Flipped Classroom Patterns - Controlling the Pace

CHRISTIAN KÖPPE, RALPH NIELS, RENÉ BAKKER and STIJN HOPPENBROUWERS
HAN University of Applied Sciences, Arnhem/Nijmegen, Netherlands

During the execution of a flipped classroom course, chances increase students are not at the level scheduled in the initial planning with some students falling behind with their knowledge acquisition and others running ahead. In those cases, adding value during the in-class meetings is much harder for teachers, as they have to take care of all the different knowledge levels. A good way of addressing this problem is to control the learning pace of the group. As a result, the knowledge level of the group will be more homogeneous which makes it easier to add value during the in-class meetings. In previous work we described the pattern CONTROLLING THE PACE. This pattern mainly addresses the course planning, but there are more aspects that need to be taken into account. In this paper we propose five patterns based on our experience that can help teachers to control the pace of student's learning in various aspects.

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1. INTRODUCTION

Bergmann and Sams made popular the flipped classroom approach to teaching with the release of their book *Flip Your Classroom* [Bergmann and Sams 2012]. A flipped (or inverted) classroom is different from traditional lecture design as instruction and introduction of learning materials are moved outside of the class. By watching explanatory videos, reading supplementary material, and making assignments, the students acquire content in their own time, before the in-class meetings. The in-class meetings, or lectures, are used for deepening the understanding of the content and better supporting the students with learning. Instead of following presentations on new material, the students will receive feedback on their home assignments, and work, alone or collaboratively, on deepening assignments. The teacher hereby is mainly available for questions and assistance in further inquiry, but also can give occasional mini lectures if needed, in order to correct misconceptions or improve deeper understanding.

Authors addresses: {christian.koppe,ralph.niels,rene.bakker,stijn.hoppenbrouwers}@han.nl
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Many schools have introduced flipped or inverted classrooms in learning and reports of small scale case studies show positive effects on learning outcomes (e.g. [Decker and Beier 2014; Handke 2014]). In 2012, we introduced flipped classes in our freshman programming courses [van Diepen et al. 2015]. Important drivers were:

—staff complaints of poor programming skills of 2nd year students,

—promising case studies on flipped classrooms, and

—promising results of flipped classroom in a 4th year course (illustrated by a student quote “I’ve never learned more than in this course, but I also never worked that hard").

Two programming courses with annually 10 classes, each of about 30 students, have been flipped. Students study a video, complete exercises at home, and submit their work in advance of each lecture. In the first hour of each lecture, feedback is given on their assignments. To enforce a disciplinary working attitude, only students who have submitted their homework are allowed to attend this part, the others use this time to do the preparations nonetheless. The remaining time is spent on deepening theory and practice. Finally the next online video’s and assignments are introduced. The results are positive in student and staff evaluations and, maybe more relevant, staff are now satisfied on the programming skills of 2nd year students.

Teaching staff for the 1st year programming courses frequently change due to personal interest and management policy. For staff learning to work in a flipped classroom, the course teams with 10 or more staff members per course, organize frequent intervision meetings. Additionally, in 2015 we started to support staff with good practices in the form of Flipped Classroom patterns for teachers who were included in the teacher’s guides of the flipped courses.

The Flipped Classroom patterns were initially derived in two pattern mining workshops. We collected user stories and best practices with groups of lecturers who have given a Flipped Classroom course at least once. These stories and practices formed the base for a collection of pattern candidates (or proto-patterns). We selected pattern candidates based on their relevance for supporting various aspects of the in-class meetings in a flipped classroom setting. These were further elaborated and all relevant pattern parts—context, problem, forces, solution, implementation details, and consequences—were identified in an iterative approach with various rounds of writing and reviewing. All patterns were then further validated through peer feedback from experts during writers’ workshops at various conferences in the Pattern Languages of Programs (PLoP) conference series[1].

In previous work we focused on patterns for improving the in-class meetings [Köppe et al. 2015a] and patterns for making good use of student solutions [Köppe et al. 2015b]. A summary of these patterns and other referenced and relevant patterns is given in the appendix.

