

Individualized exercises for continuous assessment in engineering

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S. Pineda ¹, N. Alguacil ², J. Pérez-Ruiz ¹, S. Martín ¹, A. Ruiz ¹

¹University of Málaga (Spain) ²University of Castilla-La Mancha (Spain)

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Continuous assessment at University

- ✓ Early indications of the performance of students
- ✓ Increased sense of inclusiveness
- ✓ Higher learning standards for all students
- ✗ Increase of professor working load
- ✗ Greater study pressure
- ✗ Risk of plagiarism

Online teaching platforms

- It reduces the professor working load by providing feedback to students automatically
- It alleviates the study pressure since students can decide where and when to use these platforms
- There exist ways to reduce the plagiarism by proposing exercises whose numerical solutions are different for each student
- Moodle
 - ✓ Free and open-source learning management system written in PHP
 - ✓ Already integrated in several public universities
 - ✗ Complex operations not allowed
 - ✗ IT support required to implement changes

Development of web application

- Goal: automatic assessment of individualized exercises
- Requirements:
 - Capable of solving complex engineering problems (integrals, derivatives, system of equations, complex numbers, etc.)
 - Flexible enough to implement changes according to students and professors needs
 - Programming language with a smooth learning curve so that IT support is not required
- Decision:
 - Python: a high-level, general-purpose programming language
 - Django: a Python-based free and open-source web framework

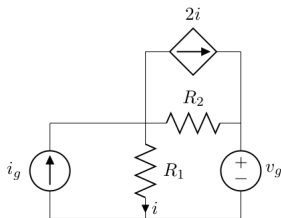
Previous steps

- 1 Divide the course in a series of blocks or didactic units with different learning objectives
- 2 Propose a series of exercises for each block ordered from lower to higher difficulty
- 3 Propose several questions for each exercise and the points obtained by the student if answered correctly
- 4 Write down each exercise formulation with some data depending on parameters $\alpha, \beta, \gamma, \dots$ (different for each student)
- 5 Write down the Python code that provides the solution to each exercise for given parameters $\alpha, \beta, \gamma, \dots$

Example of exercise and code

Ejercicio 3-13

Para el circuito de la figura, calcula la tensión v_g [V] usando las leyes de Kirchhoff y la ley de Ohm



Datos: $i = \delta$ [A], $i_g = \alpha$ [A], $R_1 = \beta$ [Ω], $R_2 = \gamma$ [Ω]

```
#Ejercicio 3-13
elif (bl ==3) and (pr==13):
    if qu=='a':
        i2 = al-3*de
        sol = be*de-ga*i2
```

Use of exercises in class

- Solved by professor: some of the exercises are solved in class by the professor using different values of parameters $\alpha, \beta, \gamma, \dots$. Students have to solve the same problem using the same procedure but with different data.
- Proposed in class: other exercises are proposed to be solved in class by each student with the help of the professors and the rest of students. If a student has solved correctly the proposed exercise, she can offer help to other students who have not finished yet.
- Proposed as homework: other exercises are proposed as homework to be solved by each student at home without any help. The student can check whether the solution is correct or not using the web application.

Features of web application (student)

- Student can check whether a solution to a problem is correct at any time from any place
- If a question is answered correctly, the student gets the corresponding points
- Each student can check the total obtained points and her position in the class ranking
- Each student must answer correctly a percentage of the questions of block 1 (decided by each professor) to be able to check her answers to the questions of block 2.
- There is a maximum number of tries to answer each question (decided by each professor). If this limit is exceeded, the student can still check whether the answer is correct but she gets no points for it.

Student view

Basic information of each student:

- Usuario: username chosen by the student
- Grupo: grade and group to which the student belongs
- Puntos: total points of the student / total points of the first student of the class
- Nivel: current level of the student / total levels of the subject
- Ranking: current position of the student / total number of students

