

# Using Peer Assessment to Enhance Higher Order Thinking Skills

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**Abstract** – One of the priorities in the European Higher Education area is the task of attracting young people wishing to engage in science and development of their creative potential. The aim is to promote the interest of children, young people and the public in researches and their application in business. Essential for young people's success are their critical thinking skills, knowledge application and problem-solving skills, as well as assessment skills. The article proposes a methodology for assessment of higher order thinking skills based on Bloom's Taxonomy. It provides a mechanism for systematic assessment of diverse skills from different levels of Bloom's cognitive domain. It is suitable for training students who have ambitions to become highly qualified specialists - scholars, medics, pedagogues, economists, legal practitioners, criminologists, etc.

**Keywords** – higher order thinking skills, critical thinking skills, methodology for assessment of higher order thinking skills.

## 1. Introduction

Higher order thinking (HOT) can be conceptualized as a non-algorithmic, complex mode of thinking that often generates multiple solutions [7]. Higher order thinking skills (HOTS) include critical, logical, reflective, metacognitive, and creative thinking [9]. Many scientists share the view

that HOTS are skills that fall into one of the following 3 categories: transfer of knowledge and skills, critical thinking and problem solving [6]. The *transfer of knowledge and skills* requires learners to be able to apply their old knowledge and skills in new, unfamiliar situations [3]. *Critical thinking* is “reflective and reasonable thinking that is focused on deciding what to believe or do” [11]. It is “skillful, responsible thinking that facilitates good judgment because it 1) relies upon criteria, 2) is self-correcting, and 3) is sensitive to context” [12]. *Problem solving* is a process in which the learner finds a new, unknown way to solve a particular problem [8] through a series of successful decisions, each of which depends on the outcome of the previous one [10].

HOTS are necessary for the successful development of every person - in personal and professional terms, as well as for the social and economic development of the society. It is the University where these skills can broadly unfold.

Educational institutions use a wide variety of *assessment forms*. The most commonly used ones are tests (open and closed questions, questions for comparison, adding information, etc.), written assignments (essays, synopses, annotations, papers, reports, etc.), practical tasks (case studies, projects, research assignments, presentations, discussions, modeling, role-plays, etc.), portfolio and so on. In general, assessment is done by the lecturer. However, other *assessment methods* are also possible, such as:

- peer assessment (colleague assessment) - students assess each other's work in pairs, in a group, through a student jury, etc.;
- self-assessment, where the learner evaluates himself / herself;
- external assessment by an independent expert - for example, in assessing practical skills.

Assessment methods where students undertake self-assessment or assess the work of their colleagues are extremely beneficial for improving the HOTS. The article proposes an approach to HOTS development using peer assessment. The main advantages and challenges are addressed.

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## 2. Bloom's Taxonomy

HOTS can be analyzed and assessed through different educational frameworks and taxonomies. One of the most famous and used taxonomies to date is the Bloom's Taxonomy. It was developed by a group of pedagogues and psychologists directed by Bloom and was published in 1956 [2]. The main motive for its development is the creation of a common framework for classifying test questions. The goal was to help teachers build tests by creating a common shared database of test questions. Still, Bloom's taxonomy is widely used in pedagogy to determine the learning objectives. It is well structured and detailed and preferred to others, such as SOLO (Structure of Observed Learning Outcomes) Taxonomy [4], Finks Taxonomy [5], Webb's Depth of Knowledge [13] and more.

Bloom's taxonomy is a set of three hierarchical models used to classify educational learning objectives, depending on their specificity. They describe the learning objectives in cognitive, affective and psychomotor domains. The cognitive area in *the cognitive domain* consists of six levels - Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation. They are ordered hierarchically - from simpler to more complex ones. It is assumed that in the learning process the learner has to go consecutively through all six levels. In general, they are defined as follows [2]:

- **Knowledge** – "... involves the recall of specifics and universals, the recall of methods and processes, or the recall of a pattern, structure, or setting.";
- **Comprehension** – "... type of understanding or apprehension such that the individual knows what is being communicated and can make use of the material of idea being communicated without necessarily relating it to other material or seeing its fullest implications.";
- **Application** – "The use of abstractions in particular and concrete situations. The abstractions may be in the form of general ideas, rules of procedures, or generalized methods."
- **Analysis** – "The breakdown of a communication into its constituent elements or parts such that the relative hierarchy of ideas is made clear and/or the relations between the ideas expressed are made explicit."
- **Synthesis** – "The putting together of elements and parts so as to form a whole. This involves the process of working with pieces, parts, elements, etc., and arranging and combining them in such a way as to constitute a pattern or structure not clearly there before."