2. FOCUS OF THIS WORK

In this work we introduce five student-centered patterns that are intended to help with controlling the pace of students’ learning in a flipped classroom course. A controlled pace is important in order to ensure that the majority of the students is more or less at the same knowledge level at all moments of the course, especially in educational systems where a course has a fixed time span and fixed learning objectives. In that case, the in-class meetings can offer the most value to most of the students.

The teacher should be aware of where the students are with their knowledge level during the whole course execution, which includes PREPARATION STATUS AWARENESS. For the students who run behind, some ADDITIONAL RESOURCES should be provided to support them further than what can be done with normal teacher activities. Determining these resources is part of the initial course design. If the ADDITIONAL RESOURCES are not sufficient or students have specific problems with knowledge acquisition, then they can also be given INDIVIDUAL SUPPORT. If groups of students have problems with certain concepts, then it might be more efficient to give DECENTRALIZED GROUP INSTRUCTION PER LEVEL. Provide CHALLENGE ASSIGNMENTS for students who might run ahead of the schedule so that they can continue with activities at the same knowledge level (but in a broader or more complex context) as all other students. Determining

[1] http://www.hillside.net/conferences

such CHALLENGE ASSIGNMENTS can be part of the initial course design, but can also be done ad-hoc in cooperation with the students. An overview of the patterns proposed in this work is given in table I.

Pattern Name	SUMMARY
PREPARATION STATUS AWARENESS	Show the students (publicly) that you are aware of the status of their preparations in order to encourage them to be prepared each meeting and to avoid negative group dynamics such as “no one else did it, so why should I?".
ADDITIONAL RESOURCES	Provide additional resources for learning to the students who have trouble with grasping all concepts based on the standard material only.
CHALLENGE ASSIGNMENTS	Provide extra assignments that do not require new knowledge but a more complex or broader application of the existing knowledge as challenge for the better students.
INDIVIDUAL SUPPORT	Give students individual support if they have specific problems with solving some of the assignments or acquiring certain knowledge parts.
DECENTRALIZED GROUP INSTRUCTION PER LEVEL	If groups emerge with different levels of content acquisition, give adjusted feedback and instructions per group in order to help all students the best possible way.

Table I. : proposed patterns

The introduced patterns are not the only ones necessary for reaching the goal of controlled pace, they should be combined with other patterns. These related patterns and the kinds of relations are described in the patterns themselves (a summary of them is given in the appendix). In future work, we also will provide an overview of all patterns and their relations and work towards workable scenarios—combinations of patterns in a given context.

Please note that the proposed patterns are likely to be applicable in regular classes and other educational settings too with only minor adjustments. However, we decided to keep the scope on flipped classroom courses in this work because in such a setting the patterns add the most value. The larger goal is to work towards a coherent pattern language for flipping the classroom. These patterns have been mined in computer science courses and their applicability in other domains also still needs to be validated.

3. THE PATTERNS

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*.

3.1 PATTERN: PREPARATION STATUS AWARENESS

Your course is running. You're doing a PREPARATION MATERIAL CHECK before each in-class meeting and observe that differences in the level of preparations start to emerge.

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Over time, students become less and less motivated to prepare for class. This leads to an increase of differences in knowledge levels at the start of the next class which in consequence makes it harder to offer valuable in-class meetings to all students.

In many student classes, group dynamics can make statements like "no one else did the homework, so why should I do it?" emerge.

And even if students see that other students prepared for class, they might become less motivated to do it themselves if they have the feeling that no one cares about whether they prepared or not. This is especially true for students who only recently started their higher education, and are still discovering what learning consists of and what their responsibilities are.

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Therefore: Show the students (publicly) that you are aware of the status of their preparations in order to encourage them to prepare each meeting. Appreciate the ones that are on schedule and encourage the ones that run behind.

The most straightforward way of keeping track of the students' status is by having a table with all students in one dimension and all required preparations—handed in homework, solved quizzes etc.—in the other dimension, and the status of the preparation in the cells, such as can be see in Figure 1. This table needs to be maintained, which requires some additional effort, but can easily be used for showing the status awareness, either to the individual student or the whole group.

