Zeszyty Naukowe Wydziału Elektrotechniki i Automatyki Politechniki Gdańskiej Nr 65

VI Konferencja

e-Technologie w Kształceniu Inżynierów eTEE'2019

Politechnika Gdańska, 19-20 września 2019

doi: 10.32016/1.65.16

APPLICATION OF INTUITIONISTIC FUZZY SETS TO THE ASSESSMENT OF TECHNICAL UNIVERSITY STUDENTS

Tacjana NIKSA-RYNKIEWICZ

Politechnika Gdańska, Wydział Oceanotechniki i Okrętownictwa
tel.: 577 123 465 e-mail:tacniksa@pg.edu.pl

Abstract: The article proposes application of artificial intelligence methods to assess students of technical universities. The level of achieved educational goals can be assessed using measurements based on the idea of Fuzzy Intuitionistic Sets (IFS). A classification algorithm was developed and an exemplary distribution of the criteria values using IFS was presented. The application of the proposed approach in online education can enrich the student evaluation process with additional information related to the uncertainty or lack of data.

Keywords: Intuitionistic Fuzzy Sets.

1. INTRODUCTION

Rules of Polish technical universities [1]–[8] inform students that assessment should take place in conditions which ensure equal treatment of all assessed. Assessment should be impartial, fair, transparent and able to confirm the reliability of the results. Academic teachers take responsibility for organizing the three kinds of assessment process: diagnostic, continuous and concluding.

Methods used for this purpose should provide support for teaching, learning and achieving learning outcomes. Most often, the academic teacher who conducts the subject is required to define detailed rules and criteria for the evaluation of this subject, both in terms of diagnostic assessment, as well as continuous and summary assessment. Assessment methods should be announced in the course syllabus and provided to the public at the right time.

2. ASSESSMENT METHODS

The principles and evaluation criteria should be comprehensive and specific [1]–[8]. They should provide an assessment of all learning outcomes assumed for a given subject and at the same time be adapted to the type and scope of individual effects. The scope of information on the rules and criteria for the evaluation of individual subjects is given to the public. The work of students of technical universities is rated most often on a scale of 2.0-5.0.

The same rules should apply the tests at all dates, carried out as part of the continuous assessment. In the same way, the same rules must apply in all dates of credits and examinations carried out as part of the summary assessment. An example of the rating scale presented in table developed (Table 1).

Table 1. A summary of information about assessments and their meanings according to the level of knowledge acquisition.

Verbal evaluation	Evaluation ECTS	Description of the required criteria	The degree of mastery of knowled ge (in %)
Very good	5,0 (A)	achieving the assumed learning outcomes covering all relevant aspects	≥ 91
Good plus	4,5 (B)	achieving the assumed learning outcomes covering all relevant aspects with some errors or inaccuracies	81-90
Good	4,0 (C)	achieving the assumed learning outcomes without taking into account some less important aspects	71-80
Sufficient plus	3,5 (D)	achieving the assumed learning outcomes, omitting some important aspects or with significant inaccuracies	61-70
Sufficient	3,0 (E)	achieving the assumed learning outcomes, omitting some important aspects or with significant inaccuracies	51-60
Insufficient	2,0 (F)	no achievement of the expected learning outcomes	≤ 50

The work of a technical university student can be assessed by using: continuous assessment, written/oral tests, final written/oral assessment, written/oral examination, attendance control, year paper, project, portfolio. A preliminary survey was conducted among students of technical universities. It was investigated which method is used most often (usually - most academic teachers use this method $\langle 100\%, 80\% \rangle$; very often use this method $(80\%, 60\%\rangle$; the leaders sometimes use this method $(60\%, 40\%\rangle$; they rarely use this method $(40\%, 20\%\rangle$, they usually do not use this method $(20\%, 0\%\rangle$. The research concerned the opinion which of the methods is considered the most important (very important, important, neutral, usually unimportant, unimportant) (Table 2).

