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PAPER

New Algorithm for Evaluation of Online Courses Based on Quality Matters Rubric Using Fuzzy Soft Expert Sets

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ABSTRACT

The field of instructional technology has experienced significant growth in recent times. Due to the rapid shift towards online courses, the technology-based learning system is facing challenges in ensuring quality and assurance. The aim of this study was to develop online course evaluation tools by proposing a new algorithm to assess the success of the provided online courses and address quality assurance issues. The proposed algorithm is based on quality matters (QM) attributes and the use of fuzzy soft expert sets (FSESs). One key advantage of the proposed algorithm is that it incorporates experts' opinions, which significantly contributes to achieving the study objective. The proposed algorithm was successfully implemented using the ASP.NET programming language. It resulted in the development of an EOC-FSES prototype system. The experimental evaluation of the prototype system confirms that it requires low effort and achieves high levels of performance, satisfaction, and behavioral intention to use. This paper includes several recommendations and suggestions.

KEYWORDS

decision support systems (DSS), instructional technology, evaluating online course, quality matters (QM) rubric, fuzzy soft expert sets (FSESs), smart systems

1 INTRODUCTION

Driven by the increasing demand for flexible and interactive learning, the progressive advancements in technology in the field of education have become the primary catalyst for the development of higher education. The demand for instructional technology has inspired researchers and developers to propose and develop numerous electronic learning (e-learning) systems [1, 2] and decision support systems (DSS) [3, 4]. Recently, DSSs have had a significant and important impact on e-learning by managing materials and exams in education to achieve the best possible

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solutions for the materials presented, especially as the demand for online courses is increasing [5–8]. The education sector has experienced significant advancements in e-learning and its assessment tools. Therefore, evaluating e-learning methods in terms of effectiveness, satisfaction, and quality-related issues will be crucial [9, 10]. The rapid growth of investment in e-learning has drawn substantial attention to the effectiveness of the online course environment [11–13]. Even though online courses share similar characteristics with traditional courses, traditional evaluation methods are not sufficient to indicate the quality of online courses. This necessitates the adoption of innovative evaluation tools aligned with the significant development in this area [14, 15].

In e-learning, there is no longer a physical location where participants meet periodically. Instead, there are virtual learning environments, each tailored to an individual participant and accessed remotely [16]. This situation highlights the importance of providing tools that can monitor the quality of the virtual environment and take into consideration the appropriate learning strategies that can facilitate the outcomes. Therefore, online course evaluation is a critically important issue that demands new strategies.

Online teaching and learning have recently garnered attention due to their accessibility, customizability, and flexibility [10, 17–22]. As the number of online courses increases, there is also a growing need for the development of their curricula and assessment tools. The Online Learning Consortium and Quality Matters (QM) are organizations that have developed specific rubrics for improving the quality of online courses [23–25]. However, there are reports of high success rates and failure rates in online courses [26, 27]. The quality management programs provide assurance criteria for quality issues through various intricate processes in the design of online courses. These procedures cover eight aspects: course overview and introduction, learning objectives, assessment and measurement, instructional materials, learning activities and learners' interaction, course technology, learner support, and accessibility [24]. Moreover, through online teaching and peer reviews, these processes enable educators to validate that the course requirements are well established and aligned with standards. The QM is considered one of the most reliable methods for obtaining quality assurance and accreditation in an online environment [28]. Therefore, the QM rubric serves as the cornerstone for structuring our new methods of evaluation.

Many of the weaknesses of online courses remain unexplored, which is due to quantitative methods. However, many higher education institutions (HEIs) still rely on traditional methods, and the level of bias is still significant. Thus, HEIs should consider adopting new methods of evaluation to overcome the limitations of traditional evaluation methods.

Over the past decades, substantial research has been conducted to investigate issues related to the quality of online courses [29, 30]. However, the traditional approach to information content has drawbacks, especially when dealing with incomplete information. The conventional information content has a precise number for its range of designs, which becomes ambiguous for incomplete information [31].

In situations of incomplete information, the fuzzy set theory [32–34] is used to address the subjectivity and ambiguity in the assessment process. This theory presents characteristic difficulties, as pointed out in [35]. The difficulties may be attributed to the absence of a parameterization tool in many theories, including probability theory, interval mathematics, and fuzzy theory. The soft set theory developed by Molodtsov [35] is suitable for the assessment process as it addresses the uncertainties that have been omitted from that theory. Only one expert has addressed fuzzy and soft sets; obtaining a greater number of expert opinions is more beneficial. In addition, relying solely on the evaluation online course (EOC) survey for quality assessment is inadequate; multiple expert opinions are necessary to evaluate each parameter in the EOC survey. Therefore, Alkhazaleh and Salleh [36] introduced a fuzzy expert set to address such issues. Subsequently, Alkhazaleh and Salleh [37] extended the concept of a soft expert set to a fuzzy soft expert set (FSES), which is more effective and useful in this research.

