The Le-Do-Loop*: a manual for teachers

** Le-Do-Loop: short for the Dutch 'Leer-Doceer-Loop', or 'Learn-Teach-Loop' in English*

A flexible method to reach higher cognitive learning objectives

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Conducted by Wageningen University, the Netherlands:

- Agnes (A.M.) Berendsen, PhD*
- Lenie (L.) van Rossem, PhD*
- Cora (M.C.) Busstra, PhD*
- Julia (J.) Diederen, PhD
- Esther (E.) Kok, MSc*
- Sol Maria (S.M.) Halleck Vega, PhD

*Division of Human Nutrition and Health, Wageningen University.
agnes.berendsen@wur.nl (corresponding author)

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1. Introduction

Online education has become more popular in recent years. Before the COVID-19 pandemic, it was a gradual process for teachers to partly shift from education in lecture rooms to blended and online education. Online education was especially valuable when aiming to reach new (online) target groups like working professionals as long-life learners. However, during the COVID-19 pandemic, many teachers in higher education provided full online education. As a teacher, you might have experienced this unexpected change, which caused several bottlenecks.

One important challenge is to reach learning objectives at higher cognitive levels (apply, evaluate, create) in online education. Organizing interactive group work, practicals and discussion sessions is difficult in an online setting. In addition, providing high-quality online education is time-consuming from a teacher's perspective, while teachers were already confronted with a higher workload due to the COVID-19 pandemic. On top of that, online education material needs to be regularly updated because of rapid developments in academic knowledge domains.

We propose a solution to those bottlenecks. Our solution is based on a principle originally described by Jean-Pol Martin (Kelchner & Martin, 1998). This principle implies that students learn new content themselves. Next, they prepare educational materials, lessons, or presentations, and then actually teach the topic to others, usually their own peers. It has been shown that actual teaching, instead of only preparing education, ensures that students develop a better and thorough understanding of the subject, resulting in higher scores on tests (Fiorella & Mayer, 2013). This solution also tackles the problem of frequently updating online materials. With this approach, students themselves become able to independently develop new knowledge and skills relevant to current and future scientific and social issues, and students not only depend on (online) teaching materials provided by their teachers.

If you recognize those bottlenecks as a teacher, the method described in this manual could facilitate your teaching. This didactical method is applicable to online education as well as on-campus education.

In this manual, we describe this innovative method which we call 'Le-Do-Loop' (In Dutch **Le**er-**Do**ceer-**Loop**, which translates in English to 'Learn-Teach-Loop'). We first give some theoretical background. Second, we describe practical guidelines and the implementation of the Le-Do-Loop in five courses at Wageningen University. Third, do's and don'ts when implementing this concept into your course design are provided and at last additional readings can be found in the reference list.

2. The 'Le-Do-Loop'

2.1 Concept

The essential characteristic of the Le-Do-Loop is that students teach each other about a specified topic. Students develop educational materials, such as a video, presentation, workshop, exercise, or vlog. In a first round, a group of students (group 1) teaches a concept to their fellow students (group 2). In a second loop, group 2 takes over the work from group 1 and elaborates on the work by adding an example or application. Again, this round results in group 2 teaching the concept, including the newly developed example or application, to a next group of students, group 3. In a third round, a solution to a problem can be added by another group of students. The final loop ends when the final group teaches all the work to the other peer students (see figure 1).

When applying this method in a course, several loops may run simultaneously. Each loop covers a different (but usually related) topic. So, each group of students works on a specific concept in loop 1. Each group teaches a peer group and passes over their work to the next group. In loop 2, each group continues with a different topic based on the work of others and so on.

In Chapter 3 several case studies are described to illustrate how this process works in practice. It illustrates how courses may differ in the number of loops and the number of loops (i.e. topics) running simultaneously. The case studies also illustrate how the time needed for each loop depends on the content and nature of the course as expressed in the learning objectives, the number of students, prior experience of the students etc. The case studies also show how the design of the Le-Do-Loop, and instructions and support given to the students varies based on prior knowledge, experience, and skill of the students. From these case studies many design principles and practical experiences are derived which are summarized as *do's and don'ts* that function as a checklist for teachers who are implementing the Le-Do-Loop (Chapter 4).

