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THE SELECTION OF PREFERRED TEXTBOOK BASED ON THE DOMINANCE METHOD

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ABSTRACT

Calculus is a mathematics subject normally taught at the tertiary level. Many calculus textbooks with different approaches and styles have been published to cater to the needs of students. The selection of calculus textbooks is essential as it can help teachers and students to optimize their usage. Textbook selection problem is one type of multiple-criteria decision-making problem where the selection is based on several criteria. Thus, ranking fuzzy numbers based on the area dominance method ranks the calculus textbook.

Keywords*: Area Dominance , Calculus Textbook, Ranking Fuzzy Numbers.*

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1. Introduction

Decision-making is an essential process of obtaining a desired result based on a set of criteria under consideration from a set of alternatives (Aniza *et al.,* 2020). The process of choosing specific textbook for the course based on the objectives is complex (Spirovska Tevdovska, 2024). Studies demonstrated that textbook selection are complex and multi-layered process, as are the beliefs that influence teachers' decisions and actions regarding textbooks (Hsiang *et al.,* 2023). Nowadays, there are many calculus textbooks exist. To evaluate calculus textbooks, certain criteria are considered. Yuen and Ting (2012) found that a majority of instructors prefer to have a textbook that would best meet their students' needs and become a good resource for class activities such as case study analysis, problem discussion, and tutorial. Furthermore, Scott *et al.* (2023) mentioned that awareness of textbook selection is important nowadays. The selection of textbooks is claimed to be critical as the efficient selection of textbooks will increase the proficiency of students in the classroom (Altay, 2013). Barbara (2009), Stevens et al.(2007), Trank and Shepherd (1987), Williams (1983) and Zabawa (2001) listed several criteria to be considered in selecting a good textbook.

Williams (1983) developed a list of criteria for choosing English language textbooks that is an up-to-date methodology, existing guidance for non-native teachers, caters to the needs of the second-language learner, and is relevant to the socio-cultural environment. Tank and Shepherd (1987) argued that to choose a good textbook, one needs to consider its cost, quality, sequence of chapters, adaptability, and pluralistic issues of the textbook. According to Zabawa (2001), selecting a textbook is not easy even for an experienced teacher. Zabawa (2001) listed that layout and design, material organization, language proficiency, teaching

reading comprehension, teaching writing, teaching grammar and vocabulary, teaching listening comprehension, teaching oral skills, content and exam practice are the criteria of consideration for choosing the best English textbook.

Stevens *et al.,* (2007) stated the differences in quantitative faculty and qualitative faculty's ratings on factors that influence the textbook selection process. They take into consideration things such as layout and design, material organization, language proficiency, teaching reading comprehension, teaching writing, teaching grammar and vocabulary, teaching listening comprehension, teaching oral skills, content, and exam practice as the criteria for a textbook selection. According to Barbara (2009), content, scope and sequence of topics, level of difficulty and interest for students, conceptual orientation and approach to the subject matter, quality of writing, pedagogical design, and cost are some of the criteria that need to be considered in selecting a good textbook. Thus, based on the criteria listed, decision-makers selected six criteria to be considered to select a good calculus textbook.

The method used in the research is based on ranking fuzzy numbers. The proposed method is an extended method of area dominance method by Tseng and Klein (1989). The extended method is presented in Hanif *et al.,* (2013) paper. The extended method has the advantage of one additional definition in the direction of domination for overlapping cases between two fuzzy numbers (the third one).

The next section of this paper is on the criteria of the textbook to be considered. The third section discusses the calculus textbook, and the following section is the procedure for selecting of calculus textbook. The final section is the conclusion of the research.

2. Criteria to Be Considered

The first criterion is the content of the textbook. A calculus textbook is preferred if it has suitable content such as real-life applications, appropriate examples, and suitability to students' level are considered as a good calculus textbook. The second criterion is the organization of topics in the textbook. The organization of a textbook is important to prevent students from getting confused with the relation of each subchapter. Hence, it is desirable if the topic of the textbook is systematically arranged. The exercise part is the third criterion to be considered. A good textbook has a sufficient exercise that is consistent with the student's level; not too easy or too difficult for the student but able to challenge the student's understanding of each topic. If the textbook has high-quality writing and is understandable by students, then it is considered a good textbook. Thus, the fourth criterion is the quality of the writing of the textbook. The design of the textbook can stimulate interest in students. Hence, the fifth criterion to be considered is the pedagogical design of the textbook. A good pedagogical design of a textbook has clear headings and subheadings, chapter previews and summaries, review questions, and glossaries. A colourful textbook can attract students more than a plain textbook. Another criterion to be considered is the price of a textbook. Students tend to purchase textbooks that are affordable for them. The reasonable price of a textbook can prevent students from photocopying it. In summary, the criteria considered in this study are:

