Segmentation of students with special needs at UL

Andrej Košir*
Janez Zaletelj*
andrej.kosir@fe.uni-lj.si
janez.zaletelj@fe.uni-lj.si
Fakulteta za elektrotehniko, Univerza v Ljubljani
Ljubljana, Slovenia

Janja Košir
Pedagoška Fakulteta, Univerza v Ljubljani
Ljubljana, Slovenia
janja.kosir@pef.uni-lj.si

ABSTRACT

This paper deals with the identification and interpretation of segments of students with disabilities at the University of Ljubljana. The data on which this segmentation is based are the students' responses to a dedicated questionnaire created through an operationalization process according to the selected aspects and objectives of the segmentation.

The segmentation aimed to identify homogeneous groups of students with disabilities in order to 1. improve the understanding of students' needs, 2. prepare reliable data for the selection of technological support for students and 3. create the basis for a subsequent project on ICT-based support for special needs students.

Through the operationalization process, we identified five areas (aspects), namely 1. Technology and overcoming study barriers, 2. Technology and study outcomes, 3. ICT and Study Obligations, 4. ICT and Study Skills, and 5. Opportunities to use ICT technology. Based on student responses, we identified segments for the first three areas, with all three areas well covered by three segments each. We identified three segments in each area: 1. Technology Enthusiasts (accept everything), 2. Skeptical Users (reject everything but the exceptions), and 3. Picky Users (accept almost everything but the exceptions). From the second and third segments, we extracted the main characteristics by technology and by activity. The results are applicable for the next steps in technology support for students with special needs.

KEYWORDS

user segmentation, special needs students, segmentation algorithm

1 INTRODUCTION

Effective technological support for students with special needs is crucial for modern teaching and learning at universities. Over the last decade, the landscape of teaching and learning has changed rapidly [17].On the other hand, the rapid development of information and communication technologies [6] and studies on technological support for students [4] has added a variety of new support options. There is no effective technological support without prior knowledge of the needs of the users - in our case, the specific needs of our students.

In this paper, we present the operationalization of the segmentation instrument (aspects and questions) and the results of the segmentation of students with disabilities at the University of Ljubljana (UL). The initial goal of segmentation is to plan and implement effective and needs-based support for students with disabilities at UL.

We have concluded that this study does not require ethical review. The study is fully consistent with the purpose of collecting data from students with disabilities and its results will be used for the direct benefit of the population.

1.1 Aims of the student segmentation

The main aim of the segmentation is to learn about the main groups of students with disabilities in relation to the opportunities for technological support for their studies provided by the university. The sub-objectives are:

(1) Identify the groups of students with disabilities at UL along with their basic characteristics.
(2) Identify meaningful groups of active students with disabilities.

To achieve the goal ad 1. we designed a questionnaire. The design of the questionnaire resulted in 12 questions, with 5 main sub-questions and a larger number of sub-questions.

To achieve objectives ad 2, we conducted an extensive data analysis (see Sec. 4) and consulted domain experts.

2 STATE OF THE ART

2.1 User segmentation

User segmentation is the process of dividing users into different groups or segments based on common characteristics. It was developed in the field of business and management. An organization can segment users by language preference, product version, geographic region or user personality [1]. A similar segmentation has been successfully applied to other areas, e.g. to the users of ICT and also to the area of ICT in special education [6].

Data mining techniques entered the field quite early on [21]. Machine learning-based techniques are the most important approach to user segmentation today [2].

Successful segmentation methods lead to homogeneous subgroups of users. A necessary next step is to understand these segments, i.e. to define and understand their typical representatives. Such a representative is called a persona, and to clearly understand the part of their behavior that is relevant to them, they are described as a living person [20]. A persona is therefore a fictional character whose characteristics and goals best fit the segment.

2.2 Operacionalisation

Operationalization is a process of 1. selecting relevant aspects of the designed instrument (set of questions) and 2. selecting an initial set of questions representing the selected aspects. There is a long history of research on this approach [16]. It is based

*Both authors contributed equally to this research.

Information Society 2024, 10–14 October 2022, Ljubljana, Slovenia

https://doi.org/https://doi.org/10.70314/is.2024.DIGIN.9

on human expert judgment. The aim of operationalization is to construct a measurement instrument that is used in data collection [12]. The validity and reliability of the resulting instruments are of central importance and the research community has developed strict guidelines on how to achieve and ensure this [3]. In our case, we have focused on relevant aspects of technological support for students with special needs.

