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Research Article

Analytical Hierarchy Process Applied to Pedagogical Method Selection Problems

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The purpose of this study is to apply multicriteria decision-making (MCDM) methods, namely, analytic hierarchy process (AHP) for selecting the best pedagogical method able to develop the soft skills required by the job market with respect to the preference level assigned by employers to each soft skill. The evaluated pedagogical strategies are experiential pedagogy (EP), project-based learning (PjBL), problem-based learning (PBL), serious games (SG), Harvard case method (HCM), and lecture course (LC). Ten criteria (soft skills) were identified from a previous quantitative content analysis of engineering job ads in Morocco in order to identify the extent to which soft skills are required by employers. These skills include communication, efficiency, adaptability, decision-making, innovation, problem resolution, team working, project management, professional responsibility, and using technology in engineering practice. After pairwise comparisons between all the evaluated alternatives with respect to each criterion, results show that experiential pedagogy is the optimal solution to develop the soft skills demanded by the job market.

1. Introduction

Soft skills refer to a set of personal and interpersonal skills that are very necessary for every job success by improving students' employability. In order to stay, competitive schools must develop the soft skills required by the job market using innovative and attractive pedagogical strategies. Choosing the best pedagogical methods able to develop the soft skills with respect to the market requirements is an important challenge faced by Moroccan engineering schools. In this work, this challenge is studied as the multicriteria decision-making problem where criteria are the soft skills needed by Moroccan employers which were identified during our previous study; pedagogical strategies involved in engineering education represent the alternatives to be evaluated using AHP method.

This research project is part of the framework of improving the employability of engineers through the promotion of the acquisition of soft skills. In the course of this study, we will highlight the importance of establishing a perpetual collaboration between the professional and academic worlds for any capitalization of needs, feedback, and good practices in the development of sustainable employability skills. The need to train qualified and operational graduates is a shared responsibility between these two stakeholders.

The paper is organized as follows. In Section 2, we present different pedagogical methods that will be evaluated through this study. In Section 3, we present the soft skills required by Moroccan job market as a result of our previous quantitative study. Section 4 shows differences between the MCDM methods and justifies the use of the AHP method. In Section 5, we apply AHP method to choose the optimal pedagogical method enabling us to achieve the study goal.

2. Pedagogical Methods

2.1. Interactive Lecture Course. Lecture course (LC) is a teaching activity belonging to the transmissive model of teaching where instructor plays a key role in the learning process by teaching oral content to a large group of students. The interactivity of the lecture course involves the student's reaction to the teacher's discourse through discussions or exercises [1, 2]. The use of this model can be justified when it comes to transmitting new concepts that do not require specific prerequisites. The relevance of lecture courses is often criticized by the fact that they are based on a simple transmission of knowledge whereas engineering or any professional training requires the development of a set of skills required by the job market [3–5].

2.2. Project-Based Learning (PjBL). Project-based learning (PjBL) belongs to active pedagogical methods where learning is centered on the student's activity. In this method, the learner develops knowledge and skills by carrying out a concrete team-based production [6, 7]. The instructor facilitates the learning progress by coaching and supervising teams. This pedagogical strategy enables students to apply the acquired knowledge and skills in practical situations in order to develop and strengthen key employability skills such as teamwork, critical thinking, communication, autonomy, decision-making, and creativity [8–10]. To make a successful project, students must be able to manage a set of factors defining the project, namely, resources, time, quality, and other specifications. In this way, the learner develops the managerial skills required by the professional world. Project-based learning can be applied according to the phases presented in Figure 1 [10].

The project must be well achievable and dimensioned in relation to the students' capacities by presenting objectives that can be achieved within an acceptable deadline. It must also allow learners to develop the skills and knowledge pre-established by the teacher who plans and defines the project according to the learning objectives. Students must understand the project specifications and plan and implement the action plan independently and under the supervision of the instructor who evaluates results achieved by students in terms of deliverables and acquired skills.

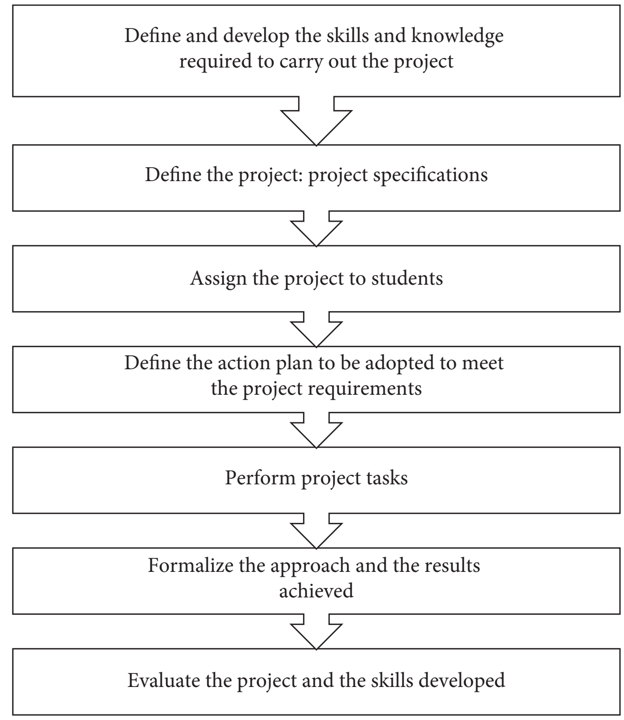

Figure 1: Implementation phases of project-based learning.

2.3. Problem-Based Learning (PBL). Problem-based learning (PBL) is an active pedagogical method based on the involvement of the learner in the learning process. It begins with a problem situation stimulating learner thinking by working as a team to find possible solutions to the problem. Teacher facilitates learning by choosing or designing the problem situation from professional context that is likely to develop the targeted skills and abilities. It also guides the problem-solving approach adopted by students [8]. After reviewing the literature, the PBL generally includes the phases described in Figure 2 [8, 11].