This research introduces a new algorithm for evaluating the success of online courses and assessing their quality based on QM rubric-related attributes using fuzzy set expert systems.

2 LITERATURE REVIEW

This section briefly provides an overview of the applications of FSES and explores the research developments in this field.

The fuzzy set expert system has been applied effectively in decision-making processes where uncertainty and subjectivity play a significant role. Alkhazaleh and Saleh [37] have proposed models that incorporate FSES to enhance the decision-making process in complex systems, such as filling a position in a company. In their work, Broumi and Smarandache [38] integrate intuitionistic fuzzy sets and soft expert sets to improve the decision-making process for filling a position in a company.

Hazaymeh et al. [39] generalized the FSES theory to solve a decision-making problem. Furthermore, they proposed an application to assess broadcasting channels and their shows by inviting experts to discuss a controversial issue and provide their opinions on the matter.

Al-Qudah et al. [40] proposed an algorithm based on FSES, which was then applied to identify the best country in terms of weather and living expenses. The algorithm's phase terms and amplitude terms indicate the extent to which the data aligns with seasonal patterns and living expenses, respectively. This application assists travelers and travel agencies in selecting the best travel destinations.

Fuzzy set expert systems have also been applied in medical diagnosis, where they can effectively model the uncertain nature of medical data and expert opinions. Khalil et al. [41] developed an FSES system to predict the likelihood of lung cancer in individuals based on factors such as age, presence of blood in sputum, chest discomfort, weight loss, and persistent cough. Hassan et al. [42] developed an FSES system to predict the likelihood of lung cancer in individuals based on factors such as age, presence of blood in sputum, chest discomfort, weight loss, and persistent cough. Furthermore, Ali et al. [43] developed an algorithm based on FSES to assess the efficacy of tests in analyzing the spread of COVID-19.

In addition, complex multi-FSES have been developed to incorporate time-sensitive information and consolidate the input of all experts into a single model. In the field of education, complex multi-FSES have been employed to identify strategies for foreign language acquisition [44]. In essence, FSES has demonstrated its robustness as a tool applicable across a wide range of sectors.

3 PRELIMINARIES

Laying the groundwork for the following sections, we present some mathematical definitions in this section.

One way to address uncertainty is through the use of fuzzy sets [32]. It assigns a membership grade to each element in the set to indicate its belongingness to that set. The fuzzy set is defined as follows:

Definition 1 [32]. A fuzzy set A over a universal set $U = \{u_i: i = 1, ..., m\}$ is characterized by a membership function

$$\mu_A(u): A \rightarrow [0, 1]$$

In a symbolical manner, a fuzzy set A over U can be written as

$$A = \{(u_1, \mu_A(u_1)): u_1 \in U\}$$

In some applications, it $u \in U$ is either inaccurate or unavailable to determine the membership of each element. The lack of parametrization tools is the reason behind that. This motivated Molodtsov [35] to define a structure other than the fuzzy set to address uncertainty. He described each element $u \in U$ in a parametric manner and referred to this structure as a soft set. Formally, the soft set is defined as follows:

Let U be a universal set, let $P = \{p_i: i = 1, ..., n\}$ be the set of all parameters, and let A be a subset of P.

Definition 2 [45]. A parameterized family

$$F: A \rightarrow P^*(U)$$

of non-empty subsets $P^*(U)$ of a universal set U is called soft set over U and is donated by (F, A).

It is worth mentioning that the notation used in this work is based on Zhu and Wen's [45] work. Interestingly, they revisited the operations of the soft set based on classical sets and their inherent properties and operations.

The following definition formally describe a fuzzy soft set by combining Definition 1 and Definition 2.

Definition 3 [46]. A parameterized family

$$\tilde{F}: A \rightarrow F^*(U)$$

of non-empty fuzzy subsets $F^*(U)$ of a universal set U is called fuzzy soft set over U and is donated by $(\tilde{F}, A)$.

The concept of the soft expert set was introduced by Alkhazaleh and Salleh [36], where experts' opinions about the knowledge stored in the soft set are considered.

Let W be a set of experts, let $O = \{1 = agree, 0 = disagree\}$ be a set of opinions, and let $Z = P \times W \times O$ and $\tilde{A} \subseteq Z$.

Definition 4 [36]. A parameterized family

$$F: \tilde{A} \rightarrow P^*(U)$$

of non-empty subsets $P^*(U)$ of a universal set U is called soft expert set over U and is donated by $(F, \tilde{A})$.

Note that in Definition 4, the set $\tilde{A}$ is a subset of Z whereas in Definition 2, the set A is a subset of P.

The soft expert set contains elements in the form

$$((e_j, w_k, O), \{u_i: u_i \in U\})$$

Where,

$$W = \{w_k: k = 1, ..., k\}$$

By combining Definition 1 and Definition 4, we obtain the definition of FSESs as originally formulated by Alkhazaleh and Salleh [37]. In fact, the FSES will be the mathematical foundation of our work.

