Flipped Classroom Patterns - Designing Valuable In-Class Meetings

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The flipping classroom approach is directed at getting students well-prepared in class so that the valuable face-to-face time during the in-class meetings can be used more efficiently to support students' learning. This requires a radical change of the role of the lecturers, as they are not knowledge transmitters anymore but learning facilitators. This role change has direct impact on the design of the in-class-meetings.
Based on five years of experience with flipped classrooms for learning programming in bachelor computing programs and on an educational and organization analysis, we started to collect and describe patterns that help with improving various aspects of Flipped Classrooms. In this paper we describe five patterns that help with the design and execution of in-class meetings in a Flipped Classroom course.

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1. INTRODUCTION

Getting better study results is a continuous drive in education as is the quest for getting prepared students in class. The *flipped classroom* (FC) is an approach for increasing student preparation and has been applied by teachers in different designs and contexts. Mainly made popular by Bergmann and Sams through their book *Flip Your Classroom* [Bergmann and Sams 2012], it is characterized by moving instruction and introduction of learning materials outside of the classroom. Its raise and popularity coincides with the popularity of Massive Open Online Courses (MOOCs) and Open Educational Resources (OER).

Content is acquired by the students on their own time by watching explanatory videos, reading supplementary material, and making home assignments. During the in-class meetings, the students are not listening to a standard

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knowledge transfer lecture. Instead, they will receive feedback on home assignments they have submitted to the teacher before entering class and work (collaboratively) on deepening assignments. They hereby have the teacher available for questions and assistance in further inquiry, which also is a change of the lecturer's role from knowledge distributor to learning facilitator. The class itself therefore opens the possibility to discuss theory and its application in more depth based on submitted work and on giving feedback to students, which in consequence helps with deepening the student's understanding of the content and better supporting their learning.

Good practices in computing, pedagogy and other domains can be described as patterns. In the pedagogical pattern community, processes have been developed to combine theory, experience and expert reviews to develop these patterns. Following this route, these good practices get a solid foundation and will be useful for our colleagues to understand how to deliver lectures in a flipped classroom setting or how to design a flipped course. We intend to develop a flipped classroom pattern language, covering all elements of design and delivery of flipped classroom courses. We hereby start with identifying the patterns that are applicable in our context—programming courses in an undergraduate computer science program—but the language will likely evolve towards a more generic one if educators in other domains will be involved too in the development of it.

To make a start with the pattern language, we describe five patterns in this paper. A list with all new patterns we have identified so far and a list with all existing patterns that are also applicable in a flipped classroom setting are given in the Appendix. Furthermore, all referenced patterns are summarized in the Appendix too.

2. FOCUS OF THIS WORK

One of the aspects of Flipped Classroom are the in-class meetings. These differ tremendously from traditional lectures, as the lecturer does not transfer new knowledge via presentations but interactively supports students with deepening the understanding of the acquired knowledge and correcting misconceptions. For this reason the design and execution of the in-class meetings needs special attention.

In this paper we describe five patterns that help with the design and delivery of in-class meetings in a flipped classroom course. An overview of these five patterns is given in Table I. They are intended to become part of a pattern language for flipped classrooms.

Pattern Name	SUMMARY
CONTROLLED PACING	Make an explicit planning per in-class meeting and handle strict deadlines.
USE STUDENT SOLUTIONS	Use the work that students have handed in as examples in class.
EVERY STUDENT SOLUTION COUNTS	Make sure that each student in the group—or most of them—will see his or her work being discussed every once in a while so that they see the relevance of it.
COMPARE SOLUTIONS	Show and discuss multiple solutions so that students learn to recognize the strengths and weaknesses of various approaches, including their own.
ADD VALUE BEYOND FEEDBACK	Interweave feedback with added value moments.

Table I. : proposed patterns for design and execution of in-class meetings

3. PATTERN MINING SOURCE

The proto-patterns described in this work were mined from two sources: pattern mining workshops for extracting our own experiences with Flipped Classrooms and an additional literature study. The complete approach and all results are described in detail in [Köppe et al. 2015b].

3.1 Own Experience

In order to improve programming skills of students in computing at HAN University of Applied Sciences, we have flipped two courses since 2012. This was based on two previous years of experience in first year programming courses with an average of 25 students[van Diepen et al. 2015]. Theory and instruction in these courses is now studied at home by

our students and they submit homework in advance of each lecture. During lectures, feedback is given on assignments, common mistakes are discussed, additional explanation is provided and homework for the next lecture is introduced.

Both courses are given to approximately 300-350 students each since 2012, where the students are spread over 10-12 classes with a maximum of 32 students in a class. All classes are taught by 10-12 different lecturers. In occasional cases one lecturer teaches the same course to two classes at the same time.

We held two pattern mining workshops, where we collected user stories and best practices together with groups of lecturers who have given at least one time a Flipped Classroom course. These stories and practices formed the base for a collection of pattern candidates (or proto-patterns). Five of those were selected and further elaborated in this work.

