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EMBEDDED SOLUTION FOR MARKETING SURVEY OF CUSTOMERS PERCEPTION

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Abstract: The main objective of the present paper is to design and implement a low-cost and friendly user electronic system used for surveys application. The proposed device is developed with a microcontroller platform, it has an LCD to display the statements, a keyboard to choose the corresponding option and an SD card on which the answers will be stored. The implemented system was tested in a marketing investigation on the customers perception on the sales-purchase services in a store. Also, the tool for the perception identification is proposed and at the respondents' answers are analyzed qualitatively and quantitatively.

Keywords: Arduino, customer perception, electronic survey, microcontroller, sales services.

1. INTRODUCTION

Microcontrollers have become very popular in last years due to its main advantages, such as low-cost, open-sources or friendly use, being a good solution in technical fields, but also in psychological or neurophysiological labs (D'Ausilio, 2012). There is a wide variety of applications where this platform brings benefit, including the improvement of customers satisfaction. In this sense, for example, a system for interacting with waiters in a restaurant was developed, making the communication easier and faster (Ahmed, *et al.*, 2022).

The Assessment of Knowledge Multiplatform Environment (AsKME) was implemented with Arduino to obtain a quiz game, using Jonny-Five platform, an infrared sensor, and a Liquid Crystal Display (LCD) screen (Khan, *et al.*, 2021). Also in quiz game area, a system for easier detection of participants was designed. The number of the contestant who pressed the button first is showed on a seven-segment display (Sarinho, *et al.*, 2018). Beside the game, some projects are developed with Arduino to obtain educational kit/platform (Ah-Fur, *et al.*, 2018, Mohamed, *et al.*, 2019, Yusoff, *et al.*, 2021, Zaharia, *et al.*, 2018) to test the students' knowledge. All these mentioned systems use a display (LCD or OLED, or the smartphone display (Ah-Fur, *et al.*, 2018) and a keyboard. The answers are validated through a message or/and with a LED (red – for wrong, green – for right).

The present paper proposes an electronic system designed and implemented with Arduino used for marketing research to identify the customers perception on the sale-purchase service in a store from Galati, Romania. The researched aspects were the staff behavior, the products organization, the environment, the shops space, the quality and presentation of the products, the schedule, and the way of the acquisition process. To identify the profile of the consumer-respondent, we added some questions regarding their gender, age and their origin environment.

Thus, the paper is an interdisciplinary one: the system for the questionnaire application and the tool for the perception identification are proposed and at the same time the obtained answers are analyzed

qualitatively and quantitatively. The system uses an LCD to display the statements, a keyboard to choose the corresponding option and an SD card on which the answers will be stored. The statements and the customers responses will be displayed on the same LCD, on different lines. There were 10 semantic differentials with simple and easy to understand text, and as answer options for the respondents appreciated the researched aspects according to the level of personal satisfaction. The assessment was made by bipolar adjective attributes, where 5 represents the maximum value given (assumes a high level of satisfaction) and 1 represents the minimum value (assumes a very low level of satisfaction).

The customers perception, opinions and satisfaction are very important in all activity sectors because the quality of services depends on these issues. The main objectives of any business are to have success and to maintain a comparative advantage in the marketplace. Evaluating the customers perception of the services they benefit from helps to improve them, it there are identified some problems in certain directions, and in the end, it can ensure their loyalty (Rusiyati, *et al.,* 2022). This is applicable in the banking sector (Osman, *et al.*, 2014), in restaurants (Namin, 2017, Rusiyati, *et al.,* 2022), in transport services (Brida, 2016), in medical sector (Widjajati, *et al.*, 2022), and also in stores industry (Avantaggiato, 2021), where the competition is fierce. In marketplace there are some key elements which directly influences the development and success of the store/shopping center, as well as the maintenance of the loyal customers. Weak points are identified using periodically a customer perception assessment tools and then improved based on the obtained results. They do not just buy objects/food/clothes etc., they also buy an experience (Dhakal, 2020). That is why this must be as pleasant as possible. The choices are not only made based on the products quality, but also based on the conditions in which these are purchased: the environment (Avantaggiato, 2021, Du, *et al.,* 2020), the lighting quality (Mayhoub, *et al.*, 2022), the atmosphere, the sellers' attitude, the price etc. (Jali, *et al.*, 2016).

