Assessment of Adaptive PBL's Impact on HOT Development of Computer Science Students

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Abstract
Meaningful learning based on PBL is new learning strategy. Compared to traditional learning strategy, the meaningful learning strategy put the student in center of the learning process. The roles of the student in the meaningful learning strategy will be increased. The Problem-based Learning (PBL) model is considered the most productive way to encourage development of higher order thinking. In this paper we introduce application of an innovative approach to complex, adaptive, and computer-mediated assessment of HOT skills development of individual students. The complexity of assessment is expressed by forming the combined creative and analytical assessments of HOT skills. Analytical assessments skills are focused on evaluating, selecting, contrasting, comparing, and ordering. Creative Assessment adaptation is provided for individual students as for a study group. Creative assessments skills are focused on originality, efficiency, flexibility, problem finding, and elaboration. Results showed that PBL changes the learning process in many ways. It changes the relationship between learner and teacher, and has an impact at the leaner level. The class has been re-organized and re- evaluated according of the principles of PBL. From the teacher's perspective, PBL demands fundamental and deep reflection on work practices.
Keywords: Problem-Based Learning, Higher-Order thinking, personalized learning, analytical thinking, critical thinking.

1. Introduction

PBL stands for both Problem-Based Learning and Project-Based Learning. PBL has proven to be a successful educational strategy in various fields. In computer science course has been developed new educational concept of PBL within higher education especially academic college for education. The goal of the proposed approach is developing HOT skills of students through adaptive problem-based learning. Adaptability of PBL is expressed by changes in fixed instructor assessments by crossing from one phase of PBL to another, choice of control tests and problems for students, and formation of heterogeneous collaborative groups. It should induce the students to develop HOT skills and collaborative skills through PBL. Adaptability of PBL is aimed at personalization of learning.

There are two distinct types of HOT skills: analytical and creative thinking skills. Analytical or logical thinking skills allow critical thinking and help select the best alternative. Analytical thinking skills are: ordering, comparing, contrasting, evaluating, and selecting. Creative thinking skills are needed for problem solving. The creative thinking skills are problem finding (identifying the problem), efficiency (producing many ideas), flexibility (producing a broad range of ideas that characterizes flexible understanding), originality (producing uncommon ideas), and elaboration (developing ideas) (Hmelo-Silver, 2004; Bednarz, 2011; Cottrell, 2011; Cottrell, 2013).

According to the proposed approach development HOT of students during study of subject by the class is realized through two phase process of Adaptive PBL. The course knowledge students acquire during the first phase. The attention on first phase is devoted by development analytical HOT skills of students. Fixed initial assessments of analytical HOT skills are set. After this phase analytical HOT skills of every student are examined by the personal control questions based on course material. It allows to assess development of the analytical skills. Next, adaptive collaborative group formation by taken into account of the assessment results of individual students is realized (Tilchin & Raiyn ,2015).

The second phase of Adaptive PBL is fulfilled by the collaborative groups through problem solving process based on course material. The main attention on this phase is devoted by development creative HOT skills and collaborative skills of students. After the second phase developing HOT skills and collaborative skills of individual students are examined. Choice of control questions for examination of analytical HOT skills development is caused by the assessments of the skills after first phase. Development of creative HOT skills of a student is examined by control problems. It allows to assess development of the personal creative skills.

2. Methodology

Adaptive PBL directed towards HOT skills development is realized by the following steps:
A. Preparation of the needed instructional materials for a course in computer science
B. Assessment of developing analytical skills of the students after the first phase of PBL
C. Building skill heterogeneous collaborative groups of the students

D.   Adaptive formation of fixed assessments of HOT skills for second phase of PBL
E.   Assessment of HOT skills development of students after second phase of PBL
F.   Assessment of collaborative skills of students