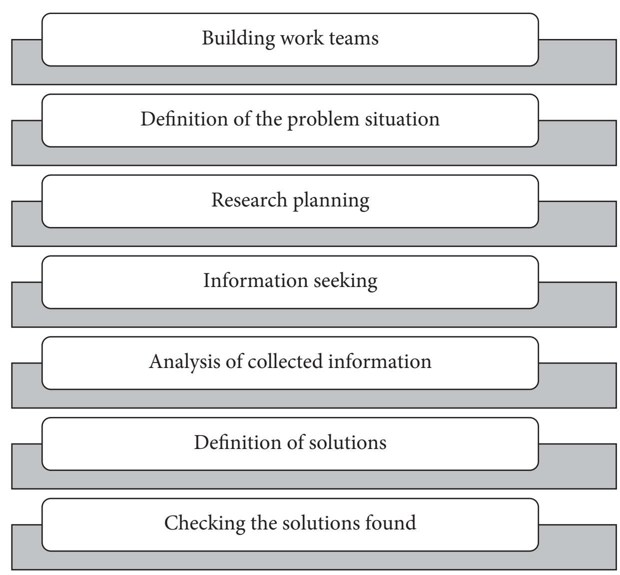

Figure 2: Phases of PBL.

PBL enables learners to develop a set of skills and abilities such as autonomy, communication, teamwork, analytical thinking, decision-making, creativity, project management, and entrepreneurship [8, 11]. PBL and PjBL are two pedagogical methods that are similar in that they are both carried out within the context of a project. However, instructors must necessarily distinguish between these two different strategies. Table 1 describes some points of divergence between PjBL and PBL [6, 8].

2.4. Harvard Case Method. Harvard case method (HCM), developed at Harvard University, is an active pedagogical strategy aimed at confronting students in small groups with experienced professional situations in order to understand the real use of the concepts studied in the course. It is based mainly on the interaction between the instructor and the

Table 1: Points of divergence between PBL and PjBL.

	Problem-based learning (PBL)	Project-based learning (PjBL)
Project duration	One to a few weeks	Several months
Team	Mono-disciplinary	Multidisciplinary
Evaluation criteria	Skills and knowledge acquisition	(i) Realization of a deliverable (ii) Skills and knowledge development
Team working	(i) Alternate collective and individual work (ii) All students perform the same tasks	(i) Dominant teamwork (ii) The students carry out different and complementary missions
Learning outcomes	All students in the team must develop the same skills	Student develops the competence related to the task assigned to him/her

student by assigning them different roles presented in Table 2 [8, 12, 13].

The case method allows the student to face a concrete decision-making situation supervised by the teacher in order to develop the skills required to train tomorrow's decision-makers such as analytical and synthetic thinking, decision-making, communication, and teamwork. This method replaces traditional application exercises with concrete case studies to motivate students to become more involved in the learning situation.

2.5. Experiential Pedagogy. Experiential pedagogy (EP) is a pedagogical method that promotes learning through participation in professional activities. The experience allows students to adapt their knowledge and abilities to the context they have encountered [14]. It also allows students to develop skills that are widely required by employers such as autonomy, self-confidence, initiative, problem solving, professional involvement, and social responsibility [15].

Experiential learning, according to Kolb, is based on two principles: the first requires that knowledge must be constructed from lived experiences; the second uses new experience to validate constructed knowledge. For him, this type of learning can only be accomplished if it is composed of four essential phases that constitute Kolb's learning cycle presented in Figure 3 [16, 17].

For example, in engineering education, students must complete their academic training with internships in companies where they benefit from academic supervision provided by a school teacher and industrial supervision provided by a field professional. The internship, as well as experience in the job market, improves the employability of future graduates by enabling them to develop the skills necessary for them to be operational in their workplace, namely, communication, social responsibility, professional commitment, and managerial attitudes.

2.6. Serious Games. Serious games (SG) are not designed for a main purpose to entertain, but instead, they are used to achieve particular learning objectives in many fields such as education, health care, manufacturing, planning, engineering, security, and crisis management. SG can be used to promote a set of skills including initiative, decision-making, adaptability, creativity, problem solving skills, communication, team working, leadership, professional ethics, and social responsibility [18–20]. They are largely used in education due to their ability to use latest modelling and simulation technologies to engage students in an environment close to the realistic experience where they will develop their skills and abilities [21]. Entertainment and learning are coupled with SG according to the following hypotheses [22]:

(i) Facilitator hypothesis: where more learning performance requires more entertainment

(ii) Distraction hypothesis: when entertainment increases, learning performances decrease

(iii) Moderate entertainment hypothesis: in which entertainment must be used moderately. If it exceeds a certain level, learning performance can decrease

Serious games are classified into three major categories presented as follows:

(i) Learning games: they aim to increase knowledge and developing skills by exposing students to a learning situation which may or may not be close to the real practice

(ii) Persuasive games: they are used to convey informative, persuasive, and subjective message and are widely adopted in particular fields including advertisements, marketing, and politics

(iii) Simulation games: they enable learners to develop particular skills and abilities by exposing them to realistic simulation situations promoting skills practice

3. Identification of the Soft Skills Required by Moroccan Job Market

Soft skills (SS) refer to a set of personal, interpersonal, managerial, social, and ethical skills that enable engineers to improve their employability. We have previously conducted a study aimed at identifying the soft skills required in Moroccan engineering education. For this reason, we have analyzed engineering job ads in different fields. This study has enabled us to determine the importance given by employers to the soft skills presented in Table 3 [23, 24].

Soft skills can be developed simultaneously by the pedagogical method presented above. In order to stay competitive, engineering schools must take advantage of the contribution of decision-making methods in order to choose teaching strategies enabling students to develop the soft skills according to the market requirements.

Table 2: Different roles of instructor and learner.

