

## **The REAP Project: Reaping the Benefits of High-stakes Assessment Frequency Boosters**

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# **Project REAP: Reaping the Benefits of High-stakes Assessment Frequency Boosters**

## **1. Introduction**

To help starting engineering students in properly preparing for their engineering careers, introductory engineering textbooks advise them to devote a minimum of two to three hours of study for every lecture-hour they attend [1]. In such textbooks, the point is often made that in high school most learning takes place in the classroom, whereas in college most learning takes place outside the classroom. This important point correlates with other studies based on cognitive psychology, which point out that the average rate of learning retention from a lecture is relatively low compared with the learning retention associated with other learning activities such as discussion or “practice by doing” [2].

In a recent study, inspired by signals and systems theory, the engineering student learning was linked to the assessment process that he/she undertakes during his/her studies. Modeled by a so-called “ideal sampler”, the assessment process is perceived as a system that takes a “snapshot of the student’s mind” on a regular basis, reconstructs the (continuous) “knowledge signal” acquired by the student and compares it to a “desired knowledge signal”. The resulting knowledge signal “error” is then used to simultaneously improve learning retention and evaluation. In this context, it is shown that the larger the sampling (assessment) frequency the more effective are both learning retention and learning evaluation. Based on field data, a minimum engineering assessment frequency bound of 1 assessment per week was estimated for valid signal reconstruction. Once more, the lesson conveyed by this study seems to say: “the more you practice the more you learn” [3].

On the ground, however, and in certain parts of the world in particular, things can be somewhat different. Modern day students are quite busy. Many of them are working students and thus have little time to practice and assess their knowledge and skills. Educators are also busy, with their time divided between teaching, research, and service. Consequently, they have little time to deploy, monitor, and evaluate valid assessments. In some institutions around the world, academic dishonesty is endemic and adds another reason for the educator to overlook regular assessments, especially in purely undergraduate institutions, where no graduate students are available to give proper feedback and control academic dishonesty. A 2018 survey of 234 local engineering students revealed that they work an average of 13.1 hours per week, on top of their average 14.4 credit-hours attended. In the same survey, these students claimed that they study an average of 14.6 hours per week. Even if their claims are accurate, they will be studying an average of 1.1 hours per lecture hour, a duration that falls significantly short of the minimum 2 to 3 hours required in introductory engineering textbooks.

One mechanism to address the deficiency in assessment frequency was called the Online Tutorial Room (OTR). Moderated by students for students, the OTR is a systematic, Blackboard-

based platform through which students are encouraged to undertake engineering assessments in a competitive, browser-friendly, and transparent teamwork environment comparable to social media. While this mechanism increases the engineering assessment frequency, it is mainly designed for every day, low-stakes learning activities aiming at improving the engineering student's learning retention, without excessively exhausting the time and effort of the engineering educator [4].

The present work, describes another project that addresses the same issue, that of boosting the engineering assessment frequency for the purpose of improving learning retention and evaluation. Dubbed the Repository of Engineering Assessment Pools (REAP), this project is also based on the Blackboard Learning Management System. However, it aims to create a standardized, self-graded, multi-threaded, and guessing-free, high-stakes engineering assessment platform, primarily targeting learning evaluation. Needless to say, the improvement of learning retention is another objective of such a platform. Similarly to OTR, the REAP project aims at minimizing the time and effort spent by engineering educators on preparing and evaluating engineering assessments, while incorporating error tolerance and countermeasures for academic dishonesty.

The international dimension of the REAP project lies in its special focus on particular problems encountered on the international scene in some parts of the world. Such problems include the relatively higher work engagement of the engineering student, the higher level of academic dishonesty among students, in addition to the higher teaching load of the engineering educator. In those parts of the world, these problems have often created an environment where one of the most basic tools of engineering education, namely the regular engineering assessment (i.e. the homework) has been practically abandoned, leaving a significant impact on the students' overall performance.

In this respect, the REAP project is not designed as a new technique aiming **directly** to improve learning! Instead, one of the direct objective of REAP is to reinforce the regular assessment culture by improving the assessment frequency and therefore enhancing the students' problem-solving skills. Learning improvement, however, is only an **indirect** objective of the REAP project linked to numerous studies confirming the close relationship between problem-solving skills and learning [5], [6], [7].