The rest of the paper is organized as follows. In section 2, the marketing analysis methodology and the electronic system design are presented, in section 3 the computed software for the microcontroller is described. The results are presented in section 4 and chapter 5 concludes the paper.

2. SYSTEM DESIGN

2.1. Methodology:

As part of this research, we performed a quantitative analysis in order to identify the customers perception of the sales-purchase service in a store in Galati. Thus, between 07.11.2022 - 27.11.2022, we ran pilot research in which the tool used for data collection was a questionnaire adapted to an electronic system based on an embedded system with an SD memory card. The sample was made up of 127 respondents, customers of the store where we implemented the electronic system.

The investigated aspects were: the behavior of the staff, the organization of the products, the variety of the product range, the cleanliness of the store, the quality of the products, the positioning (location) of the store, the presentation of the products on the shelf, the working hours of the store and the way the purchase process is carried out. In order to identify the profile of the consumer-respondent, we added questions regarding their gender, age and environment of origin.

All research data and information are confidential and are kept as such without being published. This research complies with the legal provisions regarding the norms of ethics and deontology within the institutions of the national education system.

To identify the perception the analyzed aspects, we used 10 semantic differentials with simple and easy-to-understand text, and as answer options for the respondents appreciated the researched aspects according to the level of personal satisfaction. The assessment was made by bipolar adjective attributes, where 5 represents the maximum value given (assumes a high level of satisfaction) and 1 represents the minimum value (assumes a very low level of satisfaction).

127 people participated in this survey and giving marks for each researched aspect took an average of 5 minutes. The questions ran on the LCD display and each respondent typed the answer in the form of a note for each question. All respondents received clear explanations to complete, the survey being very simple.

The aim of the study was to identify the customers' perception of the purchase process carried out in a store in Galati.

Objectives:

• Analysis of how staff behavior influences the decision to choose the store;

• Analysis of how the presentation and organization of products in the store influence the buying behavior among the respondents;

• Analysis of the environmental impact of the store in the process of choosing a place to shop;

• Identifying the respondents' attitude towards the procurement process.

2.2. Implementation:

For implementing the desired analysis an electronic system was needed. A platform based on a microcontroller was designed and used for this project. The proposed embedded system is presented in Fig. 1. It contains the following electronic parts: development board, numeric keypad, LM044L display, SD memory adapter module OKY3001. There are different types of microcontroller-based development boards but for the proposed circuit there was chosen the board which has the Atmel 2560 chip. The microcontroller has many pins grouped in different ports which can have many functions such as analog inputs, digital i/o, pwm, usart interface and SPI interface.

The microcontroller runs at 16 MHz frequency having an external oscillator mounted on the board. It also has USB support used for communicating with PC using another microcontroller named CH340G as a USB to serial converter.

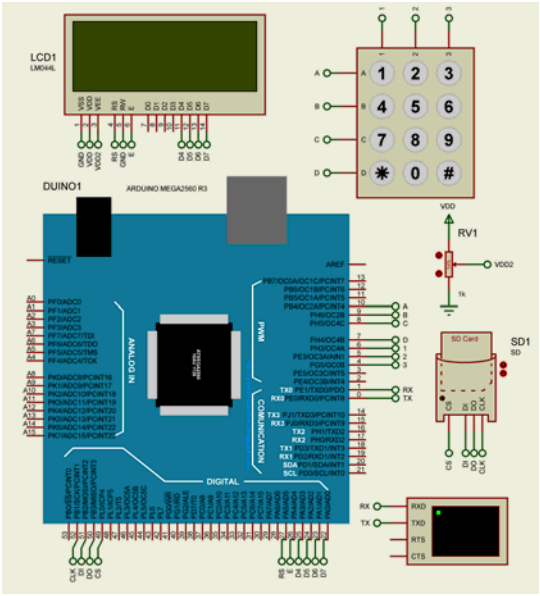


Fig. 1. Schematic of the designed system

The numeric keypad that was used has 12 buttons arranged in 4 rows and 3 columns. It can type numbers from "0" to "9" and also two symbols "*" and "#". Under each key there is a membrane switch. Switches in a row are connected together by a conductive trace and the same for the switches in the columns. The rows and columns are outputted to a total of 7 pins, a 4x3 matrix. When a button is pressed a switch closes and makes contact between a column and a row which allows the current to flow from a column pin to a row pin.