Instructor's role	Learner's role
(i) Define the case according to the learning objectives (ii) Study in depth the case to be presented to students by seeking possible solutions (iii) Facilitate, guide, and monitor the progress of the case suggested to the students	(i) Analyze the case study (ii) Propose a diagnosis (interpretation and justification of the observed phenomena) (iii) Define a plan of possible actions or decisions (iv) Choose a decision and justify it (v) Discuss the decision with colleagues and the teacher (vi) Generate principles and conclusions

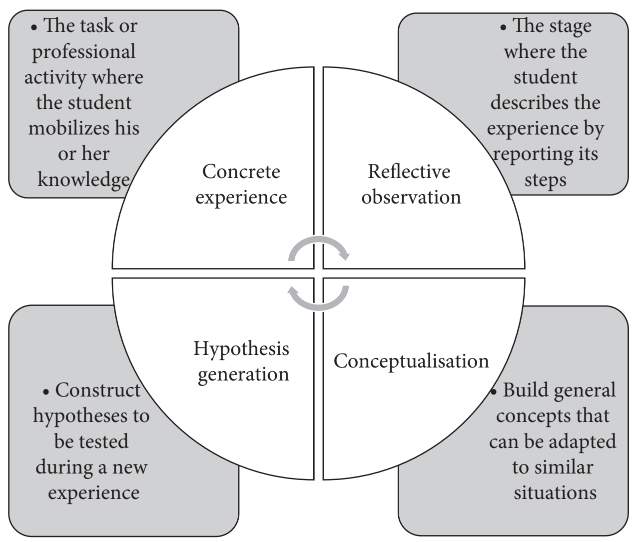

Figure 3: Kolb's learning cycle.

Table 3: Soft skills required by Moroccan job market.

Soft skills	Frequencies (%)
SS1. Communication (French, English, negotiation)	84.0
SS2. Organization, rigour, and efficiency	60.1
SS3. Using technology in engineering practice	52.8
SS4. Adaptability, initiative, and reactivity	52.1
SS5. Professional responsibility	44.8
SS6. Autonomy and decision-making	39.3
SS7. Project management	38.7
SS8. Team working	37.4
SS9. Innovation	36.2
SS10. Problem resolution (analyze, synthesis)	30.1

The improvement of Moroccan engineers requires a real collaboration between these two stakeholders:

(i) Academic staff: through their expertise in the field of engineering education. In our study, we involved academics to compare pedagogical methods on the basis of their ability to evaluate and compare different learning and teaching strategies.

(ii) Professionals in the labor market: through their feedback on the professional insertion of Moroccan engineers and their visibility on the skills required by employers. In our study, the use of professionals' feedback has enabled us to determine which soft skills are in high demand and which are in low demand.

While examining the literature, in relation to Moroccan engineers' employability, we found that there is a lack of studies that focus on collaboration between schools and industry in the development of teaching and follow-up program. Existing studies have a one-dimensional aspect, whether they work on the training aspect within the school or they are limited to the professional context. The interest of using multicriteria decision-making method in our study is justified by the willingness to take into account this considerable collaboration between academics and professionals in the job market.

4. Multicriteria Decision-Making (MCDM) Methods

In a multicriteria decision-making (MCDM) situation, decision-makers are faced with a complex problem with multiple criteria where they should choose the optimal solution using specific MCDM method according to the steps presented in Figure 4 [25, 26].

The problem must be clearly defined in order to choose the best MCDM method. Alternatives represent the possible solutions to the problem while respecting the identified goal. They are described and evaluated according to specific criteria. Decision-makers must apply a suitable MCDM method in order to achieve the optimal solution.

MCDM methods are widely applied in many fields such as business, government, manufacturing, education, research, and medicines. While examining the literature, a variety of decision-making methods can be found, each having its advantages and limitations [27–31]. The following are some of the widely used MCDM methods which will be briefly presented and compared in Table 4.

When compared to other MCDM methods (Table 4), AHP is characterized by its easiness, flexibility, and ability to simplify multicriteria and multialternative problem into a hierarchical structure. It also helps decision-makers to compare alternatives using pairwise comparison with respect to each criterion while checking judgment consistency using particular indicators. On the other hand, AHP presents two kinds of limitations:

(i) Ranking requires deep knowledge of the object to be judged: in our study, ranking is made on the basis of both academic and professional points of view; both of them have deep knowledge of engineering soft skills

(ii) Important number of pairwise comparison process: in our study, pairwise comparisons present points of intersection and communication between academics and professionals which will encourage the sharing of good practice

As a result, the disadvantages presented by the AHP method do not strongly affect our decision problem.

5. Previous Studies: AHP Use in Different Fields

A review of the literature shows that the AHP method has several uses in different multicriteria decision-making situations; Table 5 presents some of these studies.

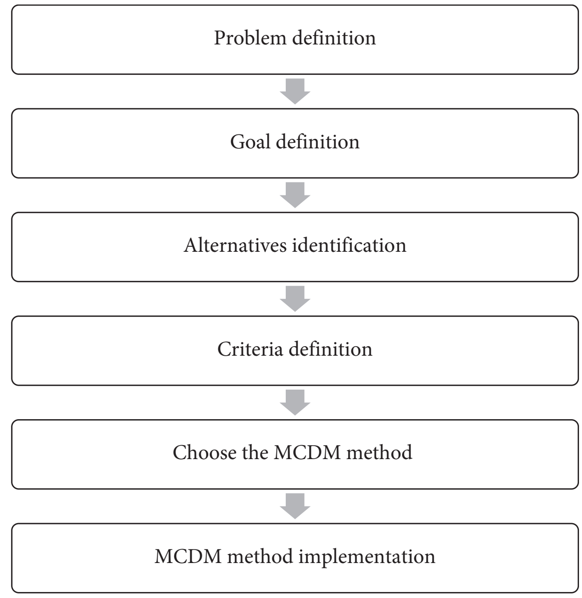

Figure 4: Steps of MCDM process.

6. Analytic Hierarchy Process (AHP) Applied to Learning Strategy Selection Problems

6.1. Decision-Makers. In order to carry out this study, we have constructed a focus group of academics (professors, heads of departments), researchers, and professionals (experts (in charge of professional skills development)). This decision problem concerns different stakeholders of the engineering school. For this reason, we have chosen a multidisciplinary team enabling us to make objective and reliable judgments.

6.2. Analytic Hierarchy Process (AHP) Steps. Analytic hierarchy process (AHP), developed by Prof. Thomas L. Saaty, is a multicriteria decision-making method that helps decompose any complex problem into a structured hierarchy of the problem goal, criteria, and alternatives to help decision-makers choose the optimal solution that best suits the problem's parameters [35]. The AHP can be applied according to the following steps presented in Figure 5.

All the steps presented in Figure 5 will be sufficiently presented in the following sections.

