A Path for Exploring the Agile Organizing Framework in Technology Education

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Abstract— **When the Agile Organizing Framework (AOF) is examined through the lens of the social constructivist pedagogy, principles and practices that define an agile learning environment emerge. This paper presents a translation of the AOF to fit the context of instruction in higher education based on the social constructivist perspective, and is not limited to software engineering education. Additional research is needed to observe, test and validate each of the agile enablers and inhibitors in the classroom, and to determine which principles and practices best contribute to the achievement of learning objectives. Furthermore, we hypothesize that integrating elements of the agile learning environment into agile software development methodologies could enhance a team's ability to successfully synchronize exploitation (the continuous improvement of existing products and practices) with exploration (the identification and implementation of breakthrough innovations).**

Keywords-agile; Agile Organizing Framework (AOF); agile learning environment; higher education; software engineering education; ambidextrous; exploration; exploitation

I. INTRODUCTION

Designing and developing curricula in software engineering and technology development can be challenging, particularly because specific technologies can change rapidly. If the functional skills to which a student is introduced in the university can quickly become obsolete, how can educators best prepare students for software development jobs?

One potential approach is to craft a classroom experience in the spirit of agile software development principles, in an attempt to imbue students with the capacity for creative and adaptive team-based problem solving so often observed in agile software development teams. It is this potential that the authors initially aimed to explore, and that simultaneously led to their interest in the Agile Organizing Framework (AOF) developed by Vidgen and Wang [1]. Although agile methods have been introduced into software engineering curricula (cf. [2]), there is no evidence that they have been applied in courses or programs outside technology development. By leveraging the AOF, there could be even greater potential for lessons learned by the agile software development community to exert wide-reaching influence on the development of progressive pedagogy in many fields.

Based on case studies examined in the context of complex adaptive systems theory, Vidgen and Wang identified the emergent capabilities of agile teams in their formulation of the AOF. Its three defining principles, based on work by Volberda and Lewin [3], are to 1) match the coevolutionary change rate between the development team and the customer, 2) optimize self-organization, and 3) synchronize exploitation (improvements in productivity, processes, and existing products) with exploration (innovation and the creation of new knowledge). These principles reflect key elements of the social constructivist pedagogy, namely the pursuit of shared meaning and evolved beliefs, planned and unplanned exploration of new ideas, and awareness of and reflection on one's own learning process.

Because the AOF supports the fundamental propositions of social constructivist pedagogy, it provides an appropriate foundation for identifying the characteristics, enablers, and inhibitors of an agile learning environment. This paper establishes a link between these two conceptual frameworks, translating the core principles of the AOF into practices that can be applied in a classroom setting to cultivate an agile learning environment.

II. PARALLELS TO SOCIAL CONSTRUCTIVIST PEDAGOGY

Constructivist learning theory posits that learning is an active process whereby humans engage in knowledge construction, taking in sensory input and making meaning out of it. It is contrasted primarily with transmission approaches to learning which characterize the process of learning as the passive reception of new information. Karl Popper refers to this knowledge construction process as "evolutionary epistemology." [4] The basic assumption is that people are not born as blank slates, rather, that all are born with a simple set of beliefs in place about the world. Through observation and experience those beliefs evolve into systems that make individuals better able to interact with the people and phenomena that are encountered within their environments.

While our efficiency at developing more "accurate" models of the world around us can be enhanced through the guidance of a teacher, constructivists hold that knowledge is not transmitted from teacher to student, but rather is reconstructed anew each time a student confronts lessons learned from experience and updates his or her world view to incorporate the new information. Social constructivist learning theories thus extend the unit of analysis from individuals to the group to demonstrate the synergistic and emergent behaviors of *groups of people* learning and working in close proximity with one another.

Constructivist pedagogical approaches tend to espouse the following [5]:

- Respect for individuals and groups involved in the learning process that leads to a genuine effort to understand the motivations and world view of the participants by the instructor
- Effort to move the group to arrive at a shared meaning of a context or situation via free and open discussion
- Exploration, planned and unplanned, of the subject matter being examined via formal and informal mechanisms
- Opportunity for individuals to change their beliefs in response to interaction with the context where knowledge and information is being experienced, and also to challenge those experiences
- Meta-awareness of one's own learning processes

Although the elements of the Agile Organizing Framework were developed without respect to or consideration of learning theories, direct comparison suggests that the AOF and social constructivist learning theory can and do lead to strikingly similar practices and conclusions. The connection itself bears further analysis and investigation.