This is the method on how the microcontroller manages to read the keypad. In software the pins are declared as rows and columns. As seen in Fig. 1 rows are declared "A, B, C, D" and columns "1, 2, 3". Fig. 2 shows the internal structure of the keypad and how the buttons are connected.

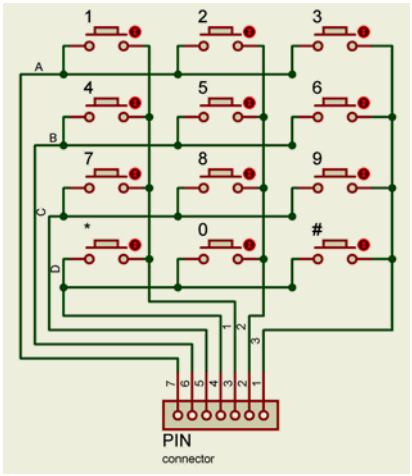


Fig. 2. Internal structure of the used keypad

For displaying the content, it was chosen a monochrome 20x04 LCD display that has 4 lines with 20 characters on each line and can show any character that is programmed in the microcontroller software. Also, the used LCD has backlight illumination which makes it ideal for our application. The potentiometer used in the schematic is for adjusting the contrast of the displayed characters. It can also be replaced with a fixed value resistor for simplicity. The display communicates with the microcontroller via parallel interface.

One important part of this project is working with data. For the data to be available first we need to store it. This process can be done in multiple ways depending on the data size and data type. For this system there was used a SD card which is popular among modern electronics like digital camera, mp3 players, mobile phones and others. SD memory cards and MicroSD memory cards have the same structure, but the size is different. With the memory card there can be done data logging in our case data from the completed questionnaires are going to be stored for further processing and analysis.

In the right side of Fig.1 there is the memory module. It has a PCB board, an SD memory socket and an AMS1117 voltage regulator chip. The voltage regulator chip is needed for the 3,3 and 5 voltage levels used in reading and writing a SD memory card.

In Fig. 3 it is presented the memory card module that will be used with the development board. Except for the power pins the module uses MOSI and MISO pins of the microcontroller along with SCK and CS pins used for communication via SPI interface. Using a SDIO interface can be faster but for our application SPI interface is enough and much easier to implement since it does require signing agreements.

The MISO pin represents the SD card module output, and it is marked on the schematic with "DO" mark meaning digital output. On the other side MOSI pin represents the SD card module input. It is marked on the schematic with "DI" which means digital input. The CLK (SCK) pin is a standard serial clock pin used in this case for synchronization of data transmission. The clock is received from our Microcontroller. The last "CS" pin is a control pin used for selecting devices on the SPI interface bus.

Fig. 3. Memory board

There are 3 different methods for powering the board. One of them is by using the USB port and the standard 5 volts. The second method consists of using the secondary power connector that needs an external power source of 7 to 12V preferably 9V. The third method is by using the microcontroller voltage input pin and one ground pin. It is advisable to not use a voltage lower than 7V because the board will become unstable due to the voltage regulator minimum input voltage required. This offers flexibility for implementing the system as it can be used as a portable system being powered using batteries or it can be powered from a power source.

In the schematic there is also included a virtual terminal for simulating UART serial interface implemented also in the Atmel 2560 microcontroller. The serial interface was implemented at a speed of 9600 baud and displays in the terminal what data is sent to the SD memory card.

3. SOFTWARE DESIGN

The following chapter presents the software implemented in the microcontroller for our proposed system.