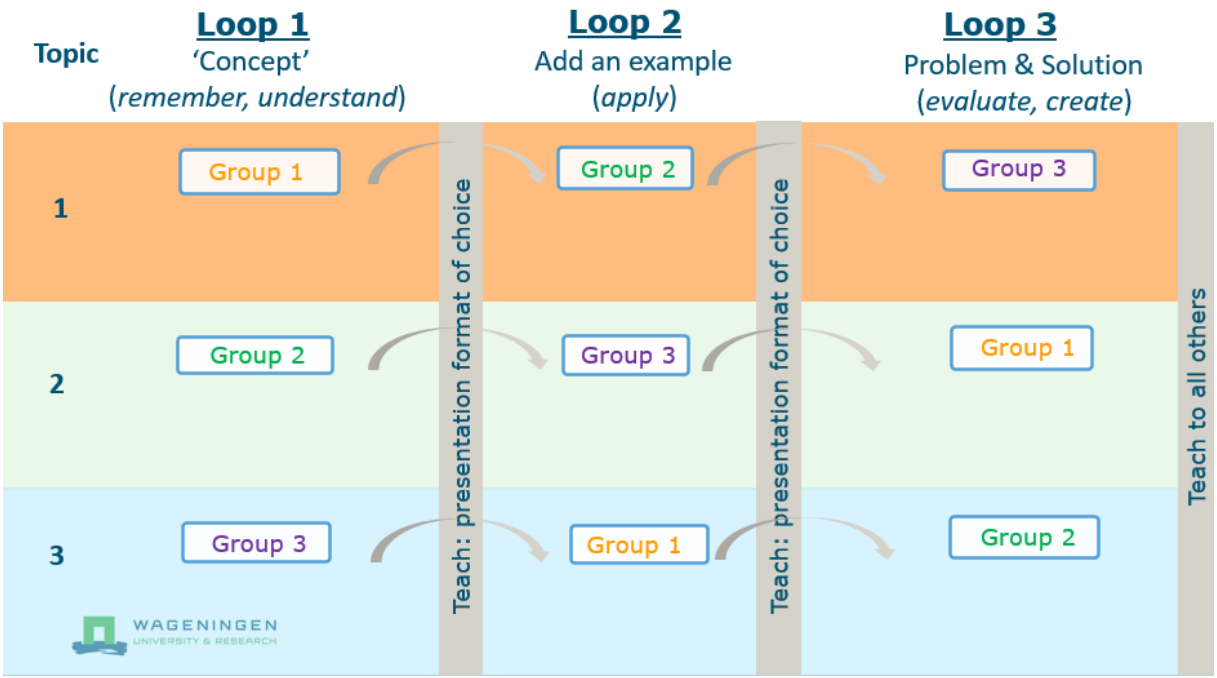

Figure 1. General design of the Le-Do-Loop, based on three groups of students and three topics.

Students receive feedback from their fellow students as well as the teacher throughout the loops. The role of the teacher in the Le-Do-Loop is twofold:

1. as content expert they provide instructions and topics for students to work on. They give feedback to students on accuracy of the produced learning materials, provide additional explanation on difficult concepts, repairs misconceptions, guarantees the work of the students reaches the expected depth or width and covers all intended aspects or concepts.
2. as coach they motivate the students, help them to overcome hurdles, give directions how to identify reliable sources, supervises the group process, give feedback on the development of personal skills etc.

2.2 Educational principles

The principle of the Le-Do-Loop originated from a modelling relay called PRESTO, a project of TU Delft (van Daalen, 2019). In this project students learn to program with help of a relay, in which building on the work of fellow students and peer-review are the main principles. The Le-Do-Loop elaborates on this idea by adding the principle of 'learning through teaching'. More specific, the Le-Do-Loop is based on four main principles.

Principle 1: "Lernen Durch Lehren":

The Le-Do-Loop is inspired by the theory of 'Lernen durch Lehren', as originally described by Jean-Pol Martin (Kelchner & Martin, 1998). This theory describes how students learn by teaching a topic or principle to each other. The principle of 'Lernen durch Lehren' involve several effective strategies such as explaining, asking questions, assessing, and giving feedback (Roscoe & Chi, 2007). It appears that the effectiveness of 'learning through teaching' mainly depends on the quality of tutor-tutee (student-student) interactions (Roscoe & Chi, 2008). Benefits of the 'Lernen durch Lehren' principle include:

- Topics are handled more intensively and versatile.
- Active learning is stimulated and passive consumption of knowledge is prevented.
- Topics are made clear from the student's point of view, which is insightful for teachers and understandable for peers. Teachers can also gain inspiration from the teaching strategies that the students use.
- The teacher can focus more on the topics that students struggle with.
- Students and teachers have more fun in this way of teaching (Kooloos et al., 2016; Rohrbeck et al., 2003; Williams et al., 2015)
- The principle can give students more trust and motivation to learn (Williams et al., 2015).
- Students work on important skills such as problem solving, communication skills, structuring information, and trust.

Principle 2: Reflective knowledge building:

The Le-Do-Loop builds on a relay principle in which students get in touch with several topics at different phases. By following this principle, reflective knowledge building will be stimulated. This strategy implies that students get the opportunity to reflect on their own understanding of the material and link it to their prior knowledge (Roscoe & Chi, 2007).

Principle 3: Deeper processing, better and longer lasting understanding:

Fiorella and Mayer (2013) found positive effects on content understanding, and higher grades on tests, when students had to teach each other. Positive effects were also found when students were asked to create a short video lecture of the course material without be asked to actively teach it to their peers.

Principle 4: Peer review:

Being asked to teach specific content to peer students may also function as peer review by the peer students who receive the teaching. This peer teaching moment, and thus peer review, occurs between each loop in the Le-Do-Loop. We will not further elaborate on the benefits of peer review as this is extensively described in earlier SURF publications (SURF).

2.3 Aims of the Le-Do-Loop

The principle of the Le-Do-Loop can be used either as the leading educational approach in a course or as a small element next to other educational approaches used in a course. Before we elaborate on the different ways to implement the Le-Do-Loop, both online and in fully on campus education, we first describe its main aims:

Aim 1: Achieving higher level cognitive learning outcomes (like 'applying', 'evaluating', 'creating')

The Le-Do-Loop facilitates higher level cognitive learning outcomes such as the objectives which in Bloom's taxonomy are labelled as 'apply', 'create', 'evaluate' (Bloom et al., 1956). Usually the first loop starts with the lower cognitive learning objectives "understand' and throughout the loops more complex higher cognitive learning objectives are obtained. These higher cognitive learning objectives are obtained through activation of students, interaction between students and interaction between students and teacher. For example, in the course "Nutritional aspects of food" (see chapter 3.1), students reach the higher cognitive learning goals "create" and "evaluate" in the third loop by evaluating a nutrition related statement and preparing a pitch.

Aim 2: Lowering workload of teachers

Initially setting up or redesign a course according to the Le-Do-Loop principle requires time investment from the teacher. The loops need to be carefully designed, instructions need to be written and starting literature needs to be identified. However, in the long run, the workload of the teacher decreases because the Le-Do-Loop can easily be adapted to new insights or topics that need to be implemented into education. Teachers do not have to develop new content themselves in advance. Instead, students develop their own learning materials and the teachers works along with the students.

Aim 3: Teaching students to become professionals that can function in a dynamic, rapidly changing environments or research domain

Working according to the Le-Do-Loop stimulates students to acquire several personal skills (such as self-discipline, critical thinking), social skills (such as collaboration, communication, argumentation), and methodological skills (such as asking questions and turning information into knowledge). With the Le-Do-Loop students learn and experience how to develop their own knowledge base and how to independently acquire new information and knowledge. This prepares them to become lifelong independent learners.

