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Integrating competencies in a curriculum through developing learning paths and reflection assignments

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ABSTRACT

Integration of competencies ensures that students are better prepared for their future career in higher engineering education. One way to integrate competencies into a curriculum is by developing a learning path together with teachers, which is guided by an overarching system of reflection. In this paper, it is described how learning paths can be designed together with teachers. Furthermore, a design for an activity which stimulates the development of competencies is given. This activity comprises a meeting related to competencies and subsequent reflection assignments, in which students write down a take-home message, reflect on their competency development, and set goals. Students upload their reflection assignments and goals in their portfolio, to be able to monitor their competency development. Two examples of integrating competencies in the bachelor Food Technology at Wageningen University are presented. First, the design of the learning path *researching* is discussed, including an example of an activity that addresses this competency. Second, a course is introduced in which students reflect and set goals on their competency development, which they upload in their portfolio. The presented approaches and examples serve as an inspiration to integrate competencies in an existing programme.

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1 INTRODUCTION

Students in higher engineering education should develop competencies to ensure that they are prepared for the current complex challenges in the world (Gerstein and Friedman 2016; Rieckmann 2012). Competency development can be fostered through integrating competencies into the curriculum of a study programme at the university. This implies competencies being developed and explicitly taught within the discipline, in addition to an emphasis of development on discipline-specific knowledge (Huijser et al. 2008; Chadha 2006).

1.1 Integration of competencies in a curriculum

To integrate competencies into a curriculum, three factors are of importance: a learning path, reflection moments, and teacher commitment. First, competencies should be integrated through establishing learning paths related to competencies across courses (Levander and Mikkola 2009). A learning path is a selection of courses in which the integration and development of a certain topic or competency is aligned and monitored throughout all courses of a curriculum. Learning paths ensure the integration of competencies through providing several opportunities in courses for students to apply them. Students start practicing these competencies on a basic level and as they progress through their study, the complexity and difficulty of the competence increases (Van Merriënboer and Kirschner 2017), resulting into a greater understanding and independence (Reekie et al. 2023). Specific learning outcomes related to competencies should be defined and included in the list of learning outcomes of a course, to ensure that the learning path is visible for both students and teachers, competencies are addressed explicitly and therefore have become a main component of a course. This makes both teachers and students aware of the presence of competencies in courses and coherence with other courses.

Second, the integration of competencies is stimulated through types of self-assessment, such as reflection moments (Virtanen and Tynjälä 2019). Through reflecting, students are stimulated to become aware of their competency development and will actively work on it (Wijngaards-de Meij and Merx 2018). They will recognize the importance of their development, which engages them in their learning (Mello and Wattret 2021). The explicitness and visibility of the development of competencies, as described above, encourage these reflection moments.

Third, to successfully integrate competencies into courses, teachers need to be involved in this change, so that their strengths can be used and they are committed to the change (Potter and Devecchi 2020). Therefore, it is important to have discussions with teachers how to integrate competencies in their courses and curriculum in general. Discussions with and among teachers can lead to valuable ideas for new learning activities. Furthermore, it makes teachers aware of the position of their course in the curriculum and therefore stimulates alignment between courses (Bath et al. 2004).

1.2 Selecting competencies in Food Technology

A proceeding step before integrating competencies into a programme is selecting competencies to be integrated. Each study programme has different needs and a different starting situation with regard to competencies. Here we shortly describe how this selection was done for the bachelor programme Food Technology at

Wageningen University (WUR), a three-year programme in which, until recently, competencies have been integrated more implicitly than explicitly. To find out which competencies need more attention, a research was performed through conducting surveys and interviews with students, graduates, teachers and other stakeholders. Four competencies were identified to need more attention in the bachelor programme: *analytical thinking*, *critical thinking*, *problem solving*, and *decision making* (Van Berkum et al. 2024b). In a follow-up study (Van Berkum et al. 2024a), the presence of these selected competencies was mapped through curriculum mapping. First, through using the outcomes of the interviews, sub-competencies were defined, which are components of the competencies described before. Subsequently, teachers were asked to complete a matrix, in which they were instructed to indicate the presence of these sub-competencies in their courses. This study resulted in a visualisation of the learning paths that were already present in the bachelor. Furthermore, by quantifying the results, sub-competencies were identified that need more attention. Mainly sub-competencies from *analytical thinking* and *critical thinking* were identified to need more attention.

Parallel to this study, the WUR defined 16 skills which need to be implemented in all bachelor programmes to stimulate students to develop skills throughout their studies (WUR 2017). The presence of these skills has been mapped, in a similar way as the curriculum mapping described above, and resulted in a list of skills that need more attention in the programme: *researching*, *data science*, *collaboration*, *feedback*, and *diversity & inclusivity*.