1. content,
2. sequence of topics,
3. level of difficulty of the exercise practice,
4. quality of writing,
5. pedagogical design, and
6. price.

3. Calculus Textbook

In this study, three calculus textbooks are used for consideration. The first one is entitled *Calculus* by Howard Anton, Irl Bivens, and Stepen Davis (eighth edition) published by John Wiley and Sons in 2005, (Anton *et al.,* 2005). The second textbook is the sixth edition of *Calculus Early Transcendental* by James Stewart published by Thomson Brooks/Cole Publishing Company in 2008, (Stewart, 2008). Third is *Calculus* by Larson Edwards, (Edward, 2006). The ninth edition of this textbook was published in 2006 by Thomson Brooks/Cole Publishing Company. For evaluation purposes, these three textbooks are represented as T_1, T_2, and T_3 respectively.

4. Procedure for Selection of Calculus Textbook

The method proposed by Stewart (2008) is adopted in the preliminary evaluation. The procedure of the method is given as follows:

Step 1:
A committee of decision-makers is formed, and the evaluation of the criteria is identified. Four decision-makers labeled DM_1, DM_2, DM_3, and DM_4 are selected to give opinions on each of the textbooks. They are experienced lecturers from the Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA. Criteria involved in this selection are given in Table 1.

Table 1. List of Criteria

Criteria	Representation
Content	C_1
The sequence of topics	C_2
Level of difficulty of the exercise practice	C_3
Quality of writing	C_4
Pedagogical design	C_5
Price	C_6

Step 2:
Decision makers will select the suitable linguistic variables for the importance weight of the criteria and the linguistic ratings for alternatives concerning criteria. Table 2 and Table 3 show the linguistic variables for the importance weight of criteria and the linguistic variables for the rating of each textbook respectively.

Table 2. Linguistic Variables for Importance Weight of Criteria

Linguistic terms	Fuzzy Numbers
Very Low	(0.0,0.05,0.1)
Low	(0.1,0.2,0.3)
Medium Low	(0.3,0.4,0.5)
Fair	(0.4,0.5,0.6)
Medium High	(0.5,0.6,0.7)
High	(0.7,0.8,0.9)
Very High	(0.8,0.9,1.0)

Table 3. Linguistic Variables for the Ratings

Linguistic terms	Fuzzy Numbers
Extremely bad	(0, 0, 0)
Very Bad	(0, 0, 0.1)
Bad	(0, 0.1, 0.3)
More or Less Bad	(0.1, 0.3, 0.5)
Fair	(0.3, 0.5, 0.7)
More or Less Good	(0.5, 0.7, 0.9)
Good	(0.7, 0.9, 1)
Very Good	(0.9, 1, 1)
Extremely Good	(1, 1, 1)

Step 3:
The weight of criteria $\tilde{q}_{C_i}$ of criterion C_i are aggregated, and the decision-maker's opinions to get the aggregated fuzzy rating $\tilde{T}j_{C_i}$ of alternative T_j under criterion C_i are pooled. The importance weight of the criteria $\tilde{q}_{C_i}$ and the rating alternatives $\tilde{T}j_{C_i}$ is obtained from survey sheets filled by decision-makers.

$$\tilde{q}_{C_i} = \frac{1}{4}(\tilde{q}_{Ci}^{DM_1} \oplus \tilde{q}_{Ci}^{DM_2} \oplus \tilde{q}_{Ci}^{DM_3} \oplus \tilde{q}_{Ci}^{DM_4})$$

$$\tilde{T}j_{C_i} = \frac{1}{4}(\tilde{T}_{Ci}^{DM_1} \oplus \tilde{T}_{Ci}^{DM_2} \oplus \tilde{T}_{Ci}^{DM_3} \oplus \tilde{T}_{Ci}^{DM_4}). \quad (1)$$

The average weight and result for average ratings for each criterion based on each textbook are represented in Tables 4 and 5.

