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Research Article

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Entropic Advancement To Education

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Abstract

Numerous scientific fields employ entropy, the Shannonian measure of disorder and inaccessible information. Current paper examines educational uses of entropy. The major objectives of this survey are to create a coherent perspective of the applicability of classical entropies and to provide a concise detailed explanation that blends technical pertinence with conceptual extraction from the most recent literature. What's more intriguing are the closing thoughts mixed with a few unsolved issues and the creation of a future work schedule in these areas.

Keywords: Entropy, Education

1. Introduction

The idea of entropy, which is based on information theory and thermodynamics, has influenced recent advancements in many domains, including artificial intelligence. It is not always possible to give an exhaustive review of entropy applications. Moreover, the reasons for entropy's incorporation into knowledge domains like computer, engineering, queueing theory, and information theory were investigated [1].

Over the last few decades, researchers have proposed various new forms of entropy to address various challenges in time series analysis, cellular automata, chaos, synchronisation, multiscale analysis, etc. The following flowchart highlights other related entropies.

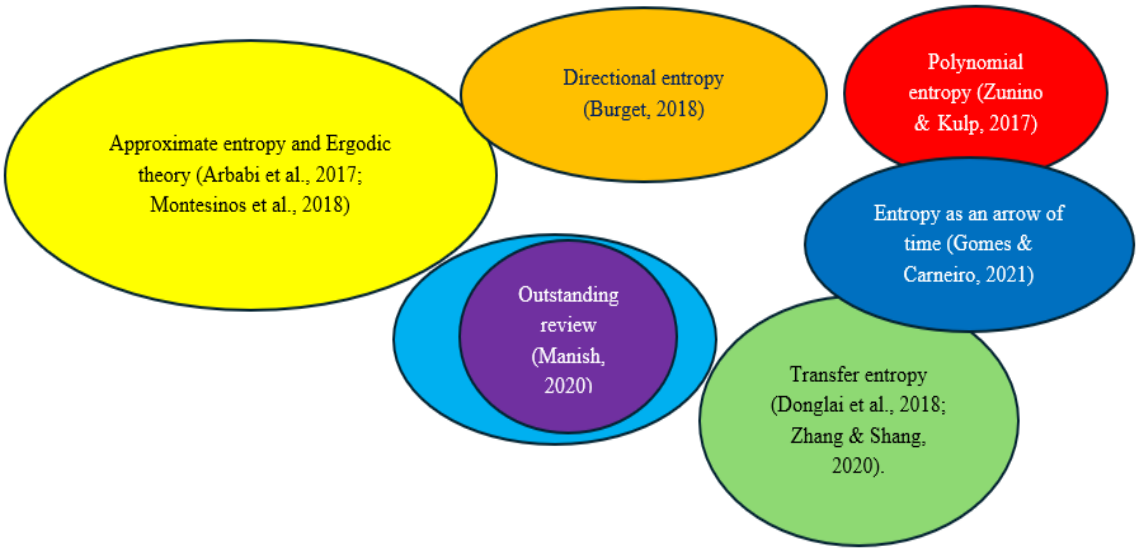

Figure 1: Illustrative Flowchart of other Related Entropies

In information theory, Shannon entropy quantifies the uncertainty or randomness of a set of symbols or data, and reads as [2]:

$$H = -\sum_{i=1}^{n} p(i) lnp(i) \quad (1)$$

Here $p(i)$ denotes the probability of symbol i.

One concept is entropy, that has different interpretations in various fields. It is widely used in different research areas, such as assessing system robustness, vulnerability, and complexity [2].

The current paper is organized as follows: Section two is concerned with some entropy applications to education. Some challenging open problems are proposed in section three. Section four is concerned with conclusion combined with the next phase of research.

2. Entropy Applications to Education

Highlighted the potential for developing assessment tools in the field of education using the concept of entropy. Several studies have explored the application of entropy in classroom assessment, such as evaluating essay content, building classification models, adaptive student assessment techniques, and assessing learner understanding based on free text answers. These approaches leverage entropy to measure the importance of words, compute information content, and determine the level of student understanding [2].

According to Akundi et al. (2023), knowledge in this case refers to the abilities and information gained via education and experience. Entropy, a measure of the average information generated based on the probability distribution of keywords in student text recordings, is introduced by the model. This aids in measuring the familiarity and comprehension of the material that students learn via classroom activities and exchanges [2].

Thus, the text introduces the concept of text entropy (*TE*), is based on keyword occurrences in a text- calculated [2].