All patterns underwent a shepherding period[1] and were discussed in a writers' workshop at the EuroPLoP'15 conference. This helped with improving the patterns and also forms a validation of the patterns by peer experts.

4. PATTERN FORMAT

The patterns use an adapted version of the Alexandrian pattern format, as described in [Alexander et al. 1977]. The first part of each pattern is a short description of the context, followed by three diamonds. In the second part, the problem (in bold) and the forces are described, followed by another three diamonds. The third part offers the core of the solution (again in bold), the solution in more detail, the positive and negative consequences of the pattern application — which are part of the resulting context — and a discussion of possible implementations. This is followed by examples of the pattern implementation, shown in *italics*.

[1] Shepherding is a special reviewing process where an experienced pattern author and expert (the shepherd) helps the author with improving the work by giving feedback. See `http://www.europlop.net/content/pattern-writing#shepherding` for more details on the process.

PATTERN: CONTROLLED PACING

You have the preparation material for the students—such as videos, readings, and home assignments—and are beginning the planning per week and/or the in-class meetings. The students likely have different levels of experience.

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Students who haven't done all preparations and students who already did preparations of later parts of the course are both on very different levels, which makes it hard to have in-class meetings which address all students appropriately.

The preparation material for the students is often completely available at the beginning of a course. Good (or more experienced) students often do these preparations in a high speed, either because they are interested where the course is heading (hereby sometimes skipping some of the exercises) or because they grasp the concepts faster than others and want to continue without waiting. Sometimes, students *believe* they have grasped the concepts faster than others, while this is not the case. This can bring them into trouble when they approach later exercises in a way that differs from how they are expected to.

Other students need more time for preparing themselves and acquiring the desired skills and concepts.

However, usually a course is executed in a fixed period and has a fixed amount of time for class meetings, so the preparations and class meetings are spread evenly over the period. Variations in the speed of walking through the topics of the course may either hinder the faster or the slower students.

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Therefore: Control the pace of the students through an explicit planning per in-class meeting and deadlines for submitting the preparations prior to the in-class meeting.

Having such planning (a more concrete version of SEMINAR PLAN) and communicating it to the students makes the pace of the course visible to everyone. This helps all students with checking if they are still "on track". Communicate this planning often and repeatedly, as also suggested in REFERENCE THE PLAN. Present the deadlines and the corresponding preparations for the next meeting at the end of each in-class meeting. Also, stress the risks of making exercises concerning subjects that are not yet discussed to avoid “Running Ahead Problems".

However, even though the material may theoretically be complete enough and offers the material using different media, e.g. screencasts, readers, websites, the lessons, etc., some students still will find it difficult to acquire all knowledge in the assigned amount of time. It is therefore good to offer optional ADDITIONAL RESOURCES that you can use as extra support for knowledge and skill acquisition.

Address the needs of the more experienced or faster students too by offering them optional CHALLENGE ASSIGNMENTS. By handing those students materials that can help them get a broader or deeper insight on the subject matter, they don't run the risk of getting themselves into trouble by running ahead.

An alternative to CONTROLLED PACING is the separation of students in different groups (or classes) by their experience levels. This way, the difference of experience levels of students in the same group will be much smaller which lowers the need for a CONTROLLED PACING.

In consequence, all students are on a level where they can get most out of the feedback given to them and the exercises done during the in-class meetings. This can be even more improved by applying ADD VALUE BEYOND FEEDBACK. Having a CONTROLLED PACING also students with working together and sharing their experiences as parts of peer learning. It also helps them with organizing their study activities.

On the other hand, this controlled pacing makes studying in one's own speed difficult. This can decrease motivation of both slower and faster students. The patterns ADDITIONAL RESOURCES and CHALLENGE ASSIGNMENTS address these problems and offer possible solutions. Furthermore, this pattern addresses only the pacing of one course, which might not fit with the pacing of other courses the students follow at the same time. It is therefore necessary to check the pace

week	lecture	preparation	in-class
1	Lec 1	*None*	introduction, part of module 1 live
	Lec 2	Module 1 + exercises + module assignment	Discussion of questions/exercises and module assignment
	Lec 3	Module 2 + exercises	Discussion of questions/exercises
2	Lec 1	Module 2 module assignment	Discussion of module assignment
	Lec 2	Module 3 + exercises	Discussion of questions/exercises
	Lec 3	Module 3 module assignment	Discussion of module assignment
3	exam		exam 1 about modules 1 and 2
	Lec 1	Module 4 + exercises	Discussion of questions/exercises
	Lec 2	Module 4 module assignment	Discussion of module assignment
	Lec 3	Module 5 + exercises	Discussion of questions/exercises
4	Lec 1	Module 5 special case study	recap exam Discussion of case study
	Lec 2	Module 5 module assignment	Discussion of module assignment
	Lec 3	Module 6 + exercises	Discussion of questions/exercises

Fig. 1: Example overview document for the course Structured Program Development (translated from Dutch, only partly shown)

of the other courses too and take that into account for planning.