Aim 4: Activating students, both in an online setting as well as in an on-campus setting

The Le-Do-Loop aims to stimulate students to be actively learners, by preparing education material and teaching to fellow students. Several case students presented in chapter 3 illustrate how this is achieved both in online as well as in on-campus settings.

3. Case studies: Implementation and evaluation of Le-Do-Loop in specific courses

This chapter describes five courses from Wageningen University & Research in which the Le-Do-Loop was implemented and evaluated. The practical lessons learned from these courses resulted in a list of do's and don'ts described in Chapter 4. The case studies can be used as inspiration and the dos and don'ts as checklist while implementing the Le-Do-Loop.

3.1 Course "Nutritional aspects of food": Le-Do-Loop as support for group work.

This case study offers an example of how the Le-Do-Loop can be implemented to support the groupwork during a course. In this example all three loops are implemented in an already existing part of the course.

General course characteristics

The course 'Nutritional aspects of food' is a 4-week bachelor course for Food Technology students. Each year between 120 and 160 international students are enrolled in this course. This course deals with correlations between prevention of major diseases and consumption of specific components or products in the diet. This course consists of laboratory classes, lectures and group work in which students analyse three cases. The Le-Do-Loop was implemented in this course to support the group work on the three cases.

Le-Do-Loop Adoption

Basically, within the Le-Do-Loop, groups of students developed three learning challenges for other groups. These challenges were based on the three cases of the course and included one challenge on the understand level (loop 1), one challenge on the apply level (loop 2) and one challenge on the create/evaluate level (loop 3). The students were divided into sub-groups of 6 students. Each cluster consisted of 6 of these sub-groups (two "green" groups, two "blue" groups, and two "yellow" groups). These clusters come together in 4 meetings. Figure 2 shows an overview of the 4 meetings and the process. For each meeting a detailed worksheet was provided to the students that guides them through the meeting. During the meetings a tutor was present to help the groups and each meeting started with an explanation.

	Meeting 1	In between meetings	Meeting 2	In between meetings	Meeting 3	In between meetings	Meeting 4
Case A	Group green: design challenge 1 for case A	Develop challenge based on the workplan	Group yellow: Complete challenge 1 from group green. Design challenge 2 for case A	Develop challenge based on the workplan	Group blue: Complete challenge 2 from group yellow Design challenge 3 for case A	Develop challenge based on the workplan	Group green: Complete challenge 3 from group blue
Case B	Group blue: design challenge 1 for case B		Group green: Complete challenge 1 from group blue Design challenge 2 for case B		Group yellow: Complete challenge 2 from group green Design challenge 3 for case B		Group blue: Complete challenge 3 from group yellow
Case C	Group yellow: design challenge 1 for case C		Group blue: Complete challenge 1 from group yellow Design challenge 2 for case C		Group green: Complete challenge 2 from group blue Design challenge 3 for case C		Group yellow: Complete challenge 3 from group green

Figure 2. Overview of the 3 loops (challenges) for three cases and the three different coloured groups.

Meeting 1

In meeting 1, which took about 1.5 hours in total, students read the text of the case (e.g. the green groups started with case A), and developed learning questions for this case. The tutor, present during the meeting, checked the learning questions at the end of this first meeting. In between meeting 1 and 2, a presentation based on these learning questions was prepared by the students, for which they received background information (literature, websites, etc). Next to this, they prepared quiz questions, based on the content of the presentation.

Meeting 2

In meeting 2, the cluster of 6 groups came together, and all gave their presentations. After the presentations, the groups did the quiz prepared by another group. So, for example, group yellow took a quiz on case A prepared by group green. This was the end of challenge 1.

In the second part of this meeting, students continued with the case about which they played a quiz . So, in the example, the yellow groups now continued with case A. They had to develop questions for a board game (game of the goose) based on the content of case A and related to food products and food components related to the diseases from case A. During the meeting students brainstormed and searched for related food components and food products and discussed the relation with the disease. In between meeting 2 and 3, students developed the game questions.

Meeting 3

In meeting 3 all groups played the game prepared by the other groups. So, for example, the blue group played the game with the questions on case A developed by the yellow group. The blue group already became familiar with the case in meeting 2 (they also listened to the presentations), and by playing the game they learned more about the content of case A. This is the end of challenge 2.

In the second part of the meeting, students started with challenge 3. They were given a statement which was related to the case. Half of the groups was supposed to agree with the statement and half

of the groups was supposed to disagree. So, both blue groups were given the same statement related to case A, and one blue group had to find information that proves the statement, while the other blue group had to find information that disproves the statement. During the meeting, the students discussed the statement, and started with brainstorming what information could prove or disprove the statement. In between meetings 3 and 4, students searched for actual information, prepared a document with their arguments and made a pitch for the next meeting. They also prepared a document with links to the background information in which they found their arguments.

Meeting 4

In the last meeting students completed the final challenge. The meeting started with each group sitting together and opening the document with links prepared by the other group. So, group green opens the document, prepared by a blue group, with links to information that proves or disproves the statement related to case A. Students now had 30 minutes to go over this information and make up their own mind about this statement. Remember, group green knew case A really well, since they prepared a presentation (challenge 1) on this topic.
Now the pitches started. For example, the 2 blue groups gave their pitches on the statement of case A, one group gave arguments that prove the statement is correct, and one group gave arguments that the statement is incorrect. After the pitches, the green group, that had just looked over the information provided by the blue group, was asked to challenge the blue groups: to ask them questions about the arguments they were given. The yellow groups listened along, and in the end could vote whether they agree or disagree with the statement based on the debate.
These debates ended the third Le-Do-Loop.

Assessment

Tutors present during the meetings, also looked at the quality of the presentation, quiz questions (challenge 1), game questions (challenge 2) and arguments and background information for these arguments (challenge 3). Based on the quality, groups were given 0, 1, 2, or 3 points for each item. Groups had to evaluate each other as well, for the quality of the prepared challenge. All points together resulted into a group grade.

Evaluation results

Students' evaluation

The Le-Do-Loop was evaluated using a questionnaire. A total of 82 students filled out the questionnaire.

