advantages	Challenges
• Applicable to many different courses • Can be used also across courses/modules • Requires only a little class time • Storing the showcases of learning requires no extra work from students	• Need for an online platform or tool • Can be challenging to evaluate • Producing the reflective parts can require extra effort from students (if not embedded in the course otherwise)

Personal development process

Ways to use the intervention to support the different phases of the students' PDP process:

Identify strengths and weaknesses	• Use job advertisements as the basis of identification competencies (would you qualify) and interests (would you apply) • Make students choose competency/ies which they wish to demonstrate and develop through ePortfolio
Prepare a plan for learning	• Make students look for training, courses etc. to develop their chosen competencies • Brainstorm with students about what to put in the ePortfolio • Have students choose one deliberate action to document to their portfolio
Act by executing the learning plan	• Ask for intermediate ePortfolio submission to ensure that the process has started • Devise reflection exercises for students to include in their portfolio
Monitor the learning process	• Make students self-assess their intermediate submission of the portfolio • Provide formative feedback on the portfolio (or use peer-feedback for it)
Reflect on the process and what is next	• Revisit the job advertisements: what have you learned?

Good support for LLL competencies:

- ☑ Locating and scrutinizing information
- ☑ Self-monitoring
- ☑ Creating a learning plan
- ☑ Willingness, motivation and curiosity to learn
- ☑ Self-reflection

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Peer or self-assessment

Description

In peer or self-assessment students evaluate their peers and/or their own competencies. Assessment can be formative (feedback) or summative (grading) and it can include qualitative and/or quantitive information. Usually, it is a good idea to support the assessment process with a rubric or some other kind of explicit instruction.

Advantages	Challenges
• Embedded into a course • Can include all types of competencies • Can be used cross-curricular • Can replace (part of) teacher's feedback (and save thus time)	• Can be influenced by team dynamics or social desirability • May not be taken seriously and/or is done with minimum effort • Implicit personal development process

Personal development process

Ways to use the intervention to support the different phases of the students' PDP-process:

Identify strengths and weaknesses	• Use SWOT-based rubric to guide self/peer-assessment • Combine self-, peer-, and teacher assessment into 360-type of assessment • Co-create an assessment rubric with the students
Prepare a plan for learning	• Ask students to set an improvement goal(s) based on self/peer assessment • Have students devise an action plan based on self/peer-assessment
Act by executing the learning plan	• Give students an opportunity to improve their work (i.e. put self/peer assessment into use) • Make students help their peers in improving their work
Monitor the learning process	• Repeat the original peer/self-assessment & have the student compare the results • Make students respond to the original assessment: what have I done based on the feedback
Reflect on the process and what is next	• Make students respond to the original assessment: what should I do next time to get a better assessment • Introduce principles of good feedback and have students evaluate the self/peer-assessment they have delivered

Good support for LLL competencies:

- ❑ Locating and scrutinizing information
- ☑ Self-monitoring
- ❑ Creating a learning plan
- ❑ Willingness, motivation and curiosity to learn
- ☑ Self-reflection

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Reflective journals or logs

Description

Reflective journal or log is a collection of thoughts, feelings, observations, notes, and other related resources created over time. Its purpose is to encourage students' critical and reflective thinking. Students can be asked to submit the entire journal or a summary or excerpts from it.

Advantages	Challenges
• Applicable to many different courses • No class time except for a short introduction • Short time investments from the teacher	• Require sustained investment from the student • Can be challenging to evaluate • Engineering students often not used to reflect

Personal development process

Ways to use the intervention to support the different phases of the students' PDP process:

Identify strengths and weaknesses	• Use prompts (e.g. digital polling tools) to invite ideas and opinions and illustrate that there are no right and wrong answers • Present a list of (exemplary) questions, with which students can get the writing going
Prepare a plan for learning	• Ask students to plan, when, where, and how they are going to write their reflective journal • Invite students to set a personal goal for writing
Act by executing the learning plan	• Connect a reflective journal and a practical project → identify & prepare parts in a log & execution during a project, monitoring and reflection in a log • Use a "minute-paper" in the class to produce the opening text in the reflective journal (e.g. what do I expect to learn from writing)
Monitor the learning process	• Ask students to self-assess their journal / part of it using the same rubric which will be used for the final assessment
Reflect on the process and what is next	• Ensure that the instructions and assessment criteria of the reflective journal allow for genuine reflection and don't invite "teacher-probably-wants-to-hear-this" texts

Good support for LLL competencies:

- ❑ Locating and scrutinizing information
- ❑ Self-monitoring
- ❑ Creating a learning plan
- ❑ Willingness, motivation and curiosity to learn
- ☑ Self-reflection

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Mentor guidance

Description

Mentor guidance means personal interaction between the teacher/mentor and the student/mentee in which the mentor orientates the mentee's development process with prompts, tasks, and questions but avoids direct orders.