Table 4. The Average Weight for each Criterion

Criteria	The Average Weight
C_1	(0.7, 0.8, 0.9)
C_2	(0.55, 0.65, 0.75)
C_3	(0.65, 0.75, 0.85)
C_4	(0.575, 0.675, 0.775)
C_5	(0.575, 0.675, 0.775)
C_6	(0.625, 0.725, 0.825)

Table 5. The Average Ratings for Each Criterion for Each Textbook

Criteria	The rating		
	$\tilde{T}_1$	$\tilde{T}_2$	$\tilde{T}_3$
C_1	(0.675, 0.825, 0.925)	(0.75, 0.925, 1)	(0.8, 0.95, 1)
C_2	(0.75, 0.9, 0.975)	(0.75, 0.925, 1)	(0.8, 0.95, 1)
C_3	(0.45, 0.65, 0.825)	(0.55, 0.75, 0.9)	(0.55, 0.725, 0.85)
C_4	(0.8, 0.95, 1)	(0.65, 0.825, 0.925)	(0.85, 0.975, 1)
C_5	(0.55, 0.75, 0.9)	(0.55, 0.75, 0.9)	(0.8, 0.925, 1)
C_6	(0.55, 0.725, 0.85)	(0.5, 0.675, 0.825)	(0.5, 0.7, 0.85)

Step 4:
The degrees of confidence of satisfaction levels of each alternative T_j are obtained. The confidence level of the decision-makers of each textbook will be determined based on the minimum value which is also obtained from the survey sheets and is represented in Table 6.

Table 6. Confidence Level of Each Textbook

Textbook	Confidence Level
T_1	0.7
T_2	0.7
T_3	0.7

Before obtaining the confidence level of each textbook, the average of each criterion of the textbook is calculated as in equation (1). The result is in Table 7.

Table 7. The Average Confidence Level of Each Textbook

Criteria	Confidence Level		
	T_1	T_2	T_3
C_1	0.8	0.9	0.8
C_2	0.8	0.9	0.9
C_3	0.7	0.9	0.9
C_4	0.9	0.8	0.9
C_5	0.8	0.7	0.9
C_6	0.9	0.7	0.7

Step 5:
The fuzzy decision matrix is constructed. All the data obtained in Step 2, Step 3, and Step 4 will be aggregated using fuzzy multi-criteria group decision-making which can be represented in matrix format as follows:

$$Z = T \otimes Q$$

$$= \begin{bmatrix} \tilde{t}_{11} & \tilde{t}_{12} & \tilde{t}_{13}\tilde{t}_{14}\tilde{t}_{15}\tilde{t}_{16} \\ \tilde{t}_{21} & \tilde{t}_{22} & \tilde{t}_{23}\tilde{t}_{24}\tilde{t}_{25}\tilde{t}_{26} \\ \tilde{t}_{31} & \tilde{t}_{32} & \tilde{t}_{33}\tilde{t}_{34}\tilde{t}_{35}\tilde{t}_{36} \end{bmatrix} \otimes \begin{bmatrix} \tilde{q}_{c_1} \\ \tilde{q}_{c_2} \\ \tilde{q}_{c_3} \\ \tilde{q}_{c_4} \\ \tilde{q}_{c_5} \\ \tilde{q}_{c_6} \end{bmatrix} = \begin{bmatrix} \tilde{T}_1 \\ \tilde{T}_2 \\ \tilde{T}_3 \end{bmatrix}, \quad (2)$$

where $\tilde{t}_{ij}$ denotes that i is the textbook and j is the criteria of the textbook. The $\otimes$ represents product operations of fuzzy numbers. Table 8 represents the aggregation for each textbook.

