

APPLYING TRANSFER IN GOAL-BASED INTERDISCIPLINARY LEARNING ENVIRONMENTS

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ABSTRACT:

Case- and problem based learning environments support learners both, in the active process of self-directed learning as well as in the consolidation of new knowledge. Especially case-based learning fosters the usage of transfer by providing appropriate stimuli to recall previous knowledge. The present contribution discusses the suitability of instructional design principles as suggested by the Goal-based Scenario approach by Roger Schank and the Learning-By-DesignTM approach by Janet Kolodner to develop blended-learning modules in the context of a new interdisciplinary Master curriculum (*Master of Mind and Brain Sciences*) at Potsdam University. From this perspective, the potential of case-based reasoning and collaborative reflection will be evaluated.

1. THE PROBLEM OF INERT KNOWLEDGE

It is widely acknowledged in the present, constructivist community of the learning sciences that the acquisition of knowledge and skills can successfully evolve when it is embedded in learning environments that motivate learners to actively engage with problem-solving.

Yet, as measurements of results in problem-based learning environments demonstrated, learners that are good at solving real-world problems often have difficulties to reflect on their experiences and fail to transfer what they have learned to new tasks.

Already Salomon & Perkins (1989) have called attention to this fact with the telling formulation "rocky roads to transfer". Thus, one of the main goals of new approaches to constructivist learning is to address the classical problems of knowledge-transfer with the help of *Goal Based Scenarios*, orchestrated learning rituals and hands-on practice.

Since the beginning of the 1990s the former AI-theoretician Roger Schank at the Institute for Learning Sciences (ILS), Northwestern University has been advocating the application of *Goal Based Scenarios*, in the following abbreviated as GBS (Schank, Berman, & Macpherson, 1999). In the context of his company CognitiveArts, real-world as well as computer based learning environments, designed according to the GBS pattern, have been developed for business administration and other purposes.

Schank criticizes that a lot of traditional learning procedures rarely support the transfer of newly acquired knowledge to vocational situations and do not foster the intrinsic motivation of learners. On the basis of his former approaches to knowledge representation, Schank developed an alternative instruction method: *learning by doing*. This approach centers on the acquisition of skills (procedural knowledge) and relevant content related knowledge that is necessary to reach a certain goal in a GBS.

According to Zumbach (2002) this process of learning is hardly ever linear, which means that for a certain problem the best strategy is not always found at once. If one fails by making a wrong decision, even this realization contributes to the process of learning, because wrong or ineffective actions can be avoided in future situations. Nevertheless, the information that can be derived from such failed expectations has to be memorized in such a way that it can be used in similar future situations. In the terminology of case-based reasoning, this means that experiences have to be correctly indexed in a case library.

Intrinsic motivation can be effectively sustained by activating learners with self-set goals in a certain task-scenario. With that, learners pay more attention to relevant knowledge than in a traditional exam.

The *Learning by DesignTM* approach (LBDTM), developed by Janet Kolodner et al., is based on the same principles of case based reasoning (CBR) derived from cognitive theories of memory, Artificial Intelligence and analogical learning. With the support of several software tools, this approach tries to undergird learning-transfer by hands-on design and exploration activities that are augmented by several stages of reflection.

In order to administer the interdisciplinary teaching practice in Cognitive Science at Potsdam University in a more coherent way, we have decided to evaluate the suitability of the Goal-based Scenario approach and LBDTM for a forthcoming Master-Curriculum.

2. CASE-BASED LEARNING

2.1. Theoretical sources: Case-based and analogical Reasoning

2.1.1. What is transfer?

Transfer can be defined as the capability to reuse knowledge and skills in a context that differs from the one in which they

have been acquired. We speak of *near transfer* when the features of the new context differ only slightly from the original learning situation. *Far transfer* on the other hand, is necessary when a learner has to use his/her prior knowledge in a completely unusual and unpractised situation.