## 2. Elements of the REAP Project

Created within the Blackboard Learn™ Learning Management System [8], The REAP Project consists of building and deploying engineering assessment question pools for a number of engineering disciplines including Signals and Systems, Feedback Control, Circuit Analysis, as well as Electric Circuits and Electronics for Non-Electrical engineers. Evidently, the project is designed to be scalable so as to be easily extendable to other engineering disciplines.

Build Pool   Import Pool		
Name ▲	Number of Questions	Date Last Edited
Chapter 10 - Bipolar Junction Transistors	33	January 15, 2019 10:32 AM
Chapter 11 - Field-Effect Transistors	16	January 15, 2019 10:32 AM
Chapter 13 - Digital Logic Circuits	19	January 15, 2019 10:32 AM
Chapter 14 - Digital Systems	4	January 15, 2019 10:32 AM
Chapter 8: Operational Amplifiers	49	January 15, 2019 10:32 AM
Chapter 9 - Semiconductors and Diodes	69	January 15, 2019 10:32 AM

Figure 1—A sample set of assessment question pools for the (Non-EE) Electronics Course.

Each pool of questions covers a major course topic (chapter), and includes a set of related questions from which test questions may be selected (Figure 1). From the outset, one major objective of the REAP project was to emulate standard engineering problems as much as possible, while adding to them the computerized, self-grading feature. For this reason, questions involving educated guesses or answers by elimination, such as multiple choice questions, were avoided. The main intention was to entice engineering students to analytically solve engineering problems from scratch in a regular, classic way, i.e. by typically partitioning the problem into phases or threads and solving each phase sequentially until reaching the final answer(s). An additional motivation for this objective was the desire to offer engineering students the chance to gain partial credits if they manage to solve parts of the problem. In Blackboard, one question type that appears to suit this multi-thread partitioning is called “Fill in Multiple Blanks” question type. However, unlike the “Calculated Numeric” type of questions (also available on Blackboard), the Fill in Multiple Blanks type of questions does not feature error tolerance. For this reason, it was deemed necessary to introduce clear formatting instructions along with the questions, in addition to using other Blackboard features outlined in Section 3.2, for the purpose of reducing formatting errors and artificially adding an error tolerance feature.

Consequently, the typical engineering question adopted in the REAP project consists of three parts (Figure 2):

In the first part (typed in blue in Figure 2), the engineering problem is stated in a generic fashion, along with a specific set of data and a clear list of objectives. Upon reading this part, the student can proceed to solve the problem on paper following his/her preferred method.

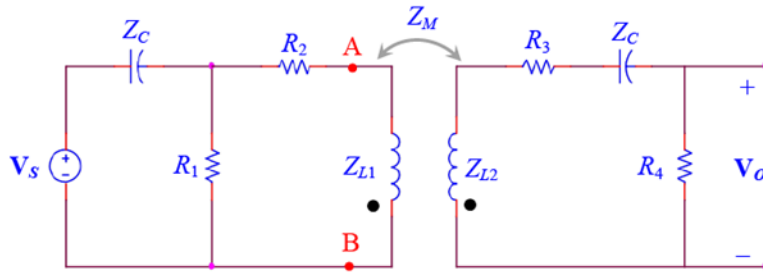
The second part (typed in red in Figure 2) consists of the formatting instructions that need to be followed in order to answer the remaining questions.

And the last part (typed in black in Figure 2) includes the list of intermediate and final questions to be answered if the problem is to be solved following a specific method.

## Question 4

25 points Save An

Consider the following magnetically-coupled circuit:



Let:  $V_S = 24 \angle 0^\circ$  V,  $R_1 = R_2 = 2 \Omega$ ,  $R_3 = R_4 = 1 \Omega$ ,  $Z_C = -j1 \Omega$ ,  $Z_{L1} = j4 \Omega$ ,  $Z_{L2} = j6 \Omega$ , and  $Z_M = j2 \Omega$ .

The objective of this question is a) to determine the Thevenin-equivalent circuit to the left of nodes A and B, b) to write the two mesh equations of the resulting equivalent circuit, and c) to solve for the output voltage phasor  $V_O$ .