6.3. Setup of the Hierarchical Structure. In order to simplify the problem, AHP method suggests starting with setting a hierarchical structure composed of the problem goal (1st level), criteria (2nd level), and the alternatives to be evaluated (3rd level) as shown in Figure 6 [36, 37].

The goal of our study is to select a suitable learning strategy able to best develop all the soft skills representing criteria which are prioritized by the employers through a quantitative content analysis of the market job ads.

Table 4: Advantages and limitations of MCDM methods.

MCDM methods	Advantages	Limitations
Elimination and choice translating reality (ELECTRE)	(i) Can be adapted to qualitative and quantitative criteria (ii) It is applied to choosing, ranking, and sorting decision problems	(i) It is time consuming (ii) Its process is difficult to be understood by the decision-maker
Grey theory	It has the ability to deal with missing data	(i) It does not give the best solution but helps to find a good solution
Analytic hierarchy process (AHP)	(i) Can be adapted to qualitative and quantitative criteria (ii) Easy and flexible (iii) Complex multicriteria, multialternative problem is simplified into a hierarchical structure (iv) Pairwise comparison of different alternatives with respect to different criteria (v) It enables checking inconsistencies to avoid bias in decision-making	(i) Important number of pairwise comparisons (ii) Ranking requires deep knowledge about the object to be judged
Technique of order preference by similarity of ideal solution (TOPSIS)	(i) It is best on the fact that optimal solution must have the shortest geometric distance from the ideal solution (ii) Can be adapted to qualitative and quantitative data	(i) Does not take into account uncertainty (ii) Can provide unreliable solutions
preference ranking organization methods for enrichment evaluation (PROMETHEE)	(i) It can be applied to qualitative and quantitative data (ii) It is used in complex problems where a group of decision-makers are engaged	It does not simplify the problem by giving a hierarchical structure; as a result, decision process becomes more difficult when many criteria and alternatives are involved

Table 5: Examples of AHP uses in different multicriteria decision-making situations.

Studies	Importance of the study
Azdast et al. [32]	The importance of this study lies in using the AHP method to investigate mechanical and morphological properties of acrylonitrile butadiene styrene nanocomposite foams. The study results show the following: (i) Holding pressure is the most effective parameter on cell size, cell density, and relative density with the contribution of 90%, 70%, and 41%, respectively (ii) Nanoclay content is the most effective parameter on the tensile strength and hardness with the contribution of 79% and 89%, respectively
Mahmudova, and Jabrailova [33]	The study develops an algorithm by using the AHP method to evaluate the functionality of software. The authors carried out several pairwise comparisons in order to determine which of these criteria, correctness, compatibility, and accuracy, is more important in measuring software performance
Jurík et al. [34]	The paper aims to present the application the AHP method for project selecting in the context sustainable development using the following criteria: (i) Production (ii) Return on investment (iii) Allocation of hours for the production of the machine (iv) Usability of an empty production area (v) Number of employees—direct staff (vi) Number of special positions—indirect staff (vii) Defect rate with less impact on the environment (%) (viii) Defect rate leading to the production of hazardous waste mercury (kg) (ix) Electricity consumption (kW)

6.4. Criteria Comparison. In order to set up the priority vector for criteria, AHP suggests an $n \times n$ pairwise comparison matrix A [36, 37].

$$A = \begin{pmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nn} \end{pmatrix} = \left(a_{ij}\right)_{ij}, \quad (1)$$

where a_{ij} is the element of row i column j of the matrix, n is the number the evaluated criteria, $a_{ji} = (1/a_{ij})$, and $a_{ii} = a_{jj} = 1$. a_{ij} represents the importance of the criterion i when compared to the criterion j:

(i) If $a_{ij} > 1$, the criterion i is more important than the criterion j

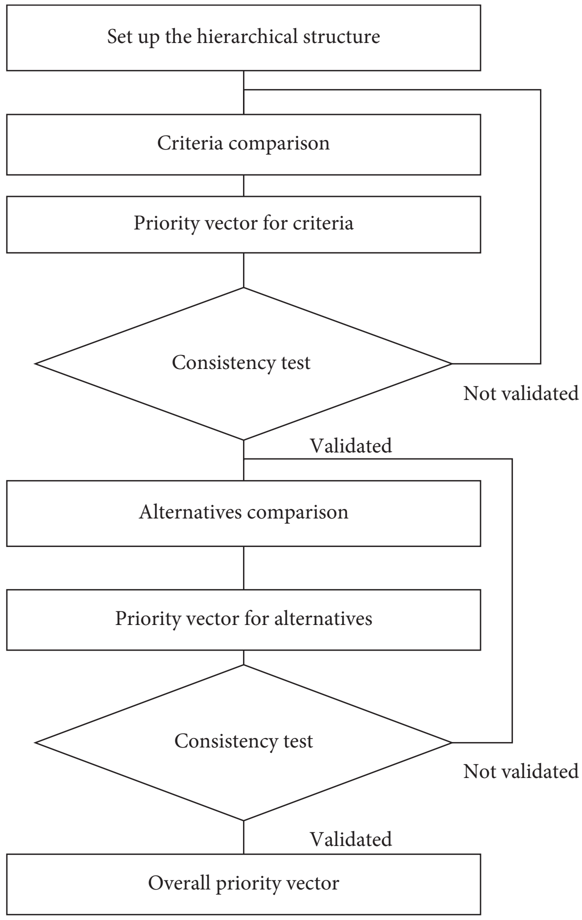

Figure 5: Analytic hierarchy process (AHP) steps.