Definition 5 [37]. A parameterized family

$$\tilde{F} : \tilde{A} \rightarrow F^* (U)$$

of non-empty fuzzy subsets F^* (U) of a universal set U is called FSES over U and is donated by $(\tilde{F}, \tilde{A})$.

Definition 6 [37]. An agree-fuzzy soft expert set $(\tilde{F}, \tilde{A})_1$ over U is a fuzzy soft expert subset of (F, A) defined as follows:

$$(\tilde{F}, \tilde{A})_1 = \{F_1(\alpha) : \alpha \in P \times W \times \{1\}\}.$$

Definition 7 [37]. A disagree-fuzzy soft expert set $(\tilde{F}, \tilde{A})_0$ over U is a fuzzy soft expert subset of (F, A) defined as follows:

$$(\tilde{F}, \tilde{A})_0 = \{F_1(\alpha) : \alpha \in P \times W \times \{0\}\}.$$

4 EVALUATING ONLINE COURSES USING FUZZY SOFT EXPERT SETS

This section introduces a new algorithm for evaluating online courses, with the QM rubric as the central component and FSES as its mathematical representation. This algorithm presupposes that the input should take the form of an online questionnaire, as stipulated by the QM rubrics. This questionnaire is anticipated to be completed by students upon the culmination of the online course. The QM standards assess online courses using eight parameters: course overview and introduction, learning objectives, assessment and measurement, instructional materials, learning activities and learner interaction, course technology, learner support, and accessibility and usability. This questionnaire should be completed by the students at the end of the online course.

Our algorithm calculates the mean for each parameter (lines 5–8). Furthermore, two experts separately provide their opinions on the value of each parameter for membership (lines 9–14). Afterwards, the algorithm transforms the membership values of all parameters and the opinion of each expert to FSES (line 15). Then, our algorithm calculates the sum for the agree-fuzzy soft expert set (line 17) and the sum for the disagree-fuzzy soft expert set (line 21). Finally, the evaluation result will be the average of the sum of all "agree" values divided by their total number and the sum of all "disagree" values divided by their total number (line 26). This algorithm is outlined in the following steps:

Algorithm: Evaluation of Online Courses

```
Procedure EOC-FSES (P, E)
    ▶Input: P = < p1, p2, p3, p4, p5, p6, p7, p8>
    ◀Output: E = < e1, e2,……, em>
  For each ocj in OC do
      For each pi in P do
          pmi ← Compute mean (Pi)
          PM ← Add (pmi) to data set
      End for
      For each pmi in PM do
          oi1 ← Enter First Expert Opinion (w1)
          O ← Add (oi1) to data set
              oi2 ← Enter Second Expert Opinion (w2)
              O ← Add (oi2) to data set
      End for
  (F̃,Z̃)j ← Transfer {PM, W, O} to construct fuzzy soft expert set
      IF (F̃,Z̃)j = agree-fuzzy soft expert set.
          cj ← Find Σi uij
                Agree++
        Else
      IF (F̃,Z̃)j = disagree-fuzzy soft expert set.
          kj ← Find Σi uij
                Disagree++
      End If
      End If
  End for
  ej ← Find ((cj/Agree) + (kj/Disagree)) /2
  E ← Add (ej) to list
Return E
End procedure
```

Subsequently, the algorithm is implemented using the ASP.NET programming language to create an EOC-FSES prototype system.