A variant of the solution is to quickly let students know that the handed-in preparation was received, e.g. by sending a short reply with "Thank you for handing in your work.". This way the students also know that the teacher is aware of their preparations, even though there won't be a complete overview as with the table. This approach takes more time to apply, especially with larger groups. If not much time is available, it might still be valuable to at least occasionally reply to students, preferably at least once for all students.

Showing students that you are aware of their preparation status clearly communicates that you do care about their learning, which is motivating for them.

However, some students might feel offended or be embarrassed when they haven't made all preparations and their preparation status is publicly exposed (as on a "wall of shame"). This is especially true if the students have good reasons for it like illness or if they tried to make the preparations and got stuck. In that case it should explicitly *not* be used for blaming the students, but rather for asking them why they haven't made the preparations and how you as a teacher can help them. As the goal is to encourage the students to prepare for each meeting, the emphasis should be primarily on the students who have prepared by giving them positive feedback and recognition. It should furthermore be emphasized that by doing the preparations for class the students learn the most and increase the chance of passing the course with a good grade.

If necessary, such a list as shown in Figure 1 could be semi-anonymized by showing only student IDs or (self-chosen) acronyms instead of full names.

This pattern is related to EVERY STUDENT SOLUTION COUNTS, in which the teacher makes sure that preparations of all students are used as an example every once in a while.

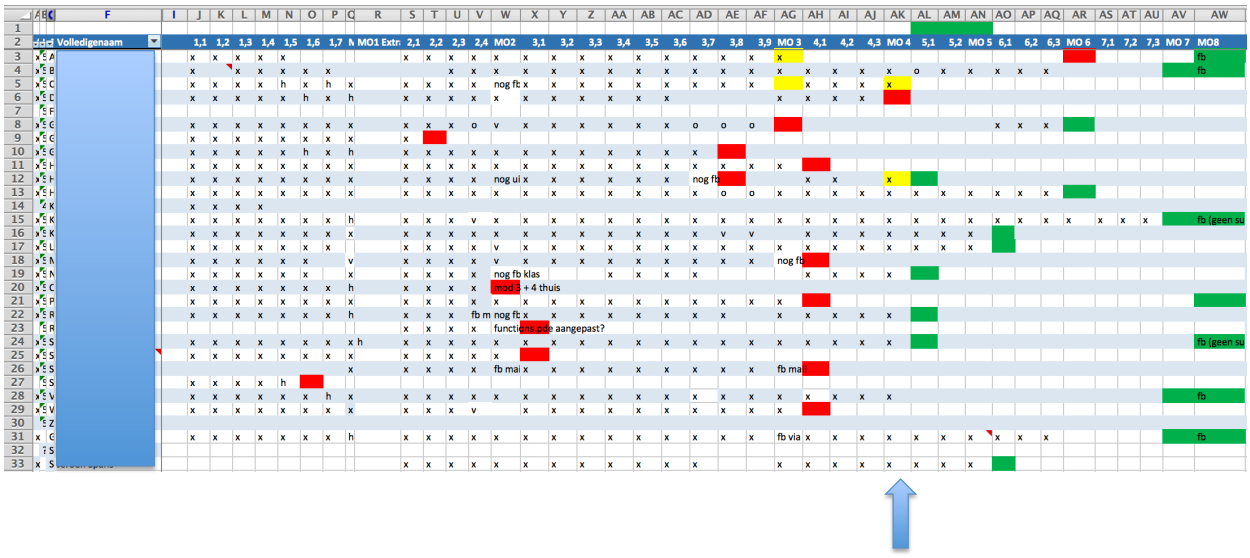

Fig. 1: Example Excel sheet with preparation status per student, the arrow indicates where students should be at the moment

In the course on Object-Oriented Program Development at HAN University, the students had to send their preparations by email prior to class. At the beginning of each in-class meeting, the lecturer opened the mailbox and scanned through all received emails, hereby also identifying the students who haven't handed in their work directly.