For the course "Structured Program Development", which is the introductory programming course at the university of the authors, an overview (see Figure 1) is given to the students containing the preparations per in-class meeting and also the exercises that will be discussed during the meetings. Most lecturers use this overview at the end of each meeting for explicitly communicating the topics and required preparations for the next meeting.

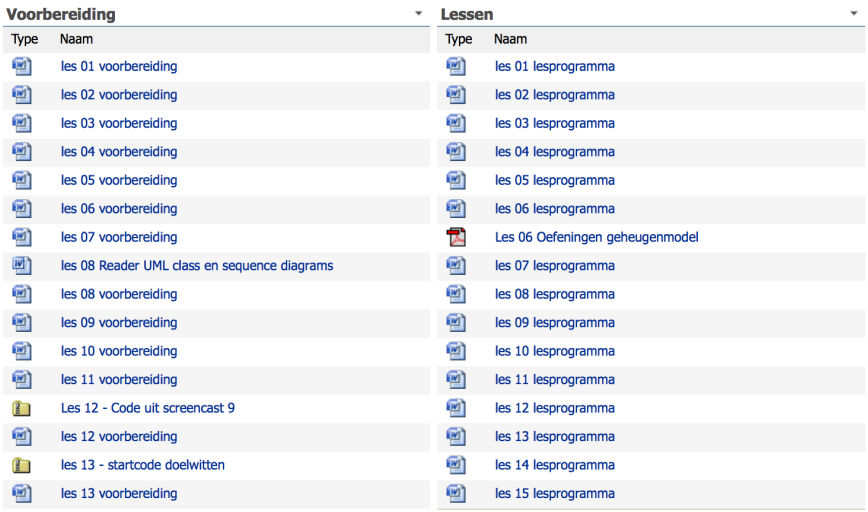

Fig. 2: Material per lecture for the course "Object Oriented Program Development' (preparation material in the left column and the material for the in-class meeting in the right column)

A similar approach is taken in the course "Object Oriented Program Development", where students and teachers are presented with a very strict and clear scheme per in-class meeting (or lecture), both for the preparations and for the meeting itself. This is communicated via the online learning system, a screenshot is shown in Figure 2.

PATTERN: USE STUDENT SOLUTIONS

Students have prepared for an in-class meeting by studying the required material and handed in their homework solutions beforehand. These homework solutions are not overly complex or extensive. You want to create a rich classroom experience with a good learning outcome.

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Students have difficulty understanding concepts when they are discussed using prefabricated solutions and generic explanations.

An important part of the learning process is resolving misconceptions. It is hard to find the misconceptions, and even if you are aware of them because you studied the submitted solutions it is hard finding good ways to help students correcting them.

For most students examples are invaluable for understanding the subject matter. However, before an example can be valuable it must be understood. Furthermore, finding suitable examples can be difficult and time consuming.

Finally, not connecting to prior knowledge may cause the classroom session to degenerate into a classical knowledge transfer lecture.

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Therefore: connect all discussion of concepts and theory to students' prior experience, by basing the classroom activities on the students' homework solutions they have handed in.

This pattern serves as an entry pattern to the approach of using student solutions for the in-class meetings, its good implementation requires the application of multiple supporting patterns (see below and [Köppe et al. 2015a]). A precondition for the application of this pattern is that the students can hand in their work before class, e.g. via email or through a learning management system.

A lot of information about the prior knowledge of students can be obtained by inspecting the homework solutions. For example, one could:

—look for common patterns in different solutions (as basis for BIRD'S EYE SUMMARY and GENERALIZED FEEDBACK FOR EVERYONE),

—look for obvious differences and remarkable exceptions (used for COMPARE SOLUTIONS or SOLUTION VARIETY), and

—relate these to the content you want to deliver.

Also pay attention to the terminology used by the students to check whether they grasped and applied the concepts of the preparation material correctly. Applying this pattern therefore also helps with identifying misconceptions, a prerequisite for correcting them.

It is easier to connect the new material to their own knowledge when the discussion is based on their own work. The solutions form hereby an excellent source of examples the students are familiar with. This makes it easier for them to understand them as they reflect their prior experience.

Using solutions can provoke or benefit teacher class interaction. Most solutions raise questions which trigger a good discussion on the topic. In class you can ask students to clarify their solution and listen carefully how they formulate their answer, hereby identifying if they really grasped all kinds of desired knowledge correctly (factual, conceptual, and procedural, as described in the revised Bloom's taxonomy [Anderson and Krathwohl 2001]).

You do not need to see the solution of every student, but should try to find a good SOLUTION VARIETY. Also make sure that you ADD VALUE BEYOND FEEDBACK and that you let students know that EVERY STUDENT SOLUTION COUNTS.

One limitation is that you'll need homework problems that are designed to expose the nuances of the subject matter as much as possible.