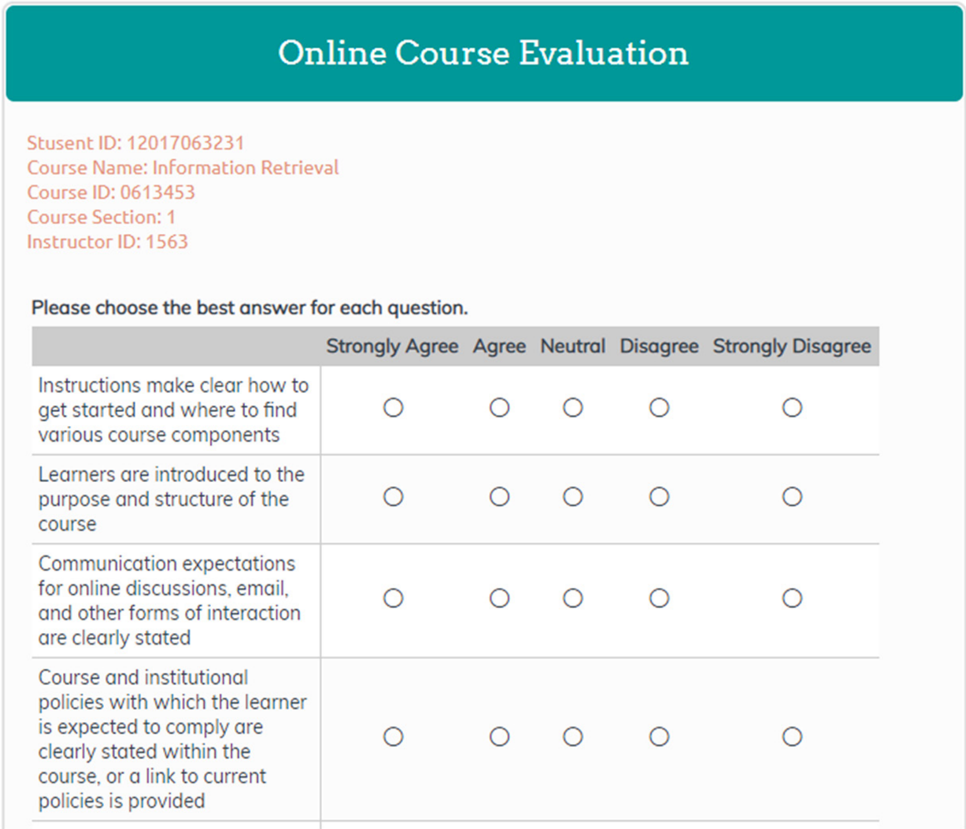
4.1 Case study

Assume that a university wants to evaluate the online courses offered by the computer information systems department. There are five online courses that make up the curriculum.

$$U = \{u_1, u_2, u_3, u_4, u_5\}$$

Where u_1, u_2, u_3, u_4, and u_5 represent the courses of information retrieval, internet programming, databases, systems analysis, and e-commerce, respectively. These five online courses will be assessed by the students based on a set of parameters, $P = \{p_1, p_2, p_3, p_4, p_5, p_6, p_7, p_8\}$, where the parameters p_i (i = 1, 2, 3, 4, 5, 6, 7, 8) stand for course overview and introduction, learning objectives, assessment and measurement, instructional materials, learning activities and learner interaction, course technology, learner support, and accessibility and usability, respectively. Finally, the dean of the faculty of information technology and the head of the computer information systems department are represented by $W = \{w_1, w_2\}$ a group of experts.

After completing the online courses, the university sends an online questionnaire to each student who attended these courses. The questionnaire is based on the eight QM rubric parameters mentioned earlier, as shown in Figure 1.



Online Course Evaluation

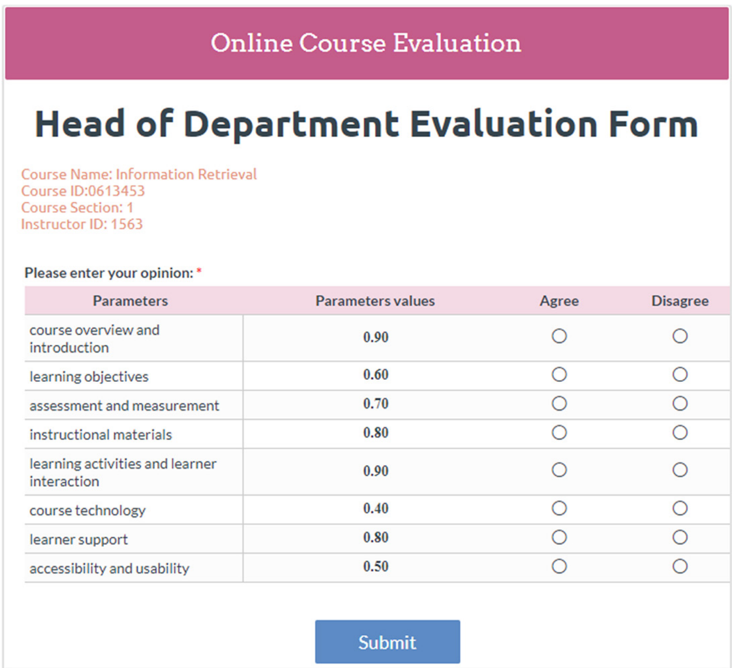
Stusent ID: 12017063231
Course Name: Information Retrieval
Course ID: 0613453
Course Section: 1
Instructor ID: 1563

Please choose the best answer for each question.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Instructions make clear how to get started and where to find various course components	○	○	○	○	○
Learners are introduced to the purpose and structure of the course	○	○	○	○	○
Communication expectations for online discussions, email, and other forms of interaction are clearly stated	○	○	○	○	○
Course and institutional policies with which the learner is expected to comply are clearly stated within the course, or a link to current policies is provided	○	○	○	○	○

Fig. 1. Online course evaluation questionnaire (students' form)

Afterward, our algorithm calculates the mean for each parameter and indexes it in the PM dataset. Next, the PM value for each course will be available for the dean of faculty (w_1) and the head of department (w_2) to be judged upon by indicating agreement (1) or disagreement (0) as shown in Figure 2.