For collecting data from the numeric keypad and store it on to an external SD memory card a software algorithm is made and written into the Atmel microcontroller. The microcontroller displays on the LCD screens 13 questions. The user of the system will respond using the numeric keypad. After each response the microcontroller sends data to the SD card to be stored. After the survey is completed, it is sent to the memory card the number of the people that have completed the responses so for each person the counter will be incremented, and the data will be stored along with the answer for each question. This data can be extracted later on from the SD card and used for different analysis. We can easily adapt the algorithm for different applications by using different question, different type of answers and storing the data on an SD memory card. Also, the system can be adapted to work not only as an interaction with a human but also as an autonomous system that can collect data from different sensors and can store it on memory support in other words a data logging system. These types of systems have a high rate of demand in industry in a lot of fields. To expand this system another module can be attached so that the project can automatically send the stored data on the internet to a specific address.

For our applications we have used 10 questions each of them having 5 possible answers, 2 of them having 2 answers and the last one 6 answers. It was also used the serial (USART) interface mostly for testing purposes since the project was implemented as a mobile portable system that can also run-on batteries.

The implemented software's block diagram is presented in Fig. 4. First try was made on a smaller microcontroller Atmel 328p but its memory was too low for our application, and we decided to use a chip that has more memory to work with. The code occupies 7% of the microcontroller program storage memory more exactly it uses 19132 bytes of 253952 bytes in total available. On the other side it uses 24% of the microcontroller dynamic memory 1980 bytes from a total of 8192 bytes. We have decided to change our microcontroller due to the reach of 90% occupied memory on the Atmel 328p. This made it instable and returned a lot of errors when running. Since the chosen Atmel 2560 has a bigger memory, it can also be very easily adapted for more complex systems. The initial step of the designed software consists in libraries initializations, variables and pins declarations and numeric keypad reading and defining the 4x3 matrix used.

Following is the initialization of the Serial interface and after this the initialization of the SD memory card module. As a precaution measure to not lose any data if the program manages to successfully initialize the SD card it will do the next steps if not it will stop and try again.

The next step is to display on the screen a text in which the person is explained how to use the numeric keypad. After a short delay the text switches to the next message in which the person is asked to start the survey by pressing the 0 button on the numeric keypad. After each of these steps a counter is incremented. If by any means the counter will fail to increment the program will remain at that step.

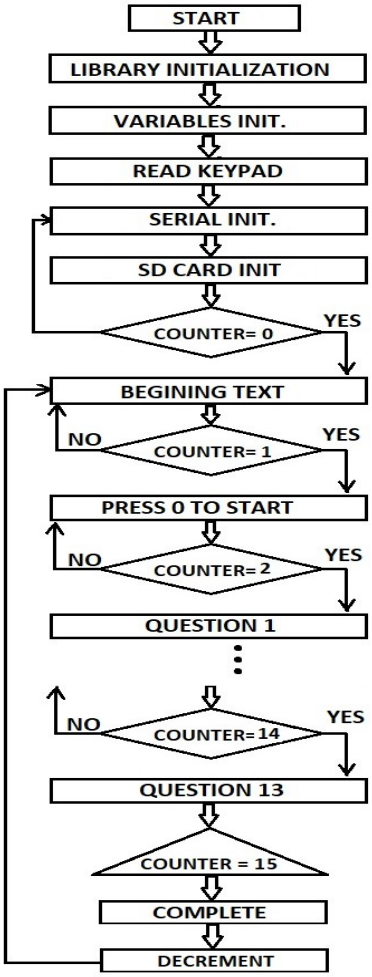


Fig. 4. Schematic of the embedded system software

After the "0" button is pressed the survey will start and, the first question will be displayed on the screen. The user can answer to it by giving a note from 1 to 5 depending on his/her level of satisfaction. By pressing the corresponding button, the counter will then increment again, and the software will pass to the next question. There are other steps in here before incrementing like sending data on the serial interface, regularly clearing LCD screen and also sending data to the SD memory card in an .txt extension file created by the microcontroller at the beginning of the SD initialization. These steps repeat for each question that we have until the survey is over.

