FROM CLUTTER TO BUTTER: INGREDIENTS FOR IMPROVING MULTIDISCIPLINARY TEAM-BASED DESIGN EDUCATION IN A LAB CONTEXT

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Abstract

In this paper a linear, human-centered design approach with three main elements (Research, Create and Design) has been evaluated by students who followed this process for 20 weeks as members of multidisciplinary design teams in a lab context. Results of the evaluation in combination with insights from recent literature illustrate the components or 'ingredients' of an improved design process. This new process, "The Design Cycle", aims at improving motivation and enhancing learning and transfer between the different phases, for both individual members and the multidisciplinary design team. More control over pace allows students to decide how long they need to spend on each phase. An iterative cycle (instead of a linear cycle) of the different phases enhances variability of practice, which enhances learning (of design) and learning transfer. Additionally, using the working framework Scrum provides the necessary structure and facilitates the freedom for a multidisciplinary design team and its members to direct their own path. Additionally, sprints and other Scrum rituals can engage team members to work more effectively and transfer knowledge with more ease between the different phases.

Keywords: Multidisciplinary Design Teams, Human-centered Design, Lab, Design Education, Scrum.

1 BACKGROUND

In recent years, (design) academies and universities have been eagerly trying to adapt to and catch up with working trends in industry and commerce, where multidisciplinary team-based working is becoming prevalent. This is partly based on indications that, if performed and managed correctly, multidisciplinary team-based working appears to bring better results in terms of speed and quality of the product and the quality of interpersonal working relationships.

Multidisciplinary Design Teams (MDTs) bring together people with a range of expertise to a (design) project [1]. Multidisciplinary involves multiple sources of knowledge, skills, and attitudes towards learning and solving problems. One of the most well known design processes that MDTs follow is currently that of human-centered design.

Modern human-centered design is generally recognized to have originated at IBM in the 1980s, emphasizing four "critical steps": 1) "Early focus upon the characteristics and needs of the intended user population"," 2) users as part of the design team, 3) empirical and experimental measurement, and 4) iterative practices [2]. Human-centered design typically follows a linear process, which resembles a process that is sometimes referred to as "waterfall", where insights and requirements need to be defined in great detail before design and prototyping can take place. Within that final design and prototyping phase, an iterative approach is taken to optimize the design. Human-centered design methodology can be effective in supporting MDTs to learn from design; therefore it also seems useful for educational settings.

In design education, multidisciplinary team-based working has gained more recognition in recent years, and so-called lab-based education has increased steadily in the course of the past years. Students are placed in MDTs and have an appointed space within a 'lab' where they often follow a human-centered design process in order to develop a design solution for a given problem (ref?).

Evers [1] identified various barriers that can prevent MDTs from learning from design, especially when a specific design methodology such as human-centered design is being followed. Using a design methodology (and its structure) can be a barrier in itself, but also the level to which an MDT is able to develop common competencies. The success of the design project depends on the development of collective design competencies, and therefore, the design methodology used must support teams to develop these competencies and evolve [1:16]. A lab context seems particularly suitable to support the development of these team competencies,as it has the space, facilities, and most often the

coaching and management that can relieve the team from a great deal of external 'worries'. This leaves more room for both individual and team learning in order to optimize the design process for the team.

1.1 Case study

In this paper, a case study in an Amsterdam based lab Design in higher education is used and analyzed to investigate the basis or 'ingredients' of a new approach in order to facilitate the MDTs in learning from design and optimizing the design output.

The abovementioned lab organizes the research and development of digital media and applications. It offers a handpicked selection of talented students from various disciplines a structured, high-paced, 20-week program in which students experiment and search for solutions in challenging projects formulated by both academic and industry partners. The project teams are multidisciplinary and international, comprising students from different cultural backgrounds and from both academic and applied study areas. At the end of the program, each team presents a working prototype to the challenging partners.

In the first semester of 2013-2014, a human-centered design approach was introduced for the MDTs to work with, accompanied by a specific workshop program focusing on skills, design process support and inspiration, and a team coach (appointed by the lab) to manage the team throughout the process.

In the lab, the design process was centered around three phases, adapted from the HCD toolkit by IDEO. The HCD (Hear, Create, Design) Toolkit provides methods to take you from one step to the next in each phase of a project. In the process, a team will move from concrete observations about people and their needs and desires, to abstract thinking as one uncovers insights and themes, then back to the concrete with tangible solutions [3]. In Fig.1, the adapted HCD process, the Research Create Design process, is illustrated.