This introduces:

$$TE_1 = -\sum p_i ln\, p_i \quad (2)$$

$$TE_{S_n} = -\sum p_i ln\, p_i \quad (3)$$

.

Where, i is a specific keyword descriptor.

TE_1 defines the entropy calculated based on keyword occurrences in the instructor's knowledge base; and TEs_n refers to the entropy calculated based on keyword occurrences from text recording of a student n.

The TE calculation is represented by equations (2) and (3), where the probability distribution of certain keywords is summed over. The article provides a conceptual overview of the elements considered when creating assessment models for various classroom settings and emphasises the significance of inter-individual interactions in complex systems like classrooms.

In the context of classroom structures, inter-individual interactions are crucial for creating meaningful structures, as stated by Vetromille-Castro. Complex systems, of which classrooms are an example, are driven by interactions between these elements. A conceptual overview of the elements considered while creating assessment models for various classroom settings, such as the Traditional Classroom Setting, Peer-Based Classroom Setting, and Self-Organized Flipped Classroom Setting, is given in figure 2 [2].

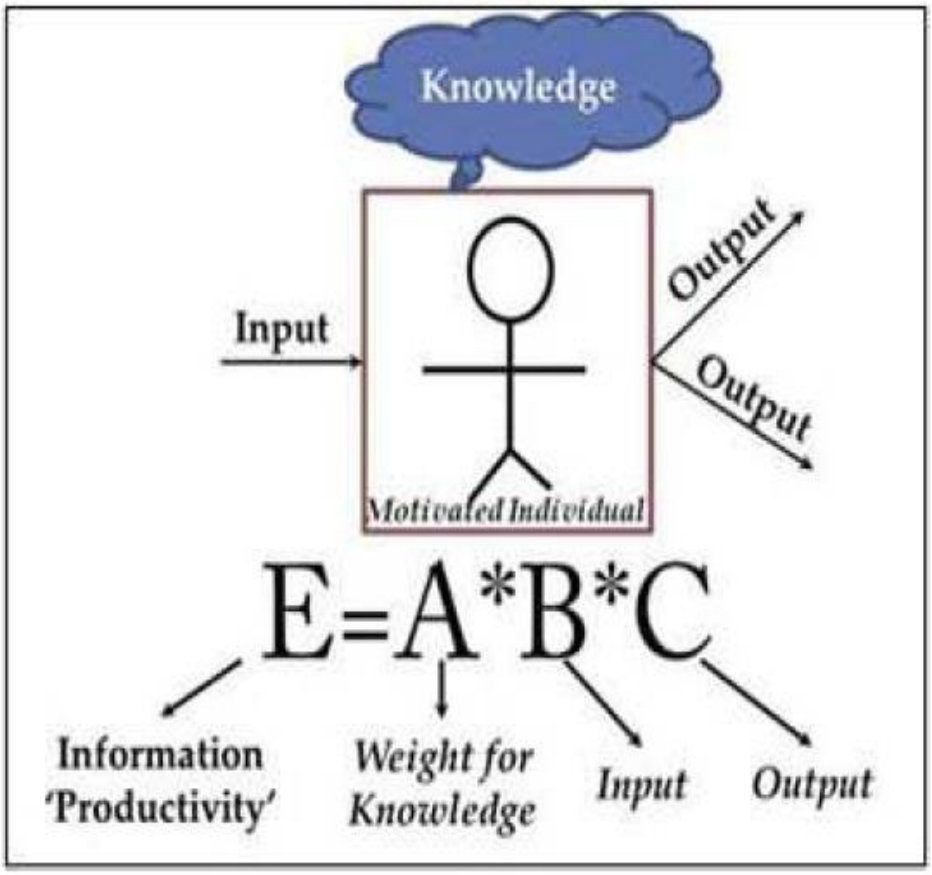

Figure 2: The Conceptual View Underlying the Development of Assessment Models Based on Entropy for Different Classroom Settings

Separately, according to Akundi et al. (2023), the evaluation model for a typical classroom is built around the supposition that there are two hierarchical levels in the classroom: a higher level for the instructors and a lower level for the pupils. Given their greater subject-matter expertise, instructors should have a lower entropy (a measure of the uncertainty of keyword occurrences) than pupils. This model only considers interactions that occur between teachers and students. Figure 3 can be used to illustrate this [2].