On the last question in this case the 13th one the counter will now reach 15 values. Now a message that the survey was completed will be displayed and the number of the client/ user will be sent to SD card and on the Serial interface.

The last step is to decrement the counter to 0 and after that the system is ready for the next client/ user to complete another survey and to collect and store data.

4. RESULTS

4.1. Embedded System simulation:

For our system validation, we have done more simulations and physical testing. The physical testing was done by combining our project with a marketing approach and the results will be presented in section 4.2. The simulation part was made in Labcenter environment software. It was used Proteus software to simulate the entire system functions and parts.

The software can also simulate code programming to Atmel microcontroller allowing the test of different features prior to making the system in real.

Fig. 5 presents the starting of the system in simulation. On the 20x04 display it can be observed the first message with instructions on how to respond to the following questions. The black window represents the serial interface simulation that displays a status message of the SD card communication.

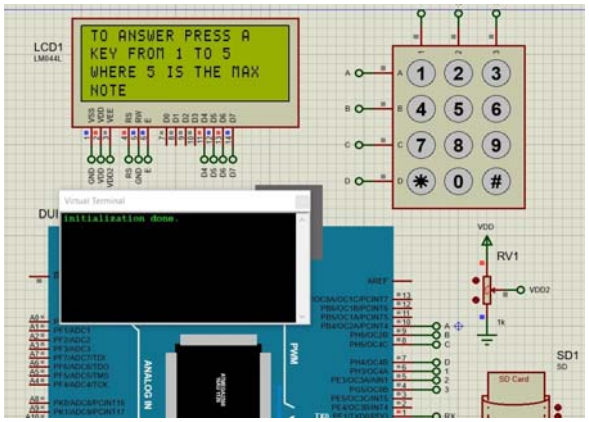


Fig. 5. Starting of simulation

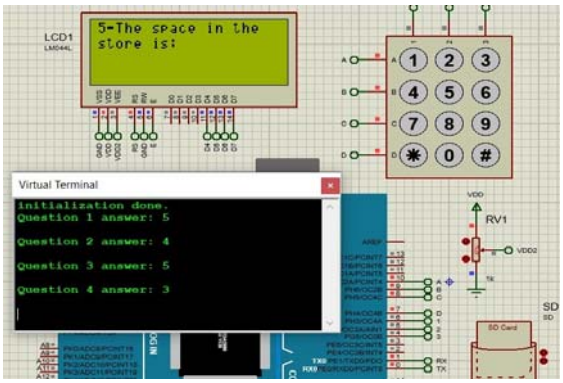


Fig. 6. Question 5 in simulation

The next figure (Fig. 6) presents the simulation of the 5th question on the LCD display. In the serial window we can see the answers to the last questions, answers that were also sent to the SD memory card using SPI interface.

After the completion of a survey the displayed messages from Fig. 7 are shown and the number of the completed surveys are sent on USART and also stored on the card (Fig. 8). In this way a database of information can be gathered.