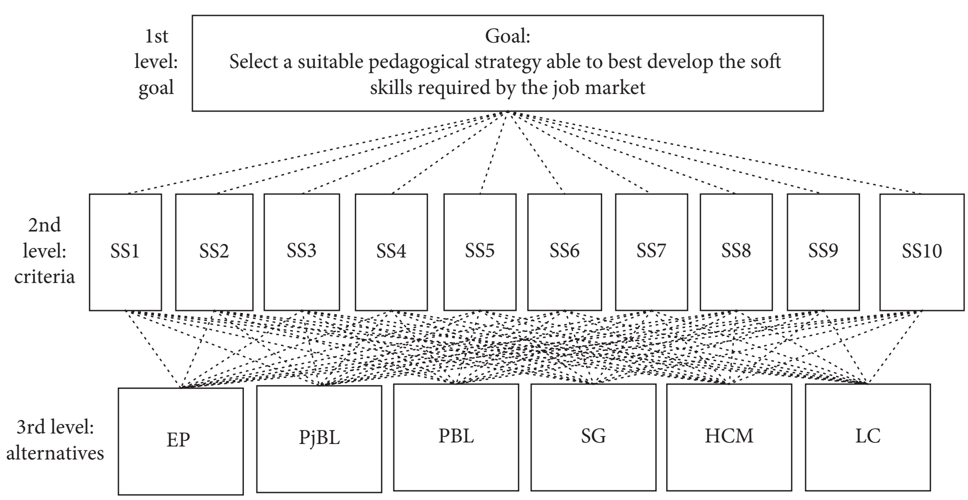

Figure 6: Hierarchical structure of the decision problem.

(ii) If $a_{ij} < 1$, the criterion i is less important than the criterion j

(iii) If $a_{ij} = 1$, the criteria i and j have the same importance

In AHP, the relative importance between two criteria is evaluated on the basis of a numerical scale ranging from 1 to 9, as described in Table 6.

Criteria comparison and AHP scale assignment have been performed by the focus group on the basis of the job market requirements shown in Table 3.

6.5. Priority Vector for Criteria. After building the matrix A, the priority vector of criteria is calculated using the following steps [38, 39]:

(1) Normalized pairwise comparison matrix A_{norm}: it is a matrix where the sum of the entries of each column is equal to 1; i.e., $\sum_{i=1}^{n} \overline{a_{ij}} = 1$.

$$A_{\text{norm}} = \begin{pmatrix} \overline{a_{11}} & \cdots & \overline{a_{1n}} \\ \vdots & \ddots & \vdots \\ \overline{a_{n1}} & \cdots & \overline{a_{nn}} \end{pmatrix} = \left(\overline{a_{ij}}\right)_{ij}. \tag{2}$$

The matrix A_{norm} entries $\overline{a_{ij}}$ are calculated using the entries a_{ij} of the matrix A using

$$\overline{a_{ij}} = \frac{a_{ij}}{\sum_{k=1}^{n} a_{kj}}. \tag{3}$$

(2) The priority vector of criteria: it is an n-dimensional column vector P.

$$P = \begin{pmatrix} p_1 \\ \vdots \\ p_n \end{pmatrix}. \tag{4}$$

P is achieved by averaging the entries of each row of the matrix A_{norm} using

$$p_i = \frac{\sum_{k=1}^{n} \overline{a_{ik}}}{n}. \tag{5}$$

6.6. Consistency Test. In order to check the consistency of the comparisons made by decision-makers, namely, the matrix A, AHP suggests a technique based on testing the consistency ratio (CR) which is calculated using formula (6) (Lokare, and Jadhav, 2016) [38, 39]:

$$\text{CR} = \frac{\text{CI}}{\text{RI}}, \tag{6}$$

where CI is calculated using

$$\text{CI} = \frac{(\lambda - n)}{n - 1}, \tag{7}$$

Table 6: AHP scale for criteria comparison.

Scale	Relative importance of factor i compared to factor j
1	Equally important
3	Moderately more important
5	Strongly more important
7	Very strongly more important
9	Extremely more important
2, 4, 6, 8	Intermediate values

Table 7: RI values according to the number of factors n.

Number of factors (n)	RI
1	0.00
2	0.00
3	0.58
4	0.90
5	1.21
6	1.24
7	1.32
8	1.41
9	1.45
10	1.49

where λ is calculated using

$$\lambda = \sum_{i=1}^{n} p_i * \sum_{k=1}^{n} a_{ki}. \tag{8}$$

RI is a random index changing according the order n of the matrix as shown in Table 7.

(i) If $0 \le \text{CR} \le 0.1$, the evaluations made by the decision-maker are consistent

(ii) If $\text{CR} > 0.1$, the judgment made by the decision-maker is inconsistent; as a result, the evaluations must be revised

The priority vector of criteria with respect to the goal is presented in Table 8 where $\text{CR} = 7.3\% \le 0.1$ which represents a validated consistency test.

6.7. Alternatives Comparison. After checking the consistency of the matrix of the criteria comparison, an m×m pairwise comparison matrix B^k must be built for each of the n criteria ($k = 1, \ldots, n$). In this matrix, alternatives are compared with respect to the criteria; m is the number of alternatives to be evaluated.

$$B^k = \begin{pmatrix} b_{11}^k & \cdots & b_{1n}^k \\ \vdots & \ddots & \vdots \\ b_{n1}^k & \cdots & b_{nn}^k \end{pmatrix} = \left(b_{ij}^k\right)_{ij}, \tag{9}$$

where b_{ij}^k represents the evaluation of the alternative i compared to the alternative j with respect to the criterion k. The entries of this matrix satisfy the following conditions:

Table 8: Pairwise comparison matrix of criteria with respect to goal.

	Pairwise comparison matrix									
	SS1	SS2	SS3	SS4	SS5	SS6	SS7	SS8	SS9	SS10
SS1	1	5	5	5	7	7	7	7	7	9
SS2	1/5	1	3	3	3	5	5	5	5	5
SS3	1/5	1/3	1	1	3	3	3	3	3	5
SS4	1/5	1/3	1	1	3	3	3	3	3	5
SS5	1/7	1/3	1/3	1/3	1	3	3	3	3	3
SS6	1/7	1/5	1/3	1/3	1/3	1	1	1	1	3
SS7	1/7	1/5	1/3	1/3	1/3	1	1	1	1	3
SS8	1/7	1/5	1/3	1/3	1/3	1	1	1	1	3
SS9	1/7	1/5	1/3	1/3	1/3	1	1	1	1	3
SS10	1/9	1/5	1/5	1/5	1/3	1/3	1/3	1/3	1/3	1
Sum	2.43	8.00	11.87	11.87	18.67	25.33	25.33	25.33	25.33	40.00