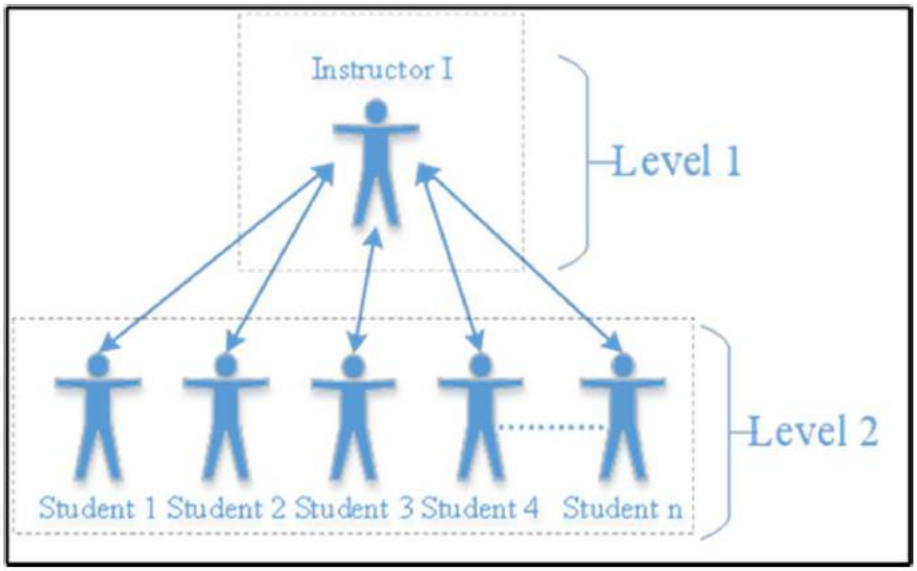

Figure 3: In a traditional classroom setting, the hierarchical representation consists of two levels: instructors at a higher level and students at a lower level. The assessment model for this structure assumes that the entropy, which represents the uncertainty of keyword occurrences, is higher for students' text recordings compared to instructors' knowledge base.

According to Akundi et al. (2023), the evaluation model for a peer-based learning structure assumes that there is a hierarchical organisation with instructors at the top, peers in the middle, and students at the base level [2]. Entropy, which measures the uncertainty in knowledge, is lower for instructors compared to peers, and lower for peers compared to students. This is because keywords with higher occurrence in their knowledge have lower entropy. The concept is predicated on the idea that teachers are more knowledgeable than their peers, who are more knowledgeable than students overall in each topic. Figure 4(c.f.,) illustrates this [2].

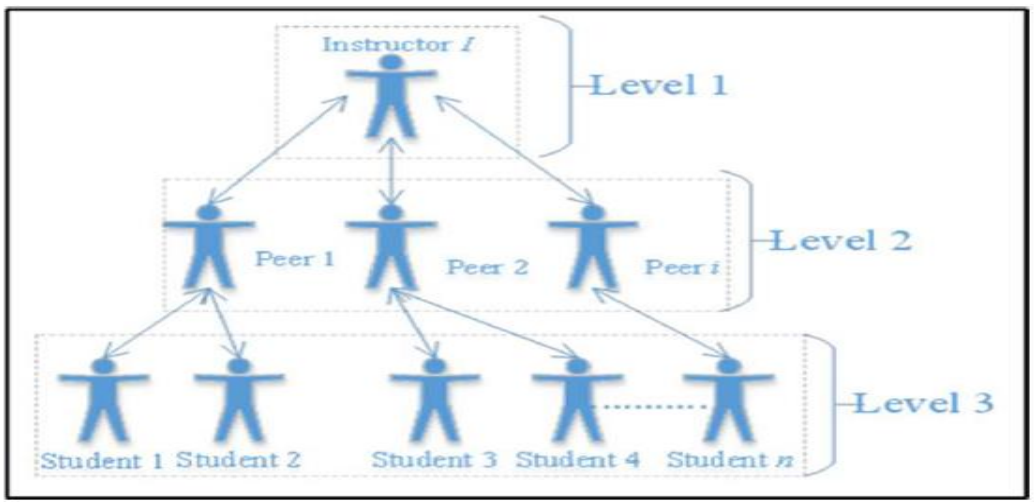

Figure 4: In an ideal peer-based learning environment, a hierarchical representation is used to illustrate the structure of interactions among students. This representation shows a clear hierarchy where students are organized into different levels based on their roles and relationships within the learning process. This hierarchical structure facilitates effective peer-to-peer interactions and promotes collaborative learning.

From a broader perspective, the entropy-based framework for classroom structural assessment is a technique for assessing and analysing the actual classroom structure. It considers variables including student engagement patterns, knowledge, student population, and classroom interface styles [2]. Through the collection of information on patterns of student communication and interaction, this framework offers a conceptual foundation for evaluating the general dynamics and structure of the classroom. Figure 5 should be consulted by the reader [2].