Another limitation is the available time for inspecting the students' solutions. Preparation may take more time, because the teacher can no longer repeat a story based on standard examples. Having clear learning goals of the classroom

sessions is invaluable. That way you can quickly relate solutions to the goals and select the most valuable ones. Having a deep understanding of the subject matter is also a requirement for this to work well.

In the course Object-Oriented Program Development, the general content of each classroom sessions is determined upfront to support a CONTROLLED PACING*. Prior to each classroom session, students have to hand in their solutions through email. Shortly before the start of as classroom session, the teacher scans through all emails to find suitable solutions to use in that session and select the ones that are most suitable for giving feedback, correcting misconceptions, and introducing new aspects of the theory.*

PATTERN: EVERY STUDENT SOLUTION COUNTS

By way of preparing for class, students have completed assignments and handed in their work before class as part of USE STUDENT SOLUTIONS. During class, these assignments are discussed, usually taking the student's work as the starting point. The group size is not overly big so that you principally could know all students.

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Students may feel that their work is not considered relevant and stop handing it in.

Usually, it is infeasible to discuss all the works of all the students: there are too many of them, and too little available time. Besides, many of the students' solutions are likely to be so similar that discussing every one of them would be mostly repetitive and not very useful.

Students, whose work is left out of the discussion too often (or never used), may start to feel their work is not considered relevant, and may loose their motivation to keep handing in finished assignments.

This problem is amplified when the teacher discovers that the work of some particular students is often very useful in class discussions (because they consistently hand in optimal solutions, or just the opposite: they consistently hand in solutions with interesting mistakes). The teacher may start to disproportionally select these students' work, leaving other students disproportionally often left out.

Contradicting forces are time limitations and the fact that too much repetition is not very useful on the one hand, and the fact that students may feel that their preparations are not important or not taken seriously if their work is not discussed during a certain class on the other hand.

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Therefore: Make sure that each student in the group—or most of them—will openly see his or her work being discussed every once in a while.

The core of this solution is that you recognize and value all students. Keep track of which students have already "had a turn", and which ones haven't yet. A simple list with the student names and the option for registering whose work has been used already is a good way of realizing this solution.

If you lose track, it may help to simply ask the students who hasn't shown something yet. However, this won't work when students are reluctant to draw attention to themselves, because, for example, they aren't confident about the quality of their work.

A positive consequence of this approach is that when every student's work is discussed every once in a while, students will see that their work is of use for all other students. They will probably be extra motivated because they know chances are high that at some point their name is being called, and they want to make sure that they always have something to show. Because the solutions include both good and less good ones, this also helps with showing that everybody makes mistakes.

A negative consequence may be that the work of a student that is selected simply because it was this student's turn (and not because their work was considered useful to discuss by the teacher), is that it may not add value (for example because a similar solution was previously discussed). Also, it is possible that if a student consequently hands in work of lower than average level, he or she may feel embarrassed.

One important way to prevent such reluctance is to be very explicit in showing appreciation (even thanking them) for the student's efforts and for allowing you to use his/her work as a basis for discussion—even (or: especially) when the solution received quite a bit of criticism. This is described in pattern STUDENT CONTRIBUTION ESTEEM. Another option to prevent this problem is to ANONYMIZE SOLUTIONS which are used in the first in-class meetings.

A randomized list of students' names can be helpful: you simply work your way from the top to the bottom of the list. This may help to keep students on their toes, knowing that their turn may come at any moment. A drawback of this

method is that students whose work has already been highlighted can be certain that it will take quite a bit of time before their next turn.

This pattern can also be applied when you use COMPARE SOLUTIONS.

For the course "Object-Oriented Program Development" at HAN university, teachers use a sheet to register which students had submitted the preparation and additionally which student solutions were used for class discussions. An (anonymized) example is shown in Figure 3. This sheet is sometimes also shown to the students in the beginning of the lecture as part of the PREPARATION MATERIAL CHECK *pattern. It also helps with realizing* STUDENT CONTRIBUTION ESTEEM.

	A	B	C	D	E	F	G	H	I	J
1		week	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3
2		les	2	3	4	5	6	7	8	9
3	identification	full name								
4	100000	student 1	x		x	x				
5	100001	student 2	x	y	x	x				
6	100002	student 3	x	y	x	x				
7	100003	student 4	x	x	x					
8	100004	student 5								
9	100005	student 6	x	x	x	x				
10	100006	student 7	x	x	x	x				
11	100007	student 8	x	x	x	x				
12	100008	student 9	x	x	x	x				
13	100009	student 10	x	x	x					
14	100010	student 11		x		x				
15	100011	student 12	x	x	x	y				
16	100012	student 13	y	x	x	x				
17	100013	student 14	x	x	x	y				
18	100014	student 15	y	x	x	x				
19	100015	student 16			x					
20	100016	student 17	x	x	x	x				
21	100017	student 18	x	x	x	x				
22	100018	student 19								
23	100019	student 20	x	x	x					
24	100020	student 21	x	x	x	x				
25	100021	student 22			x	x				
26	100022	student 23	x	x	y	x				
27	100023	student 24								
28	100024	student 25	x	x	y	x				

Fig. 3: example registration sheet, the used solutions are marked with a 'y' (not anonymized in class)

PATTERN: COMPARE SOLUTIONS

You want to USE STUDENT SOLUTIONS, so the students got assignments or problems to solve. These assignments can be solved in different ways or different approaches can be taken to come to a solution. The handed-in solutions of the students will therefore likely be very heterogeneous, but will still (attempt to) solve the same problem.