The ability to gradually transfer knowledge and skills from the academic context to applied and professional scenarios is one of the most important goals of higher education (cf. Zimmermann, 2000). Teaching students this key competence is time consuming and does not develop automatically. The *Learning by Design™*–approach takes up the two theoretical concepts of case-based and analogical reasoning, in order foster the aptitude of knowledge-transfer.

2.1.2. Case-based reasoning as a Strategy for Artificial Intelligence (AI)

Case-based Learning was inspired by AI-programs of case-based reasoning (CBR). CBR-Expert systems, such as MEDIATOR, JULIA or IMPROVISOR learn on the basis of single case-examples that are actively encoded in regard to possible, future scenarios. Errors in the application of an older case lead to a recoding, re-evaluation and interpretation of that case (cf. Kolodner, 1993). Janet Kolodner and colleagues extracted a number of principles of optimization and terminologies (case library, case indexes, case processor) to interpret and advance human learning processes. A central point of the philosophy of learning that derived from that is to confront learners with diverse contexts of usage: "...one cannot always fully interpret one's experiences well and extract the lessons learned and their applicability at the time they are experienced – because one is missing information about the situation or because one does not know enough yet. We can get around the deficiency with an iterative cycle in which a learner has multiple opportunities to revisit old experiences, attempting to apply them in a variety of situations, and each time, refining its interpretation of them based on new explanations it can derive." (Kolodner, Gray, & Frasse, 2003, p. 194).

2.1.3. Analogical Reasoning as a cognitive Process in human Learning

It has been proven in cognitive psychological theories of analogical reasoning that learning-transfer can only happen when an appropriate degree of deep understanding concerning knowledge and skills is already existing. Pure memorization of facts does not lead to knowledge-transfer. Deep understanding takes time, repeated application in different contexts, feedback and reflection of unsuccessful transfers. Students, who combine a deep understanding of concrete and single problems with underlying abstract principles in order to solve a problem, are able to think more flexible and can solve a larger amount of analogical problems (cf. Kolodner, Gray, & Fasse, 2003).

2.2. Schank's Goal-based Scenarios

2.2.1. Components of GBS-Design

The Goal-based Scenario-approach by Roger Schank and colleagues continues former theoretical work on case-based reasoning and narrative forms of learning. The primary objective of Goal-Based Scenarios is to impart skills that are relevant for a certain situation. Students shall to learn "how to" rather than "know that". Procedural knowledge is knowledge about how certain skills are used in order to reach a goal, whereas content knowledge includes the actual information,

even though the acquisition of some declarative knowledge is, of course, a necessary precondition to learn skills.

To provide an example from Cognitive Science we could imagine the following situation: A student can have read a lot about statistical methods but never have calculated a set of experimental data with a software-package for statistics. Superficial knowledge of facts does not automatically grant the ability to transfer knowledge to vocational situations.

Schank and colleagues have gradually designed and elaborated a component model of GBS that interweaves and combines cognitive, emotional and motivational factors of learning. Following Schank, & Cleary (1995) a GBS consists of the following components:

- *Learning Goals, Target Skills*: Target Skills constitute the main educational objectives of a GBS. Factual knowledge is only important in as much as it is necessary to acquire skills.
- *Mission*: The mission of a GBS shapes the challenge that students engage in. The mission has to be precise, understandable and stimulating.
- *Cover Story*: The cover story sets the context of the GBS. It serves to nourish the motivation of the learner by conveying the relevance of the learning goals.
- *Focus*: The focus defines the general class of task students have to learn. Schank emphasises four basic categories:
 - a. *Design*: create or simulate sth.
 - b. *Diagnosis*: analyse and explain problems
 - c. *Discovery*: compare and find out problems
 - d. *Control*: run and control a complex mechanism
- *Operation*: specifies the concrete tasks and activities students have to do.