A.   Preparation of the needed instructional materials for a course
Preparation of the needed instructional materials for a course includes:
- The forming of a list of course topics
- Formulation of course requirements from a student with regard to development of HOT skills. After studying a course a student should have developed HOT skills and collaborative skills. Thereby, he (she) should be able to apply effectively acquired knowledge through taking creative solutions during solving of the proposed instructional problems, and explain cause-and-effect relationships.
- The forming of a list instructional problems covering all learning outcomes and HOT skills
- Setting fixed initial assessments of analytical HOT skills. Difference of the fixed initial assessments of the skills expresses the preference of an instructor in the development of certain skills during the first phase of Adaptive PBCL. An example of setting the fixed initial assessments is represented by Table1. The "Evaluating" skill has the greatest need for development since they provide critical thinking. Consequently, the maximum fixed initial assessment is set for this skill.
- The forming of control questions and instructional problems for examination of HOT skills of students. The instructor composes: a list of control questions which should examine analytical HOT skills of students after first phase of Adaptive PBL; a list of control questions and problems for examination of analytical and creative HOT skills of students after second phase.

B.   Assessment of developing analytical skills of students after the first phase of PBL
A student's analytical HOT skills are assessed by an instructor through the answers given by   a student to control questions from the individual list. An instructor assessment of a student answer to a question varies from zero to the fixed initial assessment of analytical skill corresponding to a question. If a student cannot answer a question, or an answer is incorrect, then an instructor assessment is equal to zero. If a student answers a question corresponding to certain skill correctly, an instructor assessment is equal to fixed initial assessment of corresponding skill. It means he or she has developed this skill. If a student answer is not full, an instructor sets suitable assessment. As a result, an assessment of a student is made. Assessments of other students from a study group are set analogously.

C.   Building skill heterogeneous collaborative groups
   Effective PBCL is caused by the following conditions of building collaborative group:
- All the students studying a course should have all analytical HOT skills. It allows students to develop needed HOT skills as a result of collaboration with other students in a study group
- Maximum mutual supplementation of skills of students inside a collaborative group. This condition provides facilitation of developing skills of the students of the collaborative group through interactions compensating for the lack of personal skills
- Taking into account individual characteristics of students during the formation of collaborative groups. This condition allows to remove limitations of collaboration.
          The students will get an opportunity to develop HOT skills through collaboration owing to:
intra-group interactions among students if cumulative skills of students in collaborative group equal required analytical HOT skills; inter-group interactions among students if cumulative skills of students in a collaborative group are less then required analytical HOT skills.

D.   Adaptive formation of fixed assessments of HOT skills for second phase of PBL
The analytical skills were developing on first phase of PBL. Consequently, fixed assessment of this skill type is decreased for second phase of PBL. Furthermore, analysis of assessments of analytical HOT skills reveals a lack of development certain skills in a study group. It stipulates   the need of adaptation of a study group's analytical skills assessments to the process of developing these skills. Adaptation of assessments is realized by changing the fixed analytical HOT skills assessments. It is realized for a study group in the following way. If examination results revealed a lack of the certain skill development for the study group, then fixed assessment of this skill is increased by an instructor.

E.   Assessment of HOT skills development of students after second phase of PBL
The instructor composes individual lists of control questions on the basis of the complete list for examination of analytical skills development. An individual list can contain some questions for examination of a certain analytical skill. The individual questions are formed on the basis of skill assessments of a student after first phase of PBL**.** It provides adaptive personalized learning. Next, the instructor composes individual lists of control problems based on the complete list. Development of creative skills of a student is assessed by the instructor as a

result of solving by him the problems from the individual list. The aggregate of control questions and problems from the individual lists should provide examination of all analytical and creative skills. Assessment of HOT skills development is realized by comparison of the values of the coefficient of skill development after second phase of PBL with the correspondence values of the coefficient of skill development after first phase of PBL.

F.   Assessment of collaborative skills of students
An assessment of collaborative skills of a student is done by taking into account assessments of his (her) HOT skills of a student acquired as a result collaboration. The collaborative group is skill heterogeneous with realization of a condition of maximal mutual supplementation of skills of the collaborative group of students. It fosters and facilitates skill sharing among students. Assessment of collaborative skills is based on analysis of assessments of HOT skills of students after collaborative problem solving. The objective of the analysis is to determine a student (students) who obtained a maximal assessment. Such assessment is a result of acquiring HOT skills by students due to collaborative problem solving. It can serve as a measure of success of collaboration of a student with other students of the collaborative group and also with students of other collaborative groups. Hence, a student with a maximal assessment possesses the best collaborative skills. The assessments of collaborative skills of students in a study group are calculated proportionally to the assessments HOT skills on the basis of fixed assessment of collaborative skills. The combined summative assessments characterize outcomes of PBL. These assessments are determined by summation of combined assessments of HOT skills and assessments of collaborative skills.