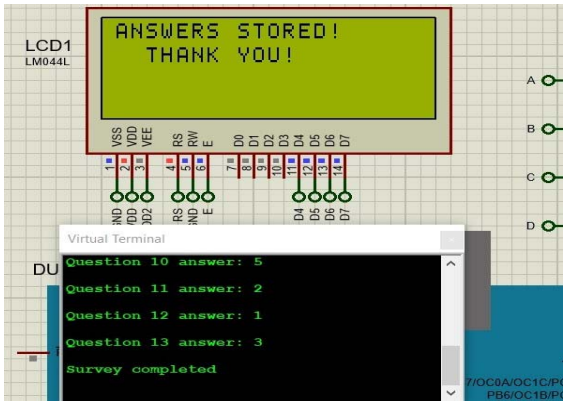


Fig. 7. Completion of one survey

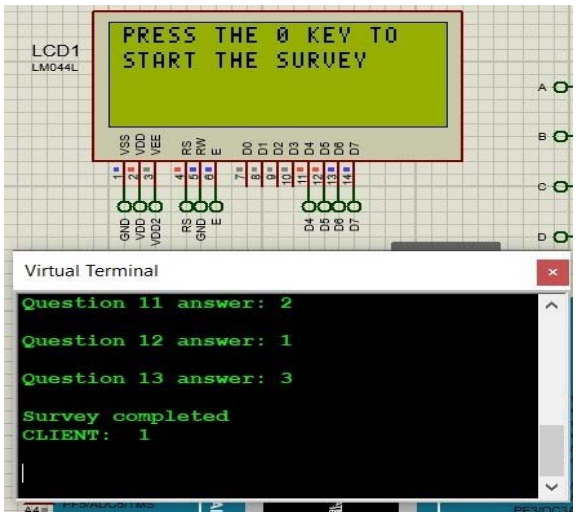


Fig. 8. Survey number sent to serial

After a completed survey, the respondents number is incremented and stored, and the questionnaire restarts so that a new survey can be applied to another customer.

In Fig. 9 a digital analysis of the LCD data signals is displayed. The image shows a virtual oscilloscope with 4 channels connected to pins D4-D7 of the parallel interface of the LCD display. The signals represent o portion of the displayed message on the display: "PRESS THE 0 KEY TO START THE SURVEY".

The next image, Fig. 10, shows the build system presented in the article. On the display it is showed the beginning of a survey.

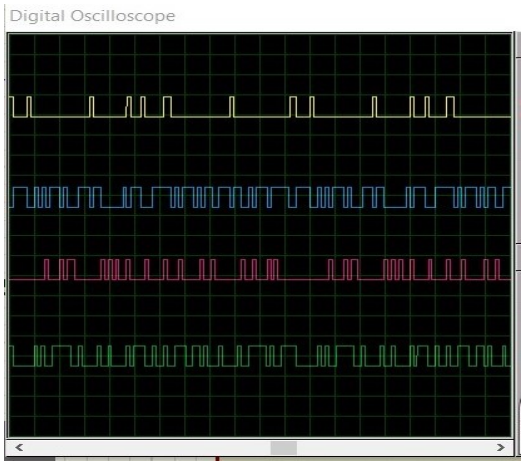


Fig. 9. Digital analysis of LCD data signals

Fig. 10. Microcontroller based system

4.2. Marketing Results:

In this section it is presented the marketing analysis implemented in the embedded system. Due to the system capabilities other analysis like sensors data logging via SD card or via internet can also be implemented in future projects. For the following an analysis and interpretation of quantitative results are made. After data centralization, the following conclusions were drawn for the survey questions included in the software part implemented in the microcontroller development board. In this research, 83 women and 44 men were participated.

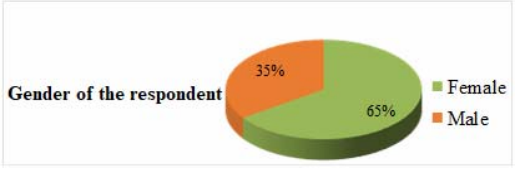


Fig. 11. Gender graphical representation

Most of the people who responded to this questionnaire come from the urban environment 77% (n=98), and 23% (n=29) from the rural environment.

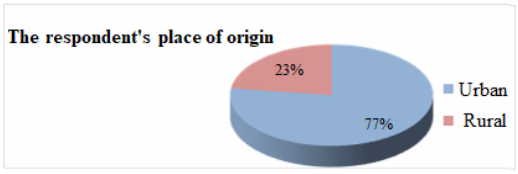


Fig. 12. Respondents' origin representation

Most of the respondents are aged between 45 - 54 years (56%, n=71), followed by the categories 35 - 44 years (17%, n=21) and 18 - 24 years (14%, n=18) and finally the 25 - 34-year-old category (13%, n=17).