	Normalized matrix										Sum	Priority vector	Check for consistency
	SS1	SS2	SS3	SS4	SS5	SS6	SS7	SS8	SS9	SS10			
SS1	0.41	0.63	0.42	0.42	0.37	0.28	0.28	0.28	0.28	0.23	3.58	0.36	
SS2	0.08	0.13	0.25	0.25	0.16	0.20	0.20	0.20	0.20	0.13	1.79	0.18	$\lambda = 10.97$
SS3	0.08	0.04	0.08	0.08	0.16	0.12	0.12	0.12	0.12	0.13	1.05	0.11	$n = 10$
SS4	0.08	0.04	0.08	0.08	0.16	0.12	0.12	0.12	0.12	0.13	1.05	0.11	RI = 1.49
SS5	0.06	0.04	0.03	0.03	0.05	0.12	0.12	0.12	0.12	0.08	0.76	0.08	CR = 7.3%
SS6	0.06	0.03	0.03	0.03	0.02	0.04	0.04	0.04	0.04	0.08	0.39	0.04	
SS7	0.06	0.03	0.03	0.03	0.02	0.04	0.04	0.04	0.04	0.08	0.39	0.04	
SS8	0.06	0.03	0.03	0.03	0.02	0.04	0.04	0.04	0.04	0.08	0.39	0.04	
SS9	0.06	0.03	0.03	0.03	0.02	0.04	0.04	0.04	0.04	0.08	0.39	0.04	
SS10	0.05	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.03	0.20	0.02	
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	10.00	1.00	

Table 9: Pairwise comparison matrix of learning strategies with respect to the criterion "SS1. Communication (French, English, negotiation)."

	Pairwise comparison matrix						Normalized matrix						Sum	Priority vector	Check for consistency
	EP	SG	PjBL	PBL	HCM	LC	EP	SG	PjBL	PBL	HCM	LC			
EP	1	3	5	5	7	9	0.50	0.60	0.48	0.48	0.36	0.28	2.70	0.45	
SG	1/3	1	3	3	5	7	0.17	0.20	0.29	0.29	0.26	0.22	1.42	0.24	$\lambda = 6,5$
PjBL	1/5	1/3	1	1	3	5	0.10	0.07	0.10	0.10	0.16	0.16	0.67	0.11	$n = 6$
PBL	1/5	1/3	1	1	3	5	0.10	0.07	0.10	0.10	0.16	0.16	0.67	0.11	RI = 1.24
HCM	1/7	1/5	1/3	1/3	1	5	0.07	0.04	0.03	0.03	0.05	0.16	0.38	0.06	CR = 8%
LC	1/9	1/7	1/5	1/5	1/5	1	0.06	0.03	0.02	0.02	0.01	0.03	0.16	0.03	
Sum	2.0	5.0	10.5	10.5	19.2	32.0	1.0	1.0	1.0	1.0	1.0	1.0	6.0	1.0	

Table 10: Pairwise comparison matrix of learning strategies with respect to the Criterion "SS2. Organization, rigour, and efficiency."

	Pairwise comparison matrix						Normalized matrix						Sum	Priority vector	Check for consistency
	EP	PjBL	PBL	SG	HCM	LC	EP	PjBL	PBL	SG	HCM	LC			
EP	1	3	4	5	7	9	0.52	0.61	0.46	0.37	0.34	0.28	2.58	0.43	
PjBL	1/3	1	3	4	5	7	0.17	0.20	0.34	0.30	0.25	0.22	1.48	0.25	$\lambda = 6,54$
PBL	1/5	1/3	1	3	4	7	0.10	0.07	0.11	0.22	0.20	0.22	0.92	0.15	$n = 6$
SG	1/7	1/4	1/3	1	3	5	0.07	0.05	0.04	0.07	0.15	0.16	0.54	0.09	RI = 1.24
HCM	1/7	1/5	1/4	1/3	1	3	0.07	0.04	0.03	0.02	0.05	0.09	0.31	0.05	CR = 8.7%
LC	1/9	1/7	1/7	1/5	1/3	1	0.06	0.03	0.02	0.01	0.02	0.03	0.17	0.03	
Sum	1.93	4.93	8.73	13.53	20.33	32.00	1.00	1.00	1.00	1.00	1.00	1.00	6.00	1.00	

$$b_{ji}^{k} = \frac{1}{b_{ij}^{k}},$$
$$b_{ii}^{k} = b_{jj}^{k} = 1. \tag{10}$$

The same scale used to compare criteria (Table 1) is used to evaluate and compare the alternatives with respect to each criterion.

In order to compare the alternatives with respect to each criterion, we repeat the steps described in Sections 6.4–6.6.

Table 11: Pairwise comparison matrix of learning strategies with respect to the Criterion "SS3. Using technology in engineering practice."

	Pairwise comparison matrix						Normalized matrix						Sum	Priority vector	Check for consistency
	SG	EP	PjBL	PBL	HCM	LC	SG	EP	PjBL	PBL	HCM	LC			
SG	1	3	5	5	5	7	0.49	0.58	0.47	0.47	0.33	0.25	2.60	0.43	
EP	1/3	1	3	3	3	5	0.16	0.19	0.28	0.28	0.20	0.18	1.30	0.22	$\lambda = 6,63$
PjBL	1/5	1/3	1	1	3	5	0.10	0.06	0.09	0.09	0.20	0.18	0.73	0.12	$n = 6$
PBL	1/5	1/3	1	1	3	5	0.10	0.06	0.09	0.09	0.20	0.18	0.73	0.12	RI = 1.24
HCM	1/6	1/3	1/3	1/3	1	5	0.08	0.06	0.03	0.03	0.07	0.18	0.45	0.08	CR = 10%
LC	1/7	1/5	1/5	1/5	1/5	1	0.07	0.04	0.02	0.02	0.01	0.04	0.20	0.03	
Sum	2.04	5.20	10.53	10.53	15.20	28.00	1.00	1.00	1.00	1.00	1.00	1.00	6.00	1.00	

Table 12: Pairwise comparison matrix of learning strategies with respect to the Criterion "SS4. Adaptability, initiative, and reactivity."