Another example application of this pattern is a spread-sheet from a lecturer that shows the status of delivered homework and also indicates who's running behind and who is on scheme (even made more explicit by the use of traffic light colors green, yellow and red). The arrow in Figure 1 indicates the moment of the course, also making clear where students are expected to be according to the schedule.

3.2 PATTERN: ADDITIONAL RESOURCES

The standard course materials which students use for preparing outside of class is ready. You are CONTROLLING THE PACE through a schedule.

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Some students do not sufficiently grasp the concepts based on the standard course material. They will likely start to run behind schedule, which makes helping them during the in-class meetings much harder and more time consuming.

Often, the material students are supposed to learn is offered to them in a particular way: the one that the teacher or the developer of the course has designed. Usually it is the standard way of a teacher explaining the matter in a video-lecture, followed by a number of pre-selected assignments, and a book or reader for reference. In most cases, however, there is just one way in which the students are offered the matter. Although this approach may work for the majority of students in a class, some of the students may benefit from another approach—one size simply does not fit all.

On the other hand, presenting the same material using different approaches that cover different preferences of learning might also be an option. For example, one might choose to have the material explained in a video, described in a reader, and followed by a discussion assignment in which the material is explained again. Although this may offer at least one fitting approach for most students, chances are that students (especially the better ones) get frustrated or bored by hearing the same story over and over again: if they have grasped a concept they want to move on to the next one instead of having to keep repeating the same thing (also described in JUST ENOUGH PRACTICE [Inventado and Scupelli 2015]).

A third approach might be to leave the students to choose their own way of retrieving the material, and letting them choose their own speed. Although this would prevent the better students from getting bored, and would offer the slower students the chance for extra practice, it would make it hard for the teacher to answer questions in a plenary way, and would make it hard or even impossible to give lectures, because for the slower students the lecture would be offered too soon, while for the faster students, it would be too late.

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Therefore: Provide optional additional resources for the same concepts as learning support to these students having trouble grasping the concepts based on the standard material only.

Such additional resources could be textbooks or sections of textbooks, websites, videos, or blogs, but also extra exercises, quizzes, or tutors. Another very valuable resource is peer support—having another student explaining it again to the student or students who have trouble with grasping the concepts. This benefits both students and could also be a CHALLENGE ASSIGNMENT for the explaining student.

Additional resources should not introduce new concepts, but only cover the same concepts as addressed in the standard material. They hereby offer a new perspective or approach to introducing the concepts again. Another option is to provide more exercises for practicing the application of the concepts more broadly. In some cases, these additional resources can even refer to earlier material that covers concepts whose understanding is necessary for learning the currently covered concepts. In any case, the additional resources should be clearly provided in an optional way, it might even be helpful to not include links to them in the standard material but only supply them when necessary. This way the students who learn sufficiently from the standard material won't be disturbed by the additional resources.

These resources can be instructor-provided or crowd-provided. The first case requires that the instructor already determines during course design which resources could be used for what concepts and when to offer them to the slower students. This determination should ideally be based on experiences from previous executions of the course. If the course is given for the first time, then the literature or general experience with teaching the concepts of the course (non-flipped) can be used as base for identifying threshold concepts and for determining appropriate additional resources. The resources can also be crowd-provided, they are collaboratively collected and shared, e.g. in a special section of the

course's digital learning environment or a course mailing list. However, this requires careful supervision of the instructor, as some of the resources might not be appropriate or might not be conform with the standard material.

In general, if additional resources are provided, students who run behind can acquire the concepts better and in their own time. By making these resources additional and optional, the better students who grasped the concepts already can easily skip them.

If such additional resources are offered, it is harder keep track of what a student exactly used for learning and how she understood the explanations provided by these resources. It therefore is necessary to be a CONSIDERATE LECTURER and also to make use of MISCONCEPTION ASSESSMENTS.

In some cases, students don't recognize by themselves that they need these additional resources, so the instructor should show them that they do.

In the course Structured Program Development (SPD) at HAN University, students who have some problems with gathering all concepts based on the standard material only are offered some more resources: an introductory programming course with the related concepts on the Pluralsight[2] *platform and a link to the website* `www.codingbat.com` *which offers additional exercises on concepts such as arrays and loops.*

For both programming courses, we offer students the help of senior students: twice a week, one or more senior students are available for two hours to offer additional explanation or help with assignments. Students of the two courses can come to these sessions without having to sign up.

