The Reinforcement Pedagogical Pattern for Industrial Training

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Abstract

Industrial training imposes some unique restrictions on pedagogical methods, both in terms of ascertaining retention, fostering class participation, and reinforcement. The Reinforcement pedagogical pattern has now been used successfully in training courses and workshops at Siemens AG with positive results. This brief paper describing the Reinforcement pattern explains the rationale for the pattern and its use. Finally our experience of using the pattern in teaching foundation and advanced requirements engineering courses are described.

1. Introduction

In a paper at the 16th IEEE International Requirements Engineering Conference (RE08), we reported on a survey given to over 200 Siemens professionals who have taken the foundation course in requirements engineering [1]. However, in that paper we did not describe any of the restrictions imposed by the global nature of Siemens or the dynamics of industrial training. In this brief paper, we describe the *Reinforcement* pedagogical pattern (not to be confused with the *Positive/Negative Reinforcement* pattern [2]). It was empirically derived through trial and error to overcome the difficulties of teaching courses worldwide to professionals, some of them quite senior, in a compressed timeframe.

Pedagogical educational patterns are well known [3]. Our pattern uses some of the suggestions in the *Seminars Pattern Language* presented in the paper by Fricke and Völter [4]. The remainder of this paper follows the structure for describing pedagogical patterns presented by the Pedagogical Patterns Organization [5], followed by conclusions. The *Reinforcement* pattern introduced in this paper consists of sets of concepts that include definitions, examples, and short class exercises organized in units and modules. The structure of the pattern is described in detail in section 5.

2. Problems/Issues

There are several problems we encountered teaching courses to Siemens professionals. We believe these issues would apply not only industrially, but also to accelerated academic programs. Seminars, workshops, and other programs, such as MBA courses for professionals, could potentially benefit from use of this pattern.

2.1. Unable to determine comprehension through traditional methods

In a traditional classroom setting, quizzes, tests, and calling on students can be used to ascertain comprehension of the material. These techniques are not feasible in an industrial setting for several reasons. First, there is no time to give examinations. Second, the participants would rebel, and the instructors might face disciplinary action. Finally, there is the real possibility of causing embarrassment; managers take courses with their subordinates, so asking managers questions they cannot answer in the presence of their subordinates might create an unpleasant situation.

For example, during one industrial RE training session, we asked for volunteers to provide requirements specifications that the class would review together. One brave soul volunteered a specification, and, upon randomly displaying a page on the screen, the entire class burst out laughing, since the material was in flagrant violation of some of the principles that had been taught in the course. The volunteer then suggested this page was a bad example, picked another section of the document, resulting in even greater laughter. Finally, the manager that had brought the authors in to teach the course volunteered a specification, and of course, there was a repeat of the previous laughter. Luckily for us the volunteers were in good humor, or that might have been the last time we taught at that facility. We have found that when dealing with professionals, one must be very careful not to put them in a position where they could be inadvertently embarrassed.

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2.2. No immediate feedback available

Unlike a traditional setting where a delay of a day or two is acceptable, e.g., give a homework assignment and review it, in short courses feedback must be immediate. The material taught is complex, but attendees may not ask questions for fear of being embarrassed. The problem of passivity is especially important for Siemens, as we teach our courses in many countries, including some where an audience tends to be extremely reserved.

2.3. The material may be difficult to understand

Requirements engineering material can be complex and difficult to comprehend [6][7]. Since an understanding of fundamentals is a prerequisite for understanding the more complex material, reinforcement is necessary for retention.

3. Audience/Context

The *Reinforcement* pattern applies whenever complex material must be taught in a relatively short period of time, the instructor must have a near instantaneous measure of student comprehension, and there may be cultural issues of passivity and organizational issues associated with instructing senior professionals.

4. Forces

Forces in industrial training are organizational, temporal, and professional. Organizational issues include first and foremost a perceived need for the training. Unlike the academic setting where students are required to take courses to receive their degree, professionals are motivated by the need to learn. Consequently, any course should be perceived as providing real skill improvement.

Course attendees cannot spare a great deal of time to participate in a course. As such, the courses must be completed quickly, usually in no more than a week, and even that may be too long a period of time. We have found that two to three days is optimal when courses are given at a central facility. When courses are given at the students' facility, up to a week may be feasible. The short duration presents a problem that the *Reinforcement* pattern mitigates. That is, retention of subject matter by the students is optimized through immediate and repeated reinforcement with examples and class and team exercises.