Students agree that the challenges encouraged them to think critically about the course content (89% agree) and to be actively engaged with the content (85%), and 73% student agreed that the challenges were a valuable learning activity. The groups indicated to have worked well together and were able to finish the challenges within the scheduled time. 85% of the students agree with the statement that after finishing the challenges I could explain my knowledge to other people in a better way.

What some students clearly did not like was the fact that they had to evaluate each other. Some students think that they were not evaluated in a fair way. Also, some students spend way more time than was needed. So clear expectations about expected time investment should be communicated with the students.

Teachers' evaluation

From the teachers' perspective, the Le-Do-Loop is a stimulating and interesting way of working together with students. Since the group is quite large, a good organization and clear information for the tutor is needed. For that, tutor documentation was prepared with details about the meeting, and with answers to possible learning questions. Also, PowerPoint presentations were provided that tutors used to guide the meetings. Tutors sometimes were somewhat confused, so more clear instructions and talking with all tutors just before the meetings might have been helpful.

Teachers see clear value in the Le-Do-Loop approach, they see that students are learning, are motivated, and also see that students are very much discussing course content with each other. What is also noticed by teachers (tutors), is that sometimes students provide wrong information and none of the students seem to recognize this. This makes it very important that the tutor also has enough knowledge to recognize this, and to make students aware of this.

3.2 Course "Analytical Epidemiology I": a two-day case study

This case study offers an example of how the Le-Do-Loop can be implemented in an existing course which mainly consists of several (full days) data analysis practicals. The Le-Do-Loop was mainly used to reflect on - , and as a recapture of the data analysis practicals. In this course, each loop took only a few days and was strongly linked to the content of the existing practicals. The teaching part of each loop only took 1.5 hour.

General course characteristics

Analytical Epidemiology I is a 4-week whole-day master course followed by around 20 to 40 students each year. The course focusses on studying diet-disease associations by means of several types of regression models. Learning goals vary from the level of understanding, up to creating and evaluating. Introduction lectures, followed by two-day data analysis practicals (using statistical analyses software) and recap lectures are the main activities during this course. Part of the course structure can be found in **Figure 3**. The Le-Do-Loop within this course was implemented to improve learning, understanding and active contributing during the data analysis practicals.

	Monday	Tuesday	Wednesday	Thursday
Week 1	**9-Jan**	**10-Jan**	**11-Jan**	**12-Jan**
8.20-9.00	Self-study	Prepare recap	Self-study	Prepare recap
9.10-9.50				
10.00-10.40	**Intro Lecture (1) *B0218***	Practical Linear regression (SH, MB) ***B0218***	**Intro Lecture (3) *B0218***	Practical Energy adjustment (SH, MB) ***B0218***
10.50-11.30			Practical Energy adjustment (SH, MB) ***B0218***	
11.40-12.20	Practical Linear regression (SH, MB) ***B0218***			
12.30-13.10				
Lunch break				
14.00-14.40	Practical Linear regression (SH, MB) ***B0417***	**Recap session Linear regression (2) *B0417***	Practical Energy adjustment (SH, MB) ***B0417***	**Recap session Energy adjustment (4, FvD) *B0417***
14.50-15.30				
15.40-16.20	Self-study	Self-study	Self-study	Self-study
16.30-17.10				

Figure 3. Course structure of HNH31506 Analytical Epidemiology I with Recap lectures scheduled at the end of each topic. Only the first week is shown as an illustration.

Le-Do-Loop Adoption

Practicals were wrapped-up at the end of the second day by means of recap sessions, in which students did teach their peers. Prior to each session, each group of students was given a specific set of questions which they had to try to answer while going through the practical's. It was also during the data analysis practicals where students prepared their presentations/teaching materials for the recap sessions. During the recap session, a student group did teach their answers on the questions they were assigned to their fellow students. Their fellow students were invited to ask clarifying questions and provide feedback to the presenting group. To stimulate this feedback process, all students were asked to think of – and write down - an exam question and reflect on whether that question could be answered based on the explanation provided. Clear instructions for preparing this recap lecture were provided by the teacher within the learning environment 'Brightspace'.

Evaluation results

Students' evaluation

Students appreciated the clear instructions that were provided for the recap lectures. In general, students enjoyed the group element of working as a group together to find, explain and present their answers. It was also noted by the students that they were better engaged in this course due to this method. As a downside some students reported to have felt anxious when presenting their answers, especially when they were not so confident about their answers. Potentially related to this, some students would have preferred to have received all the information from the teacher. Preparation time varied from 30-60 minutes for most students, while some reported to have spent 15 hours on preparing for the recap lecture – which is the amount of time that was scheduled for the data analysis practicals.

Teachers' evaluation

From the Teachers' perspective, the Le-Do-Loop was a good method to gain insight into the progress and level of students. Furthermore, this method clearly exposed any misconceptions students may have. Moreover, teachers noticed that students were much more activated and eager to really understand the assignments provided during the data analysis practicals.

As a downside it was noted that although teachers could clearly see which students were lacking behind, the Le-Do-Loop did not provide teachers with any additional time to spend on those students. This is because teachers had to prepare the recap lectures their selves as well to have material at hand just in case the explanations provided by the students was incomplete or incorrect. Furthermore, for the recap lectures to be successful, the teacher had to be focused both on the process and on the content. This made the Le-Do-Loop quite challenging for a single teacher.

3.3 Course "Spatial and regional economics": a 2-hour case study

This case study offers an example of how small peer-teaching activities can be used to deepen understanding of the course content and develop critical thinking.

General course characteristics

Each year around 35 students attend this 6-week bachelor course which instructs students about two aspects of spatial and regional economics: location theory and regional development. It consists of lectures and group work, among which practical sessions are an important part of the course. Le-Do-Loop was implemented to reach higher cognitive learning goals in the practical sessions.