3.   Performance Analysis of Adaptive HOT Skills
Since long time learners haven't changed much. They have used the traditional learning method.
However it has changed the technology tools (Raiyn, 2014). In heterogeneous class room we believe that each student has HOT skills, however with different skills level. We have divided HOT skills in three levels, low, medium, high. PBL takes into consideration student HOT skills variation between students. To overcome the difference between students we introduce personalized learning. Personalized learning means to us that I we teaching a student where they are and what they need in order to be successful. In personalized learning process the role of teachers, learners will be changed. To transform learning, teachers, learners, learning tools share the vision of how they will personalize learning for every student. In personalized learning teachers get new role. Instead of delivering knowledge and information, teachers become partners with their learners. Learners first understand how they learn best. Then they acquire the skills to choose and use the tools that work best for their learning qualities.
 Steps to Personalize Learning

3.1 Assessment and Evaluation
In this section we discuss the performance analysis of adaptive higher- order thinking skills. In computer science course we have implemented adaptive higher- order thinking assessments. We have used various adaptive higher-order thinking assessment to evaluate the creative and analytical thinking skills based on PBL assessments as illustrate figures 1 & 2. In the first phase we have measured the high order thinking skills for each student based on ordering, selection, evaluation, contracting, and comparison assessments. In the second phase we will measure the analytical skills based on flexibility, selection, efficiency, elaboration, and problem finding. The students will be divided in subgroups. The groups will be created based on creative skills performance for each student in the first phase.
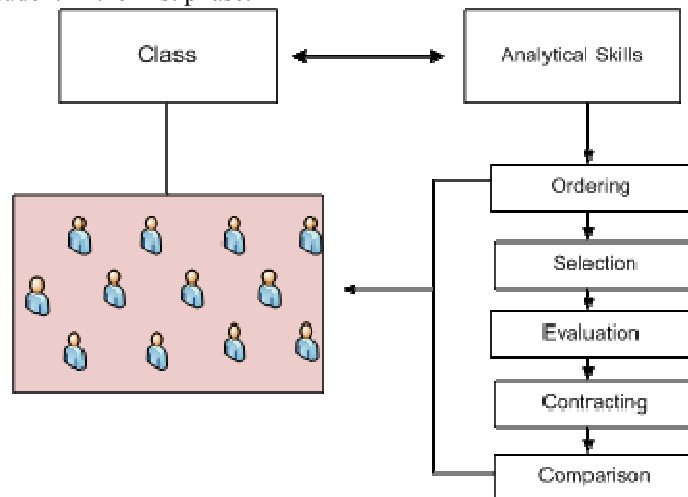

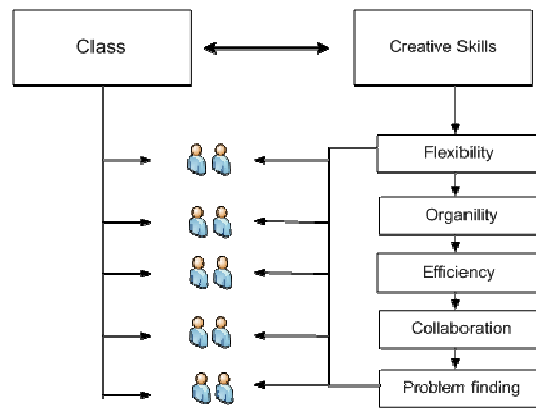Figure 1: Process of acquiring analytical skills