Online Course Evaluation

Head of Department Evaluation Form

Course Name: Information Retrieval
Course ID:0613453
Course Section: 1
Instructor ID: 1563

Please enter your opinion: *

Parameters	Parameters values	Agree	Disagree
course overview and introduction	0.90	○	○
learning objectives	0.60	○	○
assessment and measurement	0.70	○	○
instructional materials	0.80	○	○
learning activities and learner interaction	0.90	○	○
course technology	0.40	○	○
learner support	0.80	○	○
accessibility and usability	0.50	○	○

Submit

Fig. 2. Expert opinions about students' evaluation (experts' form)

The opinion values for w_1 and w_2 will be indexed in the O dataset. Then, our algorithm will transform the (PM, W, O) content to construct FSES for each online course as follows:

$$
\begin{aligned}
&(\tilde{F},\tilde{Z})_1 = \{ \\
&\left((pm_1,w_1,1),\left\{\frac{u_1}{0.9}\right\}\right),\left((pm_1w_2,1),\left\{\frac{u_1}{0.9}\right\}\right), \\
&\left((pm_2,w_1,1),\left\{\frac{u_1}{0.6}\right\}\right),\left((pm_2,w_2,1),\left\{\frac{u_1}{0.6}\right\}\right), \\
&\left((pm_3,w_1,1),\left\{\frac{u_1}{0.7}\right\}\right),\left((pm_3,w_2,1),\left\{\frac{u_1}{0.7}\right\}\right), \\
&\left((pm_4,w_1,1),\left\{\frac{u_1}{0.8}\right\}\right),\left((pm_4,w_2,1),\left\{\frac{u_1}{0.8}\right\}\right), \\
&\left((pm_5,w_1,0),\left\{\frac{u_1}{0.9}\right\}\right),\left((pm_5,w_2,0),\left\{\frac{u_1}{0.9}\right\}\right), \\
&\left((pm_6,w_1,0),\left\{\frac{u_1}{0.4}\right\}\right),\left((pm_6,w_2,0),\left\{\frac{u_1}{0.4}\right\}\right), \\
&\left((pm_7,w_1,0),\left\{\frac{u_1}{0.8}\right\}\right),\left((pm_7,w_2,0),\left\{\frac{u_1}{0.8}\right\}\right), \\
&\left((pm_8,w_1,0),\left\{\frac{u_1}{0.5}\right\}\right),\left((pm_8,w_2,0),\left\{\frac{u_1}{0.5}\right\}\right)\}
\end{aligned}
$$

$$
\begin{aligned}
&(\tilde{F},\tilde{Z})_2 = \{ \\
&\left((pm_1,w_1,1),\left\{\frac{u_2}{0.7}\right\}\right),\left((pm_1w_2,1),\left\{\frac{u_2}{0.7}\right\}\right), \\
&\left((pm_2,w_1,1),\left\{\frac{u_2}{0.8}\right\}\right),\left((pm_2,w_2,1),\left\{\frac{u_2}{0.8}\right\}\right), \\
&\left((pm_3,w_1,1),\left\{\frac{u_2}{0.6}\right\}\right),\left((pm_3,w_2,1),\left\{\frac{u_2}{0.6}\right\}\right), \\
&\left((pm_4,w_1,1),\left\{\frac{u_2}{0.4}\right\}\right),\left((pm_4,w_2,1),\left\{\frac{u_2}{0.4}\right\}\right), \\
&\left((pm_5,w_1,0),\left\{\frac{u_2}{0.3}\right\}\right),\left((pm_5,w_2,0),\left\{\frac{u_2}{0.3}\right\}\right), \\
&\left((pm_6,w_1,0),\left\{\frac{u_2}{0.9}\right\}\right),\left((pm_6,w_2,0),\left\{\frac{u_2}{0.9}\right\}\right), \\
&\left((pm_7,w_1,0),\left\{\frac{u_2}{0.4}\right\}\right),\left((pm_7,w_2,0),\left\{\frac{u_2}{0.4}\right\}\right), \\
&\left((pm_8,w_1,0),\left\{\frac{u_2}{0.4}\right\}\right),\left((pm_8,w_2,0),\left\{\frac{u_2}{0.4}\right\}\right)\}
\end{aligned}
$$

