

An Integrated Approach to Evaluation of Program Educational Objectives and Assessment of Program Outcomes Using ABET Criteria for Accreditation of Engineering Programs

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I. Abstract

For many engineering education programs, the process for evaluating program educational objectives is interpretive; that is, achievement of program educational objectives is inferred from achievement of program outcomes. What is lacking in current practice is a systematic way to examine the success of a program based on a set of interlinked program objectives evaluation and outcomes assessment processes. The new processes should accommodate differentiation between the data collection efforts associated with outcomes assessment and objectives evaluation. Such a separation is particularly important since ABET has recently adopted a change in engineering accreditation criteria that partitions outcomes assessment and objective evaluation data at the day of graduation. The procedures described in this paper accommodate the changes in criteria while providing a systematic approach that eliminates redundancy in data collection, targets relevant constituents for input, and reduces strain on limited resources. Application of the procedures in an industrial engineering program is discussed.

II. Introduction

Since ABET, Inc. (ABET) distributed the first edition of Engineering Criteria 2000 (EC 2000) in 1995 ¹, EC 2000 requirements have changed little. Modifications have been limited to minor rewordings of text of the criteria and the dropping of the criterion related to cooperative education. However, the 2004-2005 version of the Criteria for Accrediting Engineering Programs (which now include only the EC 2000 Criteria) contains several important changes adopted by the ABET Board of Directors in November 2003 ². At first glance, the alterations to Criterion 2 and Criterion 3 appear to be relatively insignificant clarifications defining the focus for each criterion. The change to Criterion 2 adds the wording:

Although institutions may use different terminology, for purposes of Criterion 2, program educational objectives are intended to be statements that describe the expected accomplishments of graduates during the first several years following graduation from the program.

The change to Criterion 3 adds the statement:

Although institutions may use different terminology, for purposes of Criterion 3, program outcomes are intended to be statements that describe what students are expected to know or be able to do by the time of graduation from the program.

Early characterizations of the appraisal activities required by Criteria 2000 included an illustration of the “two-loop process” for continuous quality improvement³. This representation clearly implied that information gathered for use in assessing program outcomes might also be used in evaluating a program’s success in achieving its educational objectives. When a faculty makes the decision to examine objectives and outcomes using closely related processes and a common pool of data, it is drawing a logical conclusion based on the text in every edition of EC 2000 up to the 2004-2005 version of the Criteria. All of the previously approved versions of Criteria 2000 specify two guidelines. First, the program educational objectives must be “consistent with the mission of the institution and these criteria [Criteria 2000].” Second, the outcomes “important to the mission of the institution and the objectives of the program including those listed above [the ABET 11 program outcomes specified in Criterion 3] are being measured³.” Thus, information derived from systematic measurements made to confirm that program graduates achieved specified outcomes, which by Criteria 3 requirements reflect program educational objectives, certainly would provide at least some evidence as to whether the program achieved its program educational objectives.

However, the new definitions for program educational objectives and program outcomes appear to mandate that engineering programs use two independent processes and distinct sets of data for evaluation of objectives and assessment of outcomes. With the proposed definitions, the time to gather data is divided into “on or before graduation” for use in outcomes assessment and “during the first several years following graduation” for educational objectives evaluation. Because of the new modifications to Criterion 2 and Criterion 3, many engineering programs may respond by creating distinctly separate objectives evaluation and outcomes assessment processes.

This paper describes a systematic way to examine the success of a program based on a set of interlinked program objectives evaluation and outcomes assessment processes. The approach accommodates the “graduation day” partitioning of evaluation and assessment data collection efforts. It also eliminates redundancy in data collection, targets relevant constituents for input, and reduces strain on limited resources. The interlinked processes offer a systematic way to examine the success of the program in achieving its program educational objectives as measured after graduation. If the faculty analyzes post-graduation data and determines that educational objectives are not achieved, then the faculty can initiate an in-depth evaluation of the program to examine achievement of related program outcomes, as measured prior to graduation. Additionally, assessment of program outcomes data grants an early indication of the success or failure of programmatic changes made to move a program toward achievement of its educational objectives.