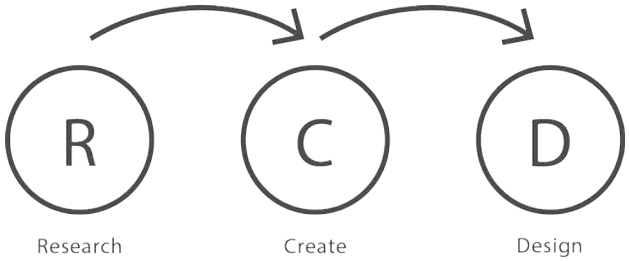

Fig.1: RCD process, a human-centered design approach

The *Research* phase provides the project with its fundamental insights, consisting of an understanding of the problem, the context and the (intended) user.

The *Create* phase translates the insights in requirements and requires prototyping ideas rapidly to test whether they can meet the requirements.

Finally, in the *Design* phase, a final design is being made and prototyped. In this particular setting, the final deliverable is a working prototype.

The length of each phase was fixed, although they did vary between the phases (from 4 to 8 weeks).

In order to find an answer to the question whether this approach and the current program support the MDTs in the lab in the way Evers [1] suggests, and optimizes learning from design and development of collective design competencies, an evaluation study was performed among the participating students just after the semester finished. This paper shows results from this evaluation study, discusses them in the light of the importance of individual/ team learning, motivation and learning transfer, in supporting MDTs and the design process, and introduces the ingredients of a new, improved model, based on these outcomes.

2 EVALUATION OF HUMAN-CENTERED DESIGN PROCESS FOR LAB MDTS

2.1 Method

2.1.1 Participants

16 students were asked to participate in the evaluation of the 20-week program that they were following in the lab. The participants had various disciplinary backgrounds, ranging from research, to design, to engineering, and cultural backgrounds, ranging from The Netherlands, to Brazil, Italy, India and Japan. Cultural differences were not taken into account in this particular study.

2.1.2 Apparatus and Procedure

Participants were invited by email to participate and follow a link to an online evaluation form, consisting of 15 questions (both open and in likert-scale form), about: general evaluation of the learning program (experience), individual learning, team learning, motivation and transfer of each phase (research, create, design), and suggestions for improvement per phase. Students had two weeks to fill in the questionnaire.

2.2 Results

13 out of the 16 students (9 male, 4 female, ranging in age from 21 to 25) completed the online evaluation form. All participants filled out all 15 questions. Results were analyzed using SPSS 20. For the likert-scale questions, descriptive statistics were performed. These descriptives are shown in Figures 2 to 5.

2.2.1 Experience

Students were asked to what level their (subjective) experience changed during the process. Experience was measured by how satisfied they were with each phase, how clear they found it, how difficult and how much fun it was.

Fig.2 shows that for satisfaction and clarity, the experience did not vary much between the phases. Results show a slight positive increase when students were further in the process. Interestingly enough, the experience of fun increased quite a lot between the research and design phase, even though students also experienced the phases as more difficult towards the end.

An explanation for this effect could be found in differences between the MDTs and the level of depth in each phase, but seen from what was actually needed or necessary in that phase for their particular challenge. One of the students explained: "I really liked the whole design process, but for each project I think there are different requirements. Some projects need more Research and others need more Design, so this could be taken in account during the 20 weeks."

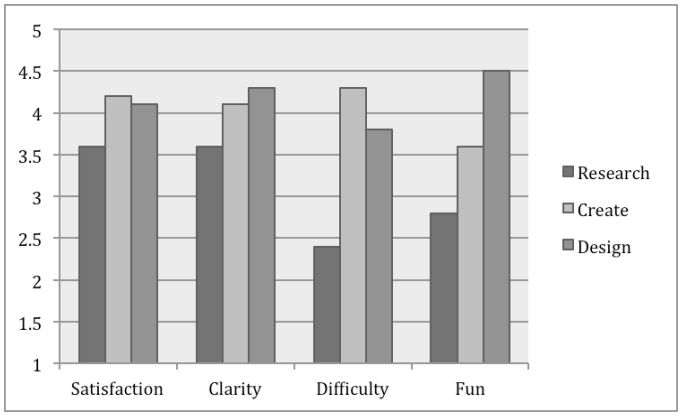

Fig.2: Experience per phase, of satisfaction, clarity, difficulty and fun

2.2.2 Motivation

For any MDT to function well and learn, it is important that motivation is consistent throughout the process. In Fig.3 an overview is shown how both individual and team motivation evolved in the lab. At the start of the process, during the research phase, motivation is not high, nor low. Once the create

phase starts, students are more motivated. Individual motivation then increases slightly in the design phase, although it decreases somewhat for team motivation.