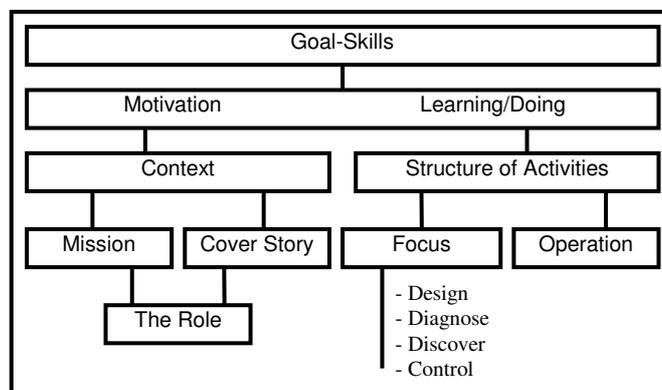


Figure. 1 : Structure of GBS, adapted from Zumbach (2002).

At the current stage of our preparations, learning content from the field of Cognitive Science is restructured to fit the needs of a GBS. This is done in order to create a stepping stone for future introductory lectures (see 3.1.1.).

2.2.2. Computer-based GBSs

In computer based GBSs these components are realized by cover stories with video clips of simulated clients or interviews with experts. In some GBSs, the learner also plays the role of a

journalist who interviews experts and has to research into given sources.

According to Zumbach (2002) GBSs allow a highly interactive training that offers an appropriate compromise between challenge and support. How can that be realized? In a GBS actions of learners alternate with reactions of the GBS, regardless whether the feedback is provided by a living expert or a virtual software environment. Goal-based Scenarios enable students to solve a certain “mission” in an authentic cover story. This way, learners are challenged to learn independently and encouraged to apply their knowledge to solve the given task.

Since the motivating nature of a goal-based *learning by doing* prevents inert knowledge, it would be desirable to apply this form of learning to suitable study situations. Yet, as a critical factor, the economic efficiency may not be neglected. According to Zumbach (2002), the development of GBSs would only be profitable at the minimum of 200 users.

2.3. Learning by Design™ according to Kolodner

2.3.1. Rituals

The *Learning by Design™* -concept has been developed and elaborated since 1997 by Janet Kolodner and colleagues at the Georgia Institute of Technology. Influenced by constructivist theories of learning, findings of case-based and analogical reasoning have been systematically applied in problem based learning scenarios. The approach aims at larger groups of students such as in university courses and high school classes. It combines case- and problem based learning with the advantages of collaborative learning scenarios. The basic idea of LBD is to involve learners into a pre-structured, active and scientific working process in order to link knowledge with cases that are easy to recall. Hands-on experiences that are gained this way are orchestrated by iterative practices and rituals in so called *cycles of activities*. These *cycles of activities* arrange experiences of learners in such a way that acquired knowledge can easily be recalled and, by means of analogical transfer, be reused in a new but similar situation.

Furthermore, LBD is enriching direct, explorative learning and experimenting with guided reflection. During the LBD cycles, stages of active experimenting and designing alternate with venues for investigation and reflection.

During the design cycle students have to (1st.) understand the design challenge and realize what they have to learn. (2nd.) They have to plan, (3rd.) develop and (4th.) conduct an experiment as well as to analyze, explain and interpret their results in front of their fellow students. The cycle of investigation is intended to clarify in collaboration with the students (1st.) what they still have to learn, (2nd.) how this knowledge can be acquired and eventually (3rd.) to help and support students to reflect on and discuss the results of their findings.

Embedded into the alternation of these cycles, are regular rituals of presentation that iteratively practise the reuse of acquired knowledge and provide the students with a constant feedback from teachers and fellow students. These rituals include in detail:

- *Pin-up sessions (Design: Present & Share)*: gives students the opportunity to present first plans for a design of experiments and to justify their decisions in front of other groups. This is intended to grant a deep understanding of the design challenge.