Table 8. The Aggregation for each Textbook

Textbook	The Aggregation
T_1	(2.358, 3.477, 4.514)
T_2	(2.346, 3.518, 4.579)
T_3	(2.683, 3.801, 4.699)

Step 6:
The fuzzy numbers are ranked accordingly using the area dominance method. The area dominance is an extension of the Tseng and Klein (1989) method of ranking fuzzy numbers is used to rank the fuzzy numbers and the algorithm is as follows:

Step 1. Find the area where $\tilde{A}$ and $\tilde{B}$ are indifferent.
Step 2. Find the areas where $\tilde{A}$ dominates $\tilde{B}$.
Step 3. Find the area where $\tilde{B}$ dominates $\tilde{A}$.
Step 4. Find the area of $\tilde{A}$ and the area of $\tilde{B}$.
Step 5. Compute $R\left(\tilde{A},\tilde{B}\right)$ and $R\left(\tilde{B},\tilde{A}\right)$ as in equation (3)

$$R(\widetilde{A},\widetilde{B}) = \frac{\left(\text{areas where } \widetilde{A} \text{ dominates } \widetilde{B}\right)+\left(\text{area where } \widetilde{A} \text{ and } \widetilde{B} \text{ are indifferent}\right)}{\left(\text{area of } \widetilde{A}\right)+\left(\text{area of } \widetilde{B}\right)}$$

$$R(\widetilde{B},\widetilde{A}) = \frac{\left(\text{areas where } \widetilde{B} \text{ dominates } \widetilde{A}\right)+\left(\text{area where } \widetilde{A} \text{ and } \widetilde{B} \text{ are indifferent}\right)}{\left(\text{area of } \widetilde{A}\right)+\left(\text{area of } \widetilde{B}\right)}$$

$$R(\widetilde{A},\widetilde{B}) + R(\widetilde{B},\widetilde{A}) = 1, \tag{3}$$

After obtaining $R\left(\tilde{A},\tilde{B}\right)$ and $R\left(\tilde{B},\tilde{A}\right)$, the ranking of $\tilde{A}$ and $\tilde{B}$ will depend on the following two cases

Case 1 If $R\left(\tilde{A},\tilde{B}\right) \neq R\left(\tilde{B},\tilde{A}\right)$

Then the ordering is as follows:

$\tilde{A} \succ \tilde{B}$ if $R\left(\tilde{A},\tilde{B}\right) > R\left(\tilde{B},\tilde{A}\right)$

$\tilde{B} \succ \tilde{A}$ if $R\left(\tilde{B},\tilde{A}\right) > R\left(\tilde{A},\tilde{B}\right)$

Fuzzy number $\tilde{A}$ is ordered higher than $\tilde{B}$ if $R\left(\tilde{A},\tilde{B}\right)$ is greater than $R\left(\tilde{B},\tilde{A}\right)$ and vice versa.

Case 2 If $R\left(\tilde{A},\tilde{B}\right) = R\left(\tilde{B},\tilde{A}\right)$

Find the spread of $\tilde{A}$ and $\tilde{B}$ denoted by $S\left(\tilde{A}\right)$ and $S\left(\tilde{B}\right)$ using equation (4). The ordering of $\tilde{A}$ and $\tilde{B}$ will then be as follows:

$\tilde{A} \succ \tilde{B}$ if $S\left(\tilde{B}\right) > S\left(\tilde{A}\right)$

$\tilde{B} \succ \tilde{A}$ if $S\left(\tilde{A}\right) > S\left(\tilde{B}\right)$

Fuzzy number $\tilde{A}$ is ordered higher than $\tilde{B}$ if $S\left(\tilde{B}\right)$ is greater than $S\left(\tilde{A}\right)$ and vice versa.

$$S\left(\widetilde{A}\right) = \frac{1}{n}\sum_{k=0}^{n}\left(r_k - l_k\right), \tag{4}$$

where l_k and r_k are the minimum and maximum values of ${}^{\alpha}\widetilde{A}$ respectively.

The direction of domination for overlapping cases between two fuzzy numbers is defined as follows:

$\tilde{A}$ is said to dominate $\tilde{B}$ if

a) the non-overlapping area belongs to $\tilde{A}$ and is on the right-hand side of the overlapping area, or
b) the non-overlapping area belongs to $\tilde{B}$ and is on the left-hand side of the overlapping area, or
c) the non-overlapping area belongs to $\tilde{A}$ and is at the upper dominance of the overlapping area.

Similarly, $\tilde{B}$ is said to dominate $\tilde{A}$ if

a) the non-overlapping area belongs to $\tilde{A}$ and is on the left-hand side of the overlapping area, or
b) the non-overlapping area belongs to $\tilde{B}$ and is on the right-hand side of the overlapping area, or
c) the non-overlapping area belongs to $\tilde{B}$ and is at the upper dominance of the overlapping area.