[2] `https://app.pluralsight.com/library/courses/java-fundamentals-language/table-of-contents`

3.3 PATTERN: CHALLENGE ASSIGNMENTS

The standard course material that students use for preparing outside of class is ready and well-designed. You're CONTROLLING THE PACE through a schedule and keep track of the levels of conceptual understanding of the students, e.g. as part of PREPARATION STATUS AWARENESS.

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It is hard to provide valuable in-class meetings for all students if some of them already grasped the concepts of the current level and want to run ahead of the schedule, and to learn the upcoming concepts of the course.

The more diverse the knowledge level of the students in a group, the more specific group feedback they require per level. This in consequence takes additional time, which is hard to allocate.

The better students, who are running ahead, might become bored and eventually demotivated to continue working for the course. The same goes for the more experienced students with pre-knowledge.

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Therefore: Provide optional extra assignments that do not introduce new concepts, but a more complex or deeper application of the existing concepts as challenge for the better students.

Intellectual excitement is a strong motivator for the students who want to learn and not only want to pass the course. Such excitement can be stimulated through optional assignments that go beyond the standard assignment without requiring new concepts. These assignments should differ from the standard ones, as students who are faced with exercises on the same level as one they have mastered already become bored and frustrated (see also JUST ENOUGH PRACTICE [Inventado and Scupelli 2015]).

There are various ways for setting up such challenge assignments:

—Extensions of other assignments, such as making the number of players for a card game flexible instead of fixed.

—Variants of other assignments, such as replacing a car traffic simulation with a train simulation, which has lots of similarities but also distinct features.

—New assignments (either teacher-defined or student-defined) that require the application of the same concepts in a new or more complex way, such as a game they like and want to develop themselves (and the implementation of such game can be realized with the already known concepts).

—The assignment could even be to support peers by explaining concepts to them they haven't understood enough yet or to design assignments for other students.

Students who want to learn (as opposed to just wanting to pass the course) will be happy to be offered opportunities to apply their knowledge in a broader context and to work on challenging assignments that trigger their intellectual excitement.

However, as these assignments are optional, some students may still prefer to move on with the course instead of applying the already known concepts again. Especially beginning students who are often less intrinsically motivated might find it hard to recognize the added value of such challenge assignments.

In the course Structured Program Development (SPD) at HAN University, the work book contains assignments that are more complex than the obligatory exercises, but do not require the application of new concepts. A concrete example is an exercise where a small program is given that calculates all prime numbers between two given values. The concepts introduced earlier was functional decomposition, so the students had to decompose the program into smaller chunks of reusable functionality.

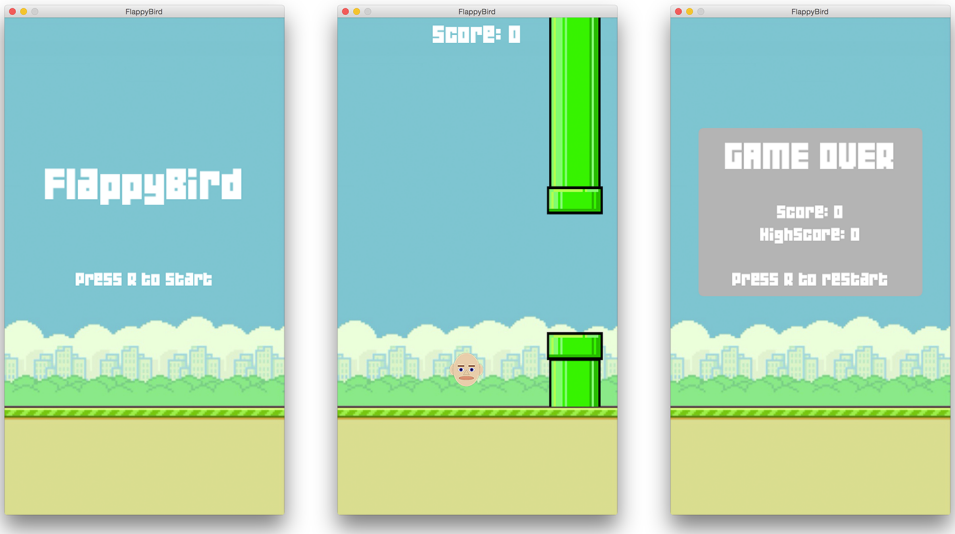

Fig. 2: FlappyBird implementation - example of a challenge assignment for an introductory programming course