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Students are only familiar with their own solution, and are unable to recognize strengths and weaknesses in them.

By themselves, students will only discover a single way of reaching a solution and try only one, or maybe few, approaches. Students are often not yet capable to judge the merits of their solution, or to criticize it.

By showing the students solutions and approaches of other students, you may take away the valuable lesson of either getting to the best solutions themselves, or of making mistakes (which often is a better way to learn than watching other people's mistakes).

Also, students may be less interested in watching other students' solutions than they are in watching their own.

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Therefore: show multiple solutions to the same problem that are comparable and differ in interesting ways. Discuss the strengths and weaknesses of them in comparison to each other.

Comparing student solutions is a good way of implementing USE STUDENT SOLUTIONS. The most simple implementation is to show two differing solutions side-by-side. Highlight the positive and (potentially) negative aspects of each (or have students name the strengths and weaknesses of the solutions themselves). Show how different approaches can come to different solutions, and how different solutions can come to the same solution, but in a more or less efficient way.

The solutions can also be used in a sequence, hereby highlighting and collecting the strengths and weaknesses of each solution and comparing these afterwards.

By applying this pattern, students gain insight in different styles of thinking about a problem. Seeing how other students approached and/or solved the problem can bring them towards a better understanding of the problem. In some cases, they will see better or more efficient solutions by other students, which will help them in getting to that solution the next time they try to solve a similar problem. In some cases, they will see solutions that are equally good as their own or that are of less quality or are less effective. This will help them to gain a better understanding of the quality of their own solutions, and it will help them recognizing, and preventing taking less successful paths in similar problems.

Students may feel the alternatives are being artificially demonstrated. This patterns should therefore not being over-applied.

An alternative for COMPARE SOLUTIONS is PEER FEEDBACK. Even though the students are exposed to different solutions (and possibly approaches) here too, this pattern lacks the advantage of being able to consciously choose didactically valuable solutions that help with overcoming known misconceptions and that show a variety of relevant approaches and solutions.

The problem that students may be less interested in watching other students' solutions than they are in watching their own can be counterbalanced by applying EVERY SOLUTIONS COUNTS.

As always when students' solutions are used, make sure to apply STUDENT CONTRIBUTION ESTEEM and optionally apply ANONYMIZE SOLUTIONS in the beginning when appropriate.

In the introductory programming course at HAN University of Applied Sciences, students start with simple programs written with the Processing[2] environment. One of the first assignments is to write a small program that prints the

[2] `http://processing.org`

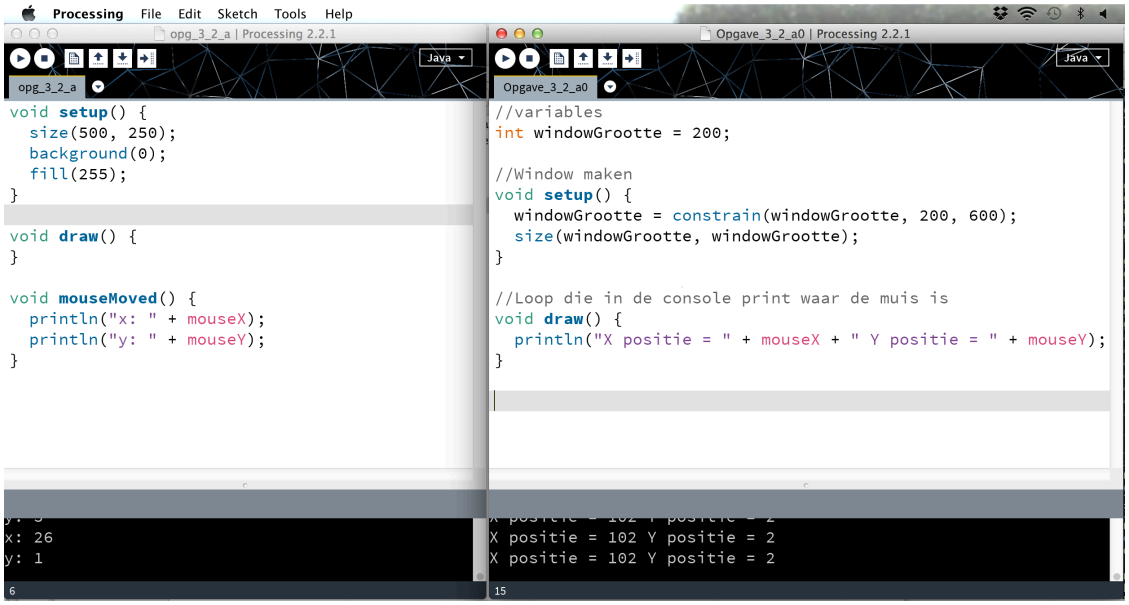

Fig. 4: Two student solutions that show both strengths and weaknesses (in comparison to each other) which were used for discussing the differences