Unless otherwise indicated, please round your answers to the nearest **ONE DECIMAL FIGURE** as in the following examples: 3.0, -15.3, 127.4)

a) Find the real part of the Thevenin-equivalent impedance, in Ohms, to the left of nodes A and B

b) Find the magnitude of the Thevenin-equivalent voltage,  $V_T$ , in Volts, to the left of nodes A and B

c) Sketch the resulting equivalent circuit. The primary/left-side mesh equation could be written in the following format:

$$(a + jb)I_1 - j2I_2 = V_T$$

where  $I_1$  and  $I_2$  are the clockwise left-mesh and right-mesh current phasors respectively, the coefficients  $a$  and  $b$  are real, and  $V_T$  is the Thevenin voltage mentioned in Part b). Determine the value of the coefficient  $b$

d) The secondary/right-side mesh equation could be written in the following format:

$$-j2I_1 + (c + jd)I_2 = 0$$

where  $I_1$  and  $I_2$  are the clockwise left-mesh and right-mesh current phasors respectively, and the coefficients  $c$  and  $d$  are integers. Determine the value of the coefficient  $c$

e) Using the mesh equations obtained in Parts c) and d), solve for the mesh currents  $I_1$  and  $I_2$ , and determine the phase of the current  $I_1$  in degrees

f) Deduce the magnitude of the output voltage,  $V_O$ , in Volts.

Figure 2—Sample assessment question in the Circuit Analysis question pool.

The purpose behind this question partitioning is to steer the engineering student's attention in a specific direction (which encompasses a certain amount of learning even during the assessment – See Section 3.3 below), and lead him/her into solving the problem step-by-step, and therefore improving his/her chance of gradually gaining partial credits while simultaneously enabling Blackboard to evaluate each part of the question autonomously. All of this is done without drastically deviating from the classic form of engineering questions.

### 3. Main Features: Redundant Randomization, Error Tolerance, and Multiplied Learning

In addition to streamlining the creation of self-graded, multi-threaded, regular engineering questions, several other features were added to the REAP project, mainly to mitigate academic dishonesty, add grading flexibility, and improve student learning at the same time. In the following, three main features are briefly outlined, namely Redundant Randomization, Error Tolerance, and the “Learning After” effect.

#### 3.1 Redundant Randomization

As mentioned in the introduction, academic dishonesty is quite rampant in many engineering schools around the world. In some regions of the world, it is no secret that the widespread

The screenshot shows the 'Question Set' configuration page in Blackboard. At the top, it indicates 'Total Questions: 4' and 'Number of Questions to display: 1'. Below this, there is a section titled 'Questions in the Set' with an 'Add Questions' button. A 'Remove Question' button and a 'Question Display' dropdown are also visible. The main part of the interface is a table with two columns: 'Question Type' and 'Question Text'. There are four rows, each representing a question of type 'Fill in Multiple Blanks'. All four questions are related to 'PID Tuning - Closed-loop Ziegler-Nichols Method' with different sub-questions (A, B, C, D). The text for each question is truncated, showing 'Consider a unity feedback system with the following loop transfer function: ...'.

Question Type	Question Text
Fill in Multiple Blanks	PID Tuning - Closed-loop Ziegler-Nichols Method - A: Consider a unity feedback system with the following loop transfer function: ...
Fill in Multiple Blanks	PID Tuning - Closed-loop Ziegler-Nichols Method - C: Consider a unity feedback system with the following loop transfer function: ...
Fill in Multiple Blanks	PID Tuning - Closed-loop Ziegler-Nichols Method - B: Consider a unity feedback system with the following loop transfer function: ...
Fill in Multiple Blanks	PID Tuning - Closed-loop Ziegler-Nichols Method - D: Consider a unity feedback system with the following loop transfer function: ...

Figure 3 – Redundant Randomization: one question randomly selected out of a Question Set.

academic dishonesty has allegedly discouraged many engineering educators from using their very basic learning tool: homework! In this respect, a computerized assessment requiring only a limited amount of data is certainly a breeding ground for academic dishonesty. For that reason,

appropriate countermeasures had to be taken over and above the question randomization feature offered by Blackboard. One such countermeasure, dubbed Redundant Randomization, was implemented in REAP. It simply consists of creating four versions of each assessment question – all of them being the same except for their associated numerical data – and using these versions as the elements of a so-called Question Set within Blackboard (Figure 3). Subsequently, Blackboard selects only one version of each question at random and associates it with a specific Exam Attempt that is delivered to a distinct student. As a result, different students in class receive the same type of questions but with possibly different values of the given variables. In this fashion, the similarity/redundancy of each question ensures assessment equitability among students, while the randomization within each Question Set handles the risk of academic dishonesty.