- *Gallery Walk (Design: Present & Share)*: here, first design experiences after first constructions, tests and an explorative collection of data are shared and discussed within each group.
- *Poster session (Investigation: Present & Share)*: here, the results, analysis and the interpretation of conducted experiments are presented. This helps to practice poster sessions at scientific conferences.
- *Messing about (Design: Understand challenge)*: in small groups, suggestions and examples from real-world situations are integrated into the present tasks.
- *Whiteboarding (Design: Understand challenge / Investigate: Clarify questions)*: In order to encourage communication between the groups, the whiteboarding session is intended to be a forum for an exchange of ideas that were gathered during the *messing about*.
- *Gathering examples (Design: Understand challenge)*: here, examples are gathered individually in order to connect what one has learned with authentic cases. Afterwards these examples are exchanged by *Whiteboarding*.
- *Creating and refining design rules of thumb (Design and Investigation)*: This activity allows to extract general rules of thumb from the design experiences that also fellow students can use. False, weak or speculative rules can be modified or rejected by the other groups. The formulation of *rules of thumb* helps students to extract abstract rules from concrete design experiences (transfer).

LBD™- rituals are gradually practiced and established in so called *mini-cycles* within one group. Several of studies of evaluation, conducted by independent evaluators, report about excellent results on all seven rating scales in favour of LBD-Learners in direct longitudinal comparison to control groups (Kolodner, Gray, & Fasse, 2003).

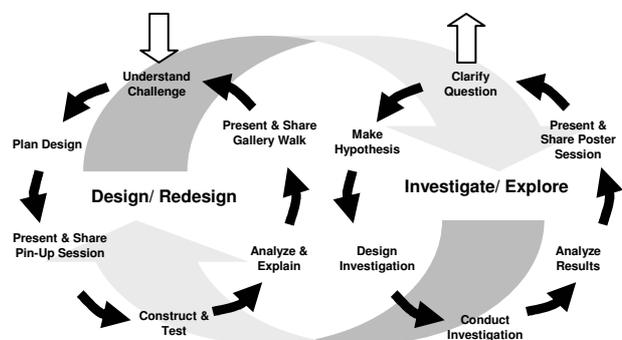


Figure. 2: LBD-cycles, Kolodner; Gray, & Fasse (2003)

2.3.2. Software: SMILE

Electronic case-based learning aids support learners to actively reflect on, interpret and explain their project experiences. Kolodner, Owensby & Guzdial (2004) demonstrate that since the late 1980's the reflection supporting merit of case-based learning aids is well known. At the beginning, it were simple electronic learning diaries, as the Instructional Software Design Project (1991) or systems that, during discussions (CSILE) or tasks (KIE), provided helping prompts. Later learning aids that were influenced by CBR took that functions up again. The electronic DDA- tool (Design Discussion Area), developed by Kolodner and colleagues, for instance, was designed as an

electronic supplement and extension of the *Poster sessions*, *Pin-up sessions* and *Gallery walks*, of the LBD cycles. It helped students to present and discuss their design ideas and results in a coherent form. When the DDA-tool turned out to be inadequate in a practical test, the Kolodner group developed the software tool SMILE (Supportive Multi-User Integrated Learning Environment). SMILE amalgamates several tools for each LBD ritual. An *Experiment Result Tool* for instance, offers learners a scaffold to structure the results of their experiments, a *Pin-Up Tool* provides templates to articulate design decisions and a *Gallery Walk Tool* helps to document the current progress.

Even though these templates and scaffolds may help to reflect on new knowledge at early stages of learning, it would be desirable to have an adaptive scaffolding that gradually withdraws according to the progress of the learner.

3. GOAL-BASED SCENARIOS AND CASE-BASED LEARNING IN COGNITIVE SCIENCE CURRICULA

3.1. Challenges of interdisciplinary teaching

How can an extensive and heterogeneous field of knowledge ranging from biology, computer science, linguistics, psychology and theoretical physics, to skills in experimental design, data analysis and computational cognitive modeling be imparted in an effective and motivating way? The founding faculty of the master program *Master of Mind and Brain Sciences* at Potsdam University is facing the task to develop and sequence curricular modules that are appropriate for students coming from diverse disciplines and facilitate knowledge transfer in order to equip students for future vocational demands.