III. Review of Literature

The traditional approach to evaluating engineering program compliance with EC 2000 is to gather and analyze what are assumed relevant data without regard to whether they are acquired

before or after graduation day. In fact, the general assessment literature ⁴ appears to support that approach because it consistently notes that there is no difference in time regarding the examination of objectives and outcomes. Further, general models ^{5,6} provide for a one-dimensional assessment practice. That is, collect and analyze the data then make curriculum modifications to rectify any problems identified through data analysis ⁷. As a refinement of the general models, assessment experts argue that the process of data triangulation, collection of three sets of data to examine the same phenomenon, strengthens the validity of assessment results ^{4,8}.

Recent research on evaluating engineering program effectiveness has focused on the portion of the ABET standards mandated in EC 2000 related to demonstrating achieving student outcomes ⁹. Examination of the literature reveals a considerable number of references to the development of program outcomes ¹⁰ and to outcomes assessment ^{11,12}. However, there are relatively few discussions in the literature on the development and assessment of program educational objectives. A paper authored by Carter, Brent, and Rajala supports this observation ¹³. Their paper describes a procedure to create, evaluate, and document achievement of program educational objectives. Unfortunately, the authors do not provide for the direct evaluation of program objectives; the achievement of objectives is tangentially or indirectly implied through their relationships to the educational outcomes. This position by Carter, et al., is consistent with the work of other assessment practitioners ^{10,11}. Felder and Brent define program educational objectives as broad goals “that address institutional and program mission statements and are responsive to the expressed interests of various groups of program stakeholders ¹⁴.” They state that the program outcomes “directly address the educational objectives and encompass certain specified outcomes ¹⁴.” While the relationship between objectives and outcomes is certainly important, although no surprise since the Criteria mandate that outcomes be selected which are important to the educational objectives of the program, what is needed is a systematic approach that faculty members can actually use to evaluate and document achievement of program educational objectives.

Rogers’ *Assessment Tools for Busy People* ¹¹ uniquely reflects the proposed definitions for objectives and outcomes; although her model and assessment strategies do not differentiate a point in time at which the data are collected. Yet, as an interesting illustration of how things will change with the adoption of the proposed definitions, alumni surveys would not be appropriate for program learning outcomes as suggested in an earlier Rogers’ reference ¹⁵. Neither would objectives be assessed by evaluating a product created in an integrated, multidisciplinary design course. Thus, identification of appropriate methods for objectives evaluation and outcomes assessment must consider at what point in time the data are collected.

Unlike the snapshot approach recommended in most of the engineering program evaluation literature, Puerzer and Rooney integrate the use of alumni surveys with other processes beyond triangulation. They suggest using alumni surveys as an “objective assessment tool” to gather data ¹⁶. “The presumption, of course, is that graduates of a program with a certain amount of post-graduate experience will have gained a perspective that allows them to reflect on the strengths and weaknesses of that program” ¹⁶. In using alumni surveys, Puerzer and Rooney propose that alumni evaluate educational outcomes on the specific dimensions of importance in their employment and in sufficiency of preparation through the academic program. Upon examining

the alumni survey data, if a threshold of significance between importance and preparation is crossed, the authors recommend using exit interviews of currently enrolled students for immediate feedback beyond the scanning information obtained from the alumni survey. They also suggest using a “focus group for pinpointing areas of concern in a program”¹⁶. The practice of using the alumni survey as a scanning tool (after graduation) and other assessment methods prior to graduation to provide more specific information if problems are identified yields a two-dimensional assessment process that “can considerably shorten the re-evaluation process and lead to quicker improvement of the overall education enterprise”¹⁶.