	Pairwise comparison matrix						Normalized matrix						Sum	Priority vector	Check for consistency
	EP	PjBL	PBL	SG	HCM	LC	EP	PjBL	PBL	SG	HCM	LC			
EP	1	3	3	4	5	7	0.44	0.52	0.52	0.35	0.27	0.27	2.37	0.40	
PjBL	1/3	1	1	3	4	5	0.15	0.17	0.17	0.26	0.22	0.19	1.17	0.19	$\lambda = 6,54$
PBL	1/3	1	1	3	4	5	0.15	0.17	0.17	0.26	0.22	0.19	1.17	0.19	$n = 6$
SG	1/4	1/3	1/3	1	4	5	0.11	0.06	0.06	0.09	0.22	0.19	0.72	0.12	RI = 1.24
HCM	1/5	1/4	1/4	1/4	1	3	0.09	0.04	0.04	0.02	0.05	0.12	0.37	0.06	CR = 9%
LC	1/7	1/5	1/5	1/5	1/3	1	0.06	0.03	0.03	0.02	0.02	0.04	0.21	0.03	
Sum	2.26	5.78	5.78	11.45	18.33	26.00	1.00	1.00	1.00	1.00	1.00	1.00	6.00	1.00	

Table 13: Pairwise comparison matrix of learning strategies with respect to the Criterion "SS5. Professional responsibility."

	Pairwise comparison matrix						Normalized matrix						Sum	Priority vector	Check for consistency
	EP	PjBL	PBL	SG	HCM	LC	EP	PjBL	PBL	SG	HCM	LC			
EP	1	5	5	7	7	9	0.56	0.64	0.64	0.48	0.43	0.30	3.03	0.51	
PjBL	1/5	1	1	3	3	5	0.11	0.13	0.13	0.20	0.19	0.17	0.92	0.15	$\lambda = 6,61$
PBL	1/5	1	1	3	3	5	0.11	0.13	0.13	0.20	0.19	0.17	0.92	0.15	$n = 6$
SG	1/7	1/3	1/3	1	2	5	0.08	0.04	0.04	0.07	0.12	0.17	0.52	0.09	RI = 1.24
HCM	1/7	1/3	1/3	1/2	1	5	0.08	0.04	0.04	0.03	0.06	0.17	0.43	0.07	CR = 10%
LC	1/9	1/5	1/5	1/5	1/5	1	0.06	0.03	0.03	0.01	0.01	0.03	0.17	0.03	
Sum	1.80	7.87	7.87	14.70	16.20	30.00	1.00	1.00	1.00	1.00	1.00	1.00	6.00	1.00	

Table 14: Pairwise comparison matrix of learning strategies with respect to the Criterion "SS6. Autonomy and decision-making."

	Pairwise comparison matrix						Normalized matrix						Sum	Priority vector	Check for consistency
	EP	PjBL	PBL	SG	HCM	LC	EP	PjBL	PBL	SG	HCM	LC			
EP	1	3	3	3	5	9	0.43	0.51	0.51	0.36	0.24	0.25	2.31	0.38	
PjBL	1/3	1	1	2	5	7	0.14	0.17	0.17	0.24	0.24	0.19	1.16	0.19	$\lambda = 6,54$
PBL	1/3	1	1	2	5	7	0.14	0.17	0.17	0.24	0.24	0.19	1.16	0.19	$n = 6$
SG	1/3	1/2	1/2	1	5	7	0.14	0.09	0.09	0.12	0.24	0.19	0.87	0.14	RI = 1.24
HCM	1/5	1/5	1/5	1/5	1	5	0.09	0.03	0.03	0.02	0.05	0.14	0.37	0.06	CR = 9%
LC	1/9	1/7	1/7	1/7	1/5	1	0.05	0.02	0.02	0.02	0.01	0.03	0.15	0.03	
Sum	2.31	5.84	5.84	8.34	21.20	36.00	1.00	1.00	1.00	1.00	1.00	1.00	6.00	1.00	

The pairwise comparisons of the alternatives (learning strategies) with respect to the ten criteria (required soft skills) SS1, SS2, SS3, SS4, SS5, SS6, SS7, SS8, SS9, and SS10 are presented in Tables 9–18.

The columns in Table 19 are the priority vectors of the alternatives with respect to each criterion as shown in Tables 9–18. The overall priority is a linear combination of multiplication between alternative priority with respect to each criterion and the criterion's priority (generated in Table 8).

Prioritization of pedagogical strategies using AHP method shows that experiential pedagogy (EP) is the best choice as a learning strategy able to develop engineering soft skills with respect to the market requirements with a highest score of 41% followed by serious games (SG), project-based learning (PjBL), and problem-based learning (PBL) with closely situated score of 19%, 17%, and 15%, respectively. Harvard case method (HCM) and lecture course (LC) have the lowest scores in relation to the goal: 6% and 3%, respectively.

Table 15: Pairwise comparison matrix of learning strategies with respect to the Criterion "SS7. Project management."

	Pairwise comparison matrix						Normalized matrix						Sum	Priority vector	Check for consistency
	EP	PjBL	PBL	SG	HCM	LC	EP	PjBL	PBL	SG	HCM	LC			
EP	1	3	3	3	8	9	0.45	0.59	0.45	0.26	0.33	0.30	2.37	0.40	
PjBL	1/3	1	2	4	5	6	0.15	0.20	0.30	0.35	0.20	0.20	1.40	0.23	$\lambda = 6,56$
PBL	1/3	1/2	1	3	5	6	0.15	0.10	0.15	0.26	0.20	0.20	1.06	0.18	$n = 6$
SG	1/3	1/4	1/3	1	5	6	0.15	0.05	0.05	0.09	0.20	0.20	0.74	0.12	RI = 1.24
HCM	1/8	1/5	1/5	1/5	1	2	0.06	0.04	0.03	0.02	0.04	0.07	0.25	0.04	CR = 9%
LC	1/9	1/6	1/6	1/6	1/2	1	0.05	0.03	0.02	0.01	0.02	0.03	0.18	0.03	
Sum	2.24	5.12	6.70	11.37	24.50	30.00	1.00	1.00	1.00	1.00	1.00	1.00	6.00	1.00	

Table 16: Pairwise comparison matrix of learning strategies with respect to the Criterion "SS8. Team working."