III. From Agile Development Team to Agile Learning Experience

The capabilities, enablers and inhibitors identified by the AOF emerged from analyzing the behaviors of agile and non-agile development teams in industry. For the AOF to be translated to the educational environment, we rely on the social constructivist view to identify how the processes and practices of an agile software development team mimic the learning process in the classroom.

In an agile development team, individuals come together to achieve a tangible development objective which requires them to explore and understand customer requirements, learn new business and technical concepts and skills, and reshape their approaches based on new insights. Very often, they must also navigate complex knowledge environments where they must rely on other members of their teams for additional information and understanding. Projects of great complexity require that the development team distribute and use their collective knowledge based on the specific interests, aptitudes and capabilities of various team members.

Similarly, in the classroom setting, students must explore and understand the instructor's requirements for the course, including specifications for assignments and projects, and learn new concepts, topics and skills to satisfy those requirements. Since each student has different aptitudes, interests, and levels of commitment, their understanding of the material and the course itself will shift over the duration of the quarter or semester. As concepts and projects become more complicated, the students will increasingly rely on their instructor and on each other to gain additional understanding to complete the required work as their beliefs shift in response to new tacit and codified knowledge.

The roles in the agile software development team also correspond directly to the roles in the classroom. The instructor functions as the customer, customer representative or project champion. The individual student or student team plays the same role as the developer or development team. Achieving a "successful learning outcome" in a classroom is similar to identifying a technological solution or delivering a project that meets the customer's expectations. Depending upon how the course is structured, the instructor can fully assume or share the role of the project manager or software development manager with his or her students.

IV. Framework for the Agile Learning Environment

In constructing the Agile Organizing Framework, the authors leverage three organizing principles from Volberda and Lewin: matching the coevolutionary change rate (of understanding and shared expectations) between the team and customer, optimizing self-organization within the team and between the team and customer, and synchronizing exploration and exploitation. For each *principle*, there are two *capabilities* identified; for each capability, several *enablers* and *inhibitors* of agility are identified.

The translation of the AOF that we present as a basis for future research and discussion retains the three core principles, retains the capabilities that correspond to each principle, and adjust the enablers and inhibitors to match the educational environment. The framework for the agile learning environment, which has been translated from the AOF, is summarized in Figure 1.

A. Match Coevolutionary Change Rate

The two agile team capabilities that were identified in support of this first principle, translated into the learning environment, are 1) coevolution of the students and instructor to create value in the form of stimulating the accomplishment of learning objectives and 2) sustainable working with rhythm. Students learn at different rates, and will adjust to the new content, the course, and the instructor's style and approach in different ways. Agile enablers promote a growing shared understanding of requirements, frequent delivery of tangible artifacts to demonstrate that learning is being achieved, and a rhythm-based pace that helps students focus on the course content rather than the logistics. Agile inhibitors will create bottlenecks in the learning process, for example, where students have to wait for instructor feedback before proceeding.

Coevolving, Self-Renewing Principles	Agile Team Capabilities	Agile Learning Environment Enablers	Agile Learning Environment Inhibitors
Principle 1: Match Coevolutionary Change Rate	Coevolution of Students and Instructor to Stimulate Accomplishment of Learning Objectives	Driven by evolving understanding and internalization of concepts: • Continuous refinement of learning objectives, e.g. by addressing them in daily stand-up meetings • Frequent iterative delivery of learning artifacts, e.g. sprints • Close, effective interaction between instructor and students, e.g. through paired learning, a la pair programming	• Instructor dictating syllabus, schedule, and assignment details, and signing off on assignments • Syllabus set in stone at the beginning of the course • Weak instructor/student relationship
	Sustainable Working with Rhythm	Change is embedded in and is core to the learning process: • Time-pacing through short, fixed-length iterations, e.g. learning sprints • Regular and frequent breaks and closure • Planning using small units of time • Multilevel planning and replanning • Small granularity of assignments and teaching problem decomposition	• Course pacing by planned events (e.g. tests) • Unsustainable time-pacing • Up-front planning for the whole course and following the plan rigidly • Large granularity of assignments, deliverables, and plans (which impedes clarity and actionability) • Overly restrictive or cumbersome course policies
Principle 2: Optimize Self-Organizing	Collective Mindfulness	Self-management and team discipline: • Shared responsibility for course management • Team discipline through peer and self-observation	• Instructor-centered course management without feedback from students • Instructor becomes bottleneck • Instructor externalized from students
	Sharing and Team Learning	Supportive structures for communication and collaboration visible to the team: • Formed by interconnected practices • Fostered by open working spaces, e.g. through innovative classroom layout • Multiskilling, e.g. through forming student teams with redundancy of skillsets	• Over-reliance on informal communication and collaboration • Tasks allocated centrally by instructor with little consultation with students • Isolated communication and collaboration depending on the willingness and attitudes of individual students
Principle 3: Synchronize Exploitation and Exploration	Process Adaptation and Improvement	Reviewing and improving process regularly: • Adapt learning process to learning context • Remove redundant activities and continuously monitor progress toward objectives, e.g. with burn down charts • Actively involve students in identifying opportunities for improvements in the learning process even for already effective practices	• Learning process in the context of course management not internalized by students • Learning process is imposed by the instructor and is seen as out of touch with students • Over reliance on "common sense"
	Product Innovation	Routinizing exploration: • Formalizing extension of assignments to independently explore other aspects of the problem • Allocate class time for independent investigation	• Course time not allocated to individual exploration • Focus on attendance and mechanically achieving minimum expectations • Lack of team-based exploration