Usuario: alumno2 Grupo: fie_giel_b Puntos: 18/551 Nivel: 2/11 Ranking: 78/93

- Puedes encontrar la teoría y ejercicios de cada tema en [esta](#)
- Si tienes problemas para abrir los archivos pdf con tu móvil o tablet, usa la aplicación Xodo que puedes [descargar para Android](#) o [iPhone](#)
- En cada ejercicio, sustituye los símbolos α , β , etc. del enunciado por los siguientes valores numéricos: $\alpha=4$, $\beta=7$, $\gamma=2$, $\delta=5$, $\epsilon=9$, $\eta=3$, $\theta=8$, $\kappa=6$, $\lambda=1$
- Resuelve el problema y envía la solución obtenida (con dos decimales) para saber si has solucionado el problema correctamente o no
- Si la solución no es correcta, revisa el procedimiento, pregunta a un compañero, o ven a tutorías
- Para subir de nivel tienes que constatar correctamente a un porcentaje de los ejercicios del tema anterior. Puedes consultar dichos porcentajes en [esta](#)
- Si encuentras algún fallo técnico, rellena este [formulario](#)
- Asegúrate de que perteneces al grupo correcto (está arriba de esta página al lado del nombre de usuario). Si no estás en el grupo correcto, rellena este [formulario](#)
 - fie_giel_a: Grado Ingeniería Eléctrica (grupo A)
 - fie_giel_b: Grado Ingeniería Eléctrica (grupo B)
 - fie_giel_c: Grado Ingeniería Electrónica Industrial (grupo A)
 - fie_giel_d: Grado Ingeniería Química (grupo A)

Ejercicio 1-1	10/10	Completo
Ejercicio 1-2	7/18	
Ejercicio 1-3	1/4	
Ejercicio 1-4	0/1	
Ejercicio 2-1	0/2	
Ejercicio 2-2	0/3	
Ejercicio 2-3	0/3	
Ejercicio 2-4	0/2	

Obtained points of a given exercise/ Maximum number of points

List of 175 exercises

Form to send the solutions to exercises

Ejercicio 1-3

- a) Correcto 1 punto Sol: 28,0
- b) Sin contestar
- c) Sin contestar
- d) Sin contestar

Course material

Material

Tema 1 (teoría+problemas)
Tema 2 (teoría+problemas)
Tema 3 (teoría+problemas)
Tema 4 (teoría+problemas)
Tema 5 (teoría+problemas)
Tema 6 (teoría+problemas)
Tema 7 (teoría+problemas)
Tema 8 (teoría+problemas)
Tema 9 (teoría+problemas)
Tema 10 (teoría+problemas)
Temas 1-10 (solo problemas)

Parameters of each student on which the data of the exercises depend

Percentages needed to pass each of the levels

Porcentajes bloques

	Porcentaje resuelto	Porcentaje pasar nivel
Bloque 1	53,0	50,0
Bloque 2	0,0	50,0
Bloque 3	0,0	50,0
Bloque 4	0,0	50,0
Bloque 5	0,0	50,0
Bloque 6	0,0	50,0
Bloque 7	0,0	50,0
Bloque 8	0,0	50,0
Bloque 9	0,0	50,0
Bloque 10	0,0	70,0

Features of web application (professor)

- The professor can check the points obtained and the current level for all students in the class to evaluate the learning process
- The professor can check the number of tries for the different questions to assess its difficulty and revisit some concepts during class
- The professor can check the number of exercises solved per day in order to detect conflicts with exams of other courses, for example.
- The professor can check the questions answered correctly for a specific student to address more particular issues related to the learning process.

Professor view

Resumen fie_giel_b

DNI	Apellidos	Nombre	Email	Puntos	Nivel	Usuario	Código	Ranking
71861894	Escamez Contreras	Ana Adriana	anaescamezcontreras@gmail.com	551	9	Ana_AdrinaEscamezContreras	742893615	1
79036676	El Labiano Siano	Oliver	oliver_17@hotmail.es	527	9	Oliver_20	794236581	2
76774270	Martin	Jorge	jorgebarralopez4@hotmail.com	517	9	jorgebarr	612749853	3
44001000	Molina Vigorel	Roberto	roberto.molina.vigorel@gmail.com	517	9	RobertoMolina	726135984	4
77810888	Escalón Biza	Jose	jose.escalonbiza@gmail.com	506	9	JoseEscal	146829537	5
77429922	Galarraga	Sergio	sergiogalarraga1984@gmail.com	502	9	SergioGalarr	925483176	6
63987127	Kildare Contreras	Araceli	araceli_g_1@hotmail.com	495	9	AraceliContr	936714852	7
77861070	Bautista Berrones	Igorio	igorio@gmail.com	493	9	Igorio	367294815	8
76079884	Escamez Gonzalez	Alvaro	alvarog7877@hotmail.com	489	9	Alvaro	719462853	9
77007700	Benito Alvarado	Jose	jose_benito@hotmail.com	485	9	AlvaradoJose	264713589	10
70000000	Escamez Barredo	Jose Angel	joseangelbarredo1@gmail.com	466	9	barredo1j	576921384	11
70007000	Molina Lopez	Miguel	miguel.molina.lopez@gmail.com	460	9	MiguelMolina	834519267	12
77810100	Martin Berlanga	Enrique	enriqueberlanga@redhok.es	454	8	Enrique	853914267	13
76077000	Ma	Jose	ma76077@gmail.com	415	9	Jose_Ma7	425867913	14
68874888	Molla	Roberto	robmolla@gmail.com	415	8	Roberto	253981764	15
77077000	Escamez Sanchez	Francisco Javier	franescosanchez1974@gmail.com	403	7	FranciscoEscamez	817463529	16
70007000	Gallego Lafuente	Igorio	igorio1974@gmail.com	401	7	Igorio	956847312	17
68871000	Carde Castro	Andrés Manuel	amandrescastro1980@gmail.com	398	7	amandresCM	712548963	18
76100000	Caballero Valdez	Christian	christiancaballero_1@hotmail.com	394	9	Christian	189473265	19
77607000	Sanchez Martin	Jose Angel	joseangelmartinsanchez1977@gmail.com	388	7	JoseAngelSanche	492387561	20
77861070	Escamez Lora	Jose El Biza	joseelbiza@hotmail.com	361	9	JoseElBiza	369471528	21
77607000	Cabera Escalante	Carolina	carolina.galarraga19@gmail.com	355	7	CarolinaC	741826935	22