2.3 Unsupervised clustering for user segmentation

User segmentation is a subfield of the highly developed field of customer segmentation. Machine learning techniques found their way into customer segmentation decades ago [19]. From various data mining approaches [21], the focus shifted to neural networks [18] and deep learning [15].

Unsupervised clustering with visualization of the cluster hierarchy is a necessary step in customer segmentation [11]. In the case of this study, understanding the user segments obtained is very important. The technique of explainable customer segmentation is discussed in [14].

3 MATERIALS AND METHODS

3.1 Operacionalisation and existing instruments

The operationalization procedure of this research focused on the existing support for students with special needs at our and other universities. Theoretical knowledge and practical experiences in supporting students with special needs were also taken into account. This is crucial to achieve good validity and reliability of the resulting instrument in fewer iterations.

To incorporate existing measurement instruments related to the use and benefit of assistive technologies, we also examined available measurement instruments. As early as 1996, the authors of [7] developed a scale "Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST)". The instrument contains 18 items and two dimensions. The construct was later reviewed in [8], where 12 items were further selected.

A scale called the Psychosocial Impact of Assistive Devices Scale (PIADS) was developed by the authors of [13]. The PIADS is a 26-item self-report questionnaire to assess the impact of an assistive device on functional independence, well-being and quality of life. The construct is three-dimensional and includes 1. competence (measures feelings of competence and effectiveness), 2. adaptability (indicates willingness to try new things and take risks) and 3. self-esteem (indicates feelings of emotional health and happiness).

The authors Dijcks et. al developed a scale (one-dimensional construct) to assess the quality of service delivery in the provision of assistive technology (KWAZO) [9]. It aims to assess the quality of the provision of assistive devices from the customer's perspective. The instrument consists of seven questions relating to accessibility, knowledge, coordination, efficiency, flexibility and user influence. The reliability of the scale is rated as very good.

As a result of all considerations, we decided to include the following aspects:

(1) Technology and overcoming study barriers
(2) Technology and study outcomes
(3) ICT and Study Obligations
(4) ICT and Study Skills
(5) Opportunities to use ICT technology

To cover these five aspects, we also constructed, selected and modified questions that led to the final instrument (not listed here for space reasons).

3.2 Participants and data collection

The selected population is all UL students with disabilities. Given the estimated number of 700 to 800 such students, the entire population was included in the sample.

The data collection was carried out by the University of Ljubljana (UL) administration services. They provided us with a list of all students with special needs at ULat UL. We then manually screened this list with the baseline descriptions and selected 723 respondents.

The inclusion criteria for selection were self-selected categories of special needs selected by the students at the time of enrolment. They covered general special needs, and deficits from disabilities (hearing, vision, speech, physical, emotional, mental health). There were no exclusion criteria for selection into the sample.

3.3 Unsuprvised clustering for user segment determination

We applied the unsupervised clustering technique K-Means with dendrogram visualization [5]. The feature space was a space of participant responses, no dimensionality reduction or location-dependent transformation [10] or similar was used. The Euclidean distance is used for K-means clustering. Other distances lead to similar clusters. Since all responses were on the same Likert scale, no prior scaling was performed. We used elbow curves to determine the optimal number of segments and basic statistics to determine the most important characteristics of the selected segments. The initial number of clusters was set to $k = 12$.

4 EXPERIMENTAL RESULTS

4.1 Student data

The sampling method chosen was to send emails to the e-mail addresses provided by the students with disabilities at the time they obtained their special education student status. The inclusion and exclusion criteria were specified in subsection 3.2. The questionnaire was administered via the web-based system 1ka (https://www.1ka.si/d/sl) and the questionnaire with response categories is available on request. Invitees received an email with explanations and instructions.

The invitations were sent out in three phases

(1) First invitation: by e-mail from the university e-mail address;
(2) Second invitation: via the Disability representatives at the faculties and academies;
(3) Third invitation: via the Association of Students with Disabilities

The invitation was sent to 733 people. A total of 18 (3.4%) responses to the first invitation were received within one week, next 7 to the second invitation and next 18 to the third invitation, altogether 43 (5.9%). At the time of study design, we estimated that the response rate of respondents would be around 10%. We did not formally identify the reasons for this low response rate, but we did gather some opinions. These can be grouped as follows:

(1) There is enough freely available technology that I can use myself and I do not need any special support from the university;
(2) In the responders' mind, the university does not have enough technical support to help individuals;

We present the results of the segmentation according to the criteria specified in Subsec. 3.1 identified aspects.

