Continuous Learning Process Assessment Model

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Abstract

Process capability maturity modeling elaborated by the Software Engineering community became applicable for any process-oriented activity assessment and improvement. The purpose of this paper is to contribute to the solution of learning improvement problem based on process quality attributes modeling approach. Two-dimensional Learning process model is developed based on R. Marzano taxonomy of learning objectives and on the staged Learning process maturity model. The consciousness as a learning process quality characteristic is introduced.

1 Introduction

Does any learning improvement problem exist? Unfortunately, in contrast to the natural ability to breathe, walk or digest, humans do not possess neither equal abilities to learn, nor uniform understanding of what is learning. There is quite widespread attitude that a capacity to learn is the ability to memorize.

Communications with students before and after exams during several decades repeatedly were coming to the situation when students were saying: "I knew everything, but I've got this one question which I did not know". In the beginning such mismatch of student's self-assessment and professor's assessment seemed as a student's self-defense to keep moral comfort, but later, due to permanent character of the situation described, there came an idea that another reason exists – students don't know what the target state of the knowledge is. If a student doesn't know what the target state is, he can't reach it.

Usually Universities do not have such lectures for learning to learn, where students could understand, what the target knowledge status is. There are a lot of lectures to deliver knowledge. It is up to the student to find what status to achieve and how to achieve it.

The situation is at some extent different in mathematics study programmes. The mathematics study programs like others do not address explicitly the problem of learning to learn. However implicitly a successful graduate in mathematics during regular mathematical studies acquires the ability to learn without any additional efforts outside mathematical subjects. Mathematical approach to learning has one deficiency – internal demand to learn everything starting from axioms. But usually learning time and efforts are limited, particularly in IT area.

What is the percent of knowledge that has been acquired at the University comparing to the all knowledge to be acquired by a graduate during whole professional career in IT area up to the retirement? Having in mind that IT technologies change every 5 years, during his professional career he may face such changes 8 times. Simple calculation allows to conclude, that knowledge gained at University comprise about 10% of the total professional knowledge. It means that 90% of knowledge must be acquired outside the University by means of one's own efforts. It is a disaster for a graduate, who has not learned to learn at University. Most probably he will be obliged to change his profession.

A lifelong learning is not regular attending in training courses. The lifelong learning is a compulsory part of a regular daily work enabled by the ability to learn acquired at University.

Therefore, the main task for a student at University is the learning to learn, but not the knowledge acquisition as it is frequently understood. The learning to learn is a learning improvement. It is a real pity that such an approach is not widely recognized at University's environment.

The main process at University is not teaching but learning. It should not be left to laissez-faire, traditionally to the mechanical operation with text fragments.

The true learning is the consciously performed structured activity resulting to the creation of mental hierarchical aggregated model as an adequate representation of the learned subject.

The goal of research provided in this paper is to create adequate learning process model as the basis for learning process improvement. The purpose of such model is to transform a learning as a "black box" into transparent box with the internals of learning seen.

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The consciousness of process performance is considered as the essential measurable learning processes characteristic determining learning success.

This research was inspired by the own experience learning and teaching during 40 years and by the experience of creation of several process capability models for creative activities, and enforced by research results in education and psychology, first of all Marzano's New Taxonomy [MAR01].

Software process community can contribute to the recognition and solution of learning improvement problem by applying methods, which were elaborated for software crisis solution and turned up being much wider applicable than software area. It has been already proven that process capability maturity modeling approach became applicable for any process oriented activity assessment and improvement, including such creative activities as software development [15504], innovation [BES12] and learning [MAR14].

Process maturity modeling is based on processes grouping into maturity levels that reflect generic process improvement path. The requirements for processes in maturity modeling are described in terms of process performance and achievement of the process goals.

Process capability modeling is related with predefined process feature – process results predictability. Process capability characteristic is standardized by ISO/IEC 33020 [33020] in terms of process capability levels and process attributes defined by process achievements. Process capability attributes, for instance, PA 2.2. – Work product management attribute or PA 3.2 – Process deployment attribute by default are targeted to processes performed by organization.

The learning processes are performed by a single learner mentally. The results of learning processes performance are knowledge acquired. Process capability characteristics, at least some process attributes are not applicable for learning processes.

In such situation the applicability of process capability maturity modeling approach for learning process improvement is "legitimated" by ISO/IEC 33003 [33003], which allows to define own process quality characteristics.

The idea of modeling process characteristics other than process capability is analyzed in [WEL03].

In the context of standardization by ISO/IEC 330xx of the new process characteristics definition, the process agility characteristic introduced in [OZC14] demonstrates the relevance of approach to employ other process quality characteristics.

The idea of this work is to create a Marzano taxonomy based adequate learning process model for the process quality characteristic – consciousness using ISO/IEC 330xx modelling technics.