In Embedded Software Development (ESD), another first year course at HAN University in which a light weight version of flipped classroom is used, the introduction of state machines can be combined with the previous subject of using the I^2C-protocol in a new assignment in which the I^2C-protocol is used in a state machine.

Alternatively teachers challenge better students to develop a program of their own choice such as a (simple) game they like. An example, shown in Figure 2, is an implementation of the famous “Flappy Birds" game, developed in the Processing[3] *environment using only basic programming constructs and no object-orientation.*

[3] `https://processing.org`

3.4 PATTERN: INDIVIDUAL SUPPORT

The course is running and some students start to fall behind the schedule with knowledge acquisition. The provided ADDITIONAL RESOURCES are not sufficient for helping these students.

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Addressing the needs of all students with general activities becomes increasingly difficult if the gap between the expected knowledge of some students and their actual knowledge is growing.

Students have different ways of learning. They are dependent on the provided material: the way it explains the concepts, how it motivates them to elaborate on the matter themselves, the exercises provided for practicing and applying the concepts as well as deepening their understanding, et cetera. Setting up material that fits all students is hard.

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Therefore: Give students individual support for a short period if they have specific problems with solving certain assignments or acquiring certain knowledge parts in order to bring them back on track.

This pattern is a follow up on CONSIDERATE LECTURER. When you find out that a student has problems with a concept, help her or him individually for a short period by giving tips on how to continue or by explaining a concept again.

This help does not necessarily need to be provided face-to-face by the teacher, but can also be given in other ways: through a forum in a learning environment, through the usage of teaching assistants, or even by asking more experienced students to help less experienced ones (making them ADDITIONAL RESOURCES too).

By giving individual support, the students have a higher chance of grasping the concepts and therefore keeping on track with the course schedule. This is therefore also helpful with CONTROLLING THE PACE.

However, providing such individual support requires more time, requires knowledge of where the students struggle with (PREPARATION STATUS AWARENESS can help here) and is not easy to apply because you as teacher have to constantly adjust your support for the individual student and her problems. This means that a standard SEMINAR PLAN does not work, it needs to be determined ad-hoc during the execution of the course. It is also very unlikely that you have enough time to give INDIVIDUAL SUPPORT to larger numbers of students. Applying DECENTRALIZED GROUP INSTRUCTION PER LEVEL might help in this case.

For both introductory programming courses at HAN University, the in-class meetings are scheduled for three times a week and three hours each. This gives the lecturers enough time for some face-to-face support of individual students.

Additionally, for both programming courses, we offer students the individual support given by senior students: twice a week, one or more senior students are available for two hours to offer additional explanation or help with assignments. Students of the two courses can come to these sessions without having to sign up.

3.5 PATTERN: DECENTRALIZED GROUP INSTRUCTION PER LEVEL

Your course is running for a while, and differences in the level of concept acquisition start to emerge. Your available time for the in-class meetings is still limited.

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A general group instruction does not work anymore if there are student groups with different levels of concept acquisition and there is not enough time to help all individual students.

Giving INDIVIDUAL SUPPORT to many students is scalable to only a limited degree. On the other hand, continuing with giving instructions to the whole group might seem more efficient, but some students won't be able to follow and the value of the in-class meetings for these students will be low.

On the other end of the spectrum, students who are ahead of schedule or have less trouble with understanding the subject, might get bored.

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Therefore: Give adjusted feedback and instructions for smaller groups of students with the same level of concept acquisition, in order to help all students the best possible way.