4.2 Basic statistics

The breakdown of the 43 respondents by gender can be found in Fig. 1 (top left), where NA indicates those who did not wish to state their gender.

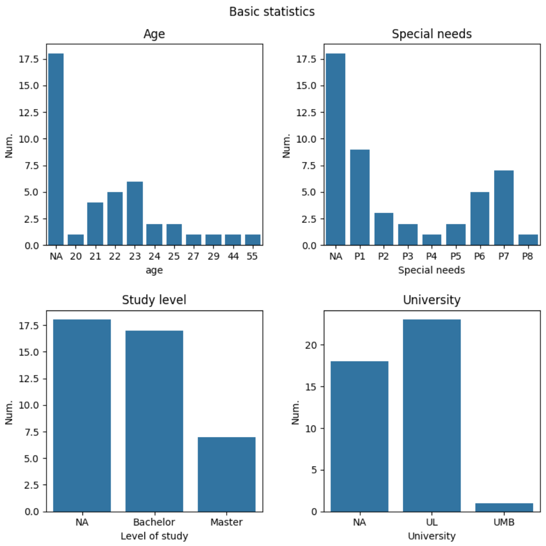

Figure 1: Response of participants: by gender (top left), age (second row left), special needs (second row right), study style (third row left) and university (third row right), where UL stands for the University of Ljubljana and UMB for the University of Maribor

The histogram by age is shown in Fig. 1 (center left), where NA denotes those who did not want to reveal their age. Respondents aged 44 and 55 were excluded from the analysis. The responses by special needs are shown in figure 1 (middle right), where the meanings of the special needs are as follows:

P1: 'Deficits in certain areas of learning (dyslexia, dysgraphia, dyscalculia ...)',
P2: 'Physical disability',
P3: 'Partial or total hearing loss',
P4: 'Partial or total loss of vision',
P5: 'Speech-language difficulties',
P6: 'Emotional and behavioral disorders',
P7: 'Long-term or chronic illness',
P8: 'Autism spectrum disorder',

In terms of university, one student was from the University of Maribor and 18 students did not specify their university. We assume that most of the students were from the University of Ljubljana.

As there are not enough complete responses for aspects Q4 and Q5 (less than 15) to draw more reliable conclusions, we only report the results for the first three aspects Q1: Technology and overcoming study barriers, Q2: Technology and study outcomes and Q3: ICT and Study Obligations.

The interpretation of the identified segments is based on manual inspection of identified clusters' specifics such as frequency of answers etc. Due to lack of space, we cannot reproduce these figures here.

4.3 Aspect Q1: Technology and overcoming study barriers

The main question was: "Please indicate how important each of the ICT assistive technologies listed is to you in overcoming the challenges you face in your studies due to your own specific needs."

Seg.	Q1a	Q1b	Q1c	Q1d	Q1e	Q1f
1	4.3	4.0	5.6	6.2	5.9	6.2
2	4.4	3.9	2.9	2.5	2.3	2.9
3	4.1	3.6	5.0	5.2	4.8	6.2
	Q1g	Q1h	Q1i	Q1j	Q1k	Q1l
1	5.9	4.1	6.1	5.5	4.9	6.0
2	2.2	3.5	4.0	3.6	3.2	3.4
3	5.3	3.6	3.5	3.8	3.9	5.3

Table 1: Aspect Q1: Averages of answers per segment.

According to the inertia curve and the dendrogram of the development of the segments, the number of identified segments can be set to 3 or 5. In line with the segment structure, we have opted for three segments.

The observed characteristics by segment are:

Seg. 1: The answers to all questions are the highest, i.e. all technologies are rated as very important. These are **technology enthusiasts**.

Seg. 2: Most questions are answered with low values. These are **technology sceptics**. Little importance is attached to most technologies, with the exception of e-materials, e-environments and multimedia content. This segment therefore scores well for e-materials, but not for content conversion tools, etc.

Seg. 3: Importance varies considerably on average. These are those who believe in and use some technologies but not others. They rate most technologies well, with the exception of visual and design customization tools.

4.4 Aspect Q2: Technology and study outcomes

The guiding question was: "Please indicate how important each of the ICT support services listed is to you in overcoming the challenges you face in your studies due to your own specific needs."

The number of segments was determined by combining the dendrogram and the "inertia" curve". We decided on 3 segments.