$$
\begin{aligned}
&(\tilde{F},\tilde{Z})_3 = \{ \\
&\left((pm_1,w_1,1),\left\{\frac{u_3}{0.6}\right\}\right),\left((pm_1w_2,1),\left\{\frac{u_3}{0.6}\right\}\right), \\
&\left((pm_2,w_1,1),\left\{\frac{u_3}{0.5}\right\}\right),\left((pm_2,w_2,1),\left\{\frac{u_3}{0.5}\right\}\right), \\
&\left((pm_3,w_1,1),\left\{\frac{u_3}{0.6}\right\}\right),\left((pm_3,w_2,1),\left\{\frac{u_3}{0.6}\right\}\right), \\
&\left((pm_4,w_1,1),\left\{\frac{u_3}{0.7}\right\}\right),\left((pm_4,w_2,1),\left\{\frac{u_3}{0.7}\right\}\right), \\
&\left((pm_5,w_1,0),\left\{\frac{u_3}{0.8}\right\}\right),\left((pm_5,w_2,0),\left\{\frac{u_3}{0.8}\right\}\right), \\
&\left((pm_6,w_1,0),\left\{\frac{u_3}{0.4}\right\}\right),\left((pm_6,w_2,0),\left\{\frac{u_3}{0.4}\right\}\right), \\
&\left((pm_7,w_1,0),\left\{\frac{u_3}{0.5}\right\}\right),\left((pm_7,w_2,0),\left\{\frac{u_3}{0.5}\right\}\right), \\
&\left((pm_8,w_1,0),\left\{\frac{u_3}{0.9}\right\}\right),\left((pm_8,w_2,0),\left\{\frac{u_3}{0.9}\right\}\right)\}
\end{aligned}
$$

$$
\begin{aligned}
&(\tilde{F},\tilde{Z})_5 = \{ \\
&\left((pm_1,w_1,1),\left\{\frac{u_5}{0.9}\right\}\right),\left((pm_1w_2,1),\left\{\frac{u_5}{0.9}\right\}\right), \\
&\left((pm_2,w_1,1),\left\{\frac{u_5}{0.7}\right\}\right),\left((pm_2,w_2,1),\left\{\frac{u_5}{0.7}\right\}\right), \\
&\left((pm_3,w_1,1),\left\{\frac{u_5}{0.6}\right\}\right),\left((pm_3w_2,1),\left\{\frac{u_5}{0.6}\right\}\right), \\
&\left((pm_4,w_1,1),\left\{\frac{u_5}{0.7}\right\}\right),\left((pm_4w_2,1),\left\{\frac{u_5}{0.7}\right\}\right), \\
&\left((pm_5,w_1,0),\left\{\frac{u_5}{0.6}\right\}\right),\left((pm_5w_2,0),\left\{\frac{u_5}{0.6}\right\}\right), \\
&\left((pm_6,w_1,0),\left\{\frac{u_5}{0.4}\right\}\right),\left((pm_6w_2,0),\left\{\frac{u_5}{0.4}\right\}\right), \\
&\left((pm_7,w_1,0),\left\{\frac{u_5}{0.5}\right\}\right),\left((pm_7w_2,0),\left\{\frac{u_5}{0.5}\right\}\right), \\
&\left((pm_8,w_1,0),\left\{\frac{u_5}{0.3}\right\}\right),\left((pm_8w_2,0),\left\{\frac{u_5}{0.3}\right\}\right)\}
\end{aligned}
$$

$$(\tilde{F},\tilde{Z})_4 = \{$$
$$\left((pm_1,w_1,1),\left\{\frac{u_4}{0.8}\right\}\right),\left((pm_1w_2,1),\left\{\frac{u_4}{0.8}\right\}\right),$$
$$\left((pm_2,w_1,1),\left\{\frac{u_4}{0.7}\right\}\right),\left((pm_2,w_2,1),\left\{\frac{u_4}{0.7}\right\}\right),$$
$$\left((pm_3,w_1,1),\left\{\frac{u_4}{0.6}\right\}\right),\left((pm_3,w_2,1),\left\{\frac{u_4}{0.6}\right\}\right),$$
$$\left((pm_4,w_1,1),\left\{\frac{u_4}{0.7}\right\}\right),\left((pm_4,w_2,1),\left\{\frac{u_4}{0.7}\right\}\right),$$
$$\left((pm_5,w_1,0),\left\{\frac{u_4}{0.6}\right\}\right),\left((pm_5,w_2,0),\left\{\frac{u_4}{0.6}\right\}\right),$$
$$\left((pm_6,w_1,0),\left\{\frac{u_4}{0.4}\right\}\right),\left((pm_6,w_2,0),\left\{\frac{u_4}{0.4}\right\}\right),$$
$$\left((pm_7,w_1,0),\left\{\frac{u_4}{0.5}\right\}\right),\left((pm_7,w_2,0),\left\{\frac{u_4}{0.5}\right\}\right),$$
$$\left((pm_8,w_1,0),\left\{\frac{u_4}{0.3}\right\}\right),\left((pm_8,w_2,0),\left\{\frac{u_4}{0.3}\right\}\right)\}$$

Subsequently, our algorithm calculates the sum of the agree-FSES and the sum of the disagree-FSES, as shown in Tables 1 and 2, respectively.

