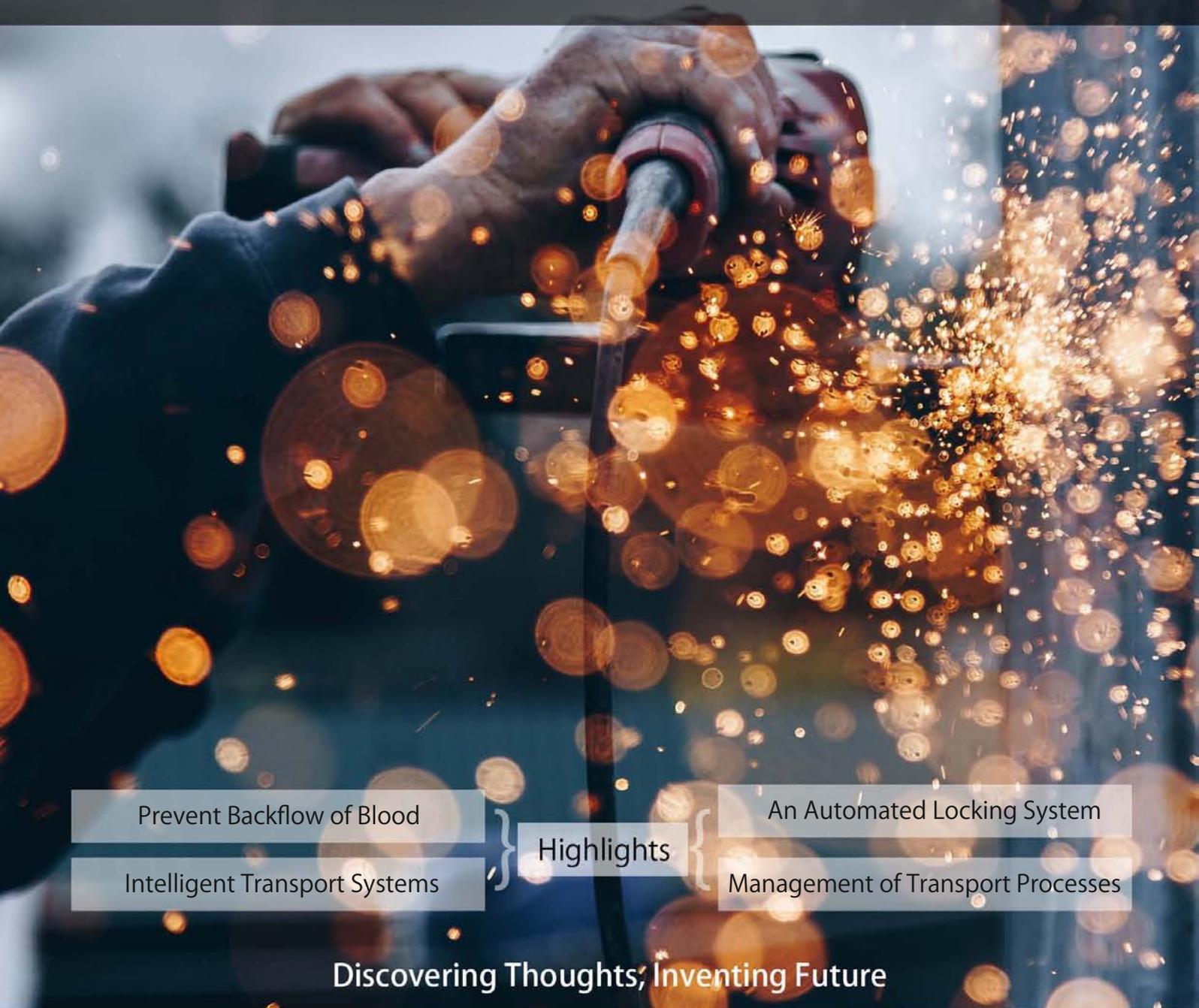


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## Quality Management System in Educational Institutions: Integration of FMEA and PROMETHEE II

By Renata Maciel de Melo, Everton Ramos dos Santos,  
Maria Helena Lasserre Ferreira & Luciano Pereira da Silva Santos

*Federal University of Pernambuco*

**Abstract-** Competitiveness is increasingly rooted in organizations. Therefore, the pursuit of excellence in the provision of services has been a challenge for those wishing to occupy prominent positions. This reality is usual in public schools that make decisive decisions in the face of constraints, as resources are limited and need to be well managed. Quality management has been a strategy adopted by many educational institutions in the pursuit of process improvement and has inspired many organizations in this regard. This work intends to be an opportunity for schools experiencing difficulties in implementing and maintaining a Quality Management System (QMS) based on ISO 21001:2018. For this, we propose a model, which aimed to integrate the *Failure Mode Effects Analysis* (FMEA) of the process and the PROMETHEE II method and the adoption of two new criteria (Difficulty for failure mode resolution and Time required for fault mode to be “solved”). The model was composed of alternatives that represent the potential failure modes of Traditional FMEA, which were raised in the literature and through a semi-structured interview with the decisionmaker.

**Keywords:** *quality management system; educational institution; FMEA; PROMETHEE II.*

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# Quality Management System in Educational Institutions: Integration of FMEA and PROMETHEE II

Renata Maciel de Melo <sup>α</sup>, Everton Ramos dos Santos <sup>σ</sup>, Maria Helena Lasserre Ferreira <sup>ρ</sup>  
& Luciano Pereira da Silva Santos <sup>ω</sup>

**Abstract-** Competitiveness is increasingly rooted in organizations. Therefore, the pursuit of excellence in the provision of services has been a challenge for those wishing to occupy prominent positions. This reality is usual in public schools that make decisive decisions in the face of constraints, as resources are limited and need to be well managed. Quality management has been a strategy adopted by many educational institutions in the pursuit of process improvement and has inspired many organizations in this regard. This work intends to be an opportunity for schools experiencing difficulties in implementing and maintaining a Quality Management System (QMS) based on ISO 21001:2018. For this, we propose a model, which aimed to integrate the *Failure Mode Effects Analysis* (FMEA) of the process and the PROMETHEE II method and the adoption of two new criteria (Difficulty for failure mode resolution and Time required for fault mode to be “solved”). The model was composed of alternatives that represent the potential failure modes of Traditional FMEA, which were raised in the literature and through a semi-structured interview with the decision-maker. The differential of this work is in the adoption of two new criteria that differ from those addressed on traditional FMEA: Difficulty in failing mode resolution and Time required for the failure mode to be “cleared.” The application happened in an institution of the integral public education system, located in the State of Pernambuco (Brazil), supported by the Visual PROMETHEE software. In the end, the ordering among the barriers considered most critical to the QMS implementation process was obtained and, there was the development of guidelines to solve them.

**Keywords:** *quality management system; educational institution; FMEA; PROMETHEE II.*

## I. INTRODUCTION

In general, consumers have changed their way of thinking and acting, being more demanding in terms of the search for the added value that products and services can provide them. This change is no different in the educational field, since defining quality in education is not trivial because it involves several functions and activities that directly or indirectly influence the concept.

The growth in the number of public education institutions in Brazil, in recent decades, has driven

studies and research on the dynamics of what has led to this evolution and its influence on the educational development of the country. From this, several opportunities arise on how to improve the management process to guarantee quality in education.

Even with so many different definitions, there is a common understanding that quality in education is not measured only by the performance of students. It is above all, according to Coutinho & Borges (2018), a consequence of well-conducted processes that lead to the expected learning, which offers an adequate for the acquisition of knowledge and well-prepared and instrumentalized teachers for the conduct of students.

According to Cassol *et al.* (2012), the quality of Brazilian education has low-performance rates when compared to other countries in the world. Among the major causes related to this, the same authors mention some: lack of investment efficiency, ill-prepared professionals, lack of adequate school management, etc. Achieving excellence in teaching is today a huge challenge and, schools need to develop different strategies than what has been offered today to achieve this goal.

Santos & Melo (2019) define that quality management is an essential perspective for the development of efficient management, and, increasingly, managers of organizations are complementing their strategic quality planning with the support of the other tools to achieve competitive advantage. In this context, having an effective quality management system (QMS) is essential to maintain a regular supply of high-quality products and services to customers (Zu & Kaynak, 2012).

Therefore, according to Cassol *et al.* (2012), the adoption of a quality management system in education seeks to ensure that planning, organization, control, and leadership are conducted, ensuring assertiveness and continuous improvement of its performance and, especially quality of education, that is the development of student's skills.