The observed characteristics by segment are:

Seg. 1: Technologies are of varying importance. These are **critical users**. They rate most technologies well, with the exception of audio-to-sketch, dictation, e-interpreting and audio-to-text tools.

seg. 2: They rate all technologies as very important. This is **technology Enthusiasts**, the first segment from a segmentation into two segments.

Seg.	Q2a	Q2b	Q2c	Q2d	Q2e	Q2f
1	3.4	3.0	3.4	2.6	3.1	4.3
2	4.4	6.0	4.9	6.2	6.3	5.8
3	1.5	1.5	1.0	1.0	1.0	1.0
	Q2g	Q2h	Q2i	Q2j	Q2k	
1	4.1	3.9	4.3	3.0	6.3	
2	5.0	5.0	5.3	5.7	6.2	
3	2.5	1.5	1.5	2.5	2.0	

Table 2: Aspect Q2: Averages of answers per segment.

Seg. 3: All technologies are classified as unimportant. These are **technology sceptics**. They classify most technologies as unimportant, with the exception of electronic communication and customized hardware.

4.5 Q3: ICT and Study Obligations

The guiding question was: "Please indicate to what extent you consider the use of ICT support important to fulfil the study requirements listed below."

Seg.	Q3a	Q3b	Q3c	Q3d	Q3e	Q3f	Q3g
1	4.2	3.6	2.4	2.2	4.4	2.2	5.4
2	4.2	4.5	5.0	4.9	5.0	4.9	5.9
3	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Table 3: Aspect Q3: Averages of answers per segment.

The number of segments was determined by combining the dendrogram and the "inertia" curve". We estimate that a reasonable number of segments is again 3.

The observed characteristics by segment are:

Seg. 1: The technologies are characterized by different applicability. These are **Critical Users**, which are Segment 1 of a two-segment segmentation. All technologies are classified as useful, with the exception of ICT to support independent work, to support group work and to support examination requirements.

Seg. 2: In this segment, all technologies are rated as very useful. This is **Technology Enthusiasts**, which is virtually identical to segment 2 of the two-segment segmentation.

Seg. 3: Here, the majority of respondents consider the technologies to be of little use. These are technology . They describe all technologies as not very useful, with the exception of support for direct distance learning.

5 CONCLUSIONS AND DISCUSSIONS

The student response rate was relatively low (5.8%, total N = 43). For the first three aspects listed in subsection 3.1, we found meaningful segmentations (for the last two aspects, there was not enough data to create segments). We did not find any common segments between the aspects. Obtained segments were expected and it was confirmed a useful grouping of students is doable. Further investigation of the segments would require at least 10 new responses in the first three aspects. In the near future, we will study the usage patterns of these students based on carefully designed case studies.

ACKNOWLEDGMENTS

This research was supported by the project P2-0246 ICT4QoL - Information and Communications Technologies for Quality of Life.

REFERENCES

[1] Miguel Alves Gomes and Tobias Meisen. 2023. A review on customer segmentation methods for personalized customer targeting in e-commerce use cases. en. *Information Systems and e-Business Management*, 21, 3, (Sept. 2023), 527–570. DOI: 10.1007/s10257-023-00640-4.

[2] R Amutha and Aazmaan Ahmed Khan. 2023. Customer Segmentation using Machine Learning Techniques. en. 44, 3.

[3] APA. 2020. APA Guidelines for Psychological Assessment and Evaluation. en. Institution: American Psychological Association. (2020). DOI: 10.1037/e510142020-001.

[4] Shu-Chen Cheng and Chiu-Lin Lai. 2020. Facilitating learning for students with special needs: a review of technology-supported special education studies. en. *Journal of Computers in Education*, 7, 2, (June 2020), 131–153. DOI: 10.1007/s40692-019-00150-8.

[5] Parag Dange et al. 2023. EXPLORING CUSTOMER SEGMENTATION WITH K-MEANS CLUSTERING ALGORITHM. en. 11, 4.

[6] Rabi Das. 2023. ICTs In Special Education: A Review. en. 11, 8.

[7] Louise Demers, Rhoda Weiss-Lambrou, and Bernadette Ska. 1996. Development of the Quebec User Evaluation of Satisfaction with assistive Technology (QUEST). en. *Assistive Technology*, 8, 1, (June 1996), 3–13. DOI: 10.1080/10400435.1996.10132268.