An industrial training class would not survive long if it included significant embarrassment or humiliation of students. In the movie The Paper Chase, Professor

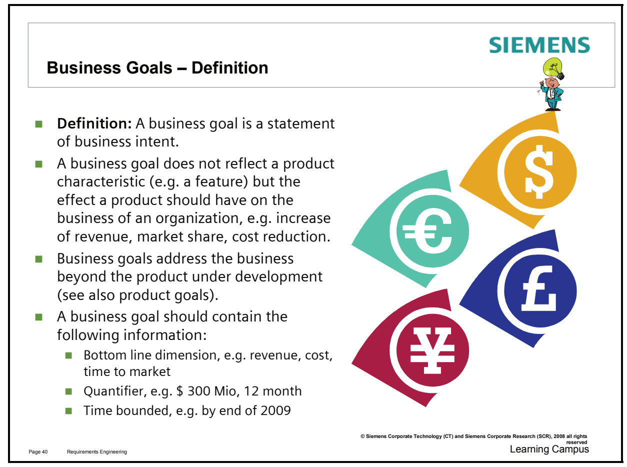

Figure 1. Concept Slide

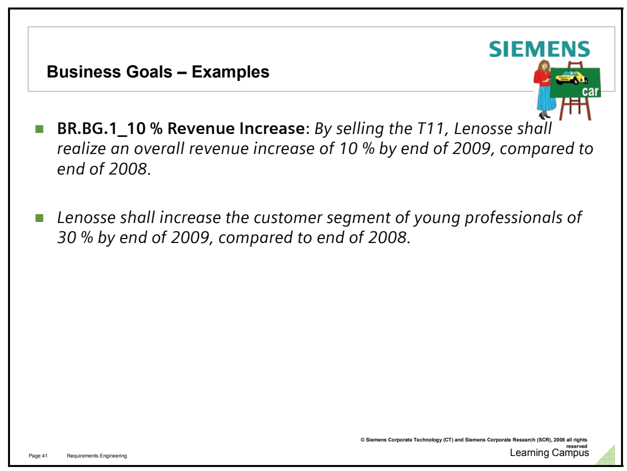

Figure 2. Example Slide

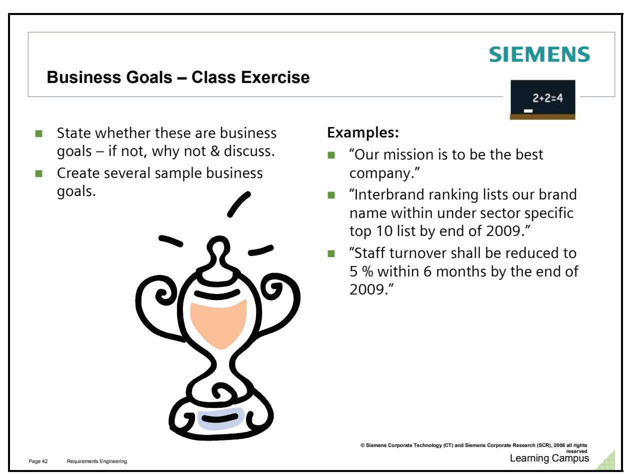

Figure 3. Class Exercise Slide

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Kingsfield tells one of his law students "Mr. Hart, here is a dime. Take it, call your mother, and tell her there is serious doubt about you ever becoming a lawyer" [8]. Not only would that behavior result in the termination of training in industry, it would also result in the permanent termination of the instructors. Consequently, techniques such as calling on students, having individuals put homework on the board, or even giving homework are not viable. Furthermore, cultural differences from country to country require that there be positive reinforcement of participation in class discussions and team exercises; we have found that this is best provided by the instructor and the student's peers.

5. Solution

The *Reinforcement* pattern uses a special structure to ensure maximum retention. The heart of the pattern is the **Concept**, where a concept is a set of three or more slides consisting of a **definition**, followed by one or more **examples**, followed by one or more **class exercises** (see Figures 1, 2, and 3). A definition slide provides the explanation or definition of the term being introduced. The example slide(s) then provide examples of the term in use. The examples are followed by a class exercise, where the students volunteer answers to questions, and then discuss the questions, answers, and can interact with the instructor. A set of related concepts is followed by a **team exercise** (see Figure 4). Team exercises usually run twenty to forty-five minutes long. The class is broken up into teams, each team is given a problem to solve, and after the exercise each team elects a spokesman to present the team solution. Finally, the class discusses the solution, and again there is discussion of the material. Typical team exercises, which tie together several concepts, might include creating a feature model for a common product line, defining a requirements management process with a metamodel, or conducting a brainstorming session. Team exercises can also be competitive, with each team answering a set of questions, and the team with the highest score winning a prize. Since we are not in a position to do formal testing of students, team exercises, especially competitive team exercises, can perform part of the role of traditional assessment of students. The set of concepts and the related team exercise make up a **unit.** Some summary slides and discussion typically follow each unit. A set of units make up a **module.** Modules tend to be disjoint; each may stand alone. However, there can be dependencies between modules, e.g., understanding fundamental definitions (a module) before being able to review requirements (a module).