Organizations regularly need to make decisions under varying criteria that conflict with each other. Based on this scenario, developing a multi criteria analysis that assists in this process will be of great help

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in minimizing the negative consequences that decision-based on only one criterion can cause.

Consequently, this work seeks to develop a multi criteria analysis to order the most critical failure modes in the process of implementing and maintaining a QMS in a public-school institution. For this, there was the integration between the FMEA of the process and PROMETHEE II.

## II. QUALITY MANAGEMENT IN EDUCATIONAL INSTITUTIONS

For the institutions to function correctly, according to Rodríguez-mantilla, Fernández-cruz & Fernández-díaz (2019), they must have enough teachers and resources to carry out their activities. However, such an action does not always happen.

In the last decades, there has been a development and massification of education, which has not always corresponded to the transfer of public funds for education in the same proportions (Parker, 2002). This situation has led educational institutions, in the sense of guaranteeing quality, to seek to do more and better with fewer resources (in relative terms) and has raised issues of management effectiveness and responsibility. For Sahney, Banwet, and Karunes (2004), quality starts with the client and at the same time is conceptualized by the client, so it is up to them to identify and provide the best performance with the resources that the organization has.

In this context, the educational institution that intends to achieve excellence in its services through a quality management system must present specific characteristics (Figueiredo Neto & Rodrigues, 2000): focus centered on its main client, the student; managers' commitment, vision, documented and optimized processes, trained employees to perform tasks, information with quick and correct circulation, concern with innovation and change and strong team spirit.

In the face of all of this discussion, a term widely applied in the practice of quality management in education and which is fundamental to the pursuit of excellence is Total Quality Management (TQM), in other words, it is a management approach used by an organization centered on quality, where the participation of all members is extremely critical and fundamental for the achievement of successful objectives. Wahid (2019) records this fundamental aspect of everyone's involvement to obtain good results at the university, for example.

In this way, TQM can be considered as the basis for the implementation of other improvement approaches. In education, a difficulty pointed out by Xavier (1991) is that the raw material of the processes, the student, is heterogeneous. Each one brings a wealth

of knowledge, customs, cultures, etc., making the exit process a very unpredictable process.

The same author also points out are five points that managers must consider in education in the search for total quality, namely:

- Compliance: the service provided by the institution must be by the previously defined specifications;
- Prevention: involves the measures used by the institution to avoid mistakes made in the process;
- Excellence: refers to meeting quality requirements at all stages of a process, turning a product or service free from defects;
- Mediation: it is the source for decision making since it is necessary to measure actions and results to find opportunities for improvement;
- Responsibility: the need for everyone involved in the institution to understand their responsibility for the functioning of the process.

On the other hand, some difficulties may arise in this attempt to get closer to the characteristics of TQM, requiring strong attention from the manager on the following points: passivity of management, change of objectives, search for immediate results, changes in administration, among others.

### a) NBR ISO 15419 AND ISO 21001

The ISO 9001 Standard contains the requirements for an organization to have its QMS certified. The scope and generality of this standard do not take into account particular and peculiar aspects of the different types of organizations and, therefore, the terminologies are generic

Thus, one of the prime difficulties in applying the ISO 9001 standard in the educational area was terminology. Hence the decision to develop a document that would offer the guidelines and enable establishments to improve management, and consequently, education.

From this, the ABNT (Brazilian Association of Technical Standards) standard NBR ISO 15419 came to be, which aims to facilitate the comprehension and interpretation of the requirements of ISO 9001 under the understanding of the organizations involved as an educational sector, using the specific terminologies of this sector.

However, in May 2018, ISO 21001:2018 was launched, which was the first edition of the international standard for management systems for educational organizations (EOMS). The Portuguese version of the norm was due to be launched in 2019. The main goal of this standard is to be a management tool, prevalent to educational organizations, to respond to the expectations of interested parties. All requirements of ISO 21001:2018 are generic and any educational organization can apply it.

While educational organizations and students are the main stakeholders and beneficiaries of this

document, all other stakeholders will also gain from standardized management systems in educational organizations.

Among the potential benefits that an organization can obtain with the implementation of an EOMS, we can mention, according to Nogueira (2018): better alignment of objectives and activities with police, greater social responsibility, more personalized learning and effective response to all students, consistent processes and assessment tools to demonstrate and increase effectiveness and efficiency, greater organization credibility, culture for organizational improvement, etc.

### III. FMEA IN THE CONTEXT OF QUALITY MANAGEMENT

Santos & Melo (2017) define that FMEA is a valuable team activity that can help in the creation or restructuring of a quality assurance program with to improve safety, quality, and efficiency.

FMEA is a tool widely used to obtain good results both in the product and in the process. For Rabelo, Silva & Peres (2014), the FMEA methodology is put in place to define and prioritize the corrective methods in a project, thus becoming aware of the critical, significant characteristics and, finally, developing a checklist of prevention for failures. According to Kibria, Kabir & Boby (2014), the successful activities by FMEA facilitate the identification of failure mode according to experiences, reducing cost and development time.

According to Ford *et al.* (2014), despite being valuable, the FMEA also has some crucial limitations that must be appreciated, one of which is the inability to identify all possible failure modes. Therefore, it is possible to see FMEA as complementary to other improvement methods and tools.

This tool takes into account the use of import elements: type of potential failure, the effect of possible fail, cause of the failure, current controls, indexes, recommended actions, implemented measures, preventive actions, containment actions, etc.

Santos & Melo (2019) point out that the faults considered most critical will be the first in the ranking, thus being a priority for the application of improvements. The determination of the risk priority index (Risk Priority Number – RPN) is performed based on the product between three indices defined by Liao & Ho (2011):

- Severity (S): indicates the degree of impact caused by the failure of an individual component or procedure;
- Occurrence (O): indicates the degree of the frequency with which a defeat can occur;
- Detection (D): indicates the degree of impact caused by the fail that cannot be detected.

In this specific work, where the process of implementing a QMS in an institution of the public

education system was analyzed, the process FMEA was used, which after collecting the main flaws/difficulties found in the literature and through a semi-structured interview with the institution's manager, it analyses their criticality about the process of implementing a QMS based on ISO 21001:2018 standard.

Due to the complexity of the QMS implementation process, the study of the main failure modes requires a multicriteria analysis, since it is difficult to make a decision based only on one criterion and, in most cases, these criteria are in conflict with each other.

### IV. MULTICRITERIA DECISION METHODS

The purchase of consumer goods, personal items, household appliances, and even the choice of an educational institution are problems faced daily by people. The solution to many of these types of difficulties is, in most cases, based on a single decision parameter, cost. Nevertheless, not all decisions are summarized just in this, which leads the decision-maker to seek the best decision support methods that satisfy his application needs.

The first methods of decision support started to emerge, in estimation, around the 70s, which for Olson (2001) the development of comparative research about the methodology of support for the multicriteria decision, has been showing that there is not one that stands out from the other, involving the entire context of the decision. Thus, it is up to the decision-maker to use the best method for that specific situation.

For Cavalcanti & Almeida (2005), we can see multicriteria decision support as a set of methods that lend themselves to clarify a problem, in which multiple criteria evaluates the alternatives, which are normally conflicting.

Gomes Júnior *et al.* (2011) put out that the main factors analyzed in choosing a multicriteria decision support method are analysis of the context, actors, and preference structure associated with the problem.

#### a) PROMETHEE II

The family of PROMETHEE methods aims to build a relationship of Outranking; this family adds information between the alternatives and the criteria and uses this relationship to support the decision. In PROMETHEE, the decision maker's preference in favor of one option over another option b increases with a bigger difference  $[f_i(a) - f_i(b)]$  between the performance of the choices for each criterion j and  $f_i(a)$  and  $f_i(b)$ , respectively, are the values of the performance of the options a and b in criterion j.

Brans and Vincke (1985) presented six different ways to determine such a preference, which have values between 0 and 1 from the definition of the general functions, or preferably. Type I – Usual Criterion, Type II- U-Shape Criterion, Type III- U-shape Criterion, Type IV– Level Criterion, Type V– Linear Criterion, and Type VI –

Gaussian Criterion are the classifications of these functions.

The PROMETHEE II, the focus of the work, took the non-compensatory hypothesis, which tends to favor more balanced alternatives (alternatives that have reasonably good ratings in all criteria) and provides a cardinal score for each proxy that is possible to use to develop a pre - complete order.