Le-Do-Loop Adoption

The Le-Do-Loop in this course included three loops, with each loop consisting of three phases (see Figure 4). Phase 1 consists of all students working on the problem in question in their individual groups. In Phase 2, the host group for that particular problem presents their findings, followed by phase 3 whereby the feedback groups respond to the presentation of the host group. The host group is expected to walk the rest of the class through their work on the problem in question. This can be done on the whiteboard or by connecting their computer to the screen, as most suitable to the question. The role of the feedback groups is to respond to the presentation of the host group. This can either be in the form of feedback on the presentation, offering additional insights that were not mentioned by the host group or a question to dig deeper into the material. The actions of the feedback groups should be for the benefit of the class and the learning process.

		Length	Activity
Round 1	Phase 1	40 min	Students work out problem 1 in groups
	Phase 2		Host groups present
	Phase 3		Other assigned groups feedback
Round 2		40 min	Repeat for problem 2
Round 3		40 min	Repeat for problem 3

Figure 4. ***Le-Do-Loop implementation in Spatial and Regional Economics practical's.***

Evaluation results

Students' evaluation

In the evaluations, particularly "This course encouraged me to think about the content critically" and "This course stimulated me to actively engage with the content" improved from a previous year where Le-Do-Loop was not yet implemented, rating highly (average of 4.4 and 3.8 out a scale of 1-5, respectively). Although direct causation cannot be proved, the Le-Do-Loop may have helped to stimulate further active learning. There were also comments by students that they very much liked the balance of both theory and exercises. Students overall felt that the practical's deepened their understanding of the concepts taught during the lectures, and that it was a great way to engage with the theory. Some suggestions were for students to also upload the answers at the end of the practical, to try to allocate more time to questions that especially involve using unfamiliar software. In this respect, knowledge clips as a pre-practical activity could be useful.

Teachers' evaluation

Overall, it was seen positively, especially in the sense that students were active and there was interaction. Most students took it seriously to work together in their groups to solve the problems; selected groups presented and there was engagement with the rest of the students; sometimes this interaction was facilitated by the lecturer. In the second time around, it was also noticed there were positive spill overs to greater engagement also in other activities of the course; e.g., attendance and engagement during lectures improved.

Some students volunteered, so it worked to not make it too formal, yet still attaining the goals of Le-Do-Loop. It was helpful to avoid people not feeling on the spot/uncomfortable if e.g. they were unable to do the exercise. In this sense, sometimes lecturers asked other groups to help in case of problems. As lecturer, this also requires one to be a bit more flexible than in 'normal' practical sessions. Another positive point is that due to the class and group sizes, free-riding is more difficult.

It was also observed to have a good balance in terms of guiding and being present as a lecturer and leaving students to work by themselves. Next to this, clear instructions help, but it is also important to make room for flexibility. Finally, other points of attention that are challenging are that some groups take less time than others and that introducing flexibility in the set-up may be less feasible with a larger class size. In that case, more structure may be best.

3.4 Course "Data Types for Signal Processing in Health and Nutrition": a whole-course case study

This case study offers an example how a newly developed 4-week course was completely build according the principles of the Le-Do-Loop.

General course characteristics

The course 'Data Types for Signal Processing in Health and Nutrition" is a course which fits into the new Master's programme at the WUR: Data Science for Food and Health (MDS). The course was a newly defined course, and as part of this education innovation project it was decided to fully build the course on the principles of the Le-Do-Loop. The focus of the educational activities in the course lie with the student developing programming skills and critical thinking skills in order to analyse data generated over time.

The first cohort of students participating in this course were a group of 20, with a variety of background, but all admissible for the MDS.

The course was a 3-ECT course in the 4th period of the WUR academic year, which means it consisted of three education weeks, and one exam preparation week.

Le-Do-Loop Adoption

As the setup of the course was based on the Le-Do-Loop format, each week represented one 'step' in the loop. The following steps of a data analysis were defined as the weekly themes:

1. Data exploration
2. Data analysis
3. Machine learning modelling

Which means the students focussed their efforts on understanding the steps and algorithms involved in data exploration in the first week, etc. From a conceptual perspective this makes sense, because the course builds on previous knowledge, so the students should be able to remember and understand data exploration steps they have seen before, should be able to apply data analysis steps they have seen before and build on that knowledge with new information, and finally apply a machine learning model to evaluate how well their data exploration and analysis steps have been performed.

The activities within the course consisted of weekly programming assignments with part of the work done by a group of students, presentation and teaching moment of their solutions, and a proper code documentation and handover at the end of the week.

Figure 5 shows the course setup, where each week each groups receives a new use case to work on, where the groups have to give each other feedback on the 'teaching' they have received from the previous group. The teaching in this case is the handover of documentation of the code, the code itself, and the presentation of the results and considerations in the steps they have performed that week.

The examination of the course was via oral exam (graded), reflection (non-graded), presentations and discussions (non-graded), and code notebook and documentation (non-graded).