Figure 1. Translation of the AOF by Vidgen & Wang (2009) into the context of an Agile Learning Environment.
(Note: Figure is not intended to capture all possible options in each category.)

B. *Optimize Self-Organizing*

The agile capabilities that support self-organizing are identical in the development environment and learning environment: 1) collective mindfulness and 2) sharing and team learning. Collective mindfulness implies that each student in the class shares responsibility for their own learning and shares in the decision rights for how to achieve that learning in the most optimal way. Sharing and team learning means that communication and collaboration are supported by course practices that encourage team interactions and an expanded context for feedback in which students can help each other improve. Agile enablers for self-organization in the learning environment help the students take responsibility for their individual and collective learning, whereas inhibitors exacerbate the gap between student and instructor and make the students over-reliant on their instructors for guidance.

C. *Synchronize Exploration and Exploitation*

Similar to principle 2, the two agile team capabilities that were identified in support of this first principle are identical in the development environment and the learning environment, and are 1) process adaptation and improvement, and 2) product innovation. The only difference is that for the development team, the product is the delivered technical solution and supporting material; in the learning environment, the artifacts are papers, projects and assignments that demonstrate learning objectives have been achieved.

In the learning environment, exploitation can manifest in at least two distinct ways. First, the students can focus on ideas, topics and exercises that are closely related to the core learning objectives. Through their questioning, the instructor can incrementally refine the material to better demonstrate concepts. Second, the students and instructor can work together to incrementally improve the policies and procedures that are characteristic of traditional course management.

Exploration, as well, can manifest in terms of the course content in addition to course management. Students can pursue new ideas that support or extend the core learning objectives, either independently or cooperatively with their instructor. Course management practices can also be adapted to evolve with the personal development of the learners to best support their intellectual growth as well as their growth as members of the development team.

V. RESEARCH QUESTIONS

We take the position that there is a rich landscape of research opportunities associated with exploring the structure of the Agile Organizing Framework (and the enablers and inhibitors that it identifies) in the classroom. Several themes can be explored, such as the link between an agile learning environment and learning outcomes, the role of an agile learning environment in producing highly skilled software developers who are adept at problem solving, and the effectiveness of an agile learning environment in non-technology courses.

Examples of research questions that could be explored using the AOF translated into a context for the agile learning environment include:

- Can an agile learning environment enhance the achievement of particular learning objectives?
- Will an agile learning environment develop more capable entry-level software developers and engineers?
- Does an agile learning environment improve critical thinking or problem-solving skills?
- What is the effectiveness of each agile practice in the classroom, as described by the agile enablers?
- Are certain agile practices more effective than others in helping students learn?
- Are ambidextrous classrooms (that balance exploitation and exploration effectively) more productive learning environments?
- What are specific course management practices that support the achievement of agility (e.g. elements of syllabus design)?

By leveraging the research that has already been done in agile methods, particularly exploring what agility is and how it can be achieved, it could be possible to create a vision for a new agile pedagogy. In this sense, what organizations have learned about how to create and deliver complex software solutions rapidly could enhance the ability of instructors in many disciplines to help their students achieve learning objectives.

REFERENCES

[1] **Vidgen, Wang, 2009**, B. Noble, and I. N. Sneddon, "On certain integrals of Lipschitz-Hankel type involving products of Bessel functions," Phil. Trans. Roy. Soc. London, vol. A247, pp. 529–551, April 1955. *(references)*

[2] **Rico, 2009**, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.

[3] **Volberda, Lewin, 2003** I. S. Jacobs and C. P. Bean, "Fine particles, thin films and exchange anisotropy," in Magnetism, vol. III, G. T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271–350.

[4] **Perkinson 1993**, *Teachers Without Goals, Students Without Purposes.* McGraw-Hill, 128p.