Table 2. The summary of information on the frequency and importance of the assessment methods used at technical universities

Assessment methods	The frequency	The importance
continuous assessment	rarely	important
written tests	usually	important
oral tests	usually not	neutral
final written assessment	usually	very important
final oral assessment	usually not	usually unimportant
attendance control	very often	usually unimportant
year paper	sometimes	important
project	very often	very important
portfolio	usually not	important

The research concerned opinions on the methodology of assessment. The survey was conducted among 289 students of technical universities in 2019. The most frequently assessed are the degree of concordance of students' project implementation with the given requirements for the project implementation (later called project implementation), the percentage of attendance to the classes and the percentage of acquired knowledge, specified by means of a written test or final written assessment. Students expressing an open opinion pointed out that: no answer is the wrong answer, justified absence is tantamount to presence (Figure 1).

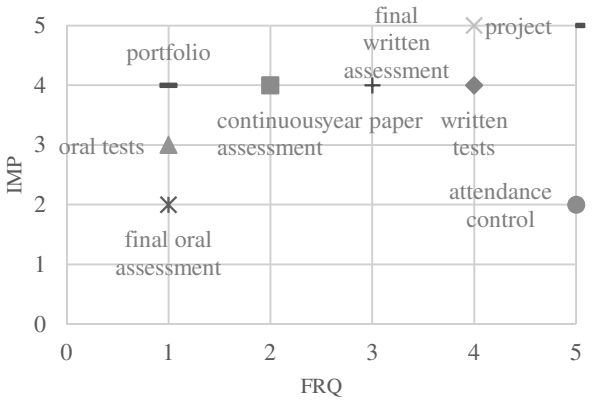

Fig 1. Chart of importance (*IMP.*) and frequency (*FRQ*) assessment methods

There is a need for individual consideration of the assessment in a broader sense [9]. The proposed evaluation system uses the idea of Intuitionistic Fuzzy Sets (IFS). The idea of IFS generalizes the definition of classic and fuzzy sets. The description of information using IFS is very convenient especially when the available data is uncertain [10]–[13].

3. INTUITIONISTIC FUZZY SETS

An IFS $\boldsymbol{A}$ in the universe of discourse $\boldsymbol{X} = \{x_1, x_2, \dots, x_{1n}\}$ is defined as follows [12]:

$$\boldsymbol{A} = \{x, \mu_A(x), \nu_A(x) > x \epsilon \boldsymbol{X}\}, \quad (1)$$

where $\mu_A: X \to [0,1]$, $\nu_B: X \to [0,1]$ represent the degree of membership and nonmembership of the element $x \epsilon \boldsymbol{X}$ belonging to IFS $\boldsymbol{A}$, respectively, with

$$\forall\, x \epsilon \boldsymbol{X}\ \ 0 \le \mu_A(x) + \nu_A(x) \le 1\,. \quad (2)$$

The special parameter of the *IFS* is $z_A(x)$, which is called the intuitionistic fuzzy index (hesitation margin),

$$\forall x \epsilon \boldsymbol{X}\ \ 0 \le z_A(x) \le 1 \quad (3)$$

and

$$z_A(x) = 1 - \mu_A(x) + \nu_A(x). \quad (4)$$

When $z_A(x)$=0, that is

$$\mu_A(x) + \nu_A(x) = 1, \quad (5)$$

the IFS would turn into a Fuzzy Sets [14]. For IFS's $\boldsymbol{A}$ and $\boldsymbol{B}$ in $\boldsymbol{X}$ the operations are defined as follows [15]:

$$\boldsymbol{A} \subseteq \boldsymbol{B}\ \ if\ \ \forall x \epsilon \boldsymbol{X}\ \ \mu_A(x) \le \mu_B(x), \nu_A(x) \le \nu_B(x) \quad (6)$$

$$\boldsymbol{A} = \boldsymbol{B}\ if\ \forall x \epsilon \boldsymbol{X}\ \mu_A(x) = \mu_B(x), \nu_A(x) = \nu_B(x). \quad (7)$$

4. THE ALGORITHM FOR CREATING IFS'S RATINGS

It is proposed that IFS's assessment should contain three values ($\mu_A(x)$, $\nu_A(x)$, $z_A(x)$). Depending on the type of assessment, these elements may be treated as determinants of the measures described in the table (Table 3).