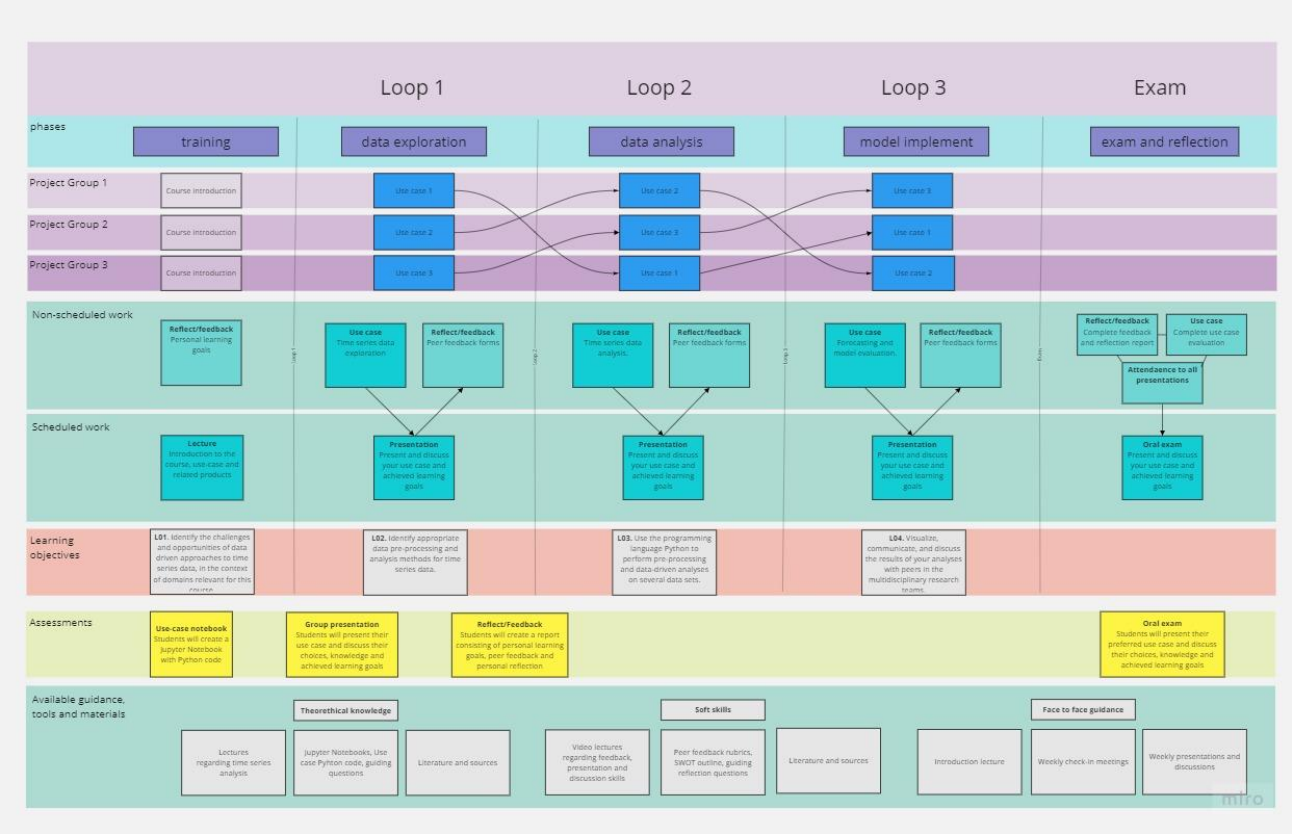

Figure 5. Course setup Data Types for Signal Processing in Health and Nutrition.

Evaluation results

Because this course was given for the first time, there is no precedent of previous evaluations, so the interpretation was mostly based on the oral feedback students gave during and at the end of the course.

Students' evaluation

Overall, the course was received positively by the students. They were interested in the topic, learned new skills, and enjoyed the freedom they had in this course. Because they had to hand over their code each week to a new group, they realized that this was a real-life approximation. In the beginning the students were quite stressed, because they did not know exactly what was expected of them, but at the end of the course they felt empowered. The following points were raised during the in-person feedback session at the end of the course.

- The positives:
    - Felt empowered after finishing the whole process
    - Felt like a real-world situation with code handovers
    - Presenting a lecture for your fellow students felt empowering and required you to dive into a topic very thoroughly
    - Loads of interesting materials to help you finish the assignment of the week
    - Some students felt the bar was set just right
    - Students felt they had a lot of input in how to tackle a project, and the lectures by staff helped pick an angle

- Points of improvement:
    - Some students require a clear structure and felt lost
    - Code handovers can feel messy if the previous group did not document correctly
    - Some students felt that because of this deep dive, you miss the opportunity to gain knowledge about the other topics
    - Sometimes hard to distinguish which materials are needed
    - Some students felt the bar was too high
    - This type of course requires a certain trust with staff members to allow the students to feel the frustration and help them through it

Since this was a group of students that had an established relationship with the teaching staff already, they felt comfortable to discuss their struggles, and trusted that they would be able to work through them together with the staff.

Techers' evaluation

From a teachers' perspective, the course was a success. It was nice to prepare a lot of materials for the students in advance and have the students work with the materials during the course. The lectures that the students taught gave insight into any knowledge gaps and allows the teacher to be an active discussion partner instead of just the sending and receiving relationship with traditional lectures.

It does require the teacher to be very focused throughout the whole course, which was very demanding. Listening to a presentation, identifying knowledge gaps, and correcting the course is hard to combine with providing the students with feedback as well. Therefore, the recommendation from this course is to 'outsource' the student feedback to the group and any teaching assistants present in the room, and have the main teaching staff focus on the content of the presentation.

3.5 Course "Nutrition and non-communicable diseases": a whole course case study.

This case study offers an example of how the Le-Do-Loop can be implemented in a fully online distance learning course.

General course characteristics

The course Nutrition and non-communicable diseases is a Master's course, and part of the distance learning master Nutritional Epidemiology and Public Health. The course is open to students from other programmes as well, given that they have the prerequisite knowledge described in the course guide. The course runs for four weeks, the last week being self-study and examination. The course is time and place independent though the students have deadlines to meet every week of the course. In 2023, around 40 students actively joined the course.

Le-Do-Loop Adoption

The Le-Do-Loop was integrated in an assignment about the Hallmarks of Cancer. The students had to make a knowledge clip about one of the Hallmarks of cancer. Then, they had to mention an example of a nutritional or lifestyle factor that could affect this Hallmark. In the last phase, students applied their knowledge by explaining and critical commenting on an epidemiological publication that studied this association. The students had to give peer feedback on three other knowledge clips, where they learned about the other Hallmarks and learned to critical review the evidence other students brought up. Lastly, the students reflected on the feedback and wrote down the things that they would do differently if that had to re-do the assignment.

Evaluation results

Students' evaluation

The evaluation was completed by 10 students, of which 9 were very positive about the course, based on the closed evaluation questions of the course (. Though we cannot specifically draw conclusions on the evaluation of the Le-Do-Loop assignment, it was a relatively large part of the course (graded for 25% of the final mark).