coordinates of the mouse in the message area. In order to compare different ways of realizing this assignment, the students' solutions were chosen and presented to the class with the projector. Figure 4 shows how two different solutions were presented to the students and then were used for comparing and discussing the strengths and points for improvement of both, e.g. printing in draw() vs. printing in mouseMoved(), usage of comments and extra variables, or usage of the constrain()-method.

PATTERN: ADD VALUE BEYOND FEEDBACK

In a Flipped Classroom course, class-sessions are based on both course content (book chapters, lecture video's etc.) that students read or watched, and homework assignments that they've handed in prior to the session. An important activity during the session is reviewing a sample of handed-in assignments and discussing them (see USE STUDENT SOLUTIONS), with the teacher giving feedback based on the work by the students.

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If a class-session is spent primarily on giving students feedback on their individual homework, students might perceive the session as not very valuable, reducing both the effect of the session and their motivation to prepare diligently for coming sessions.

Whenever a teacher is discussing the work of a particular student, the rest of the class is likely to feel that the discussion does not apply to them. Oftentimes this feeling is correct to some degree, especially if the discussion focuses on an issue with the work that isn't present in the work of other students.

Many assignments will focus on having the student practice with some aspect of the subject of the lesson. This may result in assignments that test the student's grasp of the material (an example is the puzzle-nature of assignments in engineering subjects). Feedback on such assignments tends to focus on deciding the correctness of the work, sometimes giving advice on fixing problems. If most of the discussion is focused on deciding how well students grasp the course content, the opportunity is missed to use course content and homework as a stepping stone to more advanced aspects of the subject at hand.

When the discussion of student work is the backbone of the classroom session (an important tenet of the flipped classroom method), it's difficult to plan the session in advance in a detailed way (e.g. elaborate powerpoints are of no use). This may eliminate an important mental anchor for inexperienced lecturers (or lecturers who are less familiar with the subject matter than they'd like). In such a situation, one may be inclined to adhere closely to the backbone: just stick to giving feedback to homework. This results in some stiffness in the interaction between the lecturer and the student group.

In some fields of study (e.g. STEM education), homework assignments are often designed primarily to *test* whether the student has understood some theory (or is competent in some skill). This kind of testing is intended to discover failures of skill or understanding, and to train the student in problem solving. Assignments with such a testing-character, however, often do not provide interesting cues that may trigger discussion of new aspects, introduction of new knowledge, or the relaying of elucidating anecdotes.

When the assignment is nothing more than a test of the course content that was part of the required preparation, *and* the student solution under discussion is just a correct answer, it's difficult to make the feedback ("this is the correct answer") interesting for the whole group.

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Therefore: Interweave feedback with added value moments: mini-lectures with new knowledge, interesting demo's, anecdotes with examples from real-life, generalized wisdom etc.

USE STUDENT SOLUTIONS as a stepping stone to introduce new knowledge/viewpoints/generalisations that add to the preparation material (which is part of SUITABLE CONTENT SELECTION). Preferably connect the added value moments to an assignment that's being discussed.

Make sure to express appreciation to the student whose work is used as a motivation for the added value intermezzo as suggested in STUDENT CONTRIBUTION ESTEEM (especially if the intermezzo was triggered by a defect in the work).

Designers of a Flipped Classroom course can help by including assignments that provide cues for such added value moments (and documenting those cues). There is nothing wrong with the kind of testing assignments described above, and they can remain an important part of a Flipped Classroom program. But it will help to mix them with assignments

whose nature is more *exploratory*, *experimental*, or *reflective*. If one has made the students understand that the purpose of making the homework is not to prove competence, but to provide a basis for a dialogue in class, one can even give assignments whose sole purpose is to be a starting point for the introduction of new theory in class. One may pose an interesting problem, of describe a fascinating phenomena, and ask the students to speculate about a solution, meaning or hypothesis, which is a concrete application of STUDENT MINERS.

Other related patterns are LINKING OLD TO NEW and EXPAND THE KNOWN WORLD. ADD VALUE BEYOND FEEDBACK could be a special form of a STUDENT DRIVEN LECTURE. It is also a good combination of SUITABLE CONTENT SELECTION, SUITABLE DELIVERY FORM SELECTION, and IMAGINATION STIMULATION, which are foundational lecture design patterns.

