**Research Article** 

# Working Memory Load As A Weighing Factor for Written Examination Questions. Specific Utilization of Bloom's Taxonomy

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#### Abstract

Assessment of a course outcome is carried out, among other methods, by written examinations where the incorporated openend questions are usually evaluated by summing the performance in each of the tasks required to complete the answer. The sum produced is then used as the weighing factor of the specific question in the total score of the examinee. Our proposal is that the weighing scheme applied should take into account the average load of the working memory required to complete the required tasks for each specific question. As a measure of this load, we consider the average of the integer numbers ascribed to each of the above tasks in accordance to the successive levels of thought as proposed by Bloom's taxonomy.

**Keywords**: test scoring, working memory, written examination

Among the final and maybe the more intriguing steps of didactics is the assessment of the student degree of assimilation of the topics taught throughout a course. This is usually carried out by written examinations at the end of the course [1]. There have been established several routes to carry out the assessment, generally involving the answer to a set of questions related to the content of the course [2]. In addition, several strategies may be applied involving the proposal and use of indices which attempt to evaluate the suitability and discriminating ability of each question based on the student achievement in the specific question relative to the mean achievement for the whole test [3]. A written examination generally includes questions of varying demands in order to discriminate students with low, medium and high degrees of assimilation of the course's content. Consequently, each question is assigned a weight which is taken into account when the total score of each participant to the examination has to be calculated.

Marking schemes have a long existence in the written examinations assessment and a wide variety is available to choose from. Generally, a series of tasks is determined the sum of which represents the complete answer to the question. Then, the degree of fulfillment of each task is evaluated, usually ascribed an integer (including zero) and the summation over all the tasks provides the weight of the specific question. There are numerous examples of such practice as, for example, in English language examinations for non-native English speakers none of which is free of criticism [4, 5]. In our belief, the situation is a little different for science examinations especially ones with application of mathematical formulae or elucidation of relations between observables since several discrete steps of thought have to be taken prior to the formulation of the final response. Utilization of artificial intelligence assisted scoring has been

proposed for this step and human-machine consistency investigated for the evaluation of its applicability [6].

In the current communication we propose a normalization procedure taking into consideration the average load of the examinee's working memory required for every specific question. As a measure of this load, we propose the use of the basics of Bloom's taxonomy which, in turn, proposes the existence of discrete hierarchical steps in the process of conceiving an educational target. The resulting sequence from the simpler to the more complex operation may be formulated as: remember, understand, apply, analyze [7]. The simplistic approach of assigning consecutive integer values to the levels of Bloom's taxonomy is proposed as a starting point. In this respect, the required number of steps of thought in order to formulate the full answer to the question is considered and the level of knowledge assimilation for each step is given the integer value of the corresponding Bloom taxonomy level that is essential for its completion. The assumption is made that the steps are followed sequentially and, in this way, the average load of the working memory can be quantified as the average value of the integers assigned to the discrete steps considered. The obtained numerical value is used as the scoring weight of the question in the full test marking scheme. The obtained value is generally a non-integer one and in our belief is a better measure for the student evaluation than just assuming equal weight for all the questions in a test or assigning integer weights varying with the degree of the supposed difficulty level of each question.

Testing of this proposal was carried out on first year students majoring in Chemistry following the completion of the introductory General Chemistry course. The single question considered required substantiation of the basic character of ammonia according to each of the known acid-base theories. This question besides its seemingly simple and straightforward nature involves several stages, each with **Citation:** Kontopoulou A, Ioannidou A, Gkouzou S, Papadopoulos C, Akrivos P (2025) Working Memory Load As A Weighing Factor for Written Examination Questions. Specific Utilization of Bloom's Taxonomy. American J Sci Edu Re: AJSER-246.

distinct steps and varying analogies to the levels of understanding proposed by Bloom.