The state of the art learning process capability maturity modeling is provided in the Sections 2. The Section 3 contains authors' contribution to learning process modeling - development of two-dimensional learning process model. The last Section concludes the results achieved and provides ideas for the future work to be done to complete the solution of the problem addressed.

2 Learning process Capability Maturity Modeling

Capability maturity modeling at organizational learning level is well elaborated in [PEO09]. Process capability or organizational maturity improvement is widely understood as an organizational learning. But here are few more or less direct attempts to touch capability maturity modeling at individual learning level.

Personal software process [HUM97] can be considered as learning how to improve personal performance based on planning, measurement and tracking, i.e., understanding the process performed.

Capability maturity modeling in e-Learning area [MAR04], [NOV09] gains increasing attention of researchers. E-Learning is situated in between of education as organizational activity and learning as individual activity. E-Learning creates conditions for learner centric education. Education process itself is an organizational process [MIT12] which can be modelled using ISO/IEC 15504 conformant and Enterprise SPICE based model [ENT10].

Learning process maturity model [THO04], [THO06] is oriented to software development learning and is based on the idea that learning improvement can be achieved using the same concepts as improvement in software development.

The learning as an education area stresses on mental process of a learner. This area first of all is represented by the Bloom's Taxonomy [BLO56] and followed learning models and approaches [BIG82].

Particular place among them takes Marzano's New Taxonomy [MAR01], [MAR08] because of its process orientation. According to Marzano's Taxonomy learning is conditioned by three systems of mental activity: ego system, metacognitive system and cognitive system. Ego system is responsible for decision making in learning. Metacognitive system defines the goals and its achievement strategy. Cognitive system is responsible for effective performance of the tasks related to information processing: comparison, classification, conclusion, etc. All these systems use knowledge possessed by a learner. Cognitive system consists of processes grouped into four levels of knowledge processing: retrieval, synthesis, analysis and use.

3 New approach to Learning Process Modeling

Staged Learning process maturity model for learning process assessment and improvement based on R. Marzano taxonomy of learning objectives is proposed and partially validated in [MAR14].

Staged architecture of the model fits well for the sequentially layered cognitive processes in the learning improvement path. These cognitive processes within learning activity can be treated as primary or engineering or life cycle processes. The purpose of cognitive processes is to build mentally aggregated knowledge artefacts. Similarly to engineering mental knowledge building operate with constructs and the rules of their composition into aggregates. An adequate mental model must be built before creation of everyone engineering aggregate.

Ego process is responsible for decision-making, the decision to learn or not to learn is taken at some extent quite unconsciously before learning planning and execution. However in later stages of learning proficiency the decision-making is consciously performed. For this reason continuous architecture of the model is preferred to allow to reflect the performance of learning processes at various levels of consciousness as learning quality characteristics.

The measurement framework of learning process quality characteristic - consciousness is defined based on [33003] by tailoring process capability measurement framework [33020].

3.1 Process consciousness levels and process attributes

Process consciousness is defined on a four point ordinal scale that enables consciousness to be assessed from the bottom of the scale, **Incomplete**, through to the top end of the scale, **Conscious**. The scale allows to evaluate increasing consciousness of the implemented processes, from failing to achieve the process purpose through to continually improving consciousness.

An example of two-dimensional representation of learning processes performance consciousness profile is provided in Fig. 1. It consists of learning processes dimension and process performance consciousness dimension. The process dimension is represented by 7 learning processes. Each of them can be performed at various levels of consciousness from level 0 – Incomplete to level 3 – Conscious defined here bellow.

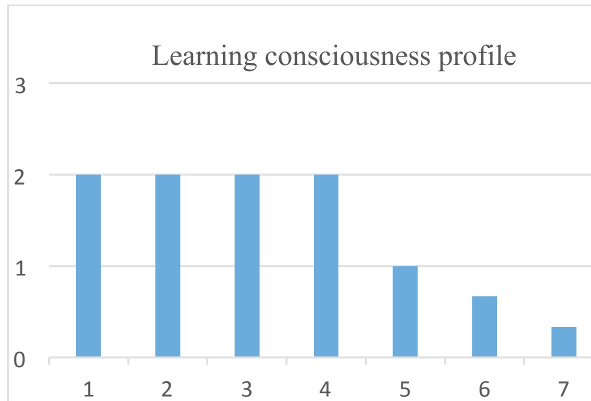

Figure 1: Learning processes consciousness profile

3.1.1 Process consciousness Level 0: Incomplete process

The process is not implemented, or fails to achieve its process purpose. At this level there is little or no evidence of any systematic achievement of the process purpose.

3.1.2 Process consciousness Level 1: Performed process

The implemented process achieves its process purpose. The following process attribute demonstrates the achievement of this level.