In the programming course "Scripting for Designers" at HAN University of Applied Sciences, about two-thirds of the theory is treated in the video's that are part of the required preparation for each lesson. The other one-third is deliberately left for the classroom session itself. Some theory is best kept for last, in the sense that sudents will understand it better ***only after*** *they've invested some mental energy in thinking about it. Assignments have been designed to trigger the introduction of new knowledge. One simple example is the homework question: "Javascript programs run in the web browser. When, do you think, does a javascript program* ***stop*** *executing?". Students will give many different answers, many of them correct. This allows the lecturer to explain the event-driven execution model of the Javascript programming language, resulting in an elaborate diagram on the whiteboard that structures and relates many of students' answers, and also introduces some new ones. Note the clause "do you think" in the question. Students have been made aware that this clause means they're allowed to speculate.*

In the course "Object-Oriented Program Development" at HAN University of Applied Sciences, students have to find errors in their programs by first manually emulating their execution step-by-step and keeping track of the values of all variables. After they understood how this is done and how it can be used to identify errors, the lecturer gives a demo of the debugger (of the Eclipse workbench), which essentially realizes the same approach in an automated way. This way the students got a better understanding of how the debugger works.

5. CONCLUSION

In this paper we presented five patterns that help with improving the in-class meetings of Flipped Classrooms. We will continue collecting and describing more patterns that help with the design of valuable in-class meetings and other aspects of Flipped Classrooms with the goal of developing a pattern language for flipping the classroom.

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APPENDIX A

Pattern Candidates

Based on the results of the pattern mining workshops, the following pattern candidates were identified (given in alphabetical order). Please note: the ones highlighted in **bold** are described in this work.

Pattern Candidate Name	Summary
ACTIVE TEACHER (probably not specific for Flipped Classrooms)	Passively waiting on questions by students and relying on looking at (some of) the handed-in solutions in order to get grip on their progress is not sufficient. You as teacher have to actively keep track of where your students are in their learning process in order to support their learning the best possible way.
ADD VALUE BEYOND FEEDBACK	Interweave feedback with added value moments.
ADDITIONAL RESOURCES (unpublished)	Offer additional resources such as websites, articles, or extra exercises, to support students that have difficulties with acquiring the concepts with the standard material only.
ANONYMIZE SOLUTIONS (described in [Köppe et al. 2015a])	If you use student solutions during in-class meetings for discussing their shortcomings, then anonymize the first ones you use to emphasize that the focus is on the solution only. This way students will be less embarrassed.
BIRD'S EYE SUMMARY (described in [Köppe et al. 2015a])	Give a general overview of the strengths and weaknesses you identified in the students' solutions.
CHALLENGE ASSIGNMENTS	Offer additional assignments for students who had no trouble acquiring the concepts with the standard material in order to challenge them to go learn more.
COLLABORATIVE EDITING (described in [Köppe et al. 2015])	Use a tool which offers access to the same content for you and the students and collaboratively edit this content with the tool.
COMPARE SOLUTIONS	Show and discuss multiple solutions so that students learn to recognize the strengths and weaknesses of various approaches, including their own.
CONTROLLED PACING	Make an explicit planning per in-class meeting and handle strict deadlines.
DECENTRALIZED GROUP INSTRUCTION PER LEVEL	If groups emerge with different levels of content acquirement, give adjusted feedback and instructions per group in order to help all students the best possible way.
EVERY STUDENT SOLUTION COUNTS	Make sure that each student in the group—or most of them—will see his or her work being discussed every once in a while so that they see the relevance of it.
GENERALIZED FEEDBACK (described in [Köppe et al. 2015a])	Generalize issues of individual students when giving feedback on them so that the whole group can learn from them.
INDIVIDUAL SUPPORT	If students have specific problems with solving some of the assignments or acquiring certain knowledge parts, then give them individual support if possible.
PREPARATION BUFFER	Offer enough time between in-class meetings for students' preparation.
PREPARATION REWARD	Making the preparations should be of value for the students. Such rewards can range from letting them feel that they learned something to making the preparations part of the grade.
PREPARATION STATUS AWARENESS	Show the students (publicly) that you are aware of the status of their preparations in order to encourage them be prepared each meeting and to avoid negative group dynamics such as "no one else did it, so why should I?".
REPAIR IT YOURSELF	Let students correct their wrong or incorrect solutions, so that they understand better how to do it right.
SCREENCASTS	Present the content in short videos which students can watch repeatedly and in their own pace.
SOLUTION VARIETY (described in [Köppe et al. 2015a])	Use multiple student solutions that differ in approach or contain different solution directions for discussing the variety of important aspects of the concepts to be learned.
STUDENT CONTRIBUTION ESTEEM (described in [Köppe et al. 2015a])	Thank students when you use their solution in class as example or as trigger for discussions.
USE STUDENT SOLUTIONS	Use the work students have handed in as examples in class.
WORKING ENVIRONMENT GUARANTEED (not specific for Flipped Classrooms)	If an environment is required for preparations where getting it working might impose problems, Have students install it during an in-class meeting so that problems immediately can be solved.