Table 3. List of indicators of intuitionistic evaluation

Assessment methods	$\mu_A(x)$	$\nu_A(x)$	$z_A(x)$
attendance control	percent attendance	the percentage of unjustified absences	Percentage of justified absences
tests, final assessment examination	percentage of correct answers	percent of incorrect answers	percentage of the questions left unanswered
continuous assessment	percentage of correctly completed tasks	percent of incorrectly completed tasks	percent of tasks not performed
project year paper	percent of good project implementation	percentage of faulty project implementation	percent of no project implementation

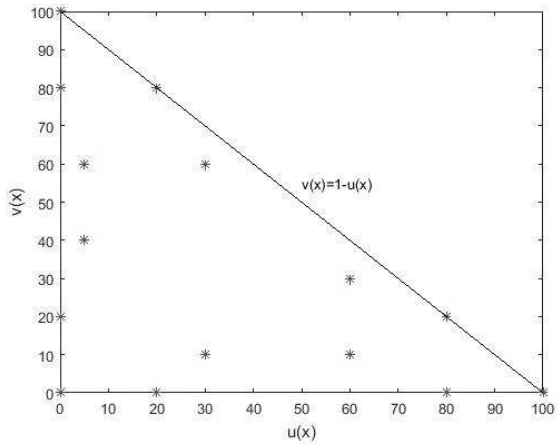

Fig. 2. Picture of examples of IFS's assessments containing $(\mu_A(x), \nu_A(x))$

The comparison of these indicators allows for easier classification of the student and for assignment of the student to the appropriate group (Table 4): G 0 - the failed course (student gets exactly this grade, low-level uncertainty); G 1 - the failed course (the student gets a negative grade with the possibility of improvement, high degree of uncertainty); G 2 - course completed good enough (the student obtained a positive grade with the possibility of improvement, high degree of uncertainty); G 3 - course completed (the student gets exactly such an assessment, low-level uncertainty),

Table 4. Summary information to assess the construction algorithm

$\mu_A(x)$ (%)	$\nu_A(x) + z_A(x)$(%)	$\nu_A(x) > z_A(x)$(%)	$\nu_A(x) \leq z_A(x)$(%)
≥ 91	<10	5,0 (A) G 3	
81-90	<19-10)	4,5(B) G 3	4,5 (B) G 2
71-80	<29-19)	4,0(C) G 3	4,0 (C) G 2
61-70	<39-29)	3,5(D) G 3	3,5 (D) G 2
51-60	<49-39)	3,0(E) G 3	3,0 (E) G 2
≤ 50	≥ 51	2,0(F) G 0	2,0 (F) G 1

Table 5. A sample of examples of IFS's assessments containing $(\mu_A(x), \nu_A(x), z_A(x))$

$\mu_A(x)$	$\nu_A(x)$	$z_A(x)$	$Group$
0	0	100	G 1
100	0	0	G 3
0	100	0	G 0
0	80	20	G 0
0	20	80	G 1
20	0	80	G 1
20	80	0	G 0
80	0	20	G 1
80	20	0	G 3
60	10	30	G 2
60	30	10	G 3
30	10	60	G 1
30	60	10	G 0

5. CONCLUSIONS

The challenge is to precisely determine the level of quality, as well as to include this assessment in a broad aspect - taking into account the context of the individual observations of the teacher. Classically applied assessment in such situations is often flattened by using standard scales. The use of fuzzy sets (FS), especially intuitively fuzzy sets (IFS), allows for the determination of the assessment in a broader scope and for deeper analysis of the level of knowledge acquirement.