This method ranks the alternatives, establishing an order of  $\Phi(a) = \Phi^+(a) - \Phi^-(a)$  (liquid flow); establishes a complete pre-order among the alternatives. (BRANS & VINCKE, 1985; BRANS & MARESCHAL, 1992; TALEB & MARESCHAL, 1995):

### V. PROPOSAL AND APPLICATION OF THE MODEL

The proposed model aims to integrate FMEA and PROMETHEE II, wanting to order the difficulties (from the most critical to the least critical) encountered in the process of implementing and maintaining a QMS, based on ISO 21001:2008, in an institution of the public comprehensive education network in the city of Bezerros, in the rough Pernambuco state.

For the construction of the model, it was necessary to identify the alternatives and the criteria that will go under evaluation, as well as their particularities, to then be applied with the aid of the Visual PROMETHEE software, and thus, obtain what is expected of it more effectively.

#### a) Description of the Education Institution of the Case to be Applied

The studied school has been operating since 2012. High school has integrated technical courses in

the areas of Administration and Maintenance and Computer Support.

The installed capacity of the school follows the standard of state technical schools in the state of Pernambuco, Brazil, and has twelve classrooms, six laboratories, two specific laboratories, for craft courses, an auditorium, a library, a multisport court (covered and with a changing room), a coffee shop, canteen, and a living area.

The school is not certified by ISO 21001:2018, but it is concerned with developing its activities with a focus on quality so that it can effectively serve interested parties. The manager has excellence as a priority and works with the expectation of making the school recognized by society as a reference for professional education.

#### b) Alternatives

Some results, gathered from the literature, were presented to the decision-maker regarding the biggest obstacles in the process of implementing and maintaining a QMS in organizations as a whole. Also, the authors conducted a semi-structured interview with the institution's manager, who addressed the five fundamental points that must be considered in education in the search for total quality, in addition to taking into account elements such as infrastructure, information exchange process, the role of the state, involvement of families, etc. From this, it was possible to identify new failure modes for the multicriteria analysis.

At the end of this stage, the authors raised the eleven main difficulties that the manager has encountered, as shown in Table 1.

Table 1: Model alternatives

Label	Alternatives	Source
A1	State bureaucratic requirements	Educational Institution Manager and MokhtarSanyet <i>et al.</i> (2013)
A2	Lack of resources	Biasini (2012); Tanabe & Souza (2006);
A3	Failure to communicate with teachers	Educational Institution Manager and Beer (2003) and Klein & Sorra (1996)
A4	Staff demotivation	Biasini (2012); Tanabe & Souza (2006); Beer (2003); Taylor & Wright (2003); Klein & Sorra (1996)
A5	Change in school culture	McLean & Antony (2014); Beer (2003); Klein & Sorra (1996); Biasini (2012); Tanabe & Souza (2006); Fleury(1993).
A6	No internship requirement for technical courses offered by the school	Educational Institution Manager, Taylor & Wright (2003) and MokhtarSanyet <i>et al.</i> (2013)
A7	Low family participation in monitoring children at school	
A8	Insufficient full-time staff	
A9	Lack of a team of psychology professionals	
A10	Resistance by the outsourced team of general services	
A11	Not knowing the demands of students regarding the technical courses offered by the school	

Source: The authors (2020)

c) *Criteria*

According to Roy (1996), we can understand a criterion as being a tool that allows the comparison between alternatives according to the point of view or from the perspective of significance.

Given that there are many sceneries that may require different levels of importance, the decision model must consider the subjectivity of the decision-maker for decision making. This approach is not common to traditional FMEA.

So, through the semi-structured interview, the decision-maker understood the definition of the criteria and considered the following criteria for this model:

- The occurrence of failure mode (O);
- Possibility of the failure not being detected (D);
- The severity of disaster (S);

- Difficulty in resolving failure mode (DIF);
- The time required for the failure mode to be “eliminated” (T).

Given the chosen criteria, it is indispensable to clarify that the first three (occurrence, detection, and severity) refer to the traditional FMEA and that the choice for the last two (difficulty and time) was so that there would be a substantial contribution to the analysis, further refining the assessment made through the FMEA and making the study more robust and refined.

For each of these criteria, the objective (minimizing and maximizing), weight (importance), and the preference function were established by the decision-maker, as shown in Table 2.

Table 2: Details of the criteria

Criteria	Objective	Weight	Preference Function
Occurrence	Maximizing	0,2	Usual
Detection	Maximizing	0,1	Usual
Severity	Maximizing	0,3	Usual
Difficulty	Maximizing	0,2	Usual
Time	Maximizing	0,2	Usual

Source: The authors (2020)

The evaluation of the weights attributed by the decision-maker occurred in a direct (interactive) way. The authors based the objective chosen for each criterion on the Likert scale used to assist in the identification of its criticality regarding the alternatives (Tables 3, 4, 5, and 6). To find the most critical flaws, the authors established to maximize the resolution time in months. For the criteria of occurrence, detection,

difficulty, and severity, the objective chosen was also the maximize, as the values of the nominal scales of the software are different comparing to those of the model (Table 3, 4, 5 and 6), in which very bad =1 and very good=5. Then, as you maximize the best outcome from the software, you also maximize the most critical result from the model.

Table 3: Scales used to determine the occurrence of failures

Occurrence		Likert Scale
Unlikely	It rarely occurs in the process	1
Too Small	Failure occur, but not too often	2
Moderate	Sometimes the cause of failure during the process occurs	3
High	Failure occurs quite frequently during the process	4
Alarming	It occurs routinely during the process	5

Source: Santos & Melo (2019)

Table 4: Scale used to determine failure detection

Detection		Likert Scale
High	The failure is immediately identified in the process as a decisive factor for the good functioning of the QMS	1
Moderate	The failure is easily identified in the QMS implementation process	2
Small	The failure is commonly found, but not in most areas	3
Too Small	The failure is is only visible in some areas	4
Unlikely	The presence of a failure is in the QMS implementation process is rarely noticed.	5

Source: Santos & Melo (2019)

Table 5: Scales used to determine the severity of failures

Severity		Likert Scale
Just Noticeable	The failure is not important, becoming irrelevant to the QMS implementation process	1
Little Importance	The failure exists, but it does not hinder the the operation of the QMS implementation process	2
Moderate	The failure exists and even though it is not so alarming, it contributes together with other flaws so that at least 50% of the functioning of the QMS implementation process is compromised	3
Serious	The failure exists and is already seen as an alarming factor that contributes together with other flaws, so that at least 80% of the functioning of the QMS implementation process is compromised	4
Very Serious	The failure exists and prevents the QMS implementation process from working	5

Source: Santos & Melo (2019)

Table 6: Scales used to determine the difficulty in solving failure modes

Difficulty	Likert Scale
Too Small	1
Small	2
Moderate	3
High	4
Very High	5

Source: Theauthors (2020)

The time necessary criterion for the failure mode to be “eliminated” was the only one not to use a five-point Likert scale since it was attributed to it the expected number of months that each alternative would take to be solved.

d) Application of the Model on Visual Promethee

The authors used Visual PROMETHEE software. To apply the model to the software, the traditional FMEA table (considering the criteria chosen for the model) was elaborated together with the decision-maker through an

interactive process, to collect information about the controls that the institution has currently to detect and prevent failure modes. Also, there was the discussion about possible preventive actions to solve these failures. Then, the manager assigned the score for each alternative based on the scales established for each criterion and settled the number of months that would be needed to solve the potential failure modes for the time criterion. Tables 7, 8, and 9 present the result of the FMEA application.

Table 7: Application of FMEA part 1

POTENTIAL FAILURE MODE	EFFECT (S) OF POTENTIAL FAILURE	SEV. (S)	POTENTIAL CAUSE (S) OF FAILURE	OCCUR. (O)	CURRENT PREVENTION CONTROL	DETEC. (D)	CURRENT DETECTION CONTROL	DIFFIC. (DIF)	TIME (T)	RECOMMENDED PREVENTIVE ACTION
Government bureaucratic requirements	Spends more time with the bureaucratic and less with the pedagogical	3	Business management applied in education	4	Demand distribution with the management team	2	There is not	4	12	Higher number of servers in the administrative part
Lack of resources	Lack of educational support material and maintenance	4	Delays in transfers and insufficient amounts	4	There is not	1	There is not	5	6	Regularize onlending and correct amounts
Failure to communicate with teachers	Lack of alignment in actions	2	Lack of standardization of the communication process	3	Confirmation of receipt of information by the messaging application	4	In stock valuations	3	2	Establish unified communication mechanisms
Staff demotivation	Low profit	2	Overwork and low pay	2	Ongoing training and pedagogical meetings	4	Bimonthly monitoring	3	6	Optimization of workload and career enhancement

Source: The authors (2020)