This adjusted feedback and instructions could be an ad-hoc mini lecture on a concept, a discussion of some additional examples, or a step-by-step execution of a process. This is done with a sub-group of students who all are more or less on the same knowledge level. Such group can be identified when one applies CONSIDERATE LECTURER, USE STUDENT SOLUTIONS, and PREPARATION STATUS AWARENESS. Make sure that this instruction is open to all students, so that all students can benefit from this extra effort.

Applying this pattern is more efficient than INDIVIDUAL SUPPORT, as the feedback and instructions are of value for a larger group of students and not individual ones. Also, students can learn from questions asked by fellow students and by co-operatively working on a (small) assignment.

During execution of the course, but especially in the later phases when the knowledge levels of the students tend to become more varied, one should consciously think about applying DECENTRALIZED GROUP INSTRUCTION PER LEVEL as part of the LECTURE STRUCTURING.

This pattern helps with improving the effectiveness and efficiency of the in-class meetings by providing more value to more students.

However, preparing such group instruction requires extra time for preparation. It also requires that the teacher has a very good grip on the students' progress, which is a skill that needs to be learned and not often comes natural to beginning teachers.

In the course Structured Program Development at HAN University, at the moment when functions with parameters are introduced, some students grasp it easily, while others struggle with getting the concept of parameters and all issues related with that, such as pass-by-value versus pass-by-reference. At this moment of the course, the lecturer prepared a small extra instruction with some additional examples for the students in the group who still have problems with grasping parameters. As all students in this group were struggling with parameters, they also dared to ask more questions than they would have in the whole group.

4. CONCLUSION

In this paper, we presented five patterns that help with addressing the important aspect of a controlled pace in a Flipped Classroom course. The patterns are most valuable when applied in combination with other patterns for Flipped Classrooms and educational patterns in general. These related patterns are partially mentioned in the pattern descriptions themselves.

However, in order to help with getting the most value out of the presented patterns, we intend to work towards a pattern language and the provision of pattern-based educational scenarios in future work.

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APPENDIX A

Table II provides a summary of all earlier described flipped classroom patterns and all other referenced patterns.

Pattern Name	Summary
ADD VALUE BEYOND FEEDBACK [Köppe et al. 2015a]	Interweave feedback with added value moments.
ANONYMIZE SOLUTIONS [Köppe et al. 2015b]	If you use bad student solutions during in-class meetings for discussing their shortcomings, then initially anonymize them, so that the students won't be embarrassed and the focus is on the solution only.
BIRD'S EYE SUMMARY [Köppe et al. 2015b]	Give a general overview of the strengths and weaknesses you identified in the students' solutions.
COLLABORATIVE EDITING [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 [Köppe et al. 2015a]	Show and discuss multiple solutions so that students learn to recognize the strengths and weaknesses of various approaches, including their own.
CONSIDERATE LECTURER [Köppe et al. 2015]	Pro-actively ask students on their progress, observe how they perform and react on what you observe in a constructive manner.
CONTROLLED PACING [Köppe et al. 2015a]	Make an explicit planning per in-class meeting and handle strict deadlines.
EVERY STUDENT SOLUTION COUNTS [Köppe et al. 2015a]	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 [Köppe et al. 2015b]	Generalize issues of individual students when giving feedback on them so that the whole group can learn from them.
LECTURE STRUCTURING [Köppe and Schalken-Pinkster 2013]	Investigate and design the optimal flow of the contents and delivery forms of a lecture.
MISCONCEPTION ASSESSMENT [Bergin et al. 2016]	Assess for possible misconceptions of key concepts in a timely manner so that they can be corrected fast.
PREPARATION MATERIAL CHECK [Köppe and Portier 2014]	Establish some check (incl. consequences) that the students have studied the required preparation material.
SOLUTION BEFORE ABSTRACTION [Bergin et al. 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.
SOLUTION VARIETY [Köppe et al. 2015b]	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 [Köppe et al. 2015b]	Thank students when you use their solution in class as example or as trigger for discussions.
USE STUDENT SOLUTIONS [Köppe et al. 2015a]	Use the work students have handed in as examples in class.

Table II. : Patterns that are relevant for Flipped Classrooms