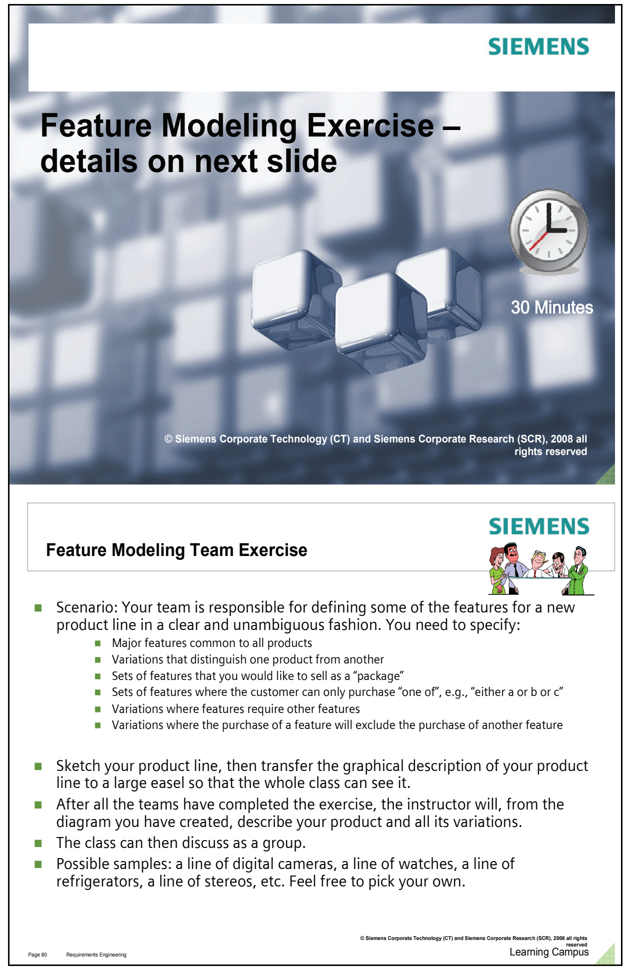

Figure 4. Team Exercise Slides

Finally, a complete course or workshop is a set of modules. The *Reinforcement* pattern can be represented in Backus–Naur Form (BNF), as shown in Figure 5 [9]. Note that unit, module, and course can each have summary slides (for an example summary slide, refer to Figure 6).

Building a course from discrete unit and module components has been found to have real advantages. While the primary goal of this structure is knowledge **reinforcement**, it makes customization very easy. When teaching for Siemens companies, we are invariably asked to reduce the time, add custom material, or skip certain subjects. Customization is normally accomplished by adding or removing **modules**, but if necessary units or even concepts can be added or removed.

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6. Discussion/ Consequences/ Implementation

We have successfully applied the *Reinforcement* pattern in several courses taught at Siemens operating companies. In our experience, the pattern successfully addresses the challenges listed in Section 2. The pattern allows the instructor to determine whether the course is paced correctly. In addition, the short feedback loop enabled by the class exercises allows immediate reinforcement of the material. Should the instructor get the impression that the students either cannot follow the material or have become bored, the instructor can then apply necessary adjustments (e.g., skipping or revisiting concepts). These adjustments are important for the successful achievement of the students' learning goals, and would be difficult to achieve by solely relying on team exercises.

<Course>::=	<Module Set> <Course Summary>
<Module Set>::=	<Module> | <Module> <Module Set>
<Module>::=	<Unit Set> <Module Summary>
<Unit Set>::=	<Unit> | <Unit> <Unit Set>
<Unit>::=	<Concept Set> <Unit Summary> | <Concept Set> <Team Exercise> <Unit Summary>
<Concept Set>::=	<Concept> | <Concept > <Concept Set>
<Concept>::=	<Definition> <Example> <Class Exercise>
<Definition>::=	One or more slides defining a concept or term.
<Example>::=	One or more slides with examples of the use of the concept or term
<Class Exercise>::=	One or more slides with questions to be answered by the class along with suggestions for discussion with the instructor.
<Couse Summary>::=	One or more slides with a summary and questions about the course.
<Module Summary>::=	One or more slides with a summary and questions about the module.
<Unit Summary>::=	One or more slides with a summary and questions about the unit.
<Team Exercise>::=	One to three slides describing an exercise to be done by three to 5 students in about half an hour.

Figure 5. Pattern Description in BNF Form

In general, the class exercises have proven to be effective in keeping students engaged and keeping the training session interactive. They also enable the instructor to involve students that may be more passive in the classroom. Where possible, the class exercises should be structured at different levels of difficulty, with the simplest exercises being presented first. The different levels help students to become more familiar with the concepts. In addition, the more challenging exercises also keep students that may be already familiar with the presented concepts engaged. Incorrect answers by the students are used as a means to correct misunderstandings. The thought process behind an incorrect answer should be explored together with the student (being respectful and mindful of the student's sensibilities). This process enables the correction of misunderstandings before they are propagated to the long-term memory of the student.