Arrhenius theory of electrolytes is presented to Greek junior high-school students in their second year of studies and Brønsted-Lowry theory is discussed in the third and final year of senior high-school with only a hint being made of the Lewis theory. The exceptionally longer acquaintance of the students with Arrhenius theory provokes their gravitation towards this definition [8]. However, for the purposes of General Chemistry course, which is taught in the first year of undergraduate studies, Lewis's theory is described in extent although for the concurrent Analytical Chemistry course Arrhenius theory is applied. Confusion arises, therefore, among the students who may conceive that the theories they come to know of are just variations of a single and simple model of interpreting acidic or basic behavior of compounds as new information interferes with long-term retained information [9]. Our findings confirmed this confusion in the form of the low percentage of correct answers given but especially in the form and extent of wrong answers or answers omitted.

The complete answer to the above question should include the names of the three theories' originators, the corresponding definitions of bases and presentations of chemical equations to validate the definition for each of the three theories. A cursory glance would reveal that the execution of 3x3, i.e. nine distinct steps is required, each of which would normally be assigned a single point, resulting in a total of nine points. It has been verified, by several independent studies, that the most important weakness of students is the application of stoicheiometric calculations and balancing chemical equations [10]. This is reflected in the documented student inability to construct a simple chemical equation to account for a definition they appear to cite correctly. When one considers that citing the name of the originator and providing the corresponding definition of base requires just remembering these facts, one could readily classify the related conception as corresponding to level 1 of Bloom's taxonomy. On the contrary, the formulation of a chemical equation to account for the given base definition certainly involves understanding of the definition (corresponding to Bloom's level 2) and further analyzing the factors influencing the writing of the complete and balanced chemical equation (Bloom's level 3). Assuming that the aforementioned nine steps are taken successively, the mean level that the working mind of one has to reach corresponds to the average of the individual stages undertaken, in the present case resulting in a value of 1.67.

A body of nine "experts" including staff members and postgraduate students were consulted about their expectation for the average first year student management of the stated question. In their belief, an average student would be expected to remember the three scientist names and cite almost correctly the three definitions while it would be possible to write only the well-known ammonia hydrolysis chemical equation, typically related to the Arrhenius theory. Therefore, in the above case study, an answering sheet reporting only the names of the three theories are given (3x1)/15= 0.2 points, one that would further include the correct definitions would be assigned (3x1 + 3x1)/15= 0.4 points. In line with the traditional marking scheme where a single point is assigned to each of the statements required for a complete answer, the mean achievement of the students should be expected to be (3x1+3x1+1x1)/9= 0.78 points or 7.8 on a 0-10 scale. Adopting the proposed correspondence of mental effort to Bloom's taxonomy, the mean expected student achievement for the case studied would result in a score of (3x1+3x1+1x3)/15=0.6 points or 6.0 on a 0-10 scale.



**Figure 1:** Schematic presentation of the weighing process for a question with three distinct tasks and their corresponding Bloom's taxonomy level indicators.

When the scoring of the answering sheets was carried out using the traditional one-point-one-task scheme the mean score was 6.49 (N=168) with a standard deviation of 2.06. According to previously acquired knowledge and the indications of the experts consulted, this specific question would be expected to rank among the most difficult for the students to deal with. Consequently, one would expect the individual score for the specific question to rank lower than the average test score. Reviewing the results of recent years revealed that the average score for the General Chemistry course lies around 5.50 with a single exception of 6.26 [11]. Applying, however, the proposed normalization scheme to the data available we obtained an average score of 4.58 with a standard deviation of 1.75. This average, although rather disappointing, appears more realistic with respect to the established boundaries of the student's average achievements in the specific course. Of course, the current proposal is not the first or the last or the better supported one on the subject and further testing is required in order to be considered as a valid assessment process. We are currently working on the evaluation of several courses and on a variety of examination formats in order to substantiate it.

#### Author contributions

Conceptualization -PA, AK, Data curation – AI, SG, AK, Formal analysis – AI, SG, CP, Investigation – AI, SG, CP, Project administration – CP, PA, Resources – AI, SG, CP, AK, Software – AI, SG, CP, AK, Supervision – PA, Validation – AI, SG, CP, AK, Writing – original draft – AK, CP, PA. Writing – review & editing – PA. **Citation:** Kontopoulou A, Ioannidou A, Gkouzou S, Papadopoulos C, Akrivos P (2025) Working Memory Load As A Weighing Factor for Written Examination Questions. Specific Utilization of Bloom's Taxonomy. American J Sci Edu Re: AJSER-246.

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