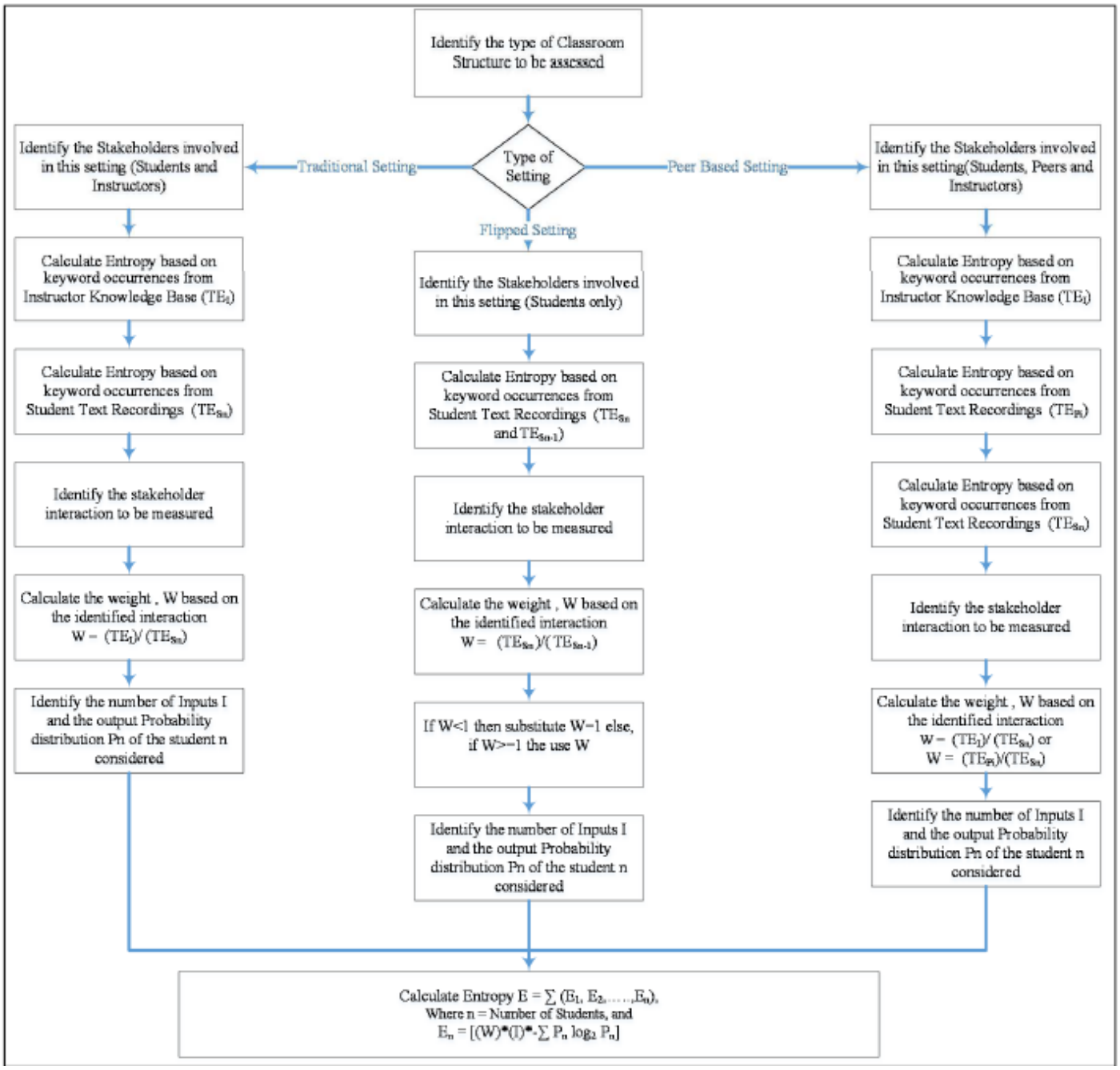

Figure 5: Entropy Based Classroom Structural Assessment Framework

The development of private universities has provided opportunities for individuals to enhance their qualifications and skills. However, educational managers face challenges in determining the appropriate strategies for university development in a competitive environment. To solve this, the study uses the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) to rank private colleges according to their performance, after applying the Entropy technique to assign weights to criteria [3]. Additionally, statistical techniques like Spearman's rank correlation coefficient and ANOVA are employed to evaluate correlations and compare criteria between groups of universities, respectively, creating an objective assessment environment for universities to establish development strategies.In essence, the research issue Wang et al. (2022) tackled was evaluating the efficiency of resources and instruction in private institutions within the current competitive landscape [3].