	Pairwise comparison matrix						Normalized matrix						Sum	Priority vector	Check for consistency
	EP	PjBL	PBL	SG	HCM	LC	EP	PjBL	PBL	SG	HCM	LC			
EP	1	3	3	4	4	9	0.44	0.52	0.52	0.33	0.33	0.24	2.37	0.39	
PjBL	1/3	1	1	3	3	7	0.15	0.17	0.17	0.25	0.25	0.18	1.17	0.19	$\lambda = 6,42$
PBL	1/3	1	1	3	3	7	0.15	0.17	0.17	0.25	0.25	0.18	1.17	0.19	$n = 6$
SG	1/4	1/3	1/3	1	1	7	0.11	0.06	0.06	0.08	0.08	0.18	0.57	0.10	RI = 1.24
HCM	1/4	1/3	1/3	1	1	7	0.11	0.06	0.06	0.08	0.08	0.18	0.57	0.10	CR = 7%
LC	1/9	1/7	1/7	1/7	1/7	1	0.05	0.02	0.02	0.01	0.01	0.03	0.15	0.02	
Sum	2.28	5.81	5.81	12.14	12.14	38.00	1.00	1.00	1.00	1.00	1.00	1.00	6.00	1.00	

Table 17: Pairwise comparison matrix of learning strategies with respect to the Criterion "SS9. Innovation."

	Pairwise comparison matrix						Normalized matrix						Sum	Priority vector	Check for consistency
	EP	PjBL	PBL	SG	HCM	LC	EP	PjBL	PBL	SG	HCM	LC			
EP	1	3	3	4	5	9	0.45	0.64	0.41	0.42	0.26	0.24	2.42	0.40	
PjBL	1/3	1	2	3	5	8	0.15	0.21	0.27	0.32	0.26	0.21	1.42	0.24	$\lambda = 6,46$
PBL	1/3		1	1	4	8	0.15	0.00	0.14	0.11	0.21	0.21	0.81	0.14	$n = 6$
SG	1/4	1/3	1	1	4	6	0.11	0.07	0.14	0.11	0.21	0.16	0.79	0.13	RI = 1.24
HCM	1/5	1/5	1/4	1/4	1	6	0.09	0.04	0.03	0.03	0.05	0.16	0.40	0.07	CR = 7%
LC	1/9	1/8	1/8	1/6	1/6	1	0.05	0.03	0.02	0.02	0.01	0.03	0.15	0.02	
Sum	2.23	4.66	7.38	9.42	19.17	38.00	1.00	1.00	1.00	1.00	1.00	1.00	6.00	1.00	

Table 18: Pairwise comparison matrix of learning strategies with respect to the Criterion "SS10. Problem resolution (analyze, synthesis)."

	Pairwise comparison matrix						Normalized matrix						Sum	Priority vector	Check for consistency
	PBL	EP	PjBL	SG	HCM	LC	PBL	EP	PjBL	SG	HCM	LC			
PBL	1	3	3	4	4	9	0.46	0.62	0.39	0.28	0.28	0.26	2.29	0.38	
EP	1/3	1	3	4	4	7	0.15	0.21	0.39	0.28	0.28	0.21	1.52	0.25	$\lambda = 6,58$
PjBL	1/3	1/3	1	4	4	6	0.15	0.07	0.13	0.28	0.28	0.18	1.09	0.18	$n = 6$
SG	1/5	1/5	1/4	1	1	7	0.09	0.04	0.03	0.07	0.07	0.21	0.51	0.09	RI = 1.24
HCM	1/5	1/5	1/4	1	1	4	0.09	0.04	0.03	0.07	0.07	0.12	0.42	0.07	CR = 7%
LC	1/9	1/7	1/6	1/7	1/4	1	0.05	0.03	0.02	0.01	0.02	0.03	0.16	0.03	
Sum	2.18	4.88	7.67	14.14	14.25	34.00	1.00	1.00	1.00	1.00	1.00	1.00	6.00	1.00	

Table 19: Overall priority vector and learning strategies ranking.

		Criteria and their priority										Overall priority	Final ranking
		SS1	SS2	SS3	SS4	SS5	SS6	SS7	SS8	SS9	SS10		
		0,36	0,18	0,11	0,11	0,08	0,04	0,04	0,04	0,04	0,02		
Alternatives	EP	0.45	0.43	0.22	0.40	0.51	0.38	0.40	0.39	0.40	0.25	0.41	I
	PjBL	0.11	0.25	0.12	0.19	0.15	0.19	0.23	0.19	0.24	0.18	0.17	III
	PBL	0.11	0.15	0.12	0.19	0.15	0.19	0.18	0.19	0.14	0.38	0.15	IV
	SG	0.24	0.09	0.43	0.12	0.09	0.14	0.12	0.10	0.13	0.09	0.19	II
	HCM	0.06	0.05	0.08	0.06	0.07	0.06	0.04	0.10	0.07	0.07	0.06	V
	LC	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.03	0.03	VI

7. Conclusion

The importance of this study lies in providing a practical case of a real collaboration between engineering schools and industry in order to reduce the skill gap between learning outcomes and on-the-job requirements. On the one hand, employers are looking for a highly skilled workforce in order to be more attractive and competitive. On the other hand, educational institutions need to improve their students' employability by developing the skills required by the job market. Through the use of the AHP method, we have shown academics and professionals the importance of their collaboration in achieving mutual benefit.

This paper aims to use AHP method to select the best pedagogical method that is able to develop soft skills while respecting the job market requirements. The study is based on a set of criteria that are identified from our previous study, where we have analyzed engineering job ads in order to determine the importance of soft skills in the engineers' employability. The decision problem consists of the comparison of different pedagogical strategies applied in engineering education. The results show that experiential pedagogy (EP) is the optimal solution to answer the market demand with a highest score of 41%. As a result, considerable efforts must be devoted to properly supervise the internships and ensure continuous monitoring and charting of student performance because this learning strategy represents a chance to make the student operational in the market by applying his/her knowledge and abilities in real professional situations.

Data Availability

The soft skills required by Moroccan employers data used to support the findings of this study have been made available in a previous work online in [23].

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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