6. BIBLIOGRAPHY

1. "Uchwała Senatu PG nr 295/2019/XXIV z 29 kwietnia 2019 r."
2. "Mamy nowy Regulamin Studiów | Życie Uczelni." [Online]. Available: https://www.zu.p.lodz.pl/mamy-nowy-regulamin-studiow. [Accessed: 01-Jul-2019].
3. "Regulaminy studiów na PK." [Online]. Available: https://www.pk.edu.pl/index.php?option=com_content&view=article&id=2323&Itemid=1006&lang=pl. [Accessed: 01-Jul-2019].
4. "Regulamin studiów | Politechnika Częstochowska." [Online].Availablewww.pcz.pl/pl/content/regulamin-studiow. [Accessed: 01-Jul-2019].
5. "Regulamin Studiów | Politechnika Lubelska." [Online]. Available: http://www.pollub.pl/pl/uczelnia/wewnetrzne-akty-prawne/dokumenty-wewnetrzne/regulamin-studiow. [Accessed: 01-Jul-2019].
6. "Regulamin studiów / Politechnika Rzeszowska im. Ignacego Łukasiewicza." [Online]. Available: https://w.prz.edu.pl/studenci_menu/regulamin-studiow-wyzszych. [Accessed: 01-Jul-2019].
7. "Statut, regulaminy, zarządzenia, ustawy | Politechnika Opolska | Twoja Uczelnia." [Online]. Available: https://www.po.opole.pl/index.php?mod=informacje;1. [Accessed: 01-Jul-2019].
8. "Regulaminy / Statut, regulaminy, zarządzenia / Uczelnia / Strona główna - Politechnika Warszawska." [Online]. Available: https://www.pw.edu.pl/Uczelnia/Statut-regulaminy-zarzadzenia/Regulaminy. [Accessed: 01-Jul-2019].
9. T. Wanner and E. Palmer, "Personalising learning: Exploring student and teacher perceptions about flexible learning and assessment in a flipped university course," *Computers & Education*, vol. 88, pp. 354–369, Oct. 2015.
10. K. T. Atanassov, *Intuitionistic Fuzzy Sets*, vol. 35. Heidelberg: Physica-Verlag HD, 1999.
11. K. T. Atanassov, "New operations defined over the intuitionistic fuzzy sets," *Fuzzy Sets and Systems*, vol. 61, no. 2, pp. 137–142, Jan. 1994.
12. K. T. Atanassov, "Intuitionistic fuzzy sets," *Fuzzy Sets and Systems*, vol. 20, no. 1, pp. 87–96, Aug. 1986.
13. D. Marasini, @bullet Piero, Q. @bullet, and E. Ripamonti, "Intuitionistic fuzzy sets in questionnaire analysis," *Quality & Quantity*, vol. 50, 2015.
14. L. A. Zadeh, "Fuzzy sets," *Information and Control*, vol. 8, no. 3, pp. 338–353, Jun. 1965.
15. K. Atanassov and G. Gargov, "Interval valued intuitionistic fuzzy sets," *Fuzzy Sets and Systems*, vol. 31, no. 3, pp. 343–349, Jul. 1989.

ZASTOSOWANIE INTUICJONISTYCZNYCH ZBIORÓW ROZMYTYCH DO OCENY STUDENTÓW TECHNICZNYCH UCZELNI

W artykule proponuje się do oceny studenta uczelni technicznych użycie intuicjonistycznych zbiorów rozmytych, które znajdują zastosowanie w metodach sztucznej inteligencji. Poziom osiąganych celów edukacyjnych można ocenić za pomocą miar opartych na idei rozmytych zbiorów intuicjonistycznych (IFS). Opracowano algorytm klasyfikacji oraz zaprezentowano przykładowy rozkład wartości kryteriów z wykorzystaniem IFS. Zastosowanie proponowanego podejścia w kształceniu on-line może wzbogacić proces oceny studenta o dodatkowe informacje związane z niepewnością lub brakiem danych.

Słowa kluczowe: Intuicjonistyczne zbiory rozmyte.