During the practical application of the pattern in courses, we also found some key success factors for its application. In order to obtain maximum reinforcement of the material with the students, the class and team exercises should be customized to the domain of the students. This customization facilitates the understanding of how the knowledge can be applied in the students' domain. When teaching complex concepts, it may be necessary to divide a complex concept into several simpler concepts that are more suited for the *Reinforcement* pattern. After all the smaller fragments have been presented, the instructor needs to demonstrate how these smaller fragments are composed into a more complex concept. In order assure that the students have successfully learned the concept, a team exercise typically follows that reinforces what has been learned.

7. Special Resources

It has been found empirically that those instructors with both requirements engineering practical experience and prior experience as instructors work best in teaching industrial RE courses. A "U" shaped arrangement offers the best layout for student interaction (e.g., a student should not be facing another student's back). For the team exercises we put an easel in each corner of the room to provide a team work area. Other resources that help are refreshments at breaks and lunch served in close proximity to the training area, so that the students can continue team exercises during breaks and lunch.

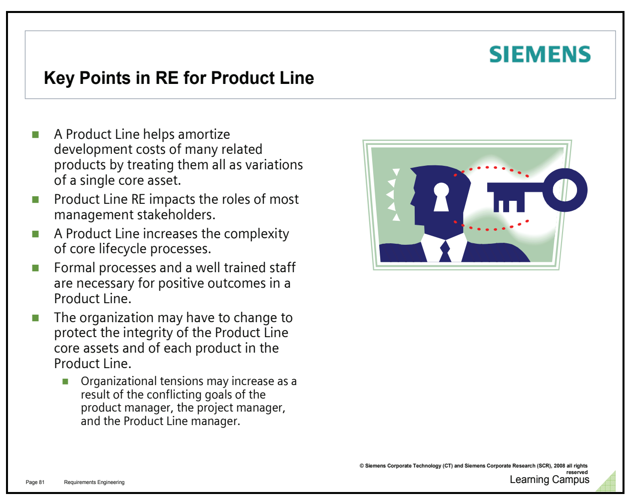

Figure 6. Sample Module Summary

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8. Related Patterns

An extensive pattern language of pedagogical patterns has been created by "The Pedagogical Pattern Project" [5]. Many of these patterns are related to our pattern, since they either describe similar concepts or also emphasize characteristics shared with our *Reinforcement* pattern. Specifically, the following pedagogical patterns are related to our pattern:

- *Active Student* pattern: Emphasizes the importance of alternating between passive phases (during which the students listen to a presentation of the material) and active phase (during which the participants actively apply the knowledge, in group work, discussions, or other forms). The passive phases should be short and the succeeding active phase should emphasize the material that was taught in the passive phase. This principle is also applied by our *Reinforcement* pattern, which uses class exercises to create an active phase that emphasizes the material taught.
- *Different Exercise Levels* pattern: Explains the importance of providing exercises at different levels of difficulty to keep students with different skill levels involved in the learning process. The *Reinforcement* pattern uses class exercises of increasing difficulty, and the team exercises are sufficiently challenging to keep more advanced students involved.
- *Feedback* pattern: Emphasizes the importance of feedback in the learning process. Feedback allows the teacher to correct misunderstandings and the students to assess their learning progress. The class exercises used in our pattern enable a short feedback loop.

Additional related patterns can be found in the *Seminars* pattern language by Fricke and Völter [4].

- *Exercises Emphasize Process* pattern: Explains that not a "right" or "wrong" solution should be judged, but the thought process of obtaining that solution should be explored with the student. By working on a problem with the student, the newly learned topic is creatively applied. The class and team exercises in the *Reinforcement* pattern enable such a creative application.
- *Relevant Examples* pattern: Emphasizes the importance of good, up-to-date, and relevant examples for the teaching of abstract concepts. Examples should not be too difficult, since it may otherwise further complicate the learning process. Ideally, examples should also be customized to the students' domain, since this customization enables the students to understand the relevance of the learned knowledge. We found this principle to be a key success factor for the successful application of the *Reinforcement* pattern.

9. Conclusions

The *Reinforcement* pattern has been successfully used to teach requirements engineering courses to hundreds of employees at Siemens with positive feedback and long term knowledge retention [1]. The pattern, in addition to fostering retention of the material, has been found to enable course customization, e.g., unit and module mix-and-match for different Siemens organizations. It has been found to be an effective way to teach short duration, intensive industrial courses to Siemens professionals from different cultures.

10. References

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