Table 8: Application of FMEA part 2

POTENTIAL FAILURE MODE	EFFECT (S) OF POTENTIAL FAILURE	SEV. (S)	POTENTIAL CAUSE (S) OF FAILURE	OCCUR. (O)	CURRENT PREVENTION CONTROL	DETEC. (D)	CURRENT DETECTION CONTROL	DIFFIC. (DIF)	TIME (T)	RECOMMENDED PREVENTIVE ACTION
Change in School Culture	Low acceptance	2	Lack of co-responsibility of school actors	3	Family meeting at school and parent and teacher meeting	4	Evaluation of family and parent and teacher meetings	3	12	Systematic planning to raise awareness among school actors
No internship requirement for technical courses offered by the school	More theoretical and less practical training	2	Change in legislation	3	Provide opportunity for contact with practice	5	Monitoring the professional life of graduates	5	12	Establish elective courses that enable professional practice
Low family participation in monitoring children at school	Lack of follow-up in students' academic life	3	Culture of non-responsibility	4	Family meeting at school and parent and teacher meeting	2	Evaluation of family and parent and teacher meetings	2	12	Planning attractive and differentiated actions for parents and guardians
Insufficient full-time staff	Non-availability of full-time professional	3	Existence of hired professionals	3	Request for full-time professionals	3	Elaboration of bimonthly plans	3	6	Location of full-time teachers to attend 100% of the workload

Source: The authors (2020)

Table 9: Application of FMEA part 3

POTENTIAL FAILURE MODE	EFFECT (S) OF POTENTIAL FAILURE	SEV. (S)	POTENTIAL CAUSE (S) OF FAILURE	OCCUR. (O)	CURRENT PREVENTION CONTROL	DETEC. (D)	CURRENT DETECTION CONTROL	DIFFIC. (DIF)	TIME (T)	RECOMMENDED PREVENTIVE ACTION
Lack of a team of psychology professionals	Large number of students with psychological problems	4	No function in schools	5	Monitoring of students and family orientation	3	Pedagogical support	5	12	Establish partnerships with entities and / or professionals in the field
Resistance by the outsourced team of general services	Lack of professional performance	4	Political interference in nominations	4	There is not	1	There is not	4	6	Selection of professionals by curriculum and experience
Not knowing the demands of students regarding the technical courses offered by the school	Offer of courses that do not meet local interest	2	Criteria for choosing courses	3	There is not	5	There is not	2	12	Optimization of the criteria for choosing the courses offered

Source: The authors (2020)

From this assessment, the Visual PROMETHEE software used pertinent information from the FMEA (Tables 7, 8, and 9) and Table 2. Following the procedures of the PROMETHEE II method, the table 10

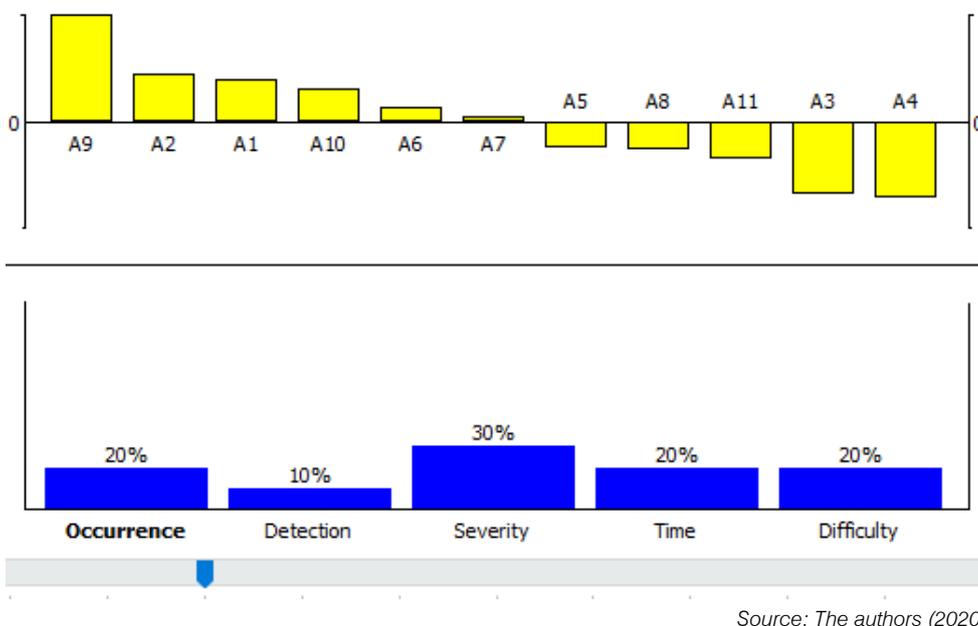
presents positive, negative, and net flows. And, from that, the general ranking was obtained. Table 10 shows these results.

Table 10: Ranking of the alternatives and the PROMETHEE II flows

RANKING	ALTERNATIVE	$\Phi$	$\Phi+$	$\Phi-$
1	A9	0,6900	0,7400	0,0500
2	A2	0,3100	0,5400	0,2300
3	A1	0,2700	0,5100	0,2400
4	A10	0,2100	0,5000	0,2900
5	A6	0,0900	0,3700	0,2800
6	A7	0,0300	0,3900	0,3600
7	A5	-0,1800	0,2200	0,4000
8	A8	-0,1900	0,2700	0,4600
9	A11	-0,2500	0,2100	0,4600
10	A3	-0,4800	0,1200	0,6000
11	A4	-0,5000	0,1200	0,6200

Source: The authors (2020)

In addition to the result shown in Table 10, the graphical form is helpful to visualize the behavior of each alternative, as shown in Figure 1.



Source: The authors (2020)

Figure 1: Behavior of each alternative

The upper part of the figure is a bar graph showing the complete ranking of PROMETHEE II, expressed as a net flow. The lower part, which is also a bar graph, shows the weights of the criteria.

attributing other weights to the criteria. In setting 1, the decision-maker is unable to express his preferences. Scene 2 is a variation of the distinct two contexts. Tables 11 and 12 show the characteristics of the situations and the comparison of the rankings obtained through them, respectively.

That done, the authors purpose an analysis of scenarios to understand the behavior of the model when

Table 11: Evaluated scenarios

Scenarios	Criteria Weights				
	O	D	S	DIF	T
Real Scenario	0,2	0,1	0,3	0,2	0,2
Scenario 1	0,2	0,2	0,2	0,2	0,2
Scenario 2	0,15	0,15	0,4	0,1	0,2

Source: The authors (2020)

Table 12: Comparison of scenario results

Ranking	Real Scenario	Scenario 1	Scenario 2
1	A9	A9	A9
2	A2	A6	A2
3	A1	A1	A1
4	A10	A2	A10
5	A6	A10	A7
6	A7	A7	A6
7	A5	A5	A8
8	A8	A11	A11
9	A11	A8	A5
10	A3	A3	A4
11	A4	A4	A3

Source: The authors (2020)

It shows that the alternative A9 remained in first place in the ranking of the three scenarios, which emphasizes the importance of developing actions to solve it. Similarly, alternatives A3 and A4 occupied the last positions in the three scenes.

## VI. FINAL CONSIDERATIONS

The model consisted of performing the integration between the FMEA of the process and the PROMETHEE II method. For this, there was the adoption of two new criteria in addition to those addressed in the calculation of the RPN: Difficulty in resolving the failure mode and Time required for the failure mode to be "eliminated." This inclusion served to refine the model, further optimizing the results.

The application of the model made it possible to identify the failure modes considered most critical in the implementation and maintenance stages of the school's QMS. As a result of the real scenario, the alternative that ranked first in the ranking was A9, followed by A2 and A1, consequently.

The A9 alternative obtained a much higher net flow compared to the others, which deserves to highlight the importance of developing actions that can solve it since the lack of a team of psychology professionals directly affects the performance of students and collaborators. Therefore, the presence of this type of professional would significantly assist in carrying out a making better use of the school's activities.

In general, alternatives A2 and A1 do not depend directly on the school to be solved, occupying the first positions in the ranking. As much as there is an interest in solving them, the lack of resources and state requirements demand external and sometimes complex actions, which leaves the school in a delicate situation, needing to develop internal mechanisms to solve it or it minimizes the impacts of these failure modes.

On the other hand, the alternatives A3 and A4 occupied the last positions of the ranking, which does not make them less significant, but at the beginning, they are not a priority. As much as they deal with the failure to communicate with teachers and demotivate staff, these obstacles happen in some specific and isolated cases since, in most cases, the school strives for adequate communication and motivation of employees.

The work brought an innovative feature since the type of approach taken in is uncommon in the literature. Through it, public and private institutions can rely on developing their models, with the necessary modifications.