3.1.2.1 Process performance attribute PA1.1

The performed process attribute is a measure of the extent to which the process purpose is achieved. As a result of the full achievement of this process attribute:

a) The process achieves its defined process outcomes.

3.1.3 Process consciousness Level 2: Motivated process

The previously described performed process is now implemented as a motivated (important, effective, emotional).

The following process attribute, together with previously defined process attribute, demonstrate the achievement of this level:

3.1.3.1 Motivated process performance attribute PA 2.1

The motivated process performance process attribute is a measure of the extent to which the process performance is motivated. As a result of the full achievement of this process attribute:

a) The importance of process performed is assessed by a learner.
b) The ability of the learner to perform process effectively is assessed.
c) The emotions of the learner concerning process performed are assessed.
d) The motivation to perform process is assessed and the decision to perform process is made.

3.1.4 Process consciousness Level 3: Conscious process

The previously described motivated process is now implemented as a planned and tracked process.

The following process attribute, together with previously defined process attributes, demonstrate the achievement of this level:

3.1.4.1 Planned process performance attribute PA 3.1

The planned process performance process attribute is a measure of the extent to which the process performance is planned. As a result of full achievement of this process attribute:

a) The clear goal of the process performed and the target knowledge state is defined by a learner.
b) The strategy to achieve process goal is created.
c) The plan to achieve the target goal is developed by the learner.
d) The resources, milestones and schedule of the target knowledge state achievement are determined.

3.1.4.2 Tracked process performance attribute PA 3.2

The tracked process performance attribute is a measure of the extent to which the process performance is tracked. As a result of full achievement of this process attribute:

a) The process performance against process plan is tracked.
b) The clarity of the knowledge learned is assessed by the learner.
c) The precision and trustworthiness of the knowledge learned is assessed by the learner.

3.2 Process attribute rating scale

Within this process measurement framework, a process attribute is a measurable property of process consciousness. A process attribute rating is a judgment of the degree of achievement of the process attribute for the assessed process.

As it is indicated in the introductory part of section 3 the measurement framework of learning process quality characteristic - consciousness is defined based on requirements [33003] by tailoring process capability measurement framework [33020]. A process attribute is measured using an ordinal scale as defined below.

N Not achieved: there is little or no evidence of achievement of the defined process attribute in the assessed process.

P- Partially achieved: there is some evidence of an approach to and some achievement of the defined process attribute in the assessed process. Many aspects of achievement of the process attribute may be unpredictable.

P+ Partially achieved: there is some evidence of an approach to and some achievement of the defined process attribute in the assessed process. Some aspects of achievement of the process attribute may be unpredictable.

L- Largely achieved: there is an evidence of the systematic approach to and significant achievement of the defined process attribute in the assessed process. Many weaknesses related to this process attribute may exist in the assessed process.

L+ Largely achieved: there is an evidence of the systematic approach to and significant achievement of the defined process attribute in the assessed process. Some weaknesses related to this process attribute may exist in the assessed process.

F Fully achieved: there is an evidence of the complete and systematic approach to and full achievement of the defined process attribute in the assessed process. No significant weaknesses related to this process attribute exist in the assessed process.

The ordinal scale defined above shall be understood in terms of achievement in percent of a process attribute.

The corresponding percentages shall be:

N Not achieved 0 to ≤ 15 % achievement

P- Partially achieved-> 15 to ≤ 32,5 % achievement

P+ Partially achieved+>32,5 to ≤ 50 % achievement

L- Largely achieved-> 50 to ≤ 67,5 % achievement

L+ Largely achieved+> 67,5 to ≤ 85 % achievement

F Fully achieved > 85 to ≤ 100 % achievement

3.3 Process attribute rating method

A process outcome is an observable result of the successful achievement of the process purpose.

A process attribute outcome is an observable result of the achievement of this process attribute.

Process outcomes and process attribute outcomes may be characterized as an intermediate step to providing a process attribute rating.

3.3.1 Rating method

The approach to process attribute rating shall satisfy the following conditions:

a) Each process attribute for each process within the scope of the assessment shall be characterized for each process instance, based on validated data.

b) Process attribute characterization for all assessed process instances shall be aggregated to provide a process attribute achievement rating.

c) The assessor may choose to apply expert judgement to summarize the ratings without employing a formal mathematical approach, alternatively an aggregation method may be used.

3.4 Learning Process consciousness level model

The learning process consciousness level shall be derived from the process attribute ratings for that process accordingly to the process consciousness level model defined in Table 1.

Table 1: Learning process consciousness level ratings Table 1:

Scale	Process attributes	Rating
Level 1	Process Performance	Largely or fully
Level 2	Process Performance Motivated Process Performance	Fully Largely or fully
Level 3	Process Performance Motivated Process Performance Planned Process Performance Tracked Process Performance	Fully Fully Largely or fully Largely or fully

3.5 Learning Process Reference model

Provided here Learning Process Reference model reuses processes from [MAR14] and forms process dimension, which consists of 7 processes to be performed by a learner. The description of these processes satisfies the ISO/IEC 33004 requirements for Process Reference Model [33004] and is provided in Table 2.