The evaluation approach described by Puerzer and Rooney has a form which is somewhat similar in structure to the industrial sampling procedures frequently used in acceptance sampling by attributes for inspection of raw materials, purchased parts, and manufactured products. In lot-by-lot acceptance sampling, a predetermined number of units (a sample) are drawn from a specified procurement/production quantity (lot). The sample is inspected, and the number of units within the sample that fail to meet inspection standards is determined. If this number of nonconforming units is less than a specified quantity, then the lot is accepted; if not, the lot is not accepted¹⁷.

There are several alternative forms of lot-by-lot acceptance sampling systems. Among these alternatives are plans that vary the type of inspection used including normal, tightened, and reduced inspection¹⁸. Plans typically begin with normal inspection. Normal inspection continues to be used as long as product quality is at an acceptable quality level or better. If the quality history of the product deteriorates, then tightened inspection is used. On the other hand, if recent quality history is very good, reduced inspection is used. Tightened inspection typically increases inspection costs, while reduced inspection generally reduces sample size and inspection costs. Obviously, the inspection process itself does not control or improve the quality level of the products undergoing lot-by-lot acceptance sampling. It is merely an auditing tool for deciding what to do with the procurement/production lots.

A practical approach to the evaluation of program educational outcomes and assessment of program outcomes can integrate information from both sides of graduation day. The integrated approach for evaluation and assessment described in the next section of this paper employs a “sequential approach”⁸ or “probing process” that is similar in form to Puerzer and Rooney’s use of the alumni survey for assessment data collection. The integrated approach also uses a “sampling approach that changes through time” based on evaluation/assessment findings similar in form to lot-by-lot acceptance sampling.

IV. Integrated Approach to Objectives Evaluation and Outcomes Assessment

With integrated assessment, the collection and analysis of data related to program educational objectives and associated program outcomes are coupled. Evaluation of program performance, strictly in terms of program educational objectives, yields a review cycle of substantial duration. In fact, if the proposed definition of program educational objectives is adopted, then the period from a curriculum’s first influence on a student as a freshman to “within the during the first several years following graduation from the program” is a period of at least six years. Monitoring and attempting to make improvements in a system with a six-year response is unwieldy at best. Fortunately, the integrated approach to program educational objectives evaluation and outcomes

assessment includes a more time sensitive, responsive process for performance review and improvement.

Three distinct processes comprise the integrated approach to evaluation of program educational objectives and assessment of program outcomes. First, program educational objectives are identified and periodically reviewed. Second, program outcomes are selected, periodically assessed, and used to drive short term programmatic adjustments. Third, evaluation of programmatic performance is employed to confirm that program educational objectives are achieved or that appropriate longer-term programmatic changes are made.

1. The *process for program educational objectives identification and review* begins with the choice of a set of program educational objectives based on the mission of the institution, the needs of program constituents, and the requirements of EC 2000⁹. These educational objectives are periodically reviewed to confirm their continued appropriateness, typically in a two-or-more year cycle. The review is performed by reflection on institutional mission, constituent needs, and EC 2000, and in consideration of program performance¹⁹.

2. The *process of program outcome selection, assessment, and use in programmatic adjustment* begins with the identification of program outcomes. EC 2000 requires that program outcomes be consistent with both the institutional mission and the program educational objectives, and that they include (directly or by mapping) the ABET 11 program outcomes specified in Criterion 3. Assessment strategies with associated indicators are chosen to measure each outcome. Then, threshold or criterion values are selected for each indicator to specify indicator values that represent attainment of the outcomes¹⁴. Program outcomes assessment is typically conducted on a one-year cycle¹⁹. Program performance data are collected for each outcome indicator and are compared to threshold or criterion values. Failure to meet the established threshold requires the faculty to identify programmatic adjustments or improvements.

3. The *integrated process for program review and improvement* is illustrated below in Figure 1. The cycles of this process begin with the scanning of program performance with respect the program educational objectives. This scanning could be in terms of constituent perceptions, perhaps by groups such as program alumni, employers of graduates, and/or a program advisory board. At some future date, direct evidence of the performance of the engineer in professional practice may be made available from sources such as documentation of accomplishments maintained in professional society databases and Professional Engineering Exam scores. If each educational objective is judged to be achieved, then no further action is taken until the next cycle of scanning. If, however, any program educational objective is viewed as not achieved, then a probe is made to identify the barrier(s) to achieving the educational objective, perhaps using focus group sessions with alumni, employers, or advisory board members.