### 3.2 Error Tolerance

Since Blackboard's Fill in Multiple Blanks question type (mainly used in the REAP project) does not offer an error tolerance feature, it was decided to manually introduce error tolerance, in order to equip the REAP project with evaluation/grading flexibility. Towards that end, a feature within Blackboard, called Pattern Matching, was exploited. Through this feature, it is possible to accept a numerical answer that belongs to a range of data as a correct answer, instead of

Specified Answer for: a	✓ 30.0
Specified Answer for: b	✗ 160
Specified Answer for: c	✗ [None Given]
Specified Answer for: d	✓ 16.0
Specified Answer for: e	✗ 81.0
Specified Answer for: f	✗ [None Given]
<b>Correct Answers for: a</b>	
<b>Evaluation Method</b>	<b>Correct Answer</b>
✓ <i>Pattern Match</i>	( )?2[89]\.[0-9] ?
✓ <i>Pattern Match</i>	( )?30\.[0-9] ?
<b>Correct Answers for: b</b>	
<b>Evaluation Method</b>	<b>Correct Answer</b>
✓ <i>Pattern Match</i>	( )?17[2-9] ?
✓ <i>Pattern Match</i>	( )?18[0-9] ?

Figure 4 - Using the Pattern Match feature in Blackboard to incorporate error tolerance.

accepting only a single answer. This measure simplifies the grading of assessments, accounts for rounding or truncation errors, and provides students with a larger margin of flexibility in solving engineering problems. However, it is relatively tedious and time-consuming for the question

designer (Figure 4). It is hoped that future versions of Blackboard Learn™ include a built-in error tolerance feature within the Fill in Multiple Blanks question type.

### **3.3 The “Learning After” Effect**

In a traditional pen-and-paper assessment, learning typically occurs more during preparation time before the assessment, than during or after the assessment itself. Although many educators do post their assessment solutions physically or electronically, not all students make an effort to compare their answers to the correct ones, often because of inconvenience. In the REAP environment, however, learning can occur even during the assessment, through the deliberately elaborated information given to students in the partitioned questions (See the sample question in Figure 2, Parts c) and d)). Additionally, the feedback provided to students after the assessment – which is the feedback offered in the Blackboard test environment – can be controlled by the educator in scope, time, and depth. In fact, after the assessment, it is possible to give each student the privilege of examining, from the comfort of his/her home, a customized soft copy of his/her Exam Attempt, conveniently including the assessment questions, his/her own answers, as well as the correct answers, in addition to personalized feedback, whenever possible. This timely and convenient feedback has a very powerful “learning after” effect that certainly improves long-term retention. At the present time, such feedback is quite limited. In future, however, it is intended to use Blackboard’s built-in feedback feature in order to improve the feedback given to students by including a detailed solution for each question at hand.

## **4. Current Status of the REAP Project: Addressing Culture Change**

Despite its numerous features, the introduction of the REAP project in Spring 2014 triggered a mild culture change in the local engineering education environment. Having been used for years to classic, pen-and-paper exams, or to multiple choice computer exams, many students found it relatively hard to decipher the parametric nature of the REAP project and to adapt to its seemingly unconventional intermediate questioning (See Figure 2, Parts c) and d)). Many students preferred to follow their own favorite solutions to the problems at hand, rather than following a prescribed, pre-determined solution path. Consequently, it is currently felt that the level of acceptance of the REAP project among students is still not sufficiently high, particularly because of its current limitations (See Section 4.2).

One long-term vision for the REAP project, however, is to use it as a low-stakes, regular assessment platform for every day learning purposes, as a substitute for the standard homework, in addition to using it as a high-stakes assessment platform. Such a vision will be realized once the scale and the level of acceptance of the project become more significant. Under such conditions, it would be possible to integrate the questions provided by this platform with lectures and class activities. Each question would be associated with a specific level of difficulty and time limit (adjusted appropriately for students with special needs), and students would be able to practice questions repeatedly for study purposes. Students would then be able to advance through these levels of difficulty depending on the level of their involvement.