Table 2: Learning Process Reference Model

LEAR.1. Knowledge Retrieve Ability Development	
Purpose	**Outcomes**
To acquire ability to recognize and reproduce target knowledge	1) Learner is able to identify and recognize knowledge items. 2) Learner is able to reproduce and perform a procedure.
LEAR.2. Knowledge Synthesis Ability Development	
Purpose	**Outcomes**
To develop ability to abstract and aggregate knowledge	1) Learner is able to recognize essential and non-essential features of a knowledge item. 2) Learner is able to generalize a set of knowledge items with identic essential features by a single abstract notion. 3) Learner is able to represent, recognize and operate with abstract notions. 4) Learner is able to aggregate

	knowledge items and structures.
LEAR.3. Knowledge Analysis Ability Development	
Purpose	**Outcomes**
To develop ability to verify consistency of aggregated knowledge and matching of new knowledge item to aggregate created.	1) Learner is able to identify similarities and differences of knowledge items. 2) Learner is able to identify knowledge items subsets and supersets. 3) Learner is able to identify mistakes in knowledge presentation. 4) Learner is able to identify special cases and derive related conclusions. 5) Learner is able to foresee possible circumstances.
LEAR.4. Knowledge Application Ability Development	
Purpose	**Outcomes**
To develop ability to apply aggregated knowledge in solving new tasks.	1) Learner is able to derive task solution based on possessed knowledge aggregate. 2) Learner is able to identify and assess solution's alternatives. 3) Learner is able to use knowledge and skills acquired as a tool for hypothesis investigation. 4) The ability to verify the trustworthiness of external information is acquired.
LEAR.5. Motivation Assessment	
Purpose	**Outcomes**
To assess motivation to learn and identify reasons for motivation	1) The importance for learner of knowledge to be acquired is assessed by learner. 2) Learner's opinion about his own ability to acquire identified knowledge and skills is self-evaluated. 3) Emotions related to knowledge and skills to be acquired and to their acquisition are identified. 4) The drives that condition learner's motivation to learn are identified.
LEAR.6. Learning Goals Definition	
Purpose	**Outcomes**
To define learning goals, level of knowledge acquisition and to select suitable strategy to reach learning goals, and to develop learning plan	1) Based on motivation target the knowledge level to be achieved (knowledge retrieve, synthesis, analysis or application ability) is identified by learner. 2) Learning goals are defined. 3) Strategy to achieve learning goals is selected. 4) Learning plan is developed. 5) Learning sources are selected.
LEAR.7. Learning Results Tracking	
Purpose	**Outcomes**
To assess acquired knowledge and skills, and to compare learning achievements with learning goals.	1) Learner is able to track the acquisition efficiency (to assess learning actions for learning goals achievement) of knowledge and skills being learned. 2) Learner is able to track the consistency and precision of knowledge and skills being learned. 3) Learner is able to track the trustworthiness of knowledge and skills being learned.

Learning process model is defined at PRM and PAM levels.

4 Model Validation

Partial validation of the model created was done for Learning process performance at the Level 1. There were selected students for learning process assessment belonging to two different groups, ten students in each group, according to exams results. The average of students learning process performance assessment results was calculated per process for each group. The comparison of learning process profiles composed for two groups is provided in Fig.2.

As it is shown in Fig.2 the classification of the groups according to exam grades was repeated for all processes of Learning process model according to model based learning assessment results.

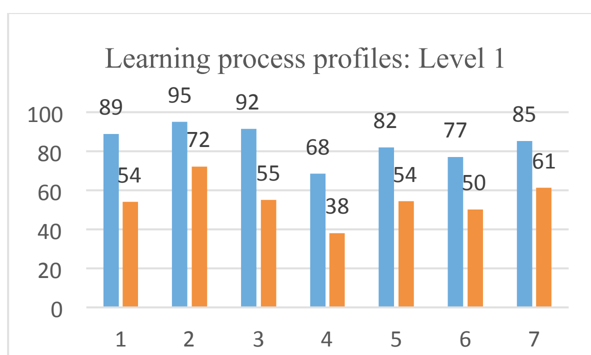

Figure 2: Comparison of Learning process profiles of two students groups

5 Conclusions and Future Work

The paper provides two-dimensional Learning process model for learning process assessment and improvement based on R. Marzano taxonomy of learning objectives and on the staged Learning process maturity model. The measurement framework of learning process quality characteristics - consciousness of learning process performance is tailored based on ISO/IEC 330xx.

Learning process model is defined at PRM and PAM levels.

An adequacy of the Learning process model developed to real learning activity should be validated in future research.

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