The students underlined several things that directly influenced their motivation, such as the linear structure with time as a fixed element. One student mentioned: "The structure of the process is too rigid and just following that wastes a lot of time. It is the biggest drawback of the program." Another drawback of the process on motivation that was mentioned by students was the fact that a 'tangible' prototype or design was mostly developed towards the end. Before that, it was mostly based on ideas, research and concepts. One student stated: "Thinking of a small idea and executing it quickly to see if it works or not is a better approach rather than taking one BIG idea and start to prototype it in the end. Knowing our own limitations early in the process is a fairly good idea and really helps to increase motivation".

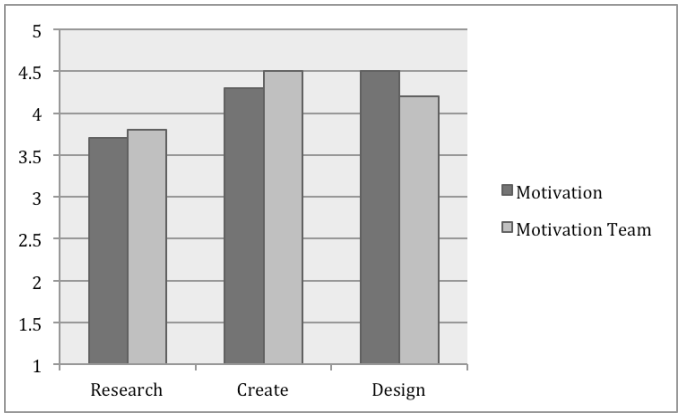

Fig.3: Individual and team motivation per phase

2.2.3 Perceived learning

Students were asked several questions in relation to what they learned both individually and as a team. This was important to find out more about the level of facilitation that was supporting the MDTs. Fig.4 illustrates how learning was perceived by students per phase, showing a very slight increase in perception of both individual and team learning throughout the process.

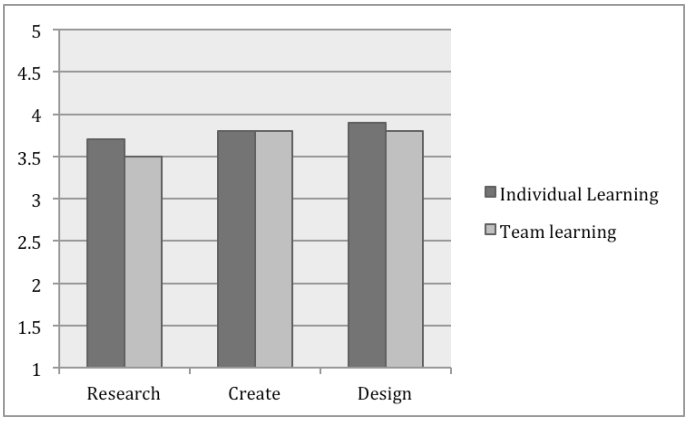

Fig.4: Perceived individual and team learning per phase

2.2.4 Perceived learning transfer

Students often find it difficult to transfer knowledge between different phases of a design process. Three types of questions were asked to gain insight in the transfer between phases: 1) To what extend did they learn about connecting the phases, 2) how relevant did they find the knowledge from one phase for the next, and 3) did they actually use information or knowledge from one phase in the next?

Fig.5 shows that knowledge that was gained in the research phase was educational for the students, was found relevant for the create phase and was actually used. In the next transfer moment, between the create and design phase, students still learned from the gained information, found it equally relevant, but did not use it to the same extend as in the previous phase. Perceived learning transfer

was still high for the insights gained from the design phase, but found less relevant for further research and used much less than in the two prior phases.