Wherefore, the studied school can develop action plans aimed at alternatives that hinder the process of implementing and maintaining the QMS and, with that, be certified by ISO 21001. Through this, its results will be even more considerable, and the school

will become a source of benchmarking to other educational institutions in the region and the country.

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# Management of Transport Processes with the use of Intelligent Transport Systems - A Case Study of the Company "Vertigo Montenegro" Ltd. - Podgorica

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**Abstract-** In the world of information technology expansion and application, intelligent transportation systems are increasingly used in all forms of transportation. These systems have been widely used in road transport, and this thesis shows one of the ways of application with all the accompanying features of the fleet control and management system developed by "NTS International" company. Considering that the fleet of each road transport company makes an important resource by which it is possible to carry out the main activity (transportation of passengers and / or goods), it is clear that managing it cannot be left to chance and that the application of its is necessary for the quality business of the company. Case study – "Vertigo Montenegro" company, from Podgorica, implemented a system of the NTS International company, and all the fleet performance indicators that are at the heart of the company's interest are listed in the paper, with accompanying photo documentation. In general, the use of its is low used in Montenegrin auto transport companies, and the main causes are: poor staff in management positions, lack of information technology education and greater confidence in traditional ways of doing business.

**Keywords:** *intelligent transport systems, auto transport company, fleet management, telemetry, fleet performance indicators.*

**GJRE-J Classification:** FOR Code: 889999



*Strictly as per the compliance and regulations of:*



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**Apstraktno-** U svijetu ekspanzije i primjene informacionih tehnologija, inteligentni transportni sistemi (skr. ITS) se sve češće koriste u svim vidovima transporta. Ovi sistemi su našli široku primjenu u drumskom saobraćaju, a kroz ovaj rad je prikazan jedan od načina primjene uz sve prateće karakteristike sistema za kontrolu i upravljanje voznim parkom koje razvija kompanija "NTS International". S obzirom da vozni park svakog autotransportnog preduzeća (skr. ATP) čini važan resurs uz pomoć kog je moguće obavljati osnovnu djelatnost (prevoz putnika i/ili robe), jasno je da se upravljanje njime ne može prepustiti slučaju i da je primjena ITS-a neophodna za kvalitetno poslovanje svakog ATP-a. Studija slučaja – preduzeće "Vertigo Montenegro" iz Podgorice implementiralo je sistem pomenute kompanije, a svi pokazatelji rada voznog parka koji su u centru interesovanja preduzeća navedeni su u radu, sa slikovnim prikazima. Generalno, u crnogorskim autotransportnim preduzećima primjena ITS-a je na niskom nivou, a glavni uzročnici tome jesu: nestručan kadar na rukovodećim pozicijama, neobrazovanje iz domena informacionih tehnologija i veće povjerenje u tradicionalne načine poslovanja.

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**Ključne riječi:** *inteligentni transportni sistemi, autotransportno preduzeće, upravljanje voznim parkom, telemetrija, pokazatelji radavoznog parka.*

## I. UVOD

Početak 21. vijeka obilježava razvoj velikih gradova koji se suočavaju sa sve većim problemima saobraćajnih gužvi, zagušenjima te zagađenjima životne sredine i nezgodama na saobraćajnicama, koji zahtijevaju rješavanje problema politikom održivog saobraćaja. Sve zemlje u razvoju se suočavaju sa problemima u kapacitetu, sigurnosti, ekološkoj i ekonomskoj učinkovitosti. Uspješno rješavanje rastućih problema odvijanja saobraćaja i obavljanja transporta više nije moguće bez primjene cjelovitog koncepta i tehnologija inteligentnih transportnih sistema.[1]

Inteligentni transportni sistem integriše telekomunikacije, elektroniku, informatiku sa saobraćajnim inženjerstvom u smislu planiranja, projektovanja i upravljanja saobraćajnim sistemima. Ova integracija povećava efikasnost i bezbjednost saobraćajnog sistema i ima pozitivan uticaj na životnu sredinu. Da bi se to ostvarilo ITS zahtijeva procedure, sisteme i opremu koje omogućavaju prikupljanje podataka, komunikaciju, analizu i distribuciju podataka i informacija do korisnika saobraćajnog sistema.[2]

Kada se govori o savremenim transportnim sistemima, važno je istaći da je njihova osnovna uloga obezbjeđivanje podataka vezanih za transportni proces ili za rad vozila tj. podrazumijevaju proces prikupljanja, prenosa, memorisanja i obrade tih podataka isporučujući ih direktno korisniku kroz određenu platformu čijom analizom se dobijaju informacije značajne zadonošenje odgovarajućih upravljačkih odluka u cilju poboljšanja efikasnosti sistema i iskorišćenja raspoloživih resursa.

Primjena telematskih sistema je sve rasprostranjenija brzim razvojem bežične komunikacione tehnologije i padom cijena elektronskih komponenti.

**Namjena ITS-a se ogleda kroz:**

- prikupljanje podataka o radu i održavanju vozila,

- praćenje rada vozača,
- upravljanje prevoznim procesima,
- uvid u trenutnu poziciju vozila ili već posjećenu lokaciju u zadatom vremenskom intervalu,
- informisanje vozača o putanjama kretanja vozila (rutiranje).[3]

Spoj informacionog i inteligentnog sistema i njihovo funkcionisanje u praksi biće prikazano kroz primjer poslovanja kompanije "NTS International" (skr. NTS) koja je razvila jedan savremeni transportni informacioni sistem isporučujući ga korisnicima kroz sledeće vrste aplikacije:

- NTS Mobile i NTS 4 iOS - aplikacije koje se koriste na mobilnom telefonu i tabletu (Android i iPhone/iPad) i imaju sličan prikaz kao i NTS@Web aplikacija;
- NTS @ Web - namijenjena korisnicima koji imaju potrebu pristupa sa bilo koje lokacije koju pokriva internet mreža;
- NTS Desktop - savremena fleet management aplikacija koja objedinjuje podatke koje GPS modem i drugi uređaji šalju sa vozila. Omogućava analitiku svih aspekata vezanih za vozni park i vozače.

## II. O KOMPANIJU NTS

Kompanija NTS osnovana je 2006. godine i od početka svog postojanja trudi se da tržištu ponudi moderne i inovativne usluge u oblasti cjelokupnog upravljanja voznim parkom.

Posluje iz 7 centara: Ljubljane, Banja Luke, Novog Sada, Beograda, Niša, Podgorice i Tirane. Kompanija trenutno zapošljava preko 50 radnika iz različitih oblasti vezanih za djelatnost iste. Razvojni tim NTS-a, sačinjen od saobraćajnih inženjera, IT stručnjaka i mnogih drugih koji svakodnevno rade na inovacijama, povećanju kvaliteta usluga, osluškivanju potreba klijenata, kao i na praćenju svjetskih trendova i implementiranju istih.

Misija NTS kompanije jeste obezbjeđivanje rješenja koja će povećati efikasnost i bezbjednost transporta i logistike uz smanjenje štetnog dejstva na životnu sredinu.

Vizija se odnosi na neprekidno unaprijeđivanje postojećih rješenja i razvijanje novih, kreiranje rješenja uz pomoć kojih klijenti mogu unaprijediti svoje poslovanje, graditi partnerski odnos sa klijentima i efikasno rješavati njihove eventualne probleme nastale tokom korišćenja isporučenih usluga.

Cilj koji NTS kompanija ima je unaprijeđivanje poslovanja firme kroz unaprijeđenje rada, kontrole voznog parka, vođenja administracije i obavljanja komunikacije.

Kao moderna IT kompanija, prije svega, važno je napomenuti da NTS ulaže u razvoj softvera, konkretno se radi dosta na održanju i poboljšanju kvaliteta

najpoznatijeg proizvoda kompanije – NTS Fleet Management System-a, dok se hardverski uređaji kupuju i ne spadaju u autorski dio proizvodnje NTS kompanije.

S obzirom da se ime ove kompanije često veže samo za ovaj proizvod, treba istaći da NTS nije sinonim za isti, već obuhvata širok spektar proizvoda koji pomažu korisnicima da upravljaju radom voznog parka, vrše kontrolu rada zaposlenih na terenu, smanje troškove komunikacije i troškova organizacije prevoza.