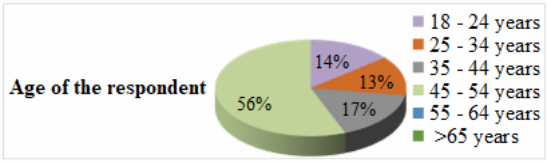


Fig. 13. Respondents age representation

The behavior of the staff score: [(100 x 5) + (21 x 4) + (6 x 3) + (0 x 2) + (0 x 1)]/127 = **4,740**

Organization of products score: [(80 x 5) + (38 x 4) + (9 x 3) + (0 x 2) + (0 x 1)]/127 = **4,559**

The ambient environment score: [(102 x 5) + (20 x 4) + (5 x 3) + (0 x 2) + (0 x 1)]/127 = **4,763**

The range of products score: [(88 x 5) + (39 x 4) + (0 x 3) + (0 x 2) + (0 x 1)]/127 = **4,692**

The space in the store: [(102 x 5) + (18 x 4) + (7 x 3) + (0 x 2) + (0 x 1)]/127 = **4,748**

The quality of the products score: [(95 x 5) + (30 x 4) + (2 x 3) + (0 x 2) + (0 x 1)]/127 = **4,732**

The location of the store: [(89 x 5) + (38 x 4) + (0 x 3) + (0 x 2) + (0 x 1)]/127 = **4,700**

The presentation of the products score: [(89 x 5) + (32 x 4) + (6 x 3) + (0 x 2) + (0 x 1)]/127 = **4,653**

The store's opening hours score: [(87 x 5) + (37 x 4) + (3 x 3) + (0 x 2) + (0 x 1)]/127 = **4,661**

The acquisition process score: [(98 x 5) + (29 x 4) + (0 x 3) + (0 x 2) + (0 x 1)]/127 = **4,771**

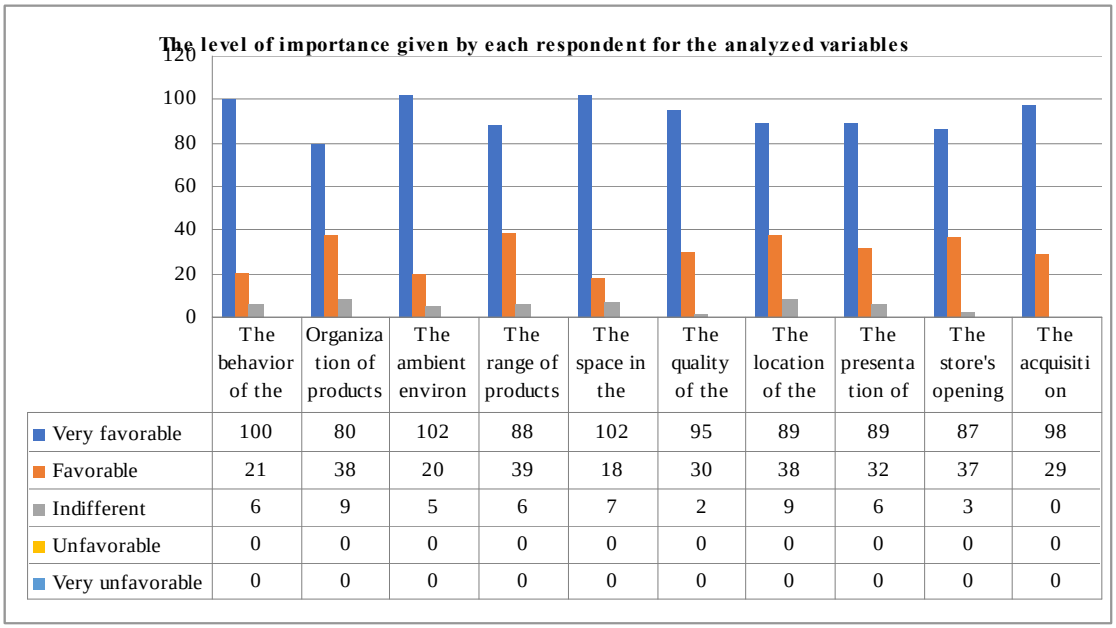
Total score: $(S + S_2 + S_3 + S_4 + S_5 + S_6 + S_7 + S_8 + S_9 + S_{10}))/ 10 = 4,701$

Regarding the application of semantic differentials, we obtained the results presented in Fig. 14.