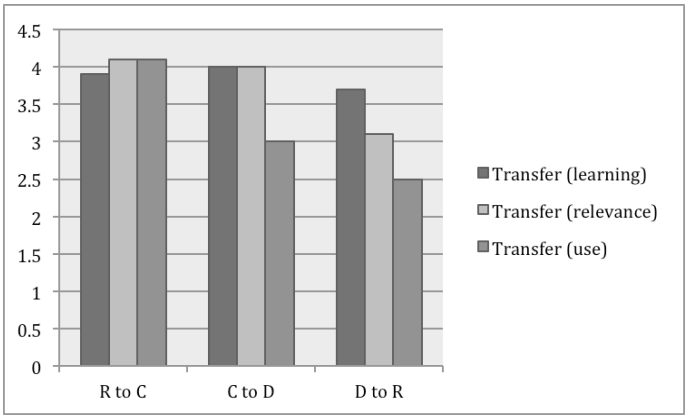

Fig.5: Transfer of knowledge from one phase to the next

3 IMPLICATIONS FOR SUPPORTING HUMAN-CENTERED DESIGN FOR MDTS IN A LAB

In this section, the most important findings of the evaluation study are discussed in the light of related research from literature. Based on these insights, the components of an improved design process are introduced.

As could be seen from the results in the case study evaluation, the specific human-centered design process, as depicted in Fig. 1., in combination with the learning program offered by the lab was evaluated quite positively in terms of satisfaction, clarity, ease and fun. Additionally, perceived learning scores also were rated quite high. However, in turn, results on both the likert-scale questions as the open questions showed fluctuations in motivation between phases and more importantly a decrease in transfer of knowledge towards the end of the process. For example, from various open comments made by the students in the questionnaire, it became evident that the structure within the phases was found to be lacking, causing motivation to drop at times (which was illustrated by the ratings). Also, statements underlined that making the connection between the different phases, and thus transferring knowledge effectively between them, was not properly facilitated or supported within the lab.

3.1 Design and Learning Methodology

As Evers [1] stated, human-centered design approaches typically lack facilitation tools to support MDTs to develop the collective competencies they need to engage effectively in human-centered design from the very start of a project. Evers therefore proposed to complement human-centered design with action learning methods, as they focus on evaluations of team-based learning from processes, and on developing skills to manage these processes [1].

In action learning, typically small groups of people (approx. 4-6) work in a so-called "set", working together on real problems [4]. The original intention of Revans (see e.g., [5]) was that individual participants would also work on individual problems "owned" by the participants, whereas in the US sets mostly covered a common problem for all set participants, such as in a project group. The main goal of action learning is that individuals are offered a safe environment where, with the help of team members, reflection and ownership of problems and challenges are encouraged (see e.g., [6]). This would in turn provoke deeper questioning and a focus on change. An important role in sets is that of the facilitator, who is trained in asking the difficult questions that others feel uncomfortable with. Additionally, the facilitator takes care that the environment is optimized for the set to work in, and ensures the team maintains the commitment and motivation to learn as a team [7]. The proposed combination of human-centered design, action learning and additionally, facilitation, was introduced and illustrated by Evers [1] in the Design and Learning Methodology (DLM). This methodology was a first step towards introducing process learning and learning from design in order for MDTs to improve their skills and knowledge, and to manage complex processes more effectively. The strength of DLM lies in the practical way it helps keep collaboration going during all phases of a project, to turn team-based learning into appropriate design decisions [1:64].

In order to improve the design process for MDTs in the lab, it should consider the most powerful elements of the Design and Learning Methodology, such as individual ownership, an appointed facilitator/ motivator in each team and the importance of continuous reflection within the MDT.

3.2 Individual and team learning

In this paper, individual and team learning is defined as a form of experiential learning, including individual and team learning through experience [8]. A well-known approach that has influenced studies on team learning is Kolb's learning cycle [1]. According to Kolbe [9], learners (in a team or outside) engage in a learning process through four stages: from concrete experience, to reflective observation, to abstract conceptualization, and to active experimentation. The learning experience can start at any of these stages, but all stages need to be done. Concrete experience, that is to say, learning from specific experiences, relate to other people as well. For instance, learning how to ride a bike can be learned from someone with more experience in riding a bike.