## III. NTS DESKTOP APLIKACIJA

Korisnicima NTS Desktop verzije aplikacije su na raspolaganju sledeći moduli:

*Modul Vozila* – u ovom modulu omogućeno je praćenje podataka o vozilu u realnom vremenu;

*Modul Istorija* – omogućava vizuelni pregled istorije kretanja vozila i pristup velikom broju izveštaja i grafika;

*Modul Vozači* – u ovom modulu omogućeno je administriranje podataka o vozačima kao i podešavanje ključeva za identifikaciju vozača;

*Modul Administracija* – u ovom modulu omogućava se zakazivanje svih servisa kao i evidencija svih troškova voznog parka;

*Mobile Office* – modul koji uz pomoć adekvatnog hardverskog uređaja omogućava komunikaciju između vozača i dispečera, kao i razmjenu raznih tipova podataka (tekstualnih i glasovnih poruka, fotografija, doc.fajlova i sl.

Pomoćni moduli aplikacije su:

*Lokacije* – kreiranje i određivanje lokacija bitnih za korisnika;

*Korisnička podešavanja* – opšta podešavanja (istorija, prevozní put (ruta), vozila, ostale opcije), I/O podešavanja, promjena lozinke (promjena lozinke, podešavanje logovanja, sigurnosna podešavanja, korisnički podaci, klijentski podaci), FMS Settings, događaji, izvještaji i grafici (podešavanja za izvještaje, rezervni geokoding, podešavanja grafika broja obrtaja motora), tahograf podešavanja;

*Plan linija* – kreiranje novih linija, izmjena i brisanje postojećih;

*Linije* – kreiranje linijskih rasporeda;

*Radno vrijeme* – unošenje vrijednosti satnica za svakog vozača i/ili vozilo koje se tiču radnih i neradnih dana (slobodnih, vikenda, praznika i sl.);

*Alarmi* – moguće je aktivirati ponuđene alarme u slučaju prekoračenja brzine, povećanja/smanjenja temperature i sl., u zavisnosti od predmeta interesovanja;

*Booking modul* – ovaj modul je kreiran za potrebe izdavanja vozila kompanije Porto Montenegro iz Tivta. U okviru ovog modula moguće je voditi evidenciju o

vremenu zakazivanja, tarifama, lokacijama preuzimanja i predaje vozila, itd;

*Putni nalog* – kreiranje novih putnih naloga, upravljanje postojećim statusima naloga (aktivnim, vraćenim, poništenim ili otkazanim i neodštampanim);

*Putanja* – koristi se za rutiranje.

#### IV. HARDVER

Hardverski dio sistema, kao i njegova ispravnost i funkcionalnost imaju veliki značaj za pravilno funkcionisanje sistema. Spektar informacija, ali i njihova dalja upotrebljivost određeni su upravo ovim komponentama.

NTS kompanija najviše koristi uređaje proizvođača „Teltonika“ i „Ruptela“, pored kojih se koriste i Eurosens-ov uređaj za mjerenje protoka i nivoa goriva u rezervoaru, Vepam-ov sigurnosni čep rezervoara i Button uređaji za identifikaciju vozača. Kada su u pitanju uređaji proizvođača Teltonika, u kompaniji NTS zastupljena su tri modema (FM5300, FM1110, FMB120) i dva adaptera (LV-CAN200 i ALL-CAN300) koji omogućavaju preuzimanje (čitanje) informacija koje generišu uređaji na vozilu. Što se tiče uređaja kompanije Ruptela, najviše se koriste tri modema (FM Pro4, FM Tco4 HCV i FM Tco4 LCV) i jedan (Click Can) adapter.

#### V. PRIMJENA NTS DESKTOP APLIKACIJE U PREDUZEĆU „VERTIGO MONTENEGRO“ DOO

Preduzeća „Vertigo Montenegro“ d.o.o. iz Podgorice, koristi nekoliko različitih informacionih sistema kroz koje efikasnije i efektivnije obavlja svakodnevne aktivnosti i zadatke, među kojima je i NTS sistem za kontrolu i upravljanje voznim parkom.

Preduzeće „Vertigo Montenegro“ d.o.o osnovano je 2002. godine u Podgorici. Osnovna djelatnost preduzeća je uvoz, skladištenje i distribucija kozmetičkih proizvoda za djecu i odrasle, hemijskih sredstava za održavanje higijene prostora, LED sijalica i dječijih igračka.

Razvojem preduzeća kroz minule godine, od mikro do malog preduzeća, proširivao se i spisak lica koje zastupaju na crnogorskom tržištu, odnosno čije proizvode plasiraju u maloprodajnim i veleprodajnim objektima. Kako se povećavao obim proizvoda koje je trebalo distribuirati na cijeloj teritoriji Crne Gore, tako se i razvijala mreža klijenata, odnosno vlasnika maloprodajnih i veleprodajnih objekata. Shodno tome, nastala je potreba za većim skladišnim prostorom i za većim brojem zaposlenih. Neizostavno, kapaciteti voznog parka su morali odgovarati obimu posla, pa je tako ovo preduzeće vlasnik šesnaest vozila različitih marki i tipova. Većinu vozila čine laka teretna, odnosno dostavna vozila upotrebljavana za prevoz robe iz logističko-distributivnog centra koji se nalazi u Podgorici u maloprodajne i veleprodajne objekte južnog,

centralnog i sjevernog dijela Crne Gore. Električni paletar se nalazi u koristi u centralnom magacinu, a putnička vozila su u upotrebi od strane komercijalista zaposlenih u ovom preduzeću.

U cilju stvaranja uslova za ocjenu i analizu rada vozila u voznom parku, potrebno je da svako preduzeće izvrši podjelu po grupama vozila koja imaju iste tehničko - eksploatacione osobine i čije je tehničko stanje približno jednako. Vozila se po pravilu razvrstavaju u grupe u funkciji: marke i tipa, godine proizvodnje, korisne nosivosti, namjene tovarnog prostora (sandučari, cistijerne, hladnjače, teretna vozila sa uređajima za samoistovar - kiperi, autobusi za međugradskitranspot, autobusi za prigradski transport, autobusi za gradski transport itd.).[4]

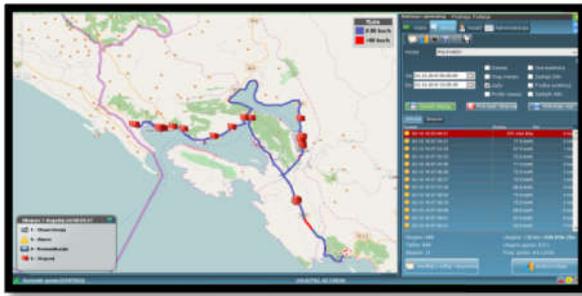
S obzirom da svako preduzeće mora da obavlja proces proizvodnje, prodaje, vođenja arhive, kadrovske evidencije, itd, nezavisno od njegove veličine mora biti organizovano.[5] Organizovanje je funkcija menadžmenta kojom se projektuju i uspostavljaju odnosi među aktivnostima i ljudima uključenim u pribavljanje, alociranje, korišćenje i zamjenu organizacionih resursa. Krajnji rezultat organizovanja je "organizacija", efikasna struktura autoriteta, odgovornosti i komunikacionih kanala za realizaciju ciljeva preduzeća, planova, budžeta, politika i procedura. [6]

Kao i u većini mikro i malih preduzeća, u preduzeću „Vertigo Montenegro“ d.o.o. radi se o najprostijem modelu organizacione strukture – linijskom modelu. Linijski model je poznat kao vojnički tip organizacije, koji je u industriji primijenjen iz vojne organizacije. Prenošenje naredjenja od menadžera i izvještaja o izvršenju zadataka od potčinjenih vrši se po liniji hijerarhije.

Preduzeće „Vertigo Montenegro“ d.o.o. ima tri sektora poslovanja koja obuhvataju: sektor prodaje, sektor za ekonomske i pravne poslove i sektor logistike.

#### VI. PRIMJENA NTS INFORMACIONOG SISTEMA

Na kraju svakog radnog dana, odnosno na početku sledećeg, rukovodilac logistike provjerava ostvarene prevozne puteve(rute) po vozilima za prethodna dvadeset četiri časa. Slika 1 prikazuje pređeni put za izabrano vozilo plavom bojom, a crvene zastavice predstavljaju tačke zaustavljanja koja su duža od tri minuta. Sa pomenute slike je jasno uočljivo da je zaposlena, komercijalistinja, za vrijeme svog radnog vremena posjetila trgovačke lance na potezu Budva-Herceg Novi, kretajući se oko Bokokotorskog zaliva. Pregledom ove rute, rukovodilac logistike može na brz način utvrditi da li je zaposlena posjetila objekte za koje je bila zadužena.