Each textbook is now represented by a fuzzy number and is compared pair-wisely with each other. Steps 1 to 5 of the area dominance method are performed using Maple software. Figure 1, 2, and 3 show the illustration of $\tilde{T}_1$ and $\tilde{T}_2$, $\tilde{T}_2$ and $\tilde{T}_3$ and $\tilde{T}_1$ and $\tilde{T}_3$ respectively and the red shaded region represent the direction of domination for overlapping case between two fuzzy numbers of $\tilde{A}$ is said to dominate $\tilde{B}$ if the non-overlapping area belongs to $\tilde{A}$ and is at the upper dominance of the overlapping area (the improved method from Tseng & Klein, 1989 by Hanif *et al.*, 2013 paper).

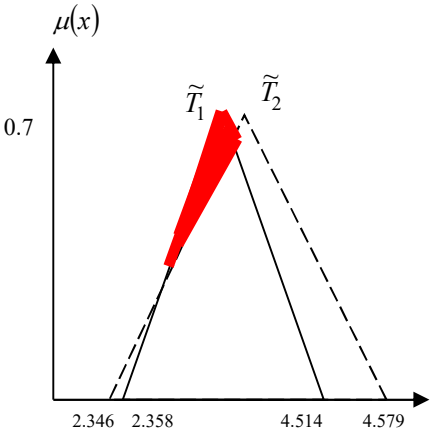

Figure 1. $\tilde{T}_1$ and $\tilde{T}_2$

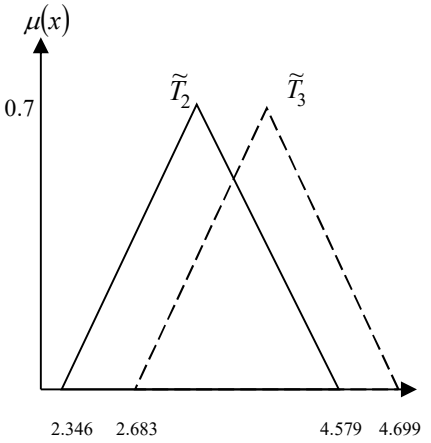

Figure. 2. $\tilde{T}_2$ and $\tilde{T}_3$

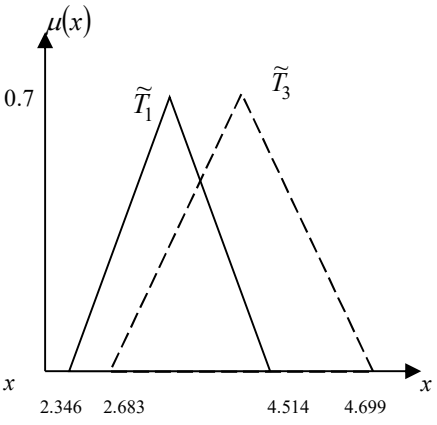

Figure. 3. $\tilde{T}_1$ and $\tilde{T}_3$

Table 9 represents the ordering of textbooks. Since there are three fuzzy numbers to be ranked, the ordinal scale method is used. The results of the ordinal scaling for the textbooks are shown in Table 10.

Table 9. Ordering of Textbooks

Set	$R(i,j)$	$R(j,i)$	Ordering
$\tilde{T}_1$ & $\tilde{T}_2$	0.49	0.51	$\tilde{T}_2 \succ \tilde{T}_1$
$\tilde{T}_2$ & $\tilde{T}_3$	0.39	0.61	$\tilde{T}_3 \succ \tilde{T}_2$
$\tilde{T}_1$ & $\tilde{T}_3$	0.37	0.63	$\tilde{T}_3 \succ \tilde{T}_1$

Table 10. Ordinal Scaling of the Textbooks

Rank	Fuzzy number	Frequency of Fuzzy Number Preferred to Others
1	$\tilde{T}_3$	2
2	$\tilde{T}_2$	1
3	$\tilde{T}_1$	0

Thus the ranking order of the textbooks is $\tilde{T}_3 \succ \tilde{T}_2 \succ \tilde{T}_1$.