Advantages	Challenges
• Personal guidance is often effective • Creates a closer relationship between lecturer and student • Problems can be easier to address in discussion than in written form	• Large time investment from lecturer • Requires specific competencies from the lecturer • Requires certain level of trust and familiarity between the partners

Personal development process

Ways to use the intervention to support the different phases of the students' PDP process:

Identify strengths and weaknesses	• Use discussions and tasks to trigger the identification of student's learning and development needs
Prepare a plan for learning	• Ask student to set personal goals for mentoring process • Co-create a contract for mentoring (with goals, commitments, code of conduct etc.)
Act by executing the learning plan	• Stick to the mentoring contract & co-revise it in case of deviations • Give mentee concrete tasks to support and prompt the reflections
Monitor the learning process	• Have the mentee self-assess the fulfillment of the goals set for mentoring • Ask the mentee feedback for on your actions
Reflect on the process and what is next	• Have mentee self-assess their actions during the mentoring • Ask mentee to give feedback on their own actions

Good support for LLL competencies:

- ❑ Locating and scrutinizing information
- ❑ Self-monitoring
- ☑ Creating a learning plan
- ❑ Willingness, motivation and curiosity to learn
- ☑ Self-reflection

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(Progress interview with) Role play

Description

In progress interviews with role play students discuss their personal development with their peer, who plays the role of a mentor. In discussion the focus shifts from an end product (like reflective journal) to the process of explaining the development. Interestingly, the students reported the role-play progress interviews to be more valuable than the mentor interviews.

Advantages	Challenges
• Personal guidance is often effective • Smaller time investment from the lecturer than with individual mentor guidance • Opening up to a peer can be easier • Students in both roles learn	• Requires an effort from the students • Requires sufficient trust and respect from the students • Challenging to assess

Personal development process

Ways to use the intervention to support the different phases of the students' PDP-process:

Identify strengths and weaknesses	• Prepare a list of questions/discussion prompts for the mentor to invite the mentee to talk about their strengths and weaknesses
Prepare a plan for learning	• Ask the mentoring pairs to agree upon goals and a code of conduct for the exercise
Act by executing the learning plan	• Ensure that role play is carried out as expected (observe, require some format of documentation etc.)
Monitor the learning process	• Instruct the pair to evaluate the reaching of their goals at the end of the exercise • Instruct the pair to evaluate the following the code of conduct at the end of the exercise
Reflect on the process and what is next	• Invite the mentor to ask mentee self-assess their actions during the mentoring • Intsruct the mentor to ask mentee to give feedback on their actions

Good support for LLL competencies:

- ❑ Locating and scrutinizing information
- ☑ Self-monitoring
- ❑ Creating a learning plan
- ❑ Willingness, motivation and curiosity to learn
- ☑ Self-reflection

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Digital storytelling

Description

Digital storytelling can be described as the use of text, images, video, and audio to present a personal development within the context of a course or a general topic. Digital storytelling has been noted to result in more engagement than a written form of assignment.

Advantages	Challenges
• Can be more motivating for students than written assignments (room for creativity) • Allows for multiple formats of self-expression → accommodates diverse students	• Diverse formats can be challenging to assess • Possible technical challenges in opening the different file-formats etc.

Personal development process

Ways to use the intervention to support the different phases of the students' PDP-process:

Identify strengths and weaknesses	• Use strengths and weaknesses as a topic of a digital storytelling assignment
Prepare a plan for learning	• Use digital storytelling as a format in student's learning plan • Ask students to make a plan about their digital storytelling production
Act by executing the learning plan	• Have students to introduce their dgital storytelling production plan and (intermediate)results to their peer
Monitor the learning process	• Ask students to monitor their progress / learning with means of digital storytelling • Ask students to self-assess their digital story (e.g. against their production plan)
Reflect on the process and what is next	• Ask students to reflect upon a specific learning event / task / challenge through digital storytelling

Good support for LLL competencies:

- ❑ Locating and scrutinizing information
- ❑ Self-monitoring
- ❑ Creating a learning plan
- ❑ Willingness, motivation and curiosity to learn
- ☑ Self-reflection

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Reflective essay

Description

A reflective essay is a personal piece of writing exploring learner's experiences, thoughts, and what they have learned from them. Unlike academic essays, the reflective essay focuses on one's unique experience and perspective rather than external sources.