When a barrier is encountered, then needed programmatic changes are identified and made. It may be the case, however, that barrier analysis reveals that the program educational objective under consideration is not appropriate or attainment of the objective at the currently specified level is not realistic. If so, the program educational objective is eliminated or altered, then appropriate changes are made in the corresponding program outcomes.

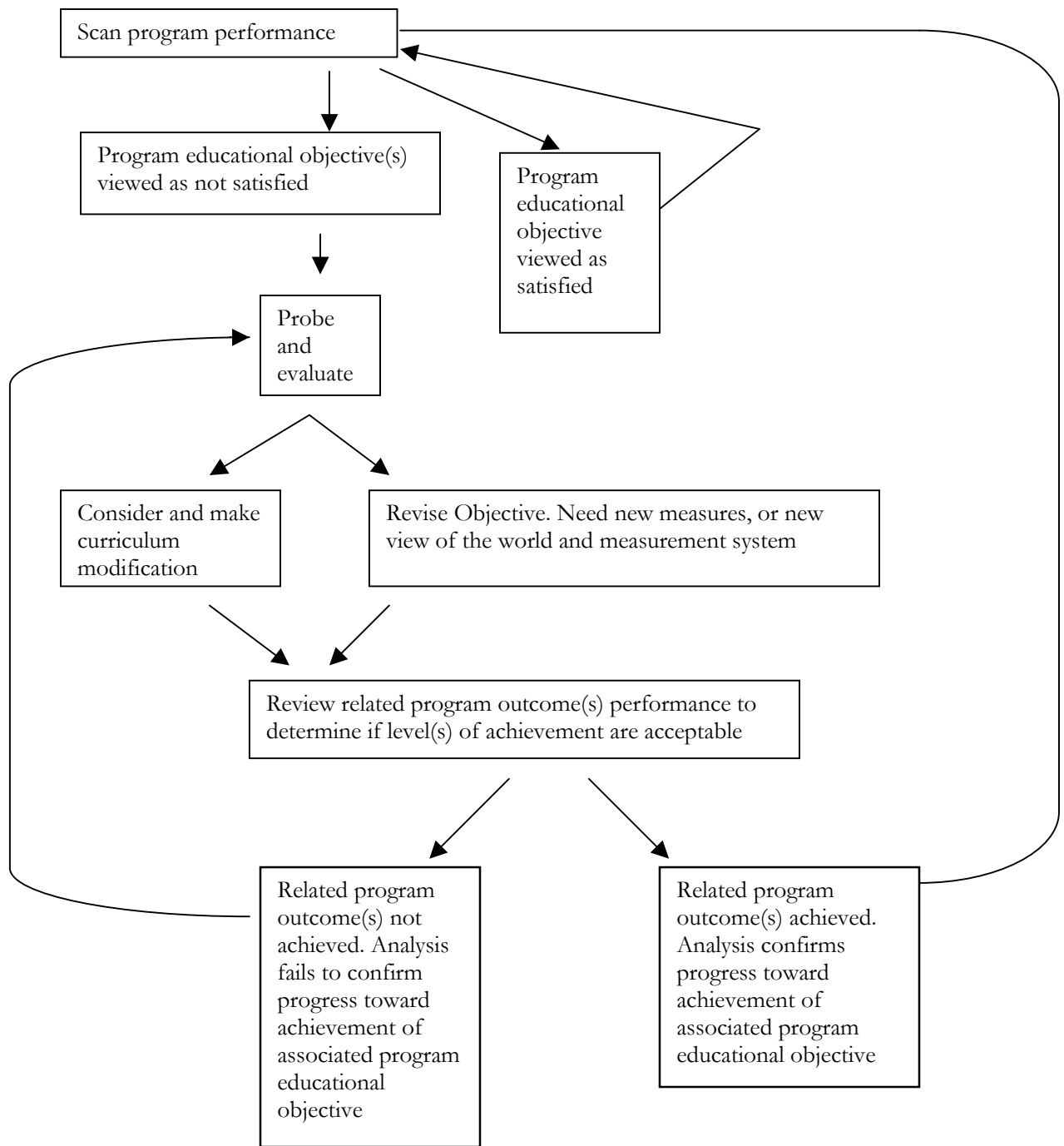


Figure 1: Integrated Approach to Program Review and Improvement

Once a change has been made to move a program toward better performance in terms of an educational objective, it should be reflected in terms of improvements in indicator data for associated program outcomes. At the next review cycle for program outcomes, which is likely to

come in less than a year, achievement of these targeted outcomes is carefully monitored. If the targeted outcomes are achieved, the authors recommend that the related program educational objectives be judged as “moving toward” achievement. In this case, the cycle of program educational objectives review should return to a periodic scan of program performance. If, however, the targeted outcomes have not been achieved or have not shown significant improvement, then the cycle of program educational objectives review should return to probe and evaluate to find out why there has not been significant improvement in program performance.

V. Discussion

The integrated process of objective evaluation and outcome assessment must be more than a proposition if it is to be useful to engineering educators. It must be possible to describe the elements of the process in a concrete example. Consider the scanning portion of the integrated approach to program review and implementation using information from the baccalaureate degree program in industrial engineering at Clemson University. The first program educational objective for this program is:

Graduates will demonstrate the ability to design, develop, implement, and improve integrated systems that include people, materials, equipment, and energy.

The scanning questions related to Program Educational Objective One are shown in Table 1. Surveys of alumni, the department’s advisory board members, and/or employers of program graduates are used to determine perceptions concerning the specific abilities of program graduates with respect to this objective.

Table 1: Scan for Achievement of Program Educational Objective One

1. Are you developing, implementing, and improving integrated systems? To what degree are you successful at doing this?
2. If you are not doing this, could you if you had the opportunity?

Responses for scanning survey questions are “strongly agree,” “agree,” “disagree,” “strongly disagree,” and “not observed.” The percentage of responses to the first question is calculated and the level of agreement is compared to a predefined value. In this case, there are two defined thresholds. First, if more than 40% of the responses fall into the categories of “strongly disagree” and “disagree” then further examination is required. On the other hand, if more than 25% of the responses fall into the category “strongly disagree”, then further action is required.

This response action may take the form of conducting two distinct alumni focus group sessions, or a focus group session with advisory board members, or two distinct alumni focus group sessions, respectively, to find barriers to satisfaction of the objective. Figure 2 below displays the process of threshold evaluation of the percentage of responses.