Table 1. Agree-fuzzy soft expert set

U	u_1	u_2	u_3	u_4	u_5
(pm_1, w_1)	0.9	0.7	0.6	0.8	0.9
(pm_1, w_2)	0.9	0.7	0.6	0.8	0.9
(pm_2, w_1)	0.6	0.8	0.5	0.7	0.4
(pm_2, w_2)	0.6	0.8	0.5	0.7	0.4
(pm_3, w_1)	0.7	0.6	0.6	0.6	0.5
(pm_3, w_2)	0.7	0.6	0.6	0.6	0.5
(pm_4, w_1)	0.8	0.4	0.7	0.7	0.7
(pm_4, w_2)	0.8	0.4	0.7	0.7	0.7
$c_j = \sum_i u_{ij}$	$c_1 = 6.0$	$c_2 = 5.0$	$c_3 = 4.8$	$c_4 = 5.6$	$c_5 = 5.2$

Table 2. Disagree-fuzzy soft expert set

U	u_1	u_2	u_3	u_4	u_5
(pm_5, w_1)	0.9	0.3	0.8	0.6	0.4
(pm_5, w_2)	0.9	0.3	0.8	0.6	0.4
(pm_6, w_1)	0.4	0.9	0.4	0.4	0.8

(Continued)

Table 2. Disagree-fuzzy soft expert set *(Continued)*

U	u_1	u_2	u_3	u_4	u_5
(pm_6, w_2)	0.4	0.9	0.4	0.4	0.8
(pm_7, w_1)	0.8	0.4	0.5	0.5	0.7
(pm_7, w_2)	0.8	0.4	0.5	0.5	0.7
(pm_8, pmw_1)	0.5	0.4	0.9	0.3	0.9
(pm_8, w_2)	0.5	0.4	0.9	0.3	0.9
$k_j = \sum_i u_{ij}$	$k_1 = 5.2$	$k_2 = 4.0$	$k_3 = 5.2$	$k_4 = 3.6$	$k_5 = 5.6$

The final step in our algorithm involves calculating the mean of the sum of all ‘agree’ values divided by their total count and the sum of all ‘disagree’ values divided by their total count, as per the equation provided in line 26 of our algorithm. Afterward, the output of this step will be the evaluation results for each online course, as presented in Table 3 and Figure 3.

Table 3. Evaluation results

$c_j = \sum_i u_{ij}$	$k_j = \sum_i u_{ij}$	(c_i/Agree)	$(k_i/\text{Disagree})$	$e_j = ((c_i/\text{Agree}) + (k_i/\text{Disagree}))\ /2)$
$c_1 = 6.0$	$k_1 = 5.2$	0.75	0.65	$e_1 = 0.70$
$c_2 = 5.0$	$k_2 = 4.0$	0.625	0.50	$e_2 = 0.563$
$c_3 = 4.8$	$k_3 = 5.2$	0.60	0.65	$e_3 = 0.625$
$c_4 = 5.6$	$k_4 = 3.6$	0.70	0.45	$e_4 = 0.575$
$c_5 = 5.2$	$k_5 = 5.6$	0.65	0.70	$e_5 = 0.675$

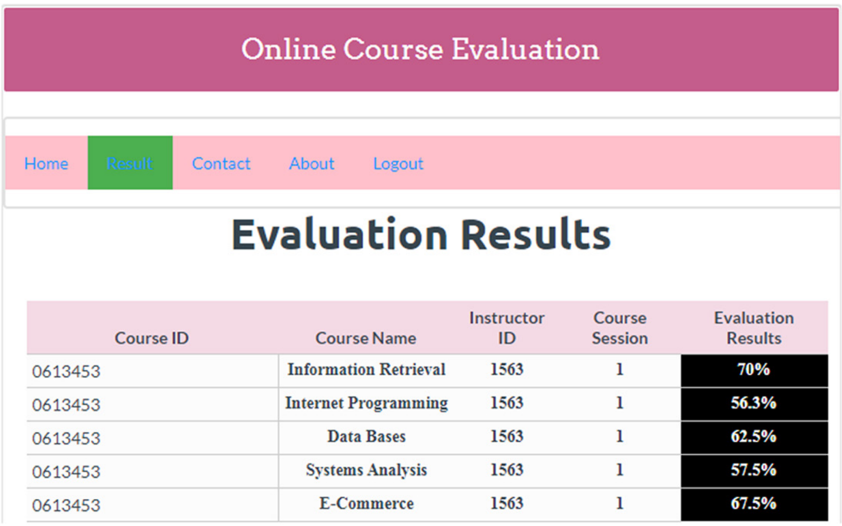


Fig. 3. Evaluation results

5 EXPERIMENTAL ASSESSMENT OF THE EOC-FSES SYSTEM

Experimental assessment of new methods or systems in the prototype stage is crucial. The experimental assessment enables decision-makers to gain insight and evaluate the extent of progress toward the expected outcomes. Thus, this study assessed the performance of the proposed EOE-FSES prototype system based on four factors: performance expectancy, effort expectancy, satisfaction expectancy, and behavioral intention to use.