5. Conclusion

The upper dominance definition is used in the pair-wise comparison between $\tilde{T}_1$ and is shaded in Figure 1. As for the ranking, the average weight of Criteria 1, C_1 is higher among other criteria with (0.7, 0.8, 0.9). For C_1, T_3 has the highest rating (0.8, 0.95, 1) followed by T_2 (0.75, 0.925, 1) and T_3 (0.675, 0.825, 0.925). This is consistent with the final ranking based on the proposed method where $\tilde{T}_3$ (*Calculus* by Larson Edwards) is ranked the highest followed by $\tilde{T}_2$ (*Calculus Early Transcendental* by James Stewart) and $\tilde{T}_1$ (*Calculus* by Howard Anton, Irl Bivens, and Stepen Davis). For future recommendation, other textbook selection may be analyzed using the same method. More flexibility for the decision-makers may be considered in terms of the selection of the linguistic term sets.

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Author Contribution

Author 1 : Methodology.
Author 2 : Expert in Fuzzy Numbers..
Author 3 : Expert in Multi – Criteria Decision Making.
Author 4 : Literature Review and Application.

Conflict of Interest

The authors have no conflicts of interest to declare.

References

Aniza, S., Ahmad, S., Mohamad, D., & Azman, N. I. (2020). Similarity Based Fuzzy Inferior Ratio for Solving Multicriteria Decision Making Problems. In Malaysian Journal of Computing (Vol. 5, Issue 2)

Altay, B. (2013). Strategies for Textbook Selection and Evaluation in Terms of Four Main Skills for EFL Classrooms. *International Journal of Pyscho-Educational Sciences*.

Anton, H., Bivens, I., & Davis, S. (2005). *Calculus* (8th ed.). John Wiley and Sons.

Barbara, G. D. (2009). *Tools for Teaching* (8th ed.). John Wiley and Sons.

Edward, L. (2006). *Calculus* (9th ed.). Thomson Brooks/Cole Publishing Company.

Hanif, H. M., Mohamad, D., Sulaiman, N. H., Mohd, H., Mohamad, D., & Hashimah, N. (2013). Solving Decision Making Problems using Fuzzy Numbers with Area Dominance Approach. *20th National Symposium on Mathematical Sciences*, 229–236. https://doi.org/10.1063/1.4801128

Hsiang, T. P., Graham, S., Liu, X., & Zhou, Z. (2023). Teachers' beliefs and practices in textbook selection and use when teaching Chinese as a second language. *Reading and Writing*, *36*(7), 1651–1684. https://doi.org/10.1007/s11145-022-10336-9

Scott, R. E., Jallas, M., Murphy, J. A., Park, R., Shelley, A., & Faculty, E. (2023). *Exploring Faculty Perspectives on Text Selection and Textbook Exploring Faculty Perspectives on Text Selection and Textbook Affordability Recommended Citation*. https://ir.library.illinoisstate.edu/fpml.

Spirovska Tevdovska, E. (2024.). *Textbook Evaluation and Materials Selection in The Context Of English For Nursing Course Development*.

Stevens, R. E., Clow, K. E., McConkey, C. W., & Tiger, A. A. (2007). Differences In Quantitative and Qualitative Professors' Criteria For Textbook Adoptions: A Pilot Study. . *Issues in Information Systems*, *VIII*(30–36).

Stewart, J. (2008). *Calculus Early Transcendental* (6th ed.). Thomson Brooks/Cole.

Trank, D. M., & Shepherd, G. J. (1987). Textbook Selection Criteria for a Multi-Section Basic Course taught exclusively by Graduate Teaching Assistants. *Paper Presented at Annual Meeting of Speech Communication Association.*

Tseng, T. Y., & Klein, C. M. (1989). New algorithm for the ranking procedure in fuzzy decision making. *IEEE Transactions on Systems, Man, and Cybernetics*, *19*(5), 1289–1296.

Williams, D. (1983). Developing criteria for textbook evaluation. *ELT Journal*, *3*(3), 251–255.

Yuen, K. K. F., & Ting, T. O. (2012). Textbook selection using fuzzy PROMETHEE II method. International Journal of Future Computer and Communication, 1(1), 76

Zabawa, J. (2001). *Criteria for FCE textbook evaluation: an attempt at a questionnaire*