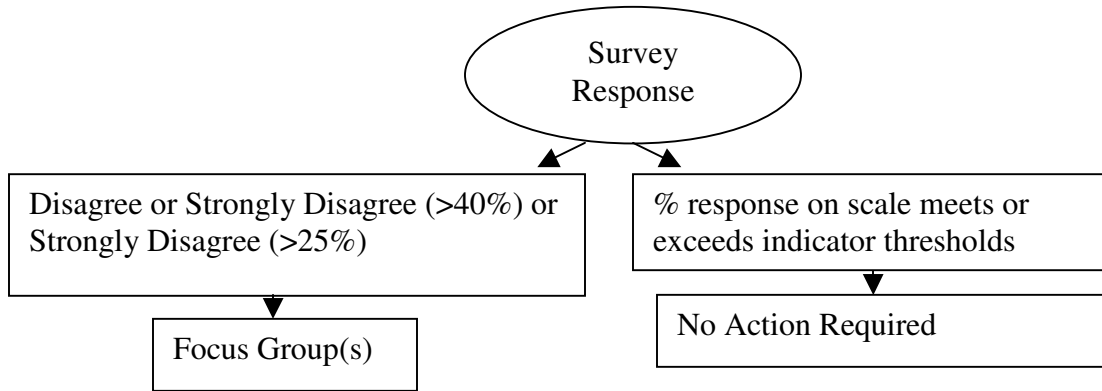


Figure 2: Analysis of Scanning Survey Response

Probing is a process to identify the nature and magnitude of barriers standing in the way of achievement of program educational objectives. A matrix of related knowledge and skills with respect to resources directs the probe with regard to the question, “To what degree are you able to incorporate the resources (people, materials, information, equipment, and energy)?” Table 2 provides an array of possible locations for barriers to achievement based on the elements of Program Educational Objective One.

Table 2: Probing to Find Barriers to Achievement of Program Educational Objective One

The question:	Areas where barriers may be			
To what degree do program graduates incorporate:	design	develop	implement	improve
people				
materials				
information				
equipment				
energy				

Once barriers have been identified, the faculty must reexamine the objective for reasonableness, based on the barriers that have been found. If, in fact, the faculty continues to believe that the objective is reasonable, then the members of that group must develop a strategy of curriculum change to permit program graduates to achieve the program educational objective.

In the next outcomes review cycle following programmatic change, the outcome indicators for program outcomes associated with Program Educational Objective One are reviewed to determine if they reflect positively the changes desired by the faculty. For the bachelors degree program in industrial engineering at Clemson, there are five program outcomes related to Program Educational Objective One. These program outcomes are:

- The ability to design a system, component, or process to meet desired needs

- An understanding of the impact of engineering solutions in a global and societal context
- The ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
- The ability to design, develop, implement and improve integrated systems
- The ability to integrate systems using appropriate analytical, computational and experimental practices

Direct evidence is collected in the form of samples of student work are collected and examined for each of these outcomes. To illustrate this confirmation effort, consider “The ability to design a system...” Table 3 shows the materials examined in the Department of Industrial Engineering at Clemson University to confirm this outcome, identified by course number and title, Bloom’s Taxonomy level of competence desired, and demonstrated ability.

Table 3: Demonstration of the ability to design a system, component, or process to meet desired needs

Course Number & Title	Taxonomy Level	Demonstrated Ability
IE 201 System Design I	Synthesis	Construct a set of target produce specifications.
IE 201 System Design I	Synthesis	Construct prototypes of a product design.
IE 201 System Design I	Evaluation	Select a concept for detail design.
IE 210 Design & Analysis of Work Systems	Knowledge	Recall fundamental concepts in the use of ergonomic analysis for workstation design, equipment, and interface design and material handling.
IE 210 Design & Analysis of Work Systems	Application	Apply methods engineering tools, ergonomics principles, work measurement techniques and facilities design principles in systems design.
IE 210 Design & Analysis of Work Systems	Synthesis	Design tools and workstation using ergonomic (anthropometric) data.
IE 361 Industrial Quality Control	Synthesis	Design control charts to meet customer requirements.

If an analysis of outcome indicator data reveals that modifications to the program or curriculum resulted in improvements in the associated outcomes, the review of program educational objectives by scanning resumes. However, if the results indicate that the outcomes are not achieved, then the process of probing is repeated to determine if the same or different barriers to objective achievement are now present.

VI. Conclusion

The presentation of the integrated approach to evaluation of program educational objectives and assessment of program outcomes has been motivated by the changes recently adopted in the ABET Criteria for Accrediting Engineering Programs. The integrated approach fits comfortably

in an environment where there is a mandated separation between evaluation and assessment data. Nevertheless, the proposed approach would be well worth considering even if the ABET Board of Directors had not adopted the changes to the accreditation criteria. The integrated approach provides a systematic way to link objectives and outcomes examinations efforts using information gained in objectives evaluation to direct outcomes assessment efforts and using outcomes assessment findings to adjust the focus and rigor of objectives evaluation efforts.

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