1.3 Aim of this paper

The aim of this paper is to provide an example how competencies can be integrated in an existing programme. In this paper, the integration of competencies in the current courses of the bachelor programme Food Technology at WUR will be used as example. First, it is explained how learning paths were designed in collaboration with teachers, to ensure the integration of competencies in the bachelor programme. Next, activities to stimulate the development of competencies, including reflection assignments, will be described.

2 METHODOLOGY

2.1 Process of integrating competencies and designing learning paths

To ensure sufficient competency development, students should have enough opportunities to practice competencies, while also receiving instruction, receiving feedback and being assessed. The integration of these aspects in the bachelor Food Technology was discussed with students and teachers. They both preferred competency development solely in existing courses, instead of designating a course for competency development. Therefore, it was decided to integrate competencies in existing courses, through implementing learning paths and moments for reflection. The main author of this paper was acquainted with all courses of the bachelor because of the curriculum mapping step, in which the presence and current position of competencies was discussed with course coordinators. While discussing, many course coordinators reflected on their courses and identified opportunities for improvement. These opportunities have been taken into account while designing a first draft of the learning paths. In these drafts, it was ensured that each learning path

included sufficient opportunities for practicing, instruction, feedback, and assessment, through including both existing and new activities. The draft of each learning path was discussed with the involved course coordinators, to align and leading to a final learning path.

2.2 Implementation of reflection moments and explicit skills meetings

In addition to practicing, instruction, feedback, and assessment, students should also have the opportunity to reflect on their competency development (Wijngaards-de Meij and Merx 2018). To give explicit attention to competencies and opportunities for reflection, new activities were designed and taught during so called 'Food Technology Skills Academy' meetings. Although the term 'competency' is used in this paper, the term 'skill' was used in the communication to students and teachers since this term is adopted by the university. Therefore, the name 'Food Technology Skills Academy' was chosen. These meetings were organised around one or two competencies, in which students discuss experiences related to course activities and exchange ideas with peers. At the end of these meetings, students were asked to reflect on their experiences and competency development and to set goals. A general template for these type of reflection assignments was developed for all courses, which consists of three exercises:

1. **Defining a take-home message**: writing down insights they acquired while discussing and reflecting with other students on:
   - what challenges they encountered;
   - what went well.

2. **Reflecting**: reflecting on sub-competencies using a single-point rubric, which enables effective student self-assessment (Fluckiger 2010). In this rubric, students indicated per subskill what they are already good at and how they can improve (Figure 1):

I am already good at the following aspects:	***Subskill***	*I can improve myself on the following aspects:*
	I was able to structure meetings and to divide the work.	
	I was able to share all information with each other and integrate this well.	
	I was able to listen to others and speak up for myself.	

Fig. 1. Example of a single-point rubric that students complete to reflect on collaboration skills

3. **Setting a goal**: selecting one subskill, for which they formulated a goal on which they can focus on in a next course.

To ensure that students have an overview of their competency development throughout the whole bachelor, it was decided to work with a portfolio system. This portfolio is linked to the online learning environment of all courses and remains accessible throughout the whole bachelor. After finishing the reflection assignments

as described above, students are asked to upload this assignment into their portfolio and insert the goal. In all courses, students can look back at their reflections and goals and are able to monitor their competency development throughout their study programme. Students are responsible and in charge for their own portfolio. Teachers can only review student's portfolio when students give access.

2.3 Evaluation of the reflection assignment and portfolio

The reflection assignments and portfolio were evaluated in the first course where they were introduced, through a survey, which was handed out after the exam of the course. In this survey, students were asked to respond to statements about the general impression of the assignments, the reflection activities and goal setting, and the general approach of skills development. A 5-point Likert scale was used, ranging from strongly disagree (1) – somewhat disagree (2) – neither agree nor disagree (3) – somewhat agree (4) – strongly agree (5).

3. RESULTS

As described above, several skills and competencies were defined which need more attention in the bachelor programme Food Technology, based on the research on competencies from (Van Berkum et al. 2024b) and the list of skills that the WUR defined. While all identified competencies as described above are being integrated in the programme, in this section we use the competencies *researching*, *collaboration*, and *diversity & inclusivity* to provide two examples how competencies were integrated. First, the process of designing and visualising the learning path of the competency *researching* is described. In addition, an example of the Food Technology Skills Academy activity related to *researching* will be given. Second, an example is provided how the reflection assignments of the competencies *collaboration* and *diversity & inclusivity* were included in the first course of the bachelor, together with the results of its evaluation.