Following Multi-Criteria Decision Making (MCDM), making well-informed judgements requires considering both quantitative and qualitative aspects [3]. The goal of MCDM, which is built on fuzzy sets, is to quantify standards, compute total scores based on weights assigned to criteria, and give decision-makers a reliable foundation upon which to make decisions. To select the option that is closest to the PIS and farthest from the negative optimal solution (NIS), TOPSIS measures the distances of each option from the positive optimum solution (PIS) and (NIS). The reader might refer to figure 56for a more visually appealing illustration [3].

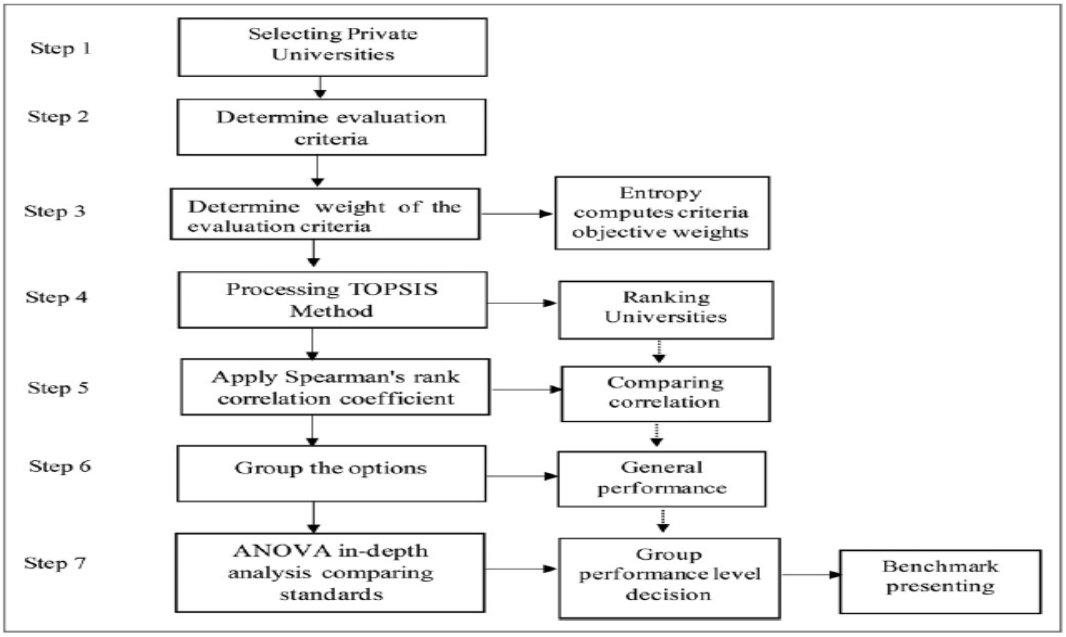

Figure 6: An outline of the steps involved in the TOPSIS method. The model involves selecting objects, determining evaluation criteria, assigning weights to the criteria, and normalizing the research data.

In their study, the main focus was primarily on evaluating the operational model of private universities based on two criteria [3]:

• Teaching effectiveness, which refers to the measure of how well educational instruction is delivered and how effectively students learn and acquire knowledge.
• Revenue efficiency, on the other hand, pertains to the effectiveness of financial resources and expenditures in generating income for the educational institution, particularly through tuition fees.

In figure 2, the formulas presented represent mathematical calculations used to assess teaching effectiveness and revenue efficiency, although the specific details and interpretations of the formulas are not provided in the given context. See figure 7.