Individual learning is vital for any MDT, as the capacity of each member of the team to learn individually determines the quality of information that is available to the whole MDT. In individual learning people focus on their own discipline or expertise and gather in-depth information from there. However, only these views from individual learning processes are not sufficient for the team to understand the complexity of a design problem as a whole. Therefore the value of team learning, and collecting collective insight and knowledge is equally vital. A team, that tries to understand a problem as a team, creates a so-called "collective mental model" [10], which is constantly adjusted as the project and level of insight progresses. Collective mental models can be made explicit, when part of the model is expressed by a representation that is agreed upon, and makes sense to the whole team [11].

In the improved design process, extra attention should be paid to the development and representation of such collective mental models in order to support team learning better.

3.3 Improving learning and transfer

One of the key aspects that the Design and Learning Methodology by Evers [1] stresses is a safe environment in which team members feel ownership and control over the process. In educational science this is also referred to as "learner control". Learner control provides learners the freedom to choose their own learning path according to their own needs and/or interests (e.g., [12]). Several studies indicate that this freedom leads higher motivation, and to higher learning and transfer than the use of a fixed sequence of tasks (e.g., [12], [13]).

Therefore to improve the design process, more learner control should be provided to students. Results showed that certain phases (for example the research phase) were perceived by students as being too lengthy. Therefore, the improved process provides students with more freedom to decide on pace and length. Moreover, students are also given more freedom on selecting which tasks and tools they want to work with in each phase.

In addition, results showed a lack of transfer of insights and information from one phase to the other. Research shows that providing students the chance to experience variability on different learning experiences helps them to focus on the underlying principles to be learned and thus enhancing transfer of learning [14]. In the improved process, students should go through the different phases several times which provides more variability.

Based on the importance of learner control and variability of learning experiences, for both learning and transfer of learning, and given the fact that in the lab, students work in MDTs, the well-known working framework of SCRUM seems appropriate to be included in the improved process.

3.4 Scrum

Scrum is an innovative approach to getting work done. Scrum is an agile framework for completing complex projects. Scrum originally was developed for software development projects, but works well in any complex problem-solving project [15]. There are several key roles in the Scrum framework: 1) Stakeholders: the mission owners, possess the idea about why to develop, what to develop, and how the process should go; 2) Product owner: the product development owner, closely working with stakeholders, creates a prioritized wish list of stories — also referred to as the Product Backlog; 3) Scrum Master: the facilitator, closely working with the Product Owner, makes sure the stories in the

product backlog will successfully be delivered as workable sub-products; 4) Scrum Team: the developers, closely working with the Scrum Master, who deliver workable sub-products according to the product backlog.

Scrum involves several rituals [16], such as working in sprints within fixed iterative cycles. At the end of each sprint, the team discusses the progress to date, receives feedback from stakeholders and external experts, and if necessary, makes adjustments to reach their goals. During these sprints, the team has daily 'stand up meetings' where in 15 minutes; each team member mentions what they did, what to do and the challenges they encountered. Each day the team works on getting the list of requirements to research/design/implement/test shorter. Progress is measured by finished outcomes.

Every story, requirement and task is visualized on a so-called Scrum-board, which is dynamically managed by the team.

For the improved process, Scrum promises to provide structure and the freedom for an MDT and its members to direct their own path. Additionally, the sprints and Scrum rituals can engage members to work more effectively and transfer knowledge with more ease between phases. To avoid becoming a victim of structure, MDTs should be able to manage the before mentioned length and pace of each sprint. Furthermore, the built in moments of reflection and feedback within the Scrum framework will help to foster continuous reflection, as was introduced within the Design and Learning Methodology.

4 THE DESIGN CYCLE - DESIGN PROCESS FOR MDTS

Taking the ingredients for improvement that were discussed in the previous section into account, an improved design process is introduced and illustrated in Fig.6.

The main phases in the Design Cycle were adopted from human-centered design, where definition and research is a first step, translating this into requirements and concepts is a second, and design and development the final step. However, the phases in the Design Cycle do not follow a linear but a cyclic order. In addition, according to learner control theories, the flexibility in length and pace of the sprints in each phase will give enough freedom to MDTs to define their own path within the process. This is expected to improve motivation and learning (transfer). In order to facilitate the MDTs with enough tools and methods in each phase, but mostly in the research part of the process, a toolkit has been developed with a plan-board and 100 method cards. The method cards contain information on the why, what, when and how of each method and can be placed on a plan board to create a planning over time for organizing and executing each method within the given time of a sprint.