[8] Louise Demers, Rhoda Weiss-Lambrou, and Bernadette Ska. 2000. Item Analysis of the Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST). en. *Assistive Technology*, 12, 2, (Dec. 2000), 96–105. DOI: 10.1080/10400435.2000.10132015.

[9] Béatrice P. J. Dijcks, Roelof D. Wessels, Suzanne L. M. De Vlieger, and Marcel W. M. Post. 2006. KWAZO, a new instrument to assess the quality of service delivery in assistive technology provision. en. *Disability and Rehabilitation*, 28, 15, (Jan. 2006), 909–914. DOI: 10.1080/09638280500301527.

[10] Xiaofei He and Partha Niyogi. 2003. Locality preserving projections. In *Proceedings of the 16th International Conference on Neural Information Processing Systems* (NIPS'03). MIT Press, Whistler, British Columbia, Canada, 153–160.

[11] Nouri Hicham and Sabri Karim. 2022. Analysis of Unsupervised Machine Learning Techniques for an Efficient Customer Segmentation using Clustering Ensemble and Spectral Clustering. en. *International Journal of Advanced Computer Science and Applications*, 13, 10. DOI: 10.14569/IJACSA.2022.0131016.

[12] Louise Norman Jespersen, Susan Ishøy Michelsen, Bjørn Evald Holstein, Tine Tjørnhøj-Thomsen, and Pernille Due. 2018. Conceptualization, operationalization, and content validity of the EQOL-questionnaire measuring quality of life and participation for persons with disabilities. en. *Health and Quality of Life Outcomes*, 16, 1, (Dec. 2018), 199. DOI: 10.1186/s12955-018-1024-6.

[13] Jeffrey Jutai and Hy Day. 2002. Psychosocial Impact of Assistive Devices Scale (PIADS). en. *Technology and Disability*, 14, 3, (Sept. 2002), 107–111. Gert Jan Gelderblom and Luc P. De Witte, editors. DOI: 10.3233/TAD-2002-14305.

[14] Riyo Hayat Khan, Dibyo Fabian Dofadar, and Md. Golam Rabiul Alam. 2021. Explainable Customer Segmentation Using K-means Clustering. en. In *2021 IEEE 12th Annual Ubiquitous Computing, Electronics & Mobile Communication Conference (UEMCON)*. IEEE, New York, NY, USA, (Dec. 2021), 0639–0643. ISBN: 978-1-66540-690-1. DOI: 10.1109/UEMCON53757.2021.9666609.

[15] Dr Chitralekha Navneet Kumar, Dr Ramchandra Vasant Mahadik, Dr Sangeeta Paliwal, Dr Pallavi, and Chaitali B Kasar. 2024. Leveraging Deep Learning for Customer Segmentation: Patterns and Preferences Unveiled. en. *International Journal of Intelligent Systems and Applications in Engineering*.

[16] Theodoros A. Kyriazos and Anastasios Stalikas. 2018. Applied Psychometrics: The Steps of Scale Development and Standardization Process. en. *Psychology*, 09, 11, 2531–2560. DOI: 10.4236/psych.2018.911145.

[17] 2018. *Learning and teaching in the European higher education area*. en. OCLC: 1142675866. European University Association asbl, Brussels ; Geneva. ISBN: 978-90-78997-65-8.

[18] Sukru Ozan and Leonardo O. Iheme. 2019. Artificial Neural Networks in Customer Segmentation. en. In *2019 27th Signal Processing and Communications Applications Conference (SIU)*. IEEE, Sivas, Turkey, (Apr. 2019), 1–4. ISBN: 978-1-72811-904-5. DOI: 10.1109/SIU.2019.8806558.

[19] Rakeshkumar Umanath Upadhyay and Prof. Nilesh Choudhary. 2023. A Review of Customer Segmentation Methods. en. *International Journal of Advanced Research in Science, Communication and Technology*, (Mar. 2023), 684–692. DOI: 10.48175/IJARSCT-8904.

[20] David A. Siegel. 2010. The mystique of numbers: belief in quantitative approaches to segmentation and persona development. en. In *CHI '10 Extended Abstracts on Human Factors in Computing Systems*. ACM, Atlanta Georgia USA, (Apr. 2010), 4721–4732. ISBN: 978-1-60558-930-5. DOI: 10.1145/1753846.1754221.

[21] Hasan Ziafat and Majid Shakeri. 2014. Using Data Mining Techniques in Customer Segmentation. en. 4, 9.