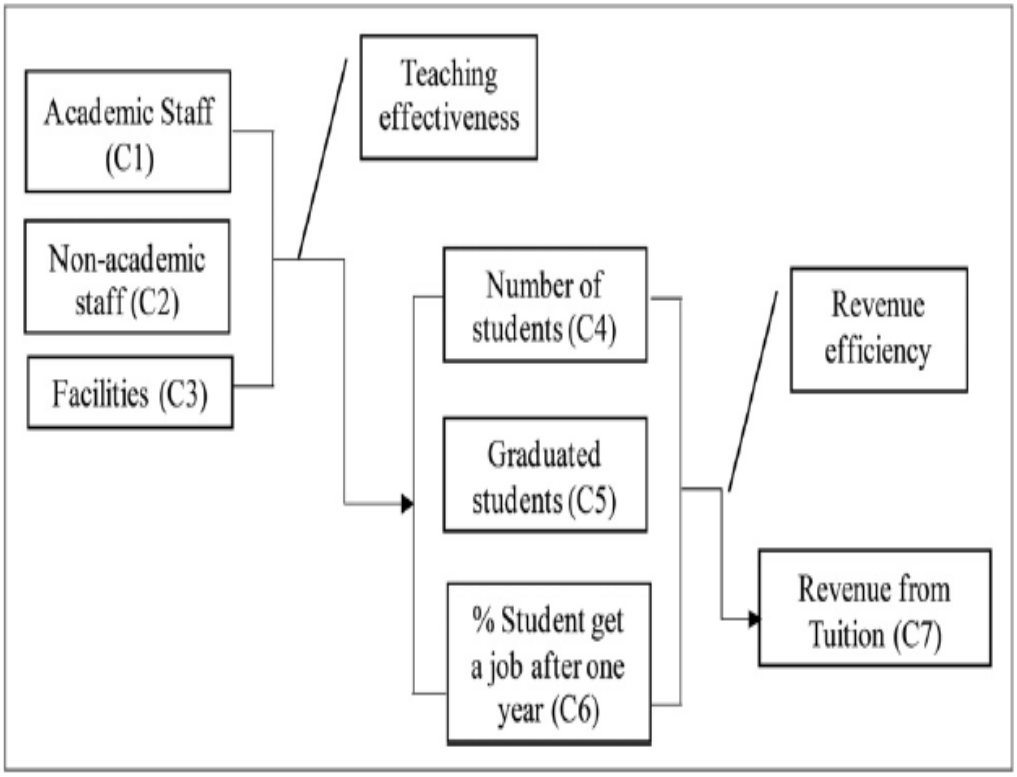

Figure 7: Teaching Effectiveness and Revenue Efficiency [4].

The objectives of sustainable development consider social, cultural, economic, and environmental factors. To empower people to work towards a sustainable future and to promote sustainable development, higher education is essential. With the goal of implementing sustainable higher education reform, this study focuses on the calibre of higher education system in Morocco [4].

The study employs an organised methodology that includes the SWOT (strengths, weaknesses, opportunities, and threats) analysis, the entropy method, and the analytic hierarchy process (AHP) to rank variables, evaluate important factors, and create a SWOT matrix for making decisions and keeping an eye on the standard of the educational system. The results emphasise the need for several adjustments to higher education reform, including better infrastructure, internationalization, competent professionals, efficient budget planning, curriculum reform, and current training.

Figure 8: The SWOT framework considers both the organization's internal capabilities and the external environment to guide decision-making and planning for organizational development [4].

Primarily focused to providing a framework for evaluating higher education institutions' (HEIs) quality and to offer sustainability suggestions. To create a hybrid strategy, the researchers combined entropy, the Analytic Hierarchy Process (AHP), and SWOT analysis. By using a step-by-step strategic planning process, this strategy assisted in identifying important elements influencing the quality of higher education reform and determining their priority. See Fahim et al. (2021) for figures 9, 10, and 11 [4].