Teachers' evaluation

From a teacher's perspective, the Le-Do-Loop as it was used in this course facilitated that students could learn about different hallmarks in a short amount of time, and that they could apply this knowledge to epidemiology. More specifically, the Le-Do-Loop was a good method to include the latest evidence on nutritional and lifestyle factors and their association with cancer, which is a broad and rapid changing area. However, for the students who were enrolled from other programmes, the last phase of the assignment seemed to be difficult. The combination of seeing other knowledge clips and receiving feedback on their clip supported them in their learning regarding this. It would have been more optimal if the parts of the assignment could have been done by different students, but given the tight schedule in combination with time and place independent learning, this was not feasible. To clarify, deadlines for distance learning students are always at the end of the week (during the weekend), and this assignment should be finished during the second course week; before starting off a new topic with another assignment.

4. Points of attention: Do's and Don'ts

A well-thought-out design, good set-up and implementation are important for the Le-Do-Loop to be successful. The case studies illustrate how the implementation of the Le-Do-Loop depends on course characteristics (time schedule, number of students, etc), content characteristics (as expressed in learning objectives), and student characteristics (e.g., prior knowledge, skills, and maturity of the students). To support teachers when preparing their course based on the Le-Do-Loop principles, a Le-Do-Loop template has been created. This template can be found in Appendix I. Start by filling in the blanks and keep the following list of suggestions and do's and don'ts in mind as checklist and guide while implementing the Le-Do-Loop.

4.1 Preparation

- Provide clear instructions for the assignment to students, explain criteria and set deadlines.
- Take time to explain why peer-teaching is chosen as a teaching method in this course. Students may at first be reluctant to participate in peer teaching. They may demand their teachers doing the teaching. The following elements you may consider mentioning to your students (depending on the student's maturity and phase of their study program):
    - Deep learning takes place once you try to explain a topic/concept to a peer. So you yourself will benefit most from the peer-teaching you provide to others, instead of the teaching you receive.
    - In most future professions you need to be able to independently learn yourself new concepts and topics and/or explain your insights to your co-workers. So, this peer-teaching method prepares for your future career.
    - The teachers will be there to repair your misconceptions and make sure at the end no incorrect knowledge/concepts are transferred by and to your peers. This peer-teaching methods is a highly efficient way to focus the teaching/feedback provided by the teachers on the misconceptions only and not waste time on the aspects already correctly understood by the students.
    - Peers are sometimes better teachers than teachers because they are on the same level.
    - Peer-teaching is a way to learn, so you are allowed to be wrong, to express incomplete understanding or are insecure. In fact, this is exactly what we want to happen because this provide opportunities for your teachers to repair your misconceptions that are now openly expressed during the peer-teaching instead remaining hidden in the brains of the students.

  Above mentioned aspects may help to build a relationship of trust among teachers and students and a safe learning space.
- The Le-Do-Loop can be implemented in the digital teaching environment of the course (e.g. Brightspace, Blackboard, Canvas, MS teams). The case studies from Wageningen University, described in this teaching manual, use a combination of Brightspace and MS teams. For example, an MS Teams page can be useful to support the process. Different channels can be created: one channel for each loop. Questions from students are posted in the associated channel and answered by the teacher or fellow students. You can also ask students to hand-in information source(s) they use within a specific loop.
- In case of large student numbers, it is advisable to have more teachers or teaching assistants to support the process.
- Consider an appropriate examination mode. Assessing part of the work related with the Le-Do-Loop can be time consuming. However, if this means that the final examination requires

no or less grading, grading the Le-Do-Loop may be beneficial. It is recommended to clearly distinguish the learning phase (formative feedback and assessment) and the assessment phase (summative assessment).

4.2 Loop 1 - UNDERSTAND

In this loop, it is important to support the students to prevent misconceptions, this can be done for example by:

- Providing the students with relevant readings and literature in advance.
- If the course build on previous courses, include a recap of the previous material. See 3.4.
- Keep a good balance in terms of guiding/being present as a lecturer and leaving students to work by themselves.
- Give feedback during the sessions in which students teach each other. However, be careful not to re-do the work of the students. Once the students realize that the teachers will teach anyways, irrespective of the peer-teaching provided by the students, they will take their peer-teaching task less seriously during the next loop. This can be prevented by keeping your feedback very closely linked to what happened during the peer-teaching and subsequent discussions.

4.3 Loop 2 – APPLY

- Students should be coached for the right application.
- Try to be flexible. Don't make it too formal. Offer a safe learning space and provide time to students for exploration.
- Let students volunteer (especially in smaller courses) and asks other students/groups to help out when there is a problem or when students are uncomfortable with teaching.
- Allow yourself to be an active discussion partner instead of just sending and receiving knowledge as in traditional lectures.
- For each teaching activity, make sure you have the knowledge to focus on the content and recognize knowledge gaps and misconceptions.

4.4 Loop 3 – CREATE, EVALUATE

- Assist in correct reasoning to aid students into reaching higher cognitive learning goals.
- Ask students to provide constructive feedback to their fellow students: specific and critical. Let them give examples, strengths/weaknesses, and tips and tops. Make sure your feedback not only focusses on the process or (soft) teaching skills, like presenting skills, but mainly on the content-specific learning objectives. Always realize that peer-teaching is not the main goal but the way to reach the content-specific.
- To being able to provide efficient feedback and to be flexible as a teacher, it is recommended to have a pair of teachers to divide tasks, support each other and to be flexible. See 3.2. For example, one teacher can focus on the process and safe learning space while the other mainly focus on the content and identification of misconceptions.

4.5 Evaluation

After applying the Le-Do-Loop in a course, it is recommended to evaluate the set-up and results of this method, both from the students' perspectives as well as from the teacher's perspective. If needed or desired, changes can be made to increase the success of the method in upcoming years. For the evaluation, one could use the set of evaluation questions as provided in Appendix II.