3.1 Example of integrating the competency *researching* through a learning path and interactive activity

In order to develop the learning path *researching*, sub-competencies of *researching* that students should developed were defined through combining subskills as described by the university and sub-competencies from the research from (Van Berkum et al. 2024a). To limit the amount of sub-competencies, it was decided to integrate several sub-competencies and subskills, while excluding aspects such as searching for literature and data analysis, since these are included in other learning paths. This resulted in the following four sub-competencies:

- Positioning research (context, knowledge gap, research question/aim and hypothesis)
- Designing research (e.g. study, experiments)
- Performing research (e.g. performing protocols in the laboratory)
- Critically analysing and evaluating the research

These sub-competencies were included in a rubric, to envision what students should have developed before finishing their study programme.

Then, a learning path for *researching* was designed through first identifying the existing activities related to *researching* and making them more explicit. Next, new

activities were added in the learning path. All sub-competencies in this learning path were planned to be addressed explicitly at least 2 times, with at least one opportunity for receiving feedback and assessment.

The draft of this learning path was discussed with teachers. Based on the discussion and feedback, the learning path was finalised. The implementation of this learning path made a strong improvement of the alignment throughout courses. Next, the learning path was visualised in the online learning environment in an interactive way, so students could see in which courses the competency is explicitly addressed and which activities are included (Fig. 2).

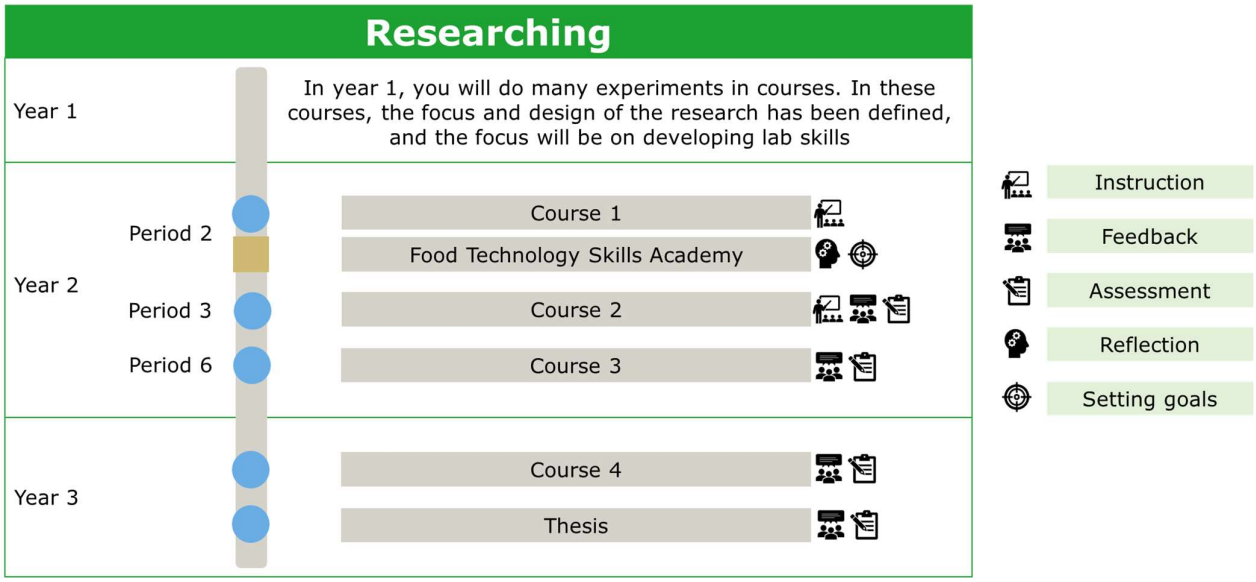

Fig. 2. Visualisation of the learning path 'researching'

To ensure that students are actively and explicitly discussing and reflecting on the competency, a compulsory Food Technology Skills Academy meeting was developed in course 1 (Fig. 2) of the learning path, which takes place in the second year of the bachelor. In this course, students designed an experimental set-up and performed experiments, and therefore focused on the subskills '*designing research*' and '*performing research*'. During the Food Technology Skills Academy meeting, students were asked to discuss and exchange their experiences related to these sub-competencies, with the following activities:

1. Discuss experiences regarding certain practical skills, such as making solutions, pipetting or using the centrifuge. Students were stimulated to discuss what they found challenging and to exchange tips with each other.
2. Identify experimental design techniques, such as blanks and duplicates. Students read lab protocols to identify the necessity of these techniques, in order to understand why they are applying certain techniques.

After the discussions, students were asked to write down interesting insights they gained. At the end of the meeting, students completed the reflection assignments as described in the methodology section. They uploaded this in their portfolio and set a goal for the next course.