Courses that use the web application (I)

- Electric circuits (EC) at University of Castilla-La Mancha (UCLM):
 - Degrees in which the course is taught:
 - Bachelor Degree in Mechanical Engineering
 - Bachelor Degree in Electrical Engineering
 - Bachelor Degree in Electronic Engineering
 - 2nd year course
 - 100-120 enrolled students per academic year
- Electric circuits (EC) at University of Málaga (UMA):
 - Degrees in which the course is taught:
 - Bachelor Degree in Mechanical Engineering
 - Bachelor Degree in Electrical Engineering
 - Bachelor Degree in Electronic Engineering
 - Bachelor Degree in Industrial Technology Engineering
 - 2nd year course
 - 700-750 enrolled students per academic year

Courses that use the web application (II)

- Power systems I (PS1) at University of Málaga (UMA):
 - Degrees in which the course is taught:
 - Bachelor Degree in Electrical Engineering
 - Bachelor Degree in Industrial Technology Engineering
 - 4th year course (Electrical Eng.) and 3rd year course (Ind. Techn. Eng.)
 - 60-80 enrolled students per academic year

- Power systems II (PS2) at University of Málaga (UMA):
 - Degrees in which the course is taught:
 - Bachelor Degree in Electrical Engineering
 - Bachelor Degree in Electrical and Mechanical Engineering
 - Bachelor Degree in Electronic and Electrical Engineering
 - 4th year course (Electrical Eng.) and 5th year course (Electrical-Mechanical, Electronic-Electrical).
 - 40-50 enrolled students per academic year

Impact of web application

- Use of the application: number of users, exercises solved correctly, etc
- Grades: percentage of students who pass the course
- Survey to students

Impact: use of web application

Course	# Exercises	# Students	# Correct answers
EC	175	1505	329495
PS1	62	127	10300
PS2	25	54	2649

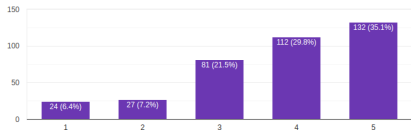
Table: Use of web application

Impact: grades

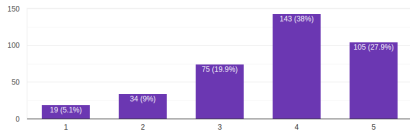
	'14+'15+'16	'17
Use of web application	✘	✔
Non attendance rate of enrolled students	12%	22%
Pass rate of students attending the exam	24%	64%
Pass rate of enrolled students	21%	50%

Table: Impact of web application on grades

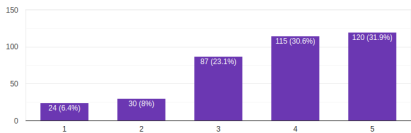
Impact: student survey



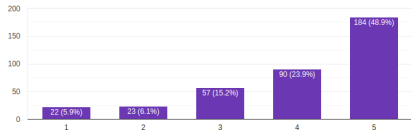
(a) The webapp has helped me to work daily on the course



(b) The application has helped me to understand concepts of the subject



(c) The application is a good preparation for the exam



(d) I would recommend the application to other students of this subject

Figure: Survey results (5: totally agree, 1: totally disagree)

Conclusions

- We present a teaching innovation project based on the development of a web application to continuously assess the learning at engineering university courses
- The web application has been tested in **2 universities** and **4 courses**. More than **1600 students** have used the application and almost **340000 questions** have been already answered correctly
- The use of individualized exercises motivates students to study on a regular basis, increases their understanding of the subject and increase the rate of student who pass the course
- Surprisingly, the class ranking drastically increased student participation

Thanks for the attention!

Questions?

spineda@uma.es