For the time being, however, the REAP project is being used as a high-stakes assessment platform, for major learning evaluation purposes only (as opposed to day-to-day learning), as a substitute for standard exams. Accordingly, to build an assessment, a number of REAP question sets is selected and assigned for students to solve during a specific period of time (typically one to two hours). At the same time, students are given the option to do their exam in a near-traditional fashion, or in addition, to fill-in the REAP multiple blanks, in return for bonus points. As a result, the so-called Hybrid Exam was born.

#### 4.1 The Hybrid Exam: Towards More Fairness and Flexibility

Description	
Instructions	<p style="text-align: center;"><b>Hybrid Examination Guidelines</b></p> <ol style="list-style-type: none"> <li>1. In the <b>HYBRID EXAM</b>, the student has the <b>option</b> to answer the exam questions only on the exam sheet (i.e. traditional exam) or to type his/her answers on Blackboard after answering the questions on the exam sheet.</li> <li>2. <b>If the student chooses to answer the exam questions only on the exam sheet</b>, he/she needs to copy the questions from the screen on his/her sheet, <b>record the question objective(s)</b>, and <b>his/her specific data, written in blue</b>, and then answer the question/objective(s) on the exam sheet.</li> <li>3. <b>If, in addition, the student decides to answer the questions on Blackboard</b>, he/she then needs, in addition to the above, to respond to the <b>subsequent questions, written in black</b>, based on the <b>formatting instructions written in red</b> after the question objectives. In that case, he/she will be entitled to a <b>REWARD REACHING UP TO TWO BONUS POINTS PER QUESTION</b></li> <li>4. <b>In all cases, the exam sheet will be used as evidence of genuine work. If an answer is graded by Blackboard as correct without being properly worked-out on the exam sheet, it may not be counted.</b></li> </ol>

Figure 5 - Excerpt from the Student Guidelines for Hybrid Exams.

As suggested above, the Hybrid Exam is a blended-type exam, where the student is given the option to do the exam in a near-traditional fashion, upon transcribing his/her exam questions, along with his/her specific data, from the computer screen onto the exam sheet. Alternatively, the student is given the additional option to fill-in the blanks of the REAP questions, in return for bonus points (See Guidelines in Figure 5). At this stage of the REAP project – still considered to be “experimental” – the student is asked to consider the exam sheet as the main exam medium, for verification and validation purposes, on one hand, and because of the remaining limitations of REAP on the other. It is expected, however, to gradually switch to the fully computerized version of REAP, once its main limitations have been overcome.

#### 4.2 Main Limitations: Formatting, Inheritance, and Data Transfer

To a large extent, the REAP assessment could simply be perceived as a structured and conditioned Blackboard Test. Accordingly, as soon as the assessment is administered, a preliminary grade is assigned by Blackboard to each Exam Attempt. Subsequently, this grade is complemented by a manual grade that accounts for the following limitations:

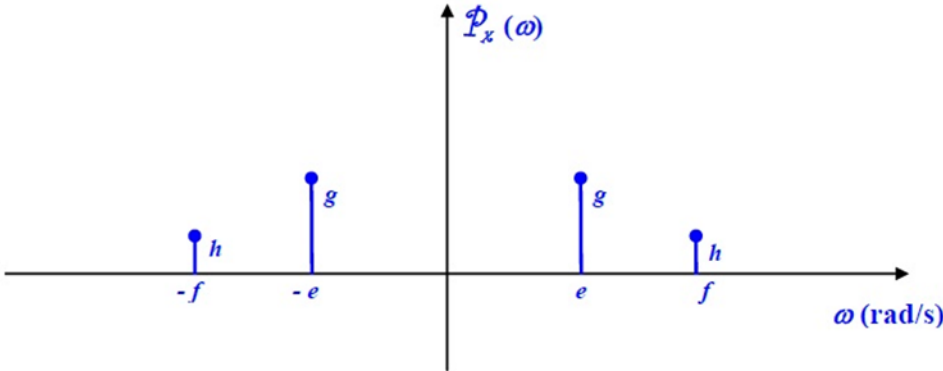
##### 4.2.1 Formatting Mistakes

In spite of the formatting instructions given in each REAP question (Figure 2, second part (typed in red)) and the error tolerance feature of REAP created via the pattern matching feature

in Blackboard, many students still use the wrong format to type their answers. Presently, Blackboard cannot distinguish a formatting mistake from any other mistake. To account for such a situation, a manual intervention is necessary.