Figure 2: Process of acquiring critical skills

Figure 2 illustrates the score of students ordering, selection, and contracting assessments. According to Figure 2 appears that the students performance are heterogeneous compared to evaluation, analysis, and comparison skills. The HOT skills gab is clear in HOT skills that are focused on selection, ordering, and contrasting.
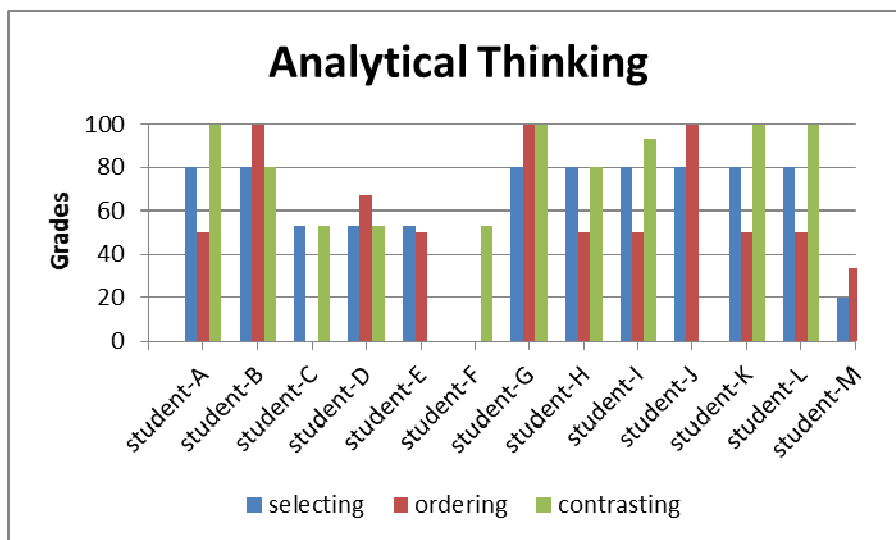

Figure 3a: HOT assessment

Figure 3a illustrates that evaluation, analysis, and comparison HOT skills by students are high and adjacent.
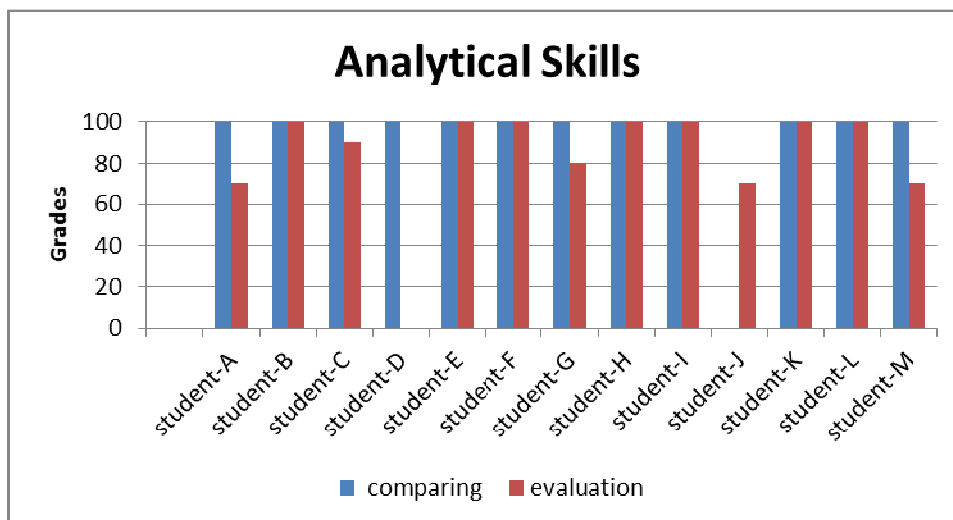