The scores obtained for the variables: staff behavior, ambient environment, space, product quality and the purchase process are high, higher than the overall score, which proves that the respondents take these criteria into account when choosing the store from which they shop, having a direct influence on the final decision.

But the variables: product organization, product range, store positioning, product presentation and working hours scored lower than the overall one, which means that these aspects need to be improved. Thus, products should be better reorganized on the shelf to attract customers' attention, the range of products is quite limited and should be diversified.

Also, product presentation should be improved, and the store's working hours should be adapted to customer requirements. The store positioning variable obtained a score almost equal to the global



	The behavior of the	Organization of products	The ambient environ	The range of products	The space in the	The quality of the	The location of the	The presentation of	The store's opening	The acquisition
Very favorable	100	80	102	88	102	95	89	89	87	98
Favorable	21	38	20	39	18	30	38	32	37	29
Indifferent	6	9	5	6	7	2	9	6	3	0
Unfavorable	0	0	0	0	0	0	0	0	0	0
Very unfavorable	0	0	0	0	0	0	0	0	0	0

Fig. 14. The level of importance given by each respondent for the analyzed variables

score, which shows that the purchase process was not greatly influenced by this aspect, customers appreciated more other aspects related to the quality of the products and the behavior of the sales staff.

Synthesizing the information gathered, we identify the importance given by the respondents to the process of choosing a store to do their daily shopping. Such research is especially effective for large stores to identify the degree of satisfaction of respondents even after the completion of the purchase process so that inconveniences can be eliminated as quickly as possible. So, the respondents can be encouraged to express their opinion, and finally be able to participate through their answers in changing the aspects that do not conform to their expectations and requirements.

In the future, for greater accuracy of the results, we want to expand the research to a national level to study a representative sample in order to obtain an overview of the purchase process and customer satisfaction in a physical store using the electronic system based on a microcontroller development board and an SD card.

Variables used in the research are:
1. Evaluate the following statement: The behavior of the staff was:
Very friendly 5 4 3 2 1 **Very unfriendly**
2. Evaluate the following statement: In the store the organization of products on the shelf is:
Very favorable 5 4 3 2 1 **Very unfavorable**
3. Evaluate the following statement: The ambient environment in the store is:
Very pleasant 5 4 3 2 1 **Very unpleasant**
4. Evaluate the following statement: The range of products is*:*
Very varied 5 4 3 2 1 **Very unvaried**
5. Evaluate the following statement: The space in the store is:
Very clean 5 4 3 2 1 **Very dirty**
6. Evaluate the following statement: The quality of the products in the store is:
Very good 5 4 3 2 1 **Very bad**
7. Evaluate the following statement: The location of the store is:
Very favorable 5 4 3 2 1 **Very unfavorable**
8. Evaluate the following statement: The presentation of the products on the shelf is:
Very favorable 5 4 3 2 1 **Very unfavorable**
9. Evaluate the following statement: The store's opening hours are:
Very favorable 5 4 3 2 1 **Very unfavorable**
10. Evaluate the following statement: The acquisition process was:
Very simple 5 4 3 2 1 **Very hard**
11. Your gender is:
Female 1 **Male** 2
12. Your home environment is:
Urban 1 **Rural** 2
13. Your age is:

18-24 years old	25-34 years old	35-44 years old	45-54 years old	55-64 years old	> 64 years old
1	**2**	**3**	**4**	**5**	**6**

5. CONCLUSIONS

The present paper proposes an electronic system using a microcontroller useful in many applications. It is able to display messages on an LCD display, interact with exterior using a numeric keypad and also can store data on an SD memory card. The system was tested in simulation environment in Labcenter program but also in real life combining a marketing solution that was detailed presented. The marketing research identifies the customers perception on the sales-purchase service in a store. The analysis was made based on the data collected from the microcontroller and stored on the SD memory card. The results showed that the questionnaire is easy to be applied on the proposed platform and some of the used variables obtained a lower score than the overall one which means that those aspects need improvements. As future research the design of the system can be adapted so that it can read data sensors and store the data on external memory or even send it via internet with the help of newly added electronic parts.

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