- **Evaluation** – "Judgments about the value of material and methods for given purposes. Quantitative and qualitative judgments about the extent to which material and methods satisfy criteria."

In 2001, Anderson and Krathwohl revised Bloom's taxonomy and published their work [3]. Later it became known as the revised Taxonomy. The modifications concern the change of names and order of cognitive levels as follows: Remember, Understand, Apply, Analyze, Evaluate and Create. In the revised taxonomy, a second dimension of knowledge related to the object type is added - Factual Knowledge, Conceptual Knowledge, Procedural Knowledge and Metacognitive Knowledge. The taxonomy is represented by a table where the columns represent the six cognitive levels, and the rows - the four types of objects of knowledge.

The question which of the two categories - Synthesis (Creation) or Evaluation is of a higher order is controversial, and there is no single answer. It is clear, however, that the learner's ability to assess is a key factor requiring critical thinking, problem solving, and knowledge transfer skills. Here we should note that in the context of Bloom's taxonomy, lower-order thinking includes the following levels - Knowledge, Comprehension and Application, while higher-order thinking includes Analysis, Synthesis and Evaluation.

## 3. Peer Assessment

*Peer assessment* is a type of assessment where a learner evaluates another learner's work. It is a natural continuation of the tendency for transforming the learning process from teacher-oriented towards student-oriented.

The learners' ability to assess the work of their colleagues is extremely important in the training of student pedagogues, medical practitioners, lawyers, managers in various fields, criminologists, etc. Students sometimes look at assignments from the same angle, often different from the teacher's. Sometimes they miss some important aspects of the learning process. Taking the roles of evaluators, they expand their vision and develop their HOTS.

When assessing higher-level skills by using peer assessment, there are several basic principles to respect:

- Clear and precise determination of the purpose of the particular exam - what knowledge, skills and competences will be assessed and at what level;
- Creating tasks that require students to demonstrate relevant knowledge, skills and competencies;

- Identifying measurable indicators showing to what extent students have demonstrated relevant knowledge and skills;
- Use of educational and testing resources unknown to students - are new to them and never used in their training;
- Differentiation in the level of difficulty (easy - difficult) and the level of thinking (lower-order skills vs. higher-order skills) and individual control at each level.

For successful peer assessment, students must be prepared for it in advance. Assessment skills need to be educated and trained. If the students' ability to judge is taken for granted and they are directly involved in peer assessment, this may lead to various problems. Preliminary preparation is necessary for this purpose, including:

- Discussing and defining assessment criteria with students;
- Conducting instructions with the students on how to apply the criteria;
- Providing feedback to students on their assessment, including evidence-based discussion on possible differences with assessments by the teacher or the colleagues [1].

#### 4. Using peer assessment for the development of HOTS

Performing a peer assessment requires preliminary preparation involving a variety of activities that we can conventionally systematize in the following way:

1. Preparation of the assignment for assessment;
2. Defining assessment criteria;
3. Explaining the assessment procedure;
4. Performing the assignment for assessment;
5. Assessment by the teacher and motivation of the assessment.

##### *Preparation of the assignment for assessment*

The assignment for assessment must be carefully prepared. The teacher must determine the **purpose of the particular exam**, i.e. the object of assessment (what will be assessed) and the subject of assessment (what knowledge, skills or competences will be assessed). **The object of assessment** can be a coursework, an essay, a constructed object, a project, a model, a presentation, a solved case or task, a presentation on a given topic, a created algorithm, a developed software application, a research task, a literary analysis, etc. In some cases, it is appropriate to carry out the assessment in a dialogue between the

two students - the assessor and the assessed. This allows clarification of the motivation for a particular solution, choice of approach, detection of weaknesses and flaws, etc. The **subject of assessment** requires determining the amount of the verified knowledge, skills or competencies, i.e. exactly what students should know or be able to do.

##### *Defining assessment criteria*

The teacher has to **define specific and measurable assessment criteria**. They may cover one or more of the Bloom's taxonomy levels, i.e. the assessment can concern:

- to what extent the learner has remembered some information and is able to reproduce it;
- to what extent the learner has learned specific ideas, facts or concepts;
- whether the learner can use given information in a new way or in new situations;
- whether the learner can discover individual parts or components of a whole, explore the relations between them, the structure and organization of the whole;
- whether the learner can synthesize components of different nature to create new objects;
- whether the learner can justify a position or decision, assessing the situation in advance, etc.