#### 4.2.2 Inheritance Mistakes

At the input of the system, a power signal is applied with the following power spectral density:



where the powers at frequencies  $e$  and  $f$  are  $g$ , and  $h$ , respectively.

Let  $a = 400$ ,  $b = 1800$ ,  $c = 30$ ,  $d = 90$ ,  $e = 600$ ,  $f = 1000$ ,  $g = 10$ , and  $h = 4$ .

The objective of this question is to determine the system magnitude frequency response and the output power spectral density and frequency spectrum at the two frequencies of the input signal.

Unless indicated otherwise, please round your answers to the nearest **INTEGER VALUE**, as in the following examples: 2, -65, 369, 1205.

a) Determine the magnitude of the system frequency response at the frequency  $e$

b) Determine the magnitude of the system frequency response at the frequency  $f$

c) Deduce the magnitude/weight of the power spectral density of the output signal at the frequency  $e$

Figure 6 - Illustration of a potential Inheritance Mistake –a mistake in Part c) could be inherited from Part a).

In the present version of the REAP project, a wrong answer to an intermediate or final question may well be due to a mistake inherited from a previous question (Consider the relationship between Parts a) and c) in the question of Figure 6). Such a situation cannot be identified by Blackboard. To improve fairness and flexibility, a manual intervention is warranted.

### 4.2.3 Data Transfer Mistakes

The third REAP limitation is about the reading mistakes that a student may make inadvertently while transcribing data from the computer screen onto his/her exam sheet or vice-versa, or from one location of his/her exam sheet to another. Once again, since such mistakes cannot be identified by Blackboard, a manual intervention presently accounts for it.

At this point, it is important to note that the above limitations may appear to defeat the purpose for which REAP was initially designed. In fact, the manual intervention may be perceived to increase rather than decrease the educator's load, contrary to the stated objectives of REAP. However, it is hoped that such limitations will be overcome in the future versions of REAP, using additional tools and techniques, as mentioned in Section 6. Additionally, the clear identification of these limitations appears to lead to certain learning-related features that could be added to the list of benefits of REAP, such as the one described in the following.

### 4.3 One More Added Value: Participatory Evaluation

<u>Hybrid Exam</u>			
<u>Grade Adjustment Claim Form</u>			
Course No:.....Semester: .....			
Assessment (Exam 1, 2, or Final): .....Date: .....			
Student Name: .....ID#:.....			
Question No:.....			
Part No.	Type of Mistake (Formatting/ Inheritance/ Data Transfer)	Explanation/Justification	Grade Claimed

Figure 7- Another added feature of REAP: Students grading their own exams! (depicted above: Grade Adjustment Claim Form).

As mentioned previously, a preliminary grade is generated by Blackboard soon after the administration of a Hybrid Exam. Subsequently, a manual intervention is typically conducted by the educator to account for the present REAP limitations, following a well-defined policy and corresponding procedure. Given the clear, structured, and restricted nature of these limitations, it is possible to involve students in the evaluation/grading adjustment process. Towards that end, a

detailed policy along with a Grade Adjustment Claim Form (Figure 7) is distributed to students including information on the three types of mistakes outlined above and on the procedure followed to claim the grade adjustment. In itself, the prospect of students participating in the grading of their own exams could be considered as a direct manifestation of the “learning after” effect and proved to be unconventionally promising.

## 5. Preliminary Outcomes

Undoubtedly, the long-term vision of the REAP project is to improve the academic benefits provided to the student. As outlined in [3], these benefits are theoretically linked to increasing the assessment (mind sampling) frequency. The higher is this frequency, the better is the learning (through a stronger closing of the learning loop) and the more accurate is the learning evaluation (through the avoidance of aliasing errors in the reconstruction of the acquired knowledge signal).

Table 1- Estimated assessment preparation and evaluation times for various engineering courses (1-hour assessments and 25-student classes).