Beside special bridging courses, such as courses on *Non-linear Dynamics of complex systems* for non-physics and other preparative courses on mathematics, it is planned to develop an integrating module as an *Introduction to Cognitive Science* according to instructional methods of case- or goal based approaches in a blended learning scenario.

The necessary preparations have to be arranged in correspondence with the responsible teaching staff.

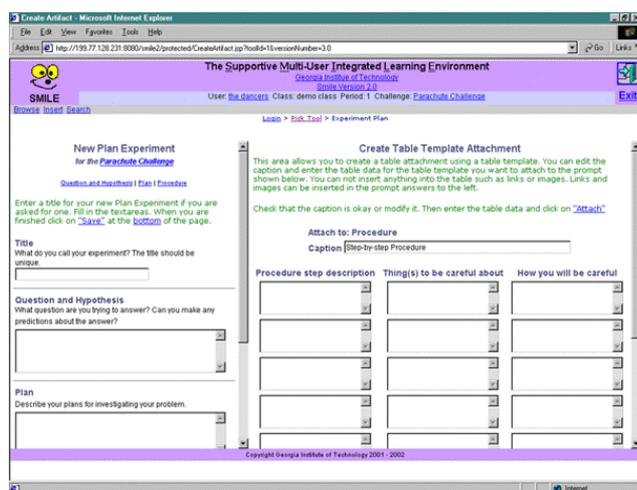


Figure 3: SMILE – Verson 2.0 Tool for Experimental Design (<http://www.cc.gatech.edu/projects/lbd/software.html>)

3.2. Blended Learning-Modules

3.2.1. Introductory module: Series of lectures and Case-based training courses.

In a first stage of expansion, a lecture series and a parallel seminar with E-learning support will be conjoined at a usual learning content management system. Lecturers of the participating cognitive science disciplines will provide a brief overview of the state-of-the-art of their subject and will then introduce a current prototypical research project (experiment, simulation, formal analysis). In a weekly, parallel seminar content related details of this project will be taught and analysed as case studies. This way case-based and goal-based instructional methods can be realized. In a final web-based project, students will work on a similar case-task in small groups. At this time the LMS serves as a platform for the electronic distribution of learning objects, for reflection in and between learning groups and supports collaborative work on case-libraries (cf. Weinberger, Fischer & Mandl, 2001).

3.2.2. GBS and LBD Modules

In a second stage of expansion, suitable components of LBD™ or of GBSs will be integrated into a prototypical seminal-model. Especially suitable for this plan are lectures that impart knowledge and skills in cognitive modelling and the design of dialogue strategies for human computer interaction.

4. SUMMARY AND OUTLOOK

Case-based learning, integrated in problem based learning environments, fosters by means of analogical reasoning and collaborative reflection processes of deep understanding and facilitates knowledge transfer to new contexts of application.

For the design of the interdisciplinary program *Master of Mind and Brain Sciences* at Potsdam University, we currently examine the applicability of both approaches in regard to the following criteria:

- Promotion of learning transfer
- Stimulation of motivation
- Suitability for interdisciplinary teaching
- Necessary effort to train lecturers
- Economic efficiency concerning the production of learning - software

In our context, especially the design principles for electronic Goal-based Scenarios, as illustrated by Schank (2005), will be considered and applied.

Furthermore, for the practical application of LBD or GBSs, it will be necessary to be mindful of Zimmermann's (2000) distinction between domain specific content knowledge and general scientific research skills. General skills of learners can only develop, when they are repeated, tested and reflected in diverse contexts. Lecturers and E-Learning authors from the heterogeneous disciplines of the *Mind and Brain Sciences* will have to be trained to develop suitable modes of case- and goal-based presentations from their own disciplines and to build scaffolds that foster interdisciplinary knowledge transfer.

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