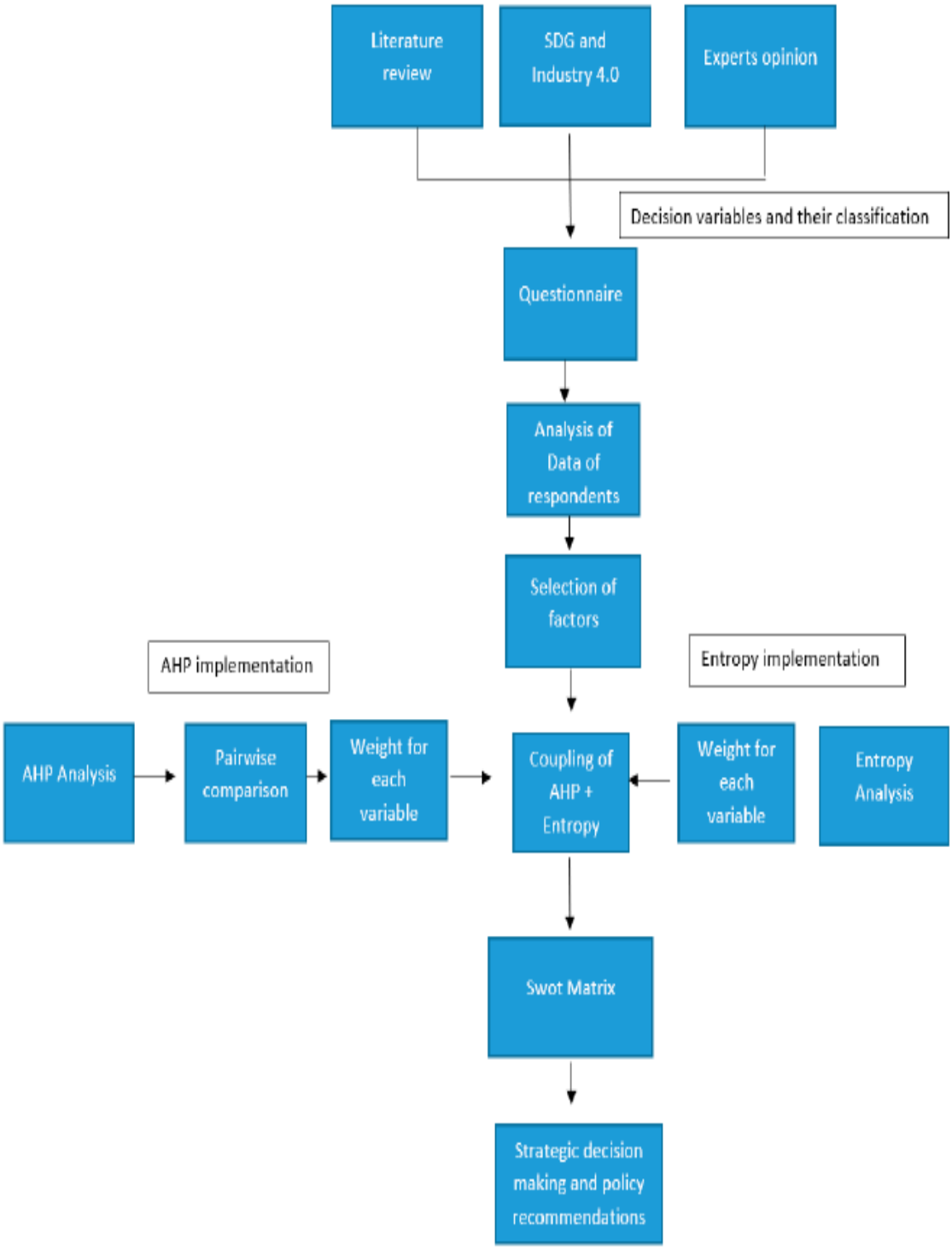

Figure 9: model is used to assess and analyze various factors related to the adoption of Sustainable Development Goals (SDGs) and Industry 4.0 in Higher Education Institutions (HEIs).