Slika 1: Pregled ostvarene rute

Upotreba službenih vozila van radnog vremena je takođe nešto što se u ovom preduzeću kontroliše. Najviše zbog potrošnje goriva, pa se nakon unijetog radnog vremena za svakog zaposlenog u sistem lako dolazi do podataka da li je i koliko vozilo korišćeno van definisanog radnog vremena. Na slici 2 prikazan je pregled vožnje van radnog vremena po danima u toku jedne sedmice.

Ovim izvještajem, rukovodilac logistike može lako izvršiti uporednu analizu u odnosu na dnevne planove koje svaki zaposleni dobija. Takođe, bitno je napomenuti da je u sistemu moguće definisati neradne dane (u ovom slučaju to su datumi označeni crvenom bojom), ali se kroz drugi izvještaj ("Izvještaj o vožnji neradnim danima") dobija prikaz eventualne aktivnost vozila za vrijeme vikenda, praznika i sl.

Vozilo	Vozilo	Datum	Kilometraža u radno vreme	Kilometraža van radnog v.	Ukupna kilometraža
Milica Krstovic	PG-FH951	22.09.2019	97.67	78.00	1.67.43
Milica Krstovic	PG-FH951	24.09.2019	106.36	83.68	1.89.97
Milica Krstovic	PG-FH951	25.09.2019	92.89	54.57	1.49.47
Milica Krstovic	PG-FH951	26.09.2019	122.74	72.14	1.94.87
Milica Krstovic	PG-FH951	27.09.2019	95.49	123.74	2.14.23
Milica Krstovic	PG-FH951	28.09.2019	0.00	0.00	0.44
Milica Krstovic	PG-FH951	29.09.2019	0.00	0.00	20.44
			500.15	400.16	944.43

Slika 2: Pregled korišćenja vozila

Ukoliko se traže razlozi povećanoj potrošnji goriva, svakako da treba uzeti u obzir rad motora u leru. Proverom detalja pređene rute komercijalistkinje na relaciji Budva – Herceg Novi uočeno je da je ukupno vrijeme provedeno u vožnji 03h: 42min: 23sek, a u leru motor je radio 02h:17h:33sek. U odnosu na to da je vozilo bilo u pokretu nepuna četiri sata, vrijeme rada motora u leru je nešto na šta treba obratiti pažnju. (Slika 3).

Vozilo	Datum od	Datum do	Ukupno vreme	Vrijeme u vožnji	Vrijeme stajanja	Vrijeme rada u leru	Postotak rada u leru
PG-FH951	02.10.19 00:00:00	03.10.19 23:59:59	23:59:59	3:42:23	20:17:36	2:17:33	30.2 %
Ukupno			23:59:59	3:42:23	20:17:36	2:17:33	30.2 %

Slika 3: Rad motora u leru

Stil vožnje znatno utiče na vijek trajanja vozila, odnosno njegovih djelova, a takođe može uticati i na potrošnju goriva. Pregledom zvještaja koji rukovodilac logistike često pokreće, a koji je za potrebe ovog rada, pokrenuo (postavivši iste parametre kao u prethodnim slučajevima), utvrđeno je da se vozilo od Budve do Herceg Novog kretalo brzinom većom od dozvoljene (80 km/h), tj. 109 km/h. Ovaj izvještaj svoju praktičnu primjenu ima za analizu uticaja na životni vijek vozila, kao i za uvid u eventualne probleme sa potrošnjom goriva u odnosu na normativ. (Slika 4).

Vozilo	Radni sati motora	Ukupno km	Ukupno goriva (l)	Prosječna potrošnja	Maksimalna brzina	Prosječna brzina	Maksimalna brzina	Prosječna brzina
PG-FH951	0:00	121.00	8.00	4.55	109.00	36.41	30.38.00	1375.50

Slika 4: Rad motora u leru

## VII. ZAKLJUČAK

Karakteristika svakog autotransportnog preduzeća drumskog transporta je da teži postizanju određenih ciljeva. Njihov uspjeh se mjeri kroz efektivnost – da li preduzeće ostvaruje postavljene ciljeve i efikasnost – način na koji je preduzeće postiglo ciljeve i metode koji su primjenjene za njihovo ostvarivanje.[7]

U ovom radu prikazan je sadržaj i način funkcionisanja Fleet Management sistema kompanije NTS koji je zapravo skup softverskih i hardverskih rješenja uz pomoć kojih je omogućeno efikasno i efektno upravljanje voznim parkom. Sistem se sastoji od različitih hardverskih jedinica (GPS/GPRS modema, antena, različitih senzora, protokomjera, FMS intefejsa i sl.) koje imaju zadatak da pruže izuzetno precizne podatke o vozilu (lokaciji, načinu vožnje, potrošnje goriva, temperature tovarnog prostora i sl.). Modemska jedinica prikuplja podatke sa svih dodatnih uređaja i putem GPRS/HSDPA mreže mobilnog operatera šalje ih ka IT centru, gdje se podaci obrađuju i isporučuju korisnicima u aplikaciju (desktop/web/mobilna verzija aplikacije).

Istraživanjem na polju primjene inteligentnih transportnih sistema u autotransportnim preduzećima u Crnoj Gori, došlo se do poražavajućih podataka. Iako je u 21. vijeku tehnologija u opštem smislu toliko napredovala da je postalo nemoguće baviti se bilo kojom djelatnošću na kvalitetan način bez primjene iste, u Crnoj Gori postoji problem neprihvatanja inteligentnih sistema, a pogotovo je to primjetno u saobraćajnoj djelatnosti. Najveća prepreka ka savremenom načinu poslovanja u većini autotransportnih preduzeća je nestručan kadar na rukovodećim pozicijama koji ne smatra neophodnim ulaganje u tehničko-tehnološki razvoj preduzeća, samim tim što ne prepoznaje

prednosti istog, a prisutno je i izvjesno nepovjerenje prema svemu što je "kompjuterizovano".

Takođe, postoje i vlasnici autotransportnih preduzeća koji se udaljavaju od tradicionalnog načina rukovođenja, pa dozvoljavaju implementaciju ITS-a u svom preduzeću, ali najčešće ne smatraju to dovoljno važnim da bi se i sami uključili u način funkcionisanja i benefite koje imaju od primjene sistema, tako da se taj dio posla prepušta nekome od zaposlenih, a u praksi se pokazalo da su to u rijetkim slučajevima oni koji pored ostalih poslovnih aktivnosti nemaju vremena za dublje analize rada voznog parka. Sa druge strane, zaposleni u autotransportnim preduzećima, pogotovo oni koji su zaduženi za upravljanje i kontrolu voznog parka, najčešće su inicijatori uvođenja nekog informacionog sistema koji će im omogućiti da posao obavljaju što produktivnije. Analizom preduzeća "Vertigo Montenegro" d.o.o iz Podgorice, došlo se do podataka koji oslikavaju način primjene ITS-a u većini autotransportnih preduzeća u Crnoj Gori. Naime, NTS sistem koriste na osnovnoj razini, najviše za kontrolu pozicije vozila (GPS praćenje) i kontrolu upotrebe vozila van radnog vremena. Od dodatnih telemetrijskih uređaja imaju CAN uređaj na jednom vozilu i kada je to vozilo u pitanju, kontrolišu preciznije potrošnju goriva sa kojom se sve završava. Pored ovog sistema, kontrolu potošnje resursa vode i eksterno, najčešće unošenjem vrijednosti u Excel tabele.

Iako, kao preduzeće kojem je distribucija proizvoda osnovna djelatnost, može imati dobrobiti od modula koji se tiču plana linija, rutiranja i sl., GPS praćenje je ono što je generalno najprihvatljivije u crnogorskim autotransportnim preduzećima. Na osnovu organizacione strukture pomenutog preduzeća može se zaključiti da je formiranje službe za razvoj neophodnost. Takva služba pratila bi izmjeritelje rada i parametre rada vozila putem uvedenih inteligentnih transportnih sistema i na osnovu toga predlagala mjere za efikasnijim, efektnijim i kvalitetnijim radom vozila.

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### Napomena

Podaci o detaljima NTS aplikacije odobreni su od strane "NTS" kompanije i kompanije "Vertigo Montenegro".



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## Determination of Some Microbiological Properties of Kombucha Produced from Different Herbal Teas

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**Abstract-** “Kombucha” is a beverage made by fermenting tea (generally black or sometimes green and oolong tea) and sugar, with a symbiotic culture of bacteria and yeast generally for 7-10 days. The final product is a sour, slightly sparkling, acidic beverage. In this study, black tea, green tea, sage (*Salvia fruticosa Mill.*), peppermint (*Mentha piperita L.*), and linden (*Tilia cordata*) leaves were used in making kombucha. Some microbiological analyzes of the samples were carried out on the 3rd, 7th, 10th, and 14th days of fermentation, which lasted 14 days at 24°C. The number of *Lactobacillus*, *Lactococcus*, yeast, and acetic acid bacteria were average 5.73, 5.66, 5.63 and 5.55 log CFU/mL on the 3rd day of fermentation; average 5.77, 5.01, 5.70 and 3.55 log CFU/mL on the 14th day of fermentation, respectively. Generally, microorganisms increased until the 7th day of fermentation and then decreased. Different herbal teas can be used to produce kombucha enhanced functional properties.