Figure 3b: HOT assessments

Figure 4 illustrates the approach of creating sub-groups. The groups will be created based on the student's performance in analytical thinking skills assessments. The subgroup's building is the bridging of the increased gap between students. The goal of the subgroups building is to overcome the increasing gab between students.
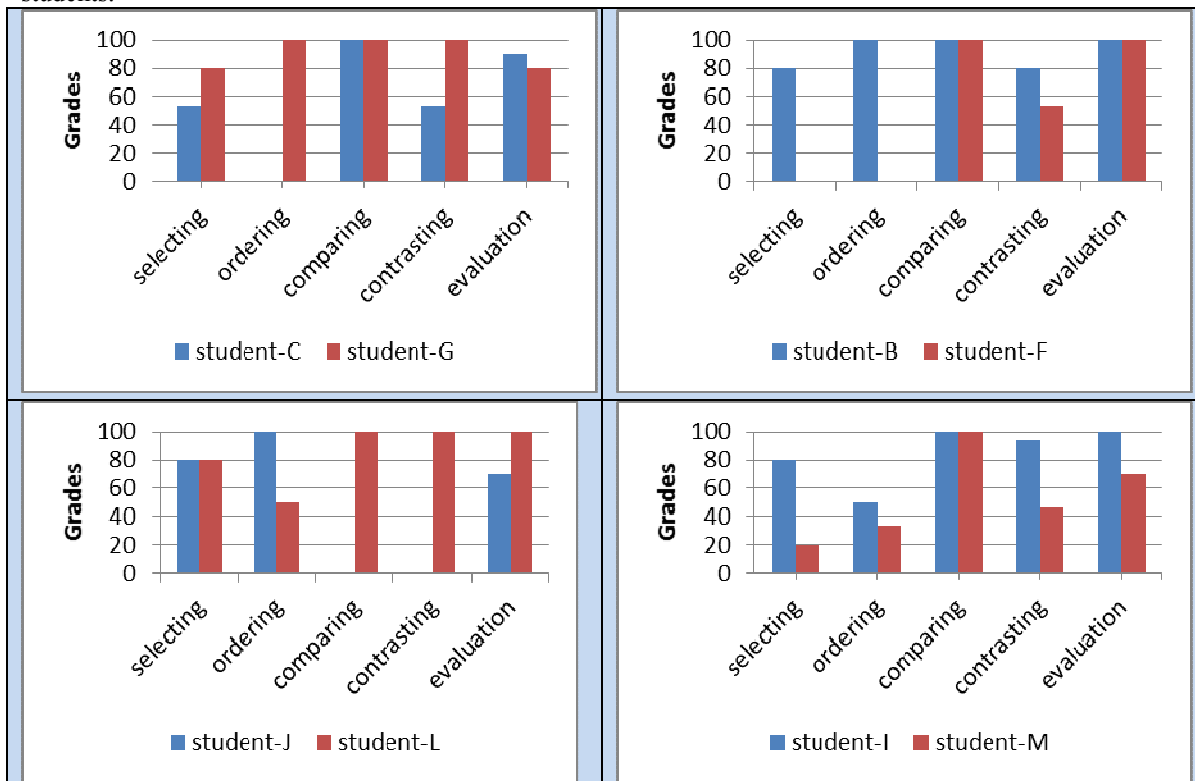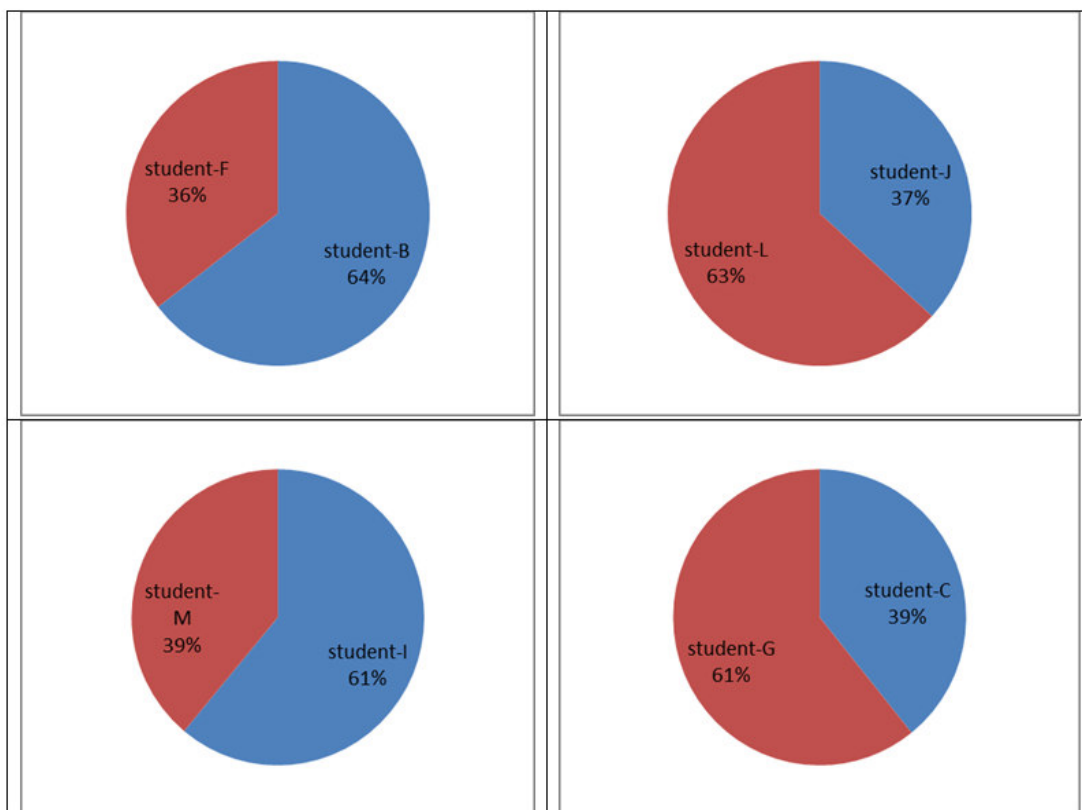