Table II. : Pattern candidates identified in the pattern mining workshops

APPENDIX B

Existing patterns applicable for in-class meetings in flipped classrooms

The following patterns are either directly applicable for in-class meetings or are related to patterns that are applicable. The list is partly derived from [Köppe 2013] and the patterns are described in alphabetical order.

Pattern Name	Summary
ACQUAINTANCE EXAMPLES [Anthony 1996]	Choose examples the students are familiar with, but which are not within the area of students' expertise.
ACTIVE STUDENT [Pedagogical Patterns Editorial Board 2012]	Students should be actively working with and on the topic.
BUILD AND MAINTAIN CONFIDENCE [Pedagogical Patterns Editorial Board 2012]	Give students problems they have to solve and help them through questions and hints, so that they recognize that there are few possible solutions and the they're able to find one of them.
CHALLENGE UNDERSTANDING [Pedagogical Patterns Editorial Board 2012]	Give the students exercises, tasks or activities that challenge their understanding so that they can identify gaps in their knowledge.
COLLABORATIVE SUMMARY [Köppe and Schalken-Pinkster 2013a]	Start with summarizing content covered in the previous or earlier lectures. Let the students come up with the elements of the summary and write it down on a visible place like a whiteboard, a projected text document etc.
DIFFERENT APPROACHES [Pedagogical Patterns Editorial Board 2012]	Provide different approaches to the same topic.
EMBRACE CORRECTION [Pedagogical Patterns Editorial Board 2012]	Give the students the chance to improve their artifacts, as it is almost impossible to get it right the first time and they can learn a lot by revising their artifacts.
EXPAND THE KNOWN WORLD [Pedagogical Patterns Editorial Board 2012]	Introduce concepts by explicitly linking them to experiences that you know the students already have.
FLASH QUIZ	todo (in assessment patterns EduPLoP15).
GOLD STAR [Pedagogical Patterns Editorial Board 2012]	Praise students publicly when they are doing well, e.g. by sharing their thoughts with the group or asking good questions.
HONOR QUESTIONS [Pedagogical Patterns Editorial Board 2012]	Motivate the students to ask questions, show them that you value this and that there are no stupid questions.
IMAGINATION STIMULATION [Köppe and Schalken-Pinkster 2013b]	Add activities to a lecture and use delivery forms and contents that stimulate the students' imagination.
LATE ATTENDANT DISCOURAGEMENT [Köppe and Portier 2014]	Create a playful intervention that discourages attendants to be late.
MAKE IT THEIR PROBLEM [Schmolitzky 2007]	Let the students first solve a problem and then direct you to realize the solution visible to all.
MINIMUM DISTANCE [Larson et al. 2008]	Close the physical separation between you and the students by moving around in the room.
MISCONCEPTION ASSESSMENT [Bergin et al. 2015]	Assess for possible misconceptions of key concepts in a timely manner so that they can be corrected fast.
ONE CONCEPT - SEVERAL IMPLEMENTATIONS [Pedagogical Patterns Editorial Board 2012]	Use different implementations as examples of one abstract concept and compare them afterwards to re-discover the abstract concept as essence.
PEER FEEDBACK [Pedagogical Patterns Editorial Board 2012]	Invite students to evaluate the artifacts of their peers.
PREPARATION MATERIAL CHECK [Köppe and Portier 2014]	Establish some check (incl. consequences) that the students have studied the required preparation material.
REFERENCE THE PLAN [Fricke and Völter 2000]	Let the students know the overall planning, where the current session is located in it and what the required preparations for the next in-class meetings are.
SEMINAR PLAN [Fricke and Völter 2000]	Make an explicit planning for the course, the preparatory assignments and the content of the in-class meetings.

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Table III – continued from previous page

Pattern Name	Summary
SOLUTION BEFORE ABSTRACTION [Pedagogical Patterns Editorial Board 2012]	Let the students first find solutions to specific concept-related problems, have them identify the common aspects of these solutions, and use these identified aspects to introduce the general, abstract concept.
SUITABLE CONTENT SELECTION [Köppe and Schalken-Pinkster 2013b]	Ensure that mainly content is selected and delivered that fits lectures as form of content delivery for the learning goals.
SUITABLE DELIVERY FORM SELECTION [Köppe and Schalken-Pinkster 2013b]	Explore different delivery forms and select the valuable ones for your lecture design so that the students are engaged and that the delivery forms fit the content.
STUDENT MINERS [Köppe and Schalken-Pinkster 2013a]	Introduce the concept through questions that are related to existing knowledge and lead towards the new concept; don't present the concept yourself directly. Let multiple students provide a variety of answers to these questions and lead the group through follow-up questions towards the new concept. Mine the new concept from all answers together with all students.

Table III. : Patterns that are relevant for Flipped Classrooms