For each of Bloom's levels, multiple indicators can be defined so that specific desired aspects can be assessed. For example, when assessing the ability to synthesize, the following skills can be evaluated individually: skills for categorizing, combining, inventing, designing, explaining, generating, modifying, rearranging, reconstructing, recognizing etc.

Students can calculate the total grade E by the formula:

$$(1) = \sum_{i=1}^6 a_i y_i,$$

where  $y_i$  is the grade for Bloom's  $i$ -th level,  $a_i$  is the weight of the corresponding level,  $a_i \geq 0$ ,  $\sum_{i=1}^6 a_i = 1$ .

For its part, the grade for Bloom's  $i$ -th level is calculated as follows:

$$(2) y_i = \sum_{j=1}^{k_i} b_{ij} x_{ij}, \text{ where}$$

$k_i$  is the number of skills to be assessed at Bloom's  $i$ -th level,  $x_{ij}$  is a grade for a cognitive skill of the Bloom's  $i$ -th level, and  $b_{ij}$  is a weight coefficient of the respective skill,  $b_{ij} \geq 0$ ,  $\sum_{j=1}^{k_i} b_{ij} = 1$  for each  $i$ . Exemplary cognitive skills for the individual Bloom levels are presented in Table 1.

A specific moment in formulating the assessment formulas is the definition of the levels and skills that are to be assessed, as well as their respective coefficients –  $a_i$  and  $b_{ij}$ . Their fixing on a case-by-case basis may depend both on the teacher’s preferences and on specific objectives set by the educational institution or regulatory bodies. In some public structures, for example, greater weight is

given to obtaining basic knowledge and skills, while others tolerate the possibilities of applying knowledge. Certain levels and skills may not participate in formulas (1) and (2) at all, or their coefficients may be set to 0. An important condition for the correct application of the formulas is all the skills and levels –  $x_{ij}$  and  $y_i$  to be evaluated on equal scales of assessment.

Table 1. Exemplary cognitive skills in Bloom’s Taxonomy

Bloom’s level	Exemplary cognitive skills
Knowledge	points, names, selects, describes, formulates, lists, reproduces
Comprehension	explains, expands, converts, compares, distinguishes, paraphrases, summarizes, gives examples, predicts, retells
Application	discovers, changes, uses, proves, solves, develops
Analysis	distinguishes, defines, points, selects, links, divides, differentiates, summarizes, illustrates, presents graphically, makes conclusions
Synthesis	recognizes, categorizes, collects, combines, rearranges, generates, creates, invents, designs, modifies, reconstructs
Evaluation	categorizes, compares, links, interprets, explains, summarizes, proves, draws conclusions, criticizes, challenges, defends, evaluates

Assessment models based on Bloom’s taxonomy are presented graphically in Figures 1-4. The coefficients in the models shown are exemplary and may vary within different specific evaluation models.

Weights of the levels and, respectively, the values of the coefficients in each model are determined by the pedagogical goals set.

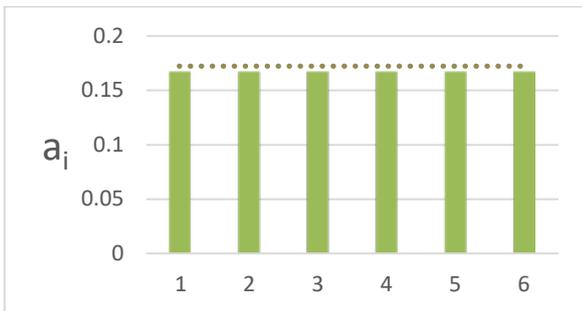


Figure 1. Flat model

All coefficients  $a_i$  are equal.

**Motivation:** cognitive skills from all Bloom's taxonomy levels are equally important.

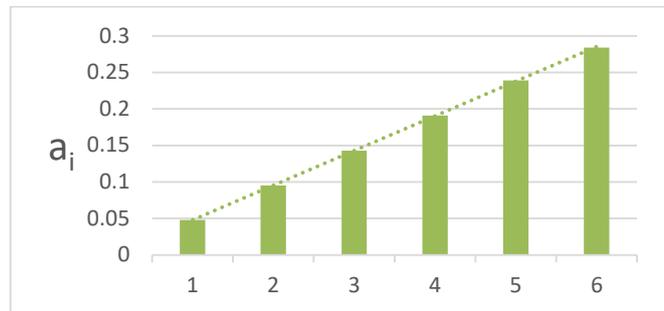


Figure 2. Progressive model

The coefficients increase at higher levels.