A survey questionnaire was utilized for this purpose. The items in this questionnaire were adapted from previous studies, as indicated in Table 4. The items were measured using a five-point Likert scale, where 1 represents "strongly disagree," 2 represents "disagree," 3 represents "neutral," 4 represents "agree," and 5 represents "strongly agree." A cover letter has been prepared for this questionnaire. It included a description of the research problem, objectives, and significance; a description of the method; and a tutorial about the system. Afterward, the questionnaire and the prototype system were distributed manually to 45 directors of quality assurance centers at universities in Jordan and Saudi Arabia. Then, the researchers collected the questionnaires and used the SPSS software to calculate descriptive statistics for the data.

The results of the descriptive analysis indicate that our prototype system performs at a high level for each assessment factor, as illustrated in Table 4 and Figure 4.

Table 4. Experimental results

Factors	Items	Item Mean	Mean	References
Performance expectancy	I find EOC-FSES system useful for evaluating online courses.	4.5	4.63	[47]
	Using EOC-FSES system enables the educational institutions to evaluate online courses quickly.	4.6		
	Using EOC-FSES system raises the accuracy of evaluation of online courses	4.8		
Effort expectancy	The EOC-FSES system is clear and understandable.	4.2	4.52	[47]
	It will be easy for me to become skillful at using the EOC-FSES system.	4.6		
	I find the EOC-FSES system easy to use.	4.7		
	Learning to operate EOC-FSES is easy for me.	4.6		
Satisfaction expectancy	I am satisfied with the EOC-FSES system	4.5	4.32	[48–50]
	The EOC-FSES system has met my expectations.	4.2		
	The EOC-FSES system provides services that are exactly what I need.	4.1		
	Overall, I am satisfied with the EOC-FSES system.	4.5		
Behavioral intention to use	I intend to use the EOC-FSES system in the next semester.	4.4	4.36	[47, 51, 52]
	I predict that I will use the EOC-FSES system in the next semester.	4.3		
	I plan to use the EOC-FSES system in the next semester.	4.4		

Most of the respondents expressed high satisfaction with our new evaluation method and its prototype system, as indicated by mean satisfaction values ranging from 4.1 to 4.8 on a five-point scale. The analysis results support the use of our proposed algorithm for evaluating online courses in the near future.

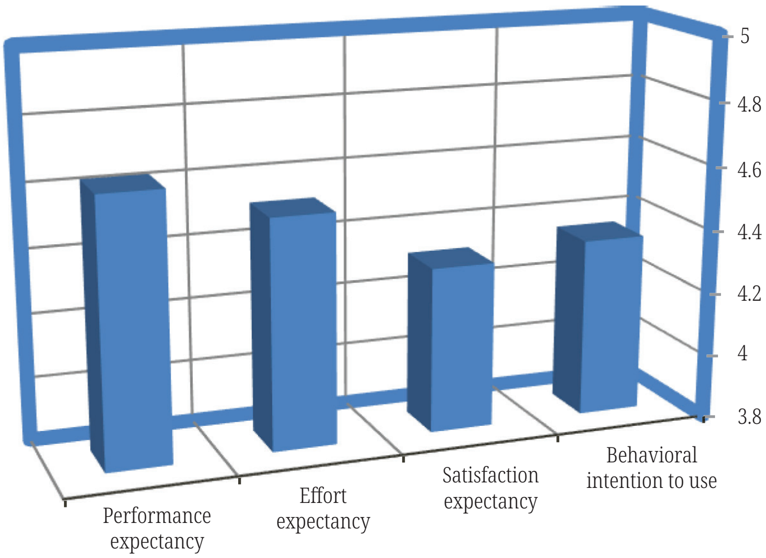


Fig. 4. Experimental results

6 CONCLUSION

Quality education is ensured when the learning objectives are efficiently and effectively achieved. In this study, we addressed the issue of vagueness in the evaluation of educational outcomes and students' biases during this process. Hence, this study overcomes this problem by proposing a new algorithm using FSES. The proposed algorithm was implemented using the ASP.NET programming language. Eight QM rubric parameters were utilized in the development of the EOC-FSES system. This process took into consideration the input of the dean of the faculty and the head of the department, who are experts in each QM rubric parameter. These parameters were evaluated by students who participated in the online course.

By implementing our algorithm, educational stakeholders can gain a deeper understanding of the strengths and weaknesses of their online courses, allowing for targeted improvements that enhance the overall learning experience for students. Furthermore, integrating expert opinions adds credibility and reliability to the evaluation process, ensuring that the assessment aligns with educational standards and best practices.

Although our algorithm is somewhat limited to online course evaluation, it can be adapted to different contexts. In future projects, we will apply our algorithm to various domains of decision support systems.

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