Figure 4: Sub-group building strategy

Figure 5: Analytical thinking skills gaps

Figure 6 illustrates results of critical thinking skills assessments. From the figure we conclude that the

performance of students in problem findings skills is weak. The result was expected because the HOT skill of PBL was based on defined project and problem for students.
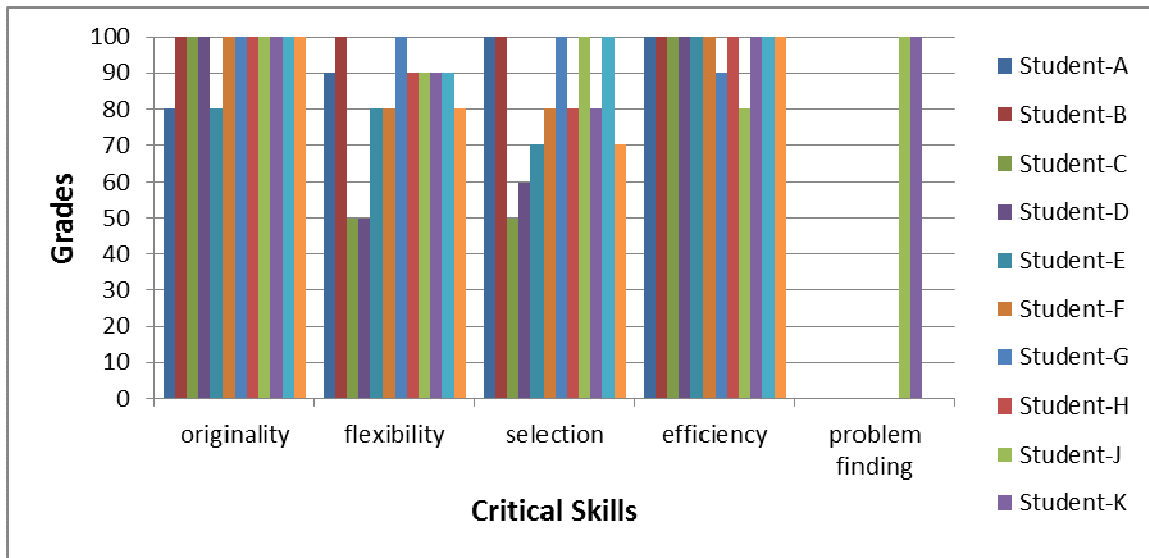