4.1 The Design Cycle elements of the improved process

Sprints

A sprint (or iteration) is the basic unit of development. The sprint is a "timeboxed" effort; that is, it is restricted to a specific duration. Each sprint, starts with a planning meeting, preferably together with all stakeholders. In this meeting tasks are identified, but more importantly the sprint goal (and duration) is set out. It is important to have a very clear goal, so that the effort can be cut down in pieces that contribute to achieving that goal more smoothly. At the end of each sprint, a meeting to reflect on both the results and the process is organized. In the Design Cycle a sprint can be performed for research, translation or creation efforts.

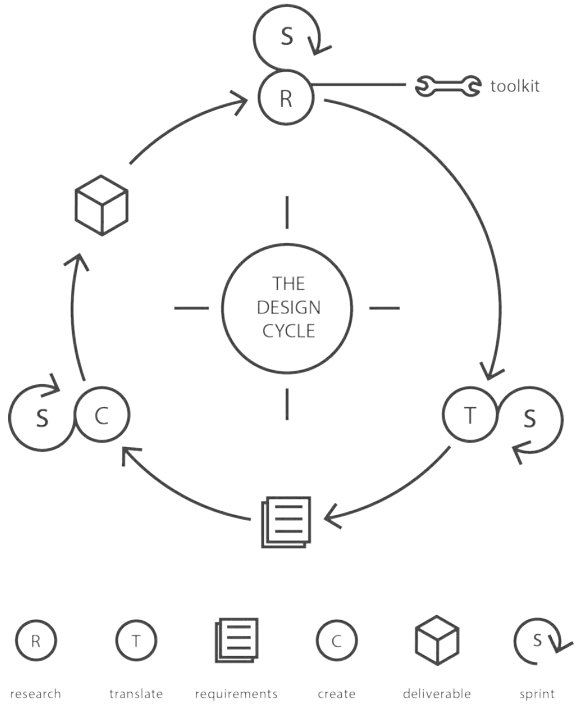

Fig.6: The Design Cycle - improved design process for MDTs in labs

Research

Any good solution and design starts with an in-depth understanding of users, stakeholders, context and possible impact. The research feeds the stories that the MDTs work with. Another goal of doing research can be to test one of your prototypes. This is vital to be able to make the right decisions in the next Design Cycle. In a research sprint the MDT should have a clear idea of which (sub)question(s) they want to have answered at the end. In planning a proper research sprint, the plan board and method kit is used.

Translate: *stories and requirements*

Once the MDTs have gathered a lot of data, content and have clustered the insights from the research, they should translate these into the stories that matter for the solution. The MDT will first come up with rough stories that have to be made more detailed based on the analysis that was done, or based on additional short-time research. At the end there is a collection of detailed stories, that are very suitable to be translated into requirements: what will the solution have to do/have/feel like in order to tackle the problem/ challenge? In a translate sprint the focus is on what is on the table, without being distracted anymore by asking a lot of questions. Now, only those questions should be asked that help get the stories right and in their place. The plan board and method kit can be used if the MDT needs to enrich some of the stories with additional insights.

Create

After the list of requirements for the particular Design Cycle has been made, the MDT can start implementing them into a design and prototype. In a create sprint it is important to be very clear about what has to be done, how it should be done and what is needed to facilitate that. The team will have to support each other as much as possible in making it a structured exercise without getting lost in possibilities, technical discussions and constraints.

The duration of each sprint

The duration of the sprint that is taken, be it research, translate or create, is up to the MDT to decide. In the earlier Design Cycles, it may be necessary to spend more time on research and translation, and in later cycles creation might need more attention and time.

5 FINAL CONCLUSIONS

In this paper, a linear, human-centered design approach with three main elements (Research, Create and Design) has been evaluated by 13 students who worked with it in multidisciplinary design teams in

a lab context. Results of the evaluation in combination with insights from recent literature, have been discussed to illustrate the components or 'ingredients' of an improved design process that aims at improving motivation and enhancing learning and transfer between the different phases, for both individual members and the multidisciplinary design teams they are part of. Learner control over pace allows students to decide how long they need to spend on each phase. An iterative cycle (instead of a linear cycle) of the different phases enhances variability of practice, which enhances learning and learning transfer. The new design approach is going to be used by new students from February 2014. Besides the results of the presented study, some preliminary insights might be available by the time of the conference.

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