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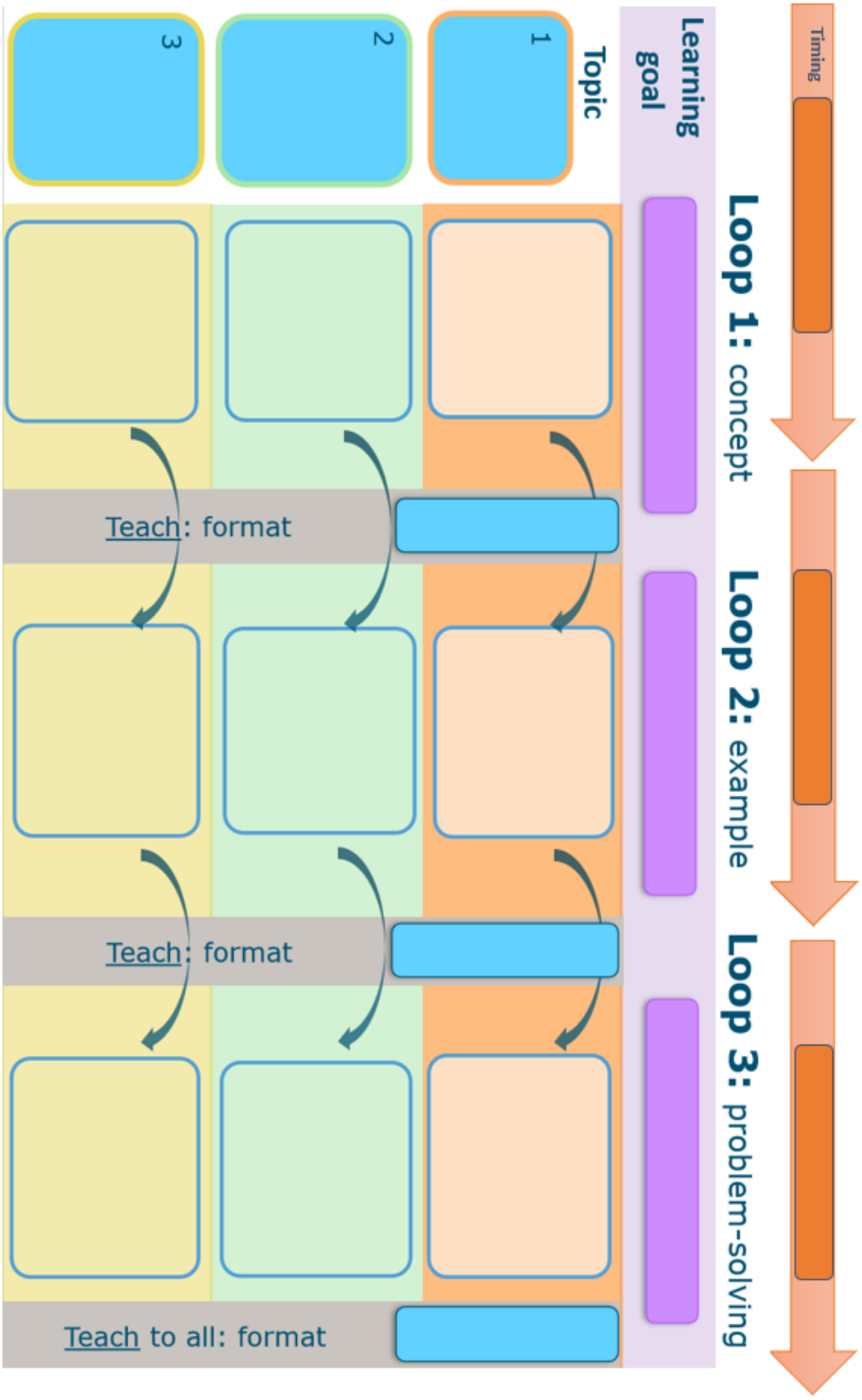
Appendices

I. Le-Do-Loop template



II. Evaluation questions students and teachers

Students	*	
1. Preparation	S	Preparing the [*presentation format*] gave me motivation to work concentrated and focused during the [*learning activity*].
	S	The workload for preparing the [*presentation format*] was feasible.
	S	The instructions for the [*presentation format/learning activity*] were clear.
	O	How much time did you spend to prepare the [*presentation format*]?
	S	The scheduling of the *[learning activities*] was well aligned with the preparation for the [*presentation format*].
2. Learning activity	S	The [*learning activity*] encouraged me to critically think about the content
	S	This [*learning activity/presentation format*] stimulated me to actively engage with the content
	O	Did you experience anxiety/unpleasent feeling for the [*presentation format*]?
	S	During the *[learning activity*], there was enough time for questions and feedback.
	S	[*learning activity*] was a valuable learning activity.
	S	The [learning activity] was an effective learning activity for the exam.
3. Group work	S	Our group worked well together in developing [*presentation format*]: we all contributed equally.
	S	We worked well together in our group for finding [*education material*]
	S	We were able to finish the [*presentation format*] within the scheduled time.
	O	Was it effective to work on this [*presentation format/learning activity*] in a group?
4. Reflection	S	I am able to reflect on what was learned during the [*learning activity*].
	S	After finishing the [*presentation format*], I could explain my knowledge to other people in a better way.
	S	After finishing the [*learning activity*], I am able to formulate questions to others in a more comprehensible way.
	O	Do you have any tops (compliments) or tips (suggestions/comments) for the [*learning activity*]?
	O	Which part of the [*learning activity*] could be improved for next year?

Teacher		
1. General	O	Were the students more actively involved in the course compared to previous year(s)?
	O	How did you experience the workload for the course compared to previous year(s)?
	O	Was the amount of students appropriate to work with the Le-Do-Loop?
	O	Were the students more motivated to work during the [*learning activity*] compared to previous year(s)?
2. Learning activity	O	Was it easier the interact with the students during the [*learning activity*] compared to previous year(s)?
	O	Were more students present during the [*learning activity*] compared to previous year(s)? (if it was not obligatory to be present)
	O	Was there enough time to focus on knowledge gaps or misconceptions during the [*learning activity*]?

	O	Did the students catch the essence of the topics?
	O	How did you experience the workload for the [*learning activity/presentation format*] compared to previous year(s)?
3. Grading	O	Did you use a grading system for assessing the *[presentation format]*?
	O	Did the final grades for the course improve compared to previous year(s)?

*S = statement; answer options: fully disagree/ disagree / no opinion / agree / fully agree
*O = open question