Figure 6: Critical thinking skills

Figure 7 illustrates that student's critical skills gaps between students have been reduced. Furthermore we conclude that the collaboration between students has been increased. Students have worked together to accomplish a task of defined problem in sub-groups. The effort of multiple individuals is clearly increased.
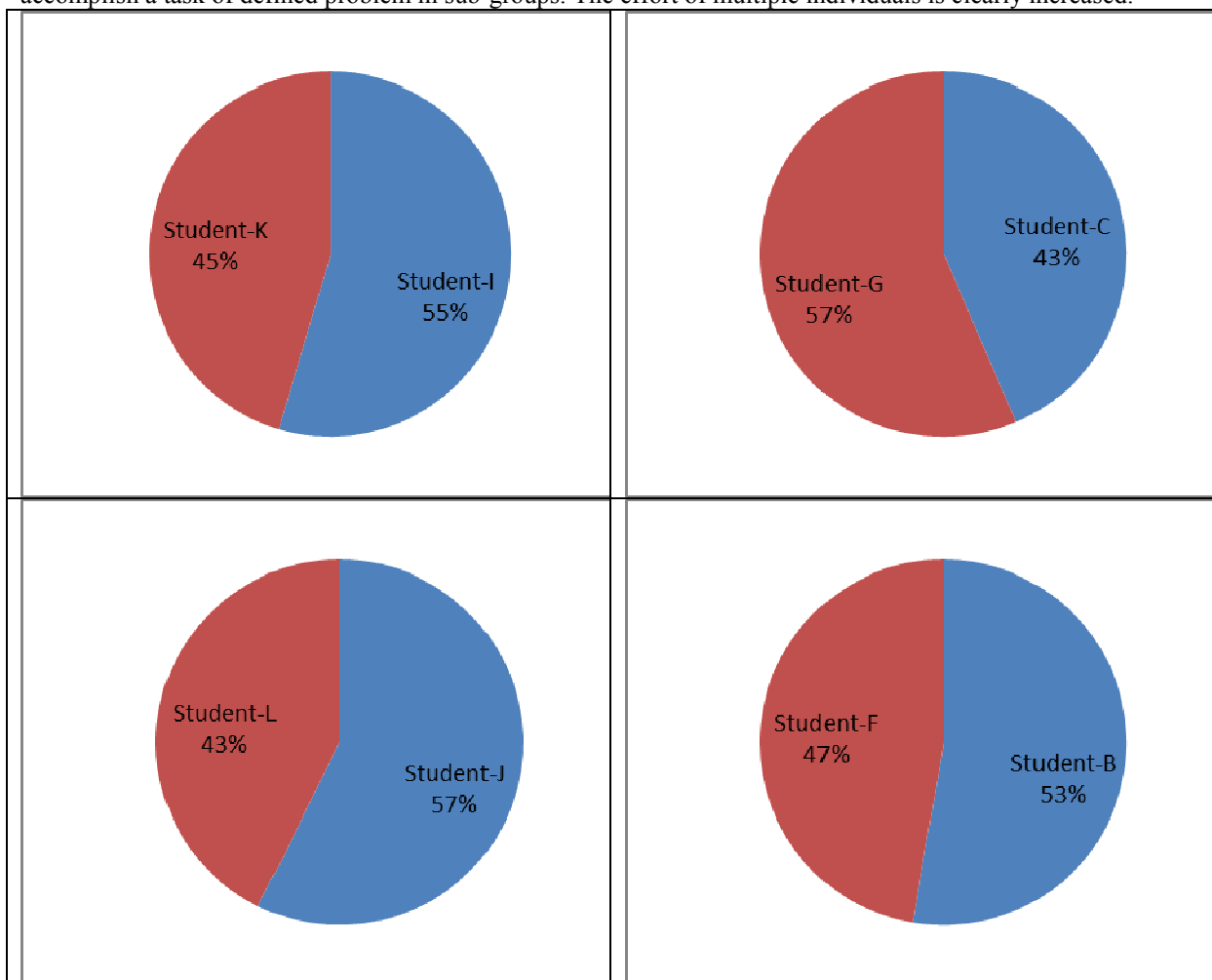

Figure 7: Critical thinking skills gaps

4. Conclusion und Future Works

In this paper we have introduced process of acquiring analytical and creative skills of high order thinking. Furthermore we have discussed higher order thinking assessment based on creative skills and analytical skills based on flexibility, selection, efficiency, elaboration, and problem finding in order to design automatic evaluation for high order thinking skills. Results showed that PBL changes the process of learning in many ways. It changes the relationship between learner and teacher, and has an impact at the leaner level. The class has been re-organized and re- evaluated according of the principles of PBL. From the teacher's perspective, PBL based on analytical skills demands fundamental and deep reflection on work practices. In the future work we aim to develop automatic evaluation of HOT skills assessments based on undefined problem.

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