3.2 Example of integrating the competencies *diversity and inclusivity* and *collaborating* and the evaluation of the reflection assignments and portfolio

At the start of the first year, students were introduced to the different disciplines within food technology. In this introduction course, also time is allocated to introduce students to the university and skills they should develop at the university, such as *personal development*, *collaboration*, *presenting, information literacy* and *diversity and inclusivity*. It was decided to start with portfolio assignments as described above on the two skills *collaboration* and *diversity & inclusivity*.

Diversity & inclusivity was selected since the bachelor Food Technology at WUR is an international programme, with students from many different backgrounds. Therefore, an interactive lecture about cultural differences was given, in which diversity and cultures in relation to collaboration were discussed. In the end, students were asked to reflect on what they learned in this lecture.

Collaboration was selected since students worked together on a case, in which they integrated all the discussed disciplines (e.g. food engineering, food chemistry). In the reflection assignment, students were asked to reflect on their collaboration skills in this course.

The use of the reflection assignments was evaluated via a survey. Results of this survey are shown in Table 1. In general, the assignments were found to be clear and students found it useful to reflect on skills. Overall, students did not find it difficult to reflect and set goals.

Table 1. Survey results on how students appreciate the reflection assignments for two different skills. Students (n=121) answered the statements on a 5-point Likert scale, ranging from strongly disagree (1) to strongly agree (5)

	Intercultural communication		Collaboration	
	Mean	SD	Mean	SD
The assignment was clear for me.	4.06	0.61	4.00	0.76
The assignment was useful.	3.49	0.90	3.41	0.92
I enjoyed working on this assignment.	3.23	0.93	3.08	0.96
I found it difficult to reflect on this skill	2.58	0.98	2.50	1.03
I found it difficult to set a useful goal on this skill.	2.90	1.07	2.75	1.08
I think it is useful to reflect on this skill.	3.84	0.87	3.83	0.82

The general way of skills development, and feedback on reflections and goal-setting has been evaluated as well (Table 2). It shows that students see the relevance and usefulness of reflecting and working on skills development. When they would like to receive feedback or discuss it, they slightly prefer to do this with teachers or study advisors, instead of with peers.

Table 2. Survey results on skills development and receiving feedback on reflection and/or goals. Students (n=121) answered the statements on a 5-point Likert scale, ranging from strongly disagree (1) to strongly agree (5)

	Mean	SD
I think it is relevant to work on skills development as part of my study.	4.13	0.70
I would like to receive feedback and/or discuss my reflections and goals with a teacher or study advisor.	3.38	1.12
I would like to receive feedback and/or discuss my reflections and goals with other students.	3.11	1.04
It was clear for me how I needed to work with the portfolio tool.	3.45	1.08

4. DISCUSSION

To integrate competencies in the curriculum, learning paths were developed in consultation with course coordinators. Furthermore, activities with reflection assignments were designed. Since the approach of designing a learning path and the reflection assignments were not tailored specifically for food technology, it shows potential to be used in other disciplines as well, However, after the integration of competencies in the first courses, some discussion remarks can be made.

Designing the learning paths together with teachers was effective. While discussing learning paths together with the involved teachers, they got acquainted with other courses as well. Together, they discussed the activities in their courses and discovered overlap or gaps, which led to adaptation and thus better alignment between courses, as was pointed out by Bath et al. (2004) as well.

Integrating competencies in existing courses appeared to be an effective approach to enable students to work on competency development. For example, when students reflected on their *researching* skills, they were able to reflect on the skills they had applied during practicals. Therefore, instead of only finishing experiments, students were stimulated to think critically about the way of executing the practical experiments. They stored their reflections and learnings in their portfolio and were able to use this in a follow-up course, which is important for their learning trajectory (Van Merriënboer and Kirschner 2017). Although students were actively discussing and working on the competency *researching*, the effectivity of the activity has not yet been evaluated: an evaluation is planned at the end of the learning path.

Students need sufficient time for competency development. Therefore, the effectiveness of the reflection assignments and portfolio cannot be evaluated after one course. However, the assignments and portfolio appeared to be useful, based on the first results of the survey. Students did not strongly desire to receive feedback from teachers, study advisors or peers. This might be explained by the fact that students prefer to be in charge of their own skills development and portfolio. Since students know that their assignments are not being assessed, they are able to write reflections in their own language, without being scared about the feedback of teachers. However, the portfolio not being accessible for teachers can also be seen as a disadvantage of the system, since it is not possible to check if all students finished the assignments seriously. Therefore, it was decided to give students

enough time to finish the assignments in class and allow them to leave after having completed it. However, it is not possible to find out if students need help or instruction with reflecting. Therefore, the effectiveness and monitoring of reflecting remains a challenge, which needs to be further studied.

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