Course	Average Exam Prep. Time (hrs) (Prior to 2014)	Average Exam Prep. Time (hrs) (Current)	Percentage of Prep. Time Saving (Current)	Average Exam Eval/Grading Time (hrs) (Prior to 2014)	Average Exam Eval/Grading Time (hrs) (Current)	Percentage Eval. Time Saving (Current)
Circuit Analysis	6	3	50%	12	8	33%
Signals and Systems	6	3	50%	12	8	33%
Control Systems	8	4	50%	14	10	29%
Electric Circuits (NEE)	4	2	50%	10	7	30%
Electronics (NEE)	4	2	50%	10	7	30%

This vision is expected to be realized when the REAP pools become populated by an abundant number of questions, when its limitations have been largely overcome, when students' familiarity with its culture improves, when it will be adopted by a significantly large community of engineering educators (preferably for the administration of low-stakes as well as high-stakes assessments), and when it receives the institutional support it surely deserves. Under such circumstances, it would be possible to measure, for example, the success rate of students using the REAP project in comparison with other students. In this respect, however, there is certainly no need to reproduce the results of the countless studies that have emphasized the benefits of regular problem solving. (e.g. [1], [2], [3])

In the short term, however, it is possible to examine some of the REAP's benefits provided to the educator, at least in terms of time savings on assessment preparation and assessment evaluation. Table 1 shows estimated numbers of hours necessary to prepare and evaluate 1-hour

assessments for classes comprising an average of 25 students in a number of courses. In this Table, the numbers of hours associated with the time period prior to 2014 were calculated based on estimates (obtained using a simple logbook) of appropriate times relating to (traditional) exams conducted between Fall 2012 and Fall 2014. However, the numbers of hours associated with the period designated as “current” were calculated based on estimates of appropriate times relating to (hybrid) exams conducted between Fall 2016 and Spring 2018. From these numbers, we note that the assessment preparation time saving has reached up to 50% while the assessment evaluation/grading time saving reached up to 33%, at present. Needless to say, these numbers are expected to improve in future upon overcoming REAP’s limitations.

## **6. Conclusion and Future Directions**

In short, the REAP project promises a number of significant academic benefits. Based on a solid signals-and-systems theory relating to the sampling frequency of the knowledge signal, this project addresses numerous academic concerns and caters for the interests of many stakeholders at the same time.

To the engineering student, the REAP project provides engineering assessments made up of fully-fledged, guessing-free problems, typically including many parts (problem threads). Unlike multiple-choice problems, the solution of a multi-thread engineering problem often requires detailed analysis, synthesis, and rigorous calculations, away from “educated guesses” or answers by elimination. At the same time, partial credits given for partial effort certainly offer students more fairness and flexibility than the “all or nothing” approach (typically adopted in numerous soft learning support systems). Additional flexibility is also given through the error tolerance feature. But perhaps the most important feature of the REAP project is its ability to provide learning before, during, and after assessments. The “learning after” effect is particularly manifested in the opportunity offered to the student to participate in the evaluation of his/her own exam.

To the engineering educator, the REAP project offers the possibility of combating academic dishonesty through its redundant randomization feature. In addition, REAP’s reusability feature allows the educator to save significant time on assessment preparation and evaluation. Furthermore, the REAP project offers the educator the opportunity to increase assessment frequency (for the purpose of improving learning and evaluation), although this feature does depend to a large extent on the level of institutional adoption and support.

Finally, to the institution, the REAP project offers an engineering assessment platform with no additional human or financial requirements other than the Blackboard system. Once its limitations have been overcome, and upon full deployment, the REAP project will constitute an autonomous learning feedback system, with practically little need for academic or teaching assistance. At the same time, the project will contribute to improving students’ learning outcomes because of its numerous student-related benefits.

There remains the question of overcoming the present limitations of REAP. Towards that end, it is envisaged to use, in the future, additional assessment and learning tools such as Maple T.A. or Möbius<sup>TM</sup> which, in addition to being compatible with Blackboard, are specifically tailored for mathematically-intensive assessments and offer a range of valuable capabilities including adaptive, interactive, and algorithmic questioning, graph sketching, flexible error tolerance, and intelligent grading [9], [10].

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