Advantages	Challenges
• Applicable to many different courses • No class time (unless done in a class) except for a short introduction • Can be used for a very specific topic	• Require some investment from the student • Can be challenging to evaluate • Engineering students often not used to reflect

Personal development process

Ways to use the intervention to support the different phases of the students' PDP-process:

Identify strengths and weaknesses	• Use strengths and weaknesses as a topic of a reflective essay assignment
Prepare a plan for learning	• Ask students to write a reflective essay about their learning goals in the course
Act by executing the learning plan	• If necessary provide practical support for their essay writing
Monitor the learning process	• At the end of a course, ask students to revisit their reflective essay on learning goals and amend it with evaluations of their achievement
Reflect on the process and what is next	• Ask students to reflect upon a specific learning event / task / challenge in a reflective essay

Good support for LLL competencies:

- ❑ Locating and scrutinizing information
- ❑ Self-monitoring
- ❑ Creating a learning plan
- ❑ Willingness, motivation and curiosity to learn
- ☑ Self-reflection

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Lecture on LLL and/or PDP

Description

An oral presentation by the teacher about lifelong learning and/or personal development. Can contain general information about the topics (what do they mean or consist of etc.), specific information about their role in engineering education and/or career, and or practical tips on how to become lifelong learner / develop personally.

Advantages	Challenges
• Easy to administer • Can be recorded for later purposes (e.g. to be part of self-study or instruction material)	• Student activation may be difficult • Requires class-time

Personal development process

Ways to use the intervention to support the different phases of the students' PDP-process:

Identify strengths and weaknesses	• Explain the importance of identification for learning and personal development processes • Introduce methods and tools for identification
Prepare a plan for learning	• Explain the importance of preparation for learning and personal development processes • Introduce methods and tools for preparation / planning
Act by executing the learning plan	• Activate students during the lecture with small assignments or tasks
Monitor the learning process	• Explain the importance of monitoring for learning and personal development processes • Introduce methods and tools for monitoring
Reflect on the process and what is next	• Explain the importance of reflection for learning and personal development processes • Introduce methods and tools for reflection

Good support for LLL competencies:

- ☑ Locating and scrutinizing information
- ❑ Self-monitoring
- ❑ Creating a learning plan
- ❑ Willingness, motivation and curiosity to learn
- ❑ Self-reflection

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Online resources on LLL/PDP

Description

An online compilation of information about lifelong learning and/or personal developmentCan contain general information about the topics (what do they mean or consist of etc.), specific information about their role in engineering education and/or career, and or practical tips on how to become lifelong learner / develop personally.

Advantages	Challenges
• Light on resources after the start investment • No class time except for a short introduction • Applicable to many different courses • Flexible format for students	• Collecting the resources (start investment) takes time • Requires regular maintenance (checking the links etc.) • No control/view over students' doing

Personal development process

Ways to use the intervention to support the different phases of the students' PDPprocess:

Identify strengths and weaknesses	• Provide material on the importance of identification for learning and personal development processes • Introduce methods and tools for identification • Provide online tools for identification
Prepare a plan for learning	• Provide material on the importance of preparation for learning and personal development processes • Introduce methods and tools for preparation / planning • Provide online tools for planning
Act by executing the learning plan	• Provide interactive materials and online tasks • Use online resources as a basis for part of course assessment
Monitor the learning process	• Provide material on the importance of monitoring for learning and personal development processes • Introduce methods and tools for monitoring • Provide online tools for monitoring learning
Reflect on the process and what is next	• Provide material on the importance of reflection for learning and personal development processes • Introduce methods and tools for reflection • Provide online tools for reflection

Good support for LLL competencies:

- ☑ Locating and scrutinizing information
- ☐ Self-monitoring
- ☑ Creating a learning plan
- ☐ Willingness, motivation and curiosity to learn
- ☐ Self-reflection

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