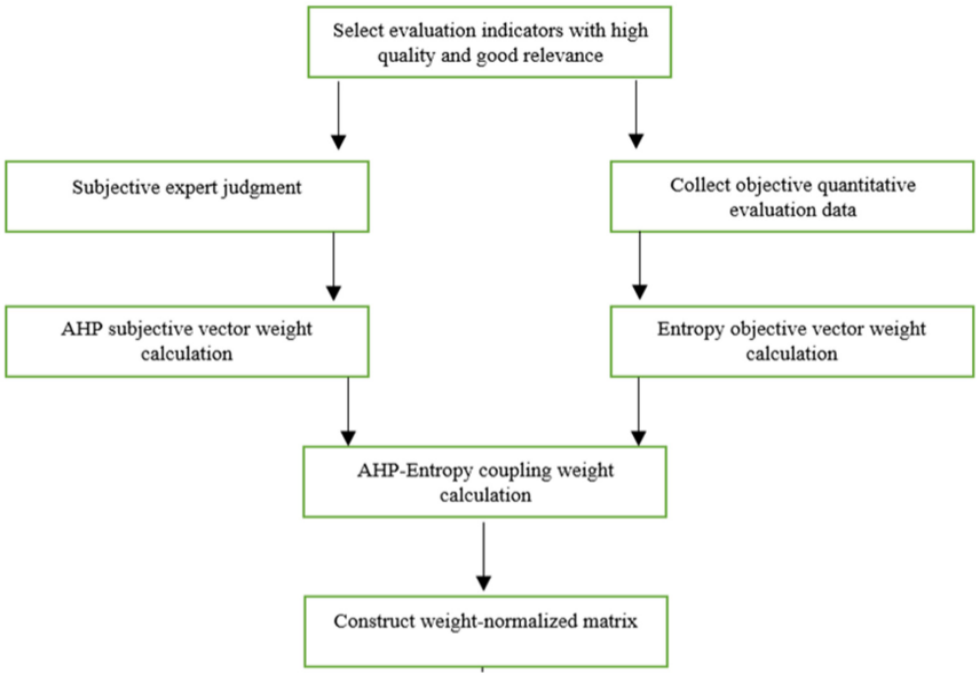

Figure 10: The construction of a method that combines the AHP- entropy approach. This coupling method aims to calculate comprehensive weight values by using a geometric mean. The process involves utilizing the SWOT matrix for decision-making, where important factors within each SWOT group are obtained and a quadrilateral model is built based on their priorities.

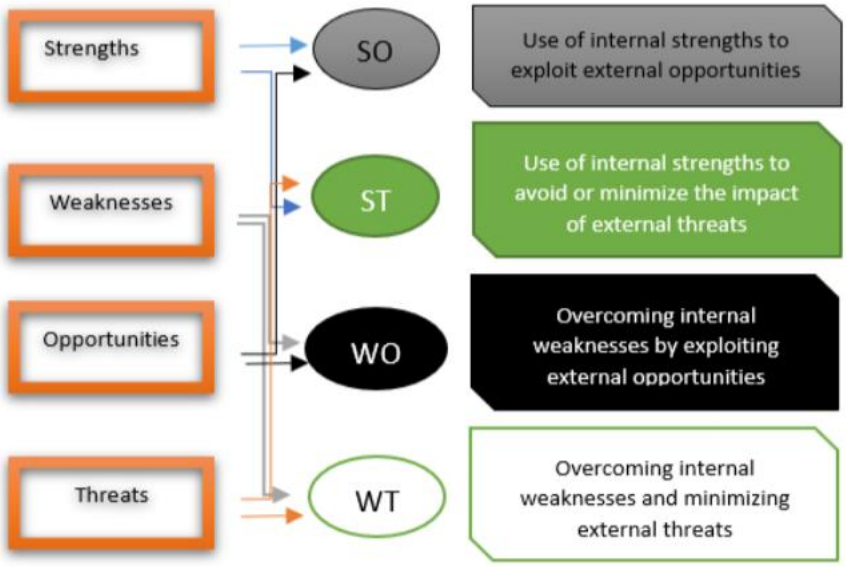

Figure 11: The AHP- Entropy Approach

To this end, The study presented in has yielded significant results and suggests the potential for further exploration using various MCDM approaches [4]. Future research could benefit from incorporating fuzzy multicriteria models and expert input through questionnaire development, as well as considering advanced MCDM models like COMET(Characteristic objects method) or SPOTIS.

3. Open Problems

- Considering, is it feasible to suggest an entropy-based assessment framework for the analysis and evaluation of a classroom's structural setting that considers elements like interaction patterns, actor knowledge, actor count, and classroom interface types? The question is still open [2].
- The proposed model, does not consider operational efficiency comprehensively or evaluate the impact of scientific research activities, which vary among universities. Additionally, the analysis does not cover all private universities and does not consider factors like reputation, establishment time, or location that can influence rankings.

This proposes an open problem that needs to be addressed and applied to various international educational settings [3].

- Having Shannon's entropy (c.f., Equation(1)) would be the very basic entropy to employ. On another strong note, the use of Ismail's innovative entropy forms (Mageed, 2022, 2023(a), 2023(b), 2023(c)) would add more to the stellar fusion of the educational profile on all settings. This is based on the variety of the involved parameters, especially, the information-theoretic parameter q(q□(0.5,1)) that fine tunes LRIs(long-range interactions), while q(q□(0.5,1)) is a unique descriptor of SRIs(short-range interactions). Both LRIs and SRIs will have a significant impact on all educational setting and performance.

4. Closing Moments

This report provides updates on the state of education. There remain numerous obstacles to overcome to expand and unearth fresh findings and broaden the scope of entropy's application in this field. There are several advancements that can be made to broaden the field in which entropy is applicable. The reader will be able to obtain knowledge from an overview thanks to the survey's report on the most recent developments in entropy applications. Subsequent scholars can think about examining the significance of other ideas like chaos and complexity. More intriguingly, it's possible that the entropic applicability's range is constrained and cannot be expanded to encompass additional domains of knowledge. Entropy ideas will surely find more applications in the field of education. Apart from maximizing the applications, greater emphasis must be placed on resolving the proposed open problems and exploring entropic applications related to emotional intelligence.

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