**Motivation:** cognitive skills at each level accumulate knowledge from the previous levels.

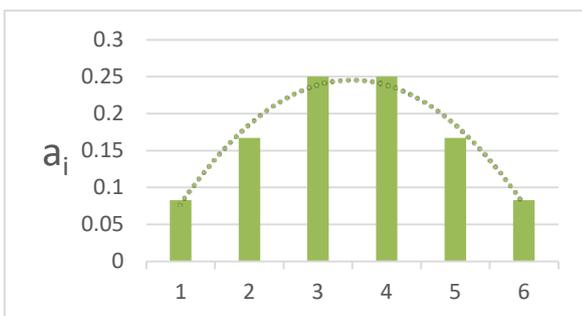


Figure 3. Basic model

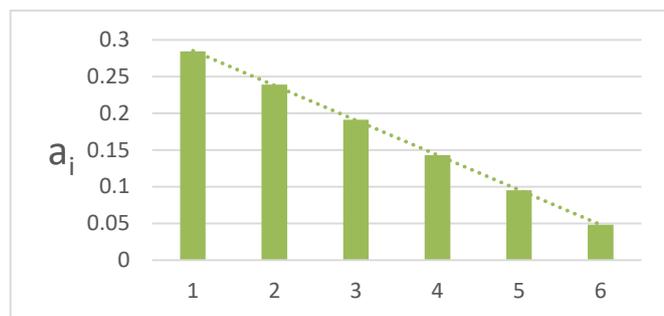


Figure 4. Regressive model

Middle levels are more important and have heavier coefficients.

**Motivation:** Cognitive skills at lower levels are mandatory, and skills at the highest levels are too complex.

The coefficients decrease at higher levels.

**Motivation:** Cognitive skills become more and more difficult with each level.

### ***Explaining the assessment procedure***

The teacher should explain to the students ***what the assessment procedure is***. This includes the place, time and manner of conducting the assessment. The assessment may be synchronous or asynchronous, anonymous or non-anonymous; it may be performed in a dialog with the author of the object being assessed, etc. The students should be familiar with the basic principles of assessment - objectivity, ethics, transparency, adequacy and responsibility.

The teacher should also clarify ***the technical aspects of the assessment***. Most eLearning platforms support a wide variety of learning activities that can be partly or wholly used to organize and conduct assessment procedures. This includes: conducting online seminars, tests, forums, wiki-based assignments, discussions, video chats, polls, etc. (Moodle [15], Blackboard [14], ATutor [16], Classroom [17], Litmos [18] Learning management systems and others). It is also appropriate to use standard Web 2.0 technologies, such as: social networks, programs for joint project work, forums, chats, blogs, conferencing programs, etc.

### ***Performing the assessment assignment***

The assessment must be conducted according to established rules and procedures. It should be noted that the teacher should assess the student's ability to evaluate a colleague, taking into account a variety of skills such as skills to compare, make conclusions, criticize, explain, differentiate, prove, interpret, link, summarize, point out, challenge, defend, etc. This requires the assessing student to evaluate the work or performance of their colleague in a very detailed and reasoned manner.

### ***Assessment by the teacher and motivation of the assessment***

The teacher must evaluate one or several HOTS – ability to analyze, evaluate, think creatively and critically, solve problems, etc. The very act of assessment by the teacher is not of such importance by itself. To improve the students' assessment skills, it is extremely important that the teacher provides ***feedback to learners***. This may include analysis, clarifications and discussing possible differences between the evaluating student's assessment and the teacher's assessment, motivated by objective evidence.

***Peer assessment has its risks.*** Problems of psychological, emotional or cognitive nature may arise:

- learners are generally unwilling to comment on their colleagues' work;
- a tendency to overestimate or underestimate for personal or emotional reasons;
- inability to make objective assessment due to incompetence in applying the criteria, lack of a benchmark and/or assessment experience.

Nevertheless, careful planning and performing of peer assessment can be an extremely effective tool in the improvement of HOTS.

## **5. Conclusion**

The development of HOTS requires considerable effort on the teachers' part. They need to use a variety of learning approaches to develop the students' abilities to transfer knowledge and skills, their critical thinking and problem solving skills. Peer assessment is a method that is extremely appropriate for this purpose. There are many benefits:

- students are strongly motivated to learn the material so they can properly evaluate their colleagues' work;
- the awareness of influence and control in assessing a colleague increases the students' self-esteem and importance and develops a sense of responsibility;
- key skills are developed - to explore, analyze and evaluate, discuss, defend a thesis, and so on;
- learners are encouraged to analyze other people's thoughts and actions.

The effective learning through peer assessment requires thorough preliminary preparation. When appropriately conducted, it provides a mechanism for authentic assessment and is extremely relevant and effective for HOTS training.

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