**Keywords:** kombucha, SCOBY, fermented black tea, fermented green tea, fermented linden tea, fermented sage tea, fermented mint tea.

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## I. INTRODUCTION

Kombucha is a type of refreshing beverage that is commercially produced by many companies and produced homemade. It is widely consumed in the world. It has a delicious taste, antioxidant properties of tea extracts, and beneficial effects of fermentative bacteria, which have antioxidant properties. Because of these, its consumption is increasing day by day. Phenolic substances found in the leaves of tea used in kombucha production also have antimicrobial effects on microorganisms such as *Aeromonas*, *Bacillus*, *Clostridium botulinum*, *Clostridium perfringens*, *Enterobacter*, *Klebsiella*, *Proteus*, *Pseudomonas*, *Shigella*, *Staphylococcus aureus*, *Streptococcus* [1,2].

Bacteria and yeasts lead a symbiotic life in the cellulosic film layer, where the microorganisms that play a role in the fermentation of kombucha are found. Gram-negative aerobic bacilli, yeasts, and lactic acid bacteria in the *Acetobacteraceae* family were identified in this film

layer [3,4,5,6]. This cellulosic structure, which increases in thickness as fermentation progresses, provides the necessary oxygen for microorganisms [3,6]. These microorganisms create free phenolics using phenolic compounds in tea leaves, and they create useful fermentation products such as various organic acids, vitamins, and minerals for the health and also contribute to the sensory properties of the product. The metabolites formed depend on the variety of tea leaves, the variety of microorganisms in symbiotic culture and fermentation conditions [3,6,7,8,9,10].

Kombucha is usually prepared from black tea and green tea. This research was carried out by considering it would be beneficial to prepare kombucha by sage, linden, and mint teas, which are highly valuable for health. In sage, flavones such as apigenin, luteolin, kaempferol, and quercetin were determined.

Carnosol and carnosic acids are also antioxidant phenolic compounds found in sage. Mint (*Mentha piperita* L.) is one of the commonly consumed herbal teas. The leaves of mint contain phenolic components rosmarinic acid and various flavonoids such as eriocitrin, luteolin, and hesperidin. Peppermint has significant antimicrobial and antiviral activities, strong antioxidant and antitumor activities, and some anti-allergenic potential [11]. Some of the beneficial effects of kombucha are anti-microbial, antioxidant, anti-carcinogenic, and anti-diabetic properties that have positive effects on stomach ulcers and high cholesterol. It is also recommended for use in the treatment of different diseases such as AIDS, arthritis, atherosclerosis, cancer, constipation, gallbladder diseases, hemorrhoids, hair growth, hypertension, and indigestion. It has also been shown to be effective in immune responses and liver detoxification [9]. Kombucha regulates intestinal flora, strengthens cells, helps the body maintain acid-alkaline balance, and acts as a natural antibiotic [12]. Great attention should be paid in home-made kombucha since pathogenic microorganisms are likely to contaminate the tea. Some people consuming homemade tea have dizziness, headache, nausea, and allergic reactions. For this reason, it can lead to contraindications in pregnant and lactating women and should be consumed with caution [8]. However, as a result of tests carried out by the U.S.

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Food and Drug Administration, kombucha has been reported to be safe for human consumption [10].

In this study, black tea, green tea, sage, mint, and linden teas were used in making the kombucha. The fermentation period was kept for 14 days in making kombucha.

## II. MATERIAL AND METHODS

### a) Materials

Black tea, green tea, mint, linden, sage, used for making kombucha in the research were obtained from local markets in Tekirdag. Kombucha mushrooms were purchased from the online shopping site via the internet.

### b) Preparation and Fermentation of Herbal Teas

In order to extract the teas, 10 g of each tea sample, which is used as a bacterial medium for fermentation, was left in 1 L of boiled water for 15 minutes [13]. After extraction, the suitable medium was prepared by adding 70 g/L of sucrose. The prepared tea samples were transferred to glass jars, which were sterilized at 121°C for 20 minutes (Fig. 1). After we waited until these samples reached room temperature, all samples were inoculated with 7 g/L kombucha mushroom culture. After glass jars were covered with cheesecloth, left to fermentation at  $24 \pm 1^\circ\text{C}$  and in the dark for 14 days. Tea samples were taken from the incubator at 3-day intervals, and analyzes were performed.



Figure 1: Black, green, mint, linden and sage teas before fermentation

### c) Microbiological Analysis

Serial dilutions of kombucha samples were prepared in aseptic conditions using sterile saline containing 0.89% NaCl. MRS Agar (de Man Rogosa Sharpe, Merck) was used for counting lactobacilli, Petri plates were incubated for 72 hours at 30°C [14]. Lactococci were counted after 48 hours incubation at 30°C in M17 Agar (Oxoid) [15]. PDA (potato dextrose agar) was used for total yeast count, and Petri plates were incubated for three days at 25°C [16]. For total acetic acid bacteria count, a medium containing 1% glucose, 1% yeast extract, 2% CaCO<sub>3</sub>, and 1.8% agar (Calcium Carbonate Agar) was prepared and sterilized, and then 3% ethanol (95%) (Merck 100983) was added. Then the Petri dishes were incubated for three days at 30°C [17]. Colonies were evaluated for all microorganisms at the end of the incubation, and the results were expressed as "log CFU/mL".

### d) Statistical analysis

To test the differences between the parameters analyzed before and after fermentation in tea samples, two ways analysis of variance (ANOVA) was performed.

Significant differences between means were determined by Duncan's multiple range tests at  $P < 0.05$  significance level.

## III. RESULTS AND DISCUSSION

Kombucha is a fermented beverage. Ambient temperature, pH, oxygen content, dissolved CO<sub>2</sub>, process conditions, and composition of the medium affect fermentation [18]. As a result of this, the nutritional quality, the organoleptic properties, and other physicochemical properties of the product are affected. The different plant varieties, sugar concentrations, fermentation time, and the composition of the tea mushroom also affect fermentation and the properties of the fermented product [10,19].

Kombucha is created with the help of a symbiotic culture. This symbiotic culture consists of acetic acid bacteria (*Gluconobacter* and *Acetobacter* sp., *Komagataeibacter*) [20] lactic acid bacteria (*Lactobacillus*, *Lactococcus*) [18]. And yeasts (*Saccharomyces cerevisiae*, *Saccharomycodes ludwigii*,

*Schizosaccharomyces pombe*, *Zygosaccharomyces bailii*, *Kloeckera apiculata*, *Torulasporea delbrueckii*, *Brettanomyces bruxellensis* [21], *Candida*, *Pichia*, *Lachancea*, and *Kluyveromyces* [9,18,21].

Kombucha fermentation includes alcohol, lactic acid and acetic acid fermentation. In the fermentation of Kombucha, fermented tea and biofilm are formed as a result of the activity of different yeasts and bacteria species. First, in fermentation, sucrose breaks down into glucose and fructose as a result of yeast hydrolysis. Alcohol occurs as a result of fermentation of glucose

and fructose. Then acetic acid bacteria convert alcohol into acetic acid. In addition to acetic acid, gluconic and glucuronic also occur [10].

Kombucha tea is usually made from black and green tea. In this study, different herbal teas known to be beneficial for health were also used. The aim is to make the benefit of the kombucha tea even more useful with these herbs. The number of *Lactobacillus*, *Lactococcus*, yeast, and acetic acid bacteria determined during fermentation were shown in Table 1.

Table 1: Changes of some microbiological properties of Kombucha samples during fermentation (log CFU/mL)

Samples	Days	<i>Lactobacillus</i> log CFU/mL	<i>Lactococcus</i> log CFU/mL	Yeast log CFU/mL	Acetic Acid Bacteria log CFU/mL
Black Tea	3	5,53 A*a**	6,47 ABb	6,45 Bab	6,05 Cd
	7	6,04 Ab	5,37 ABb	6,30 Bc	6,01 Cc
	10	5,90 Aab	5,09 ABb	6,21 Bb	4,44 Cb
	14	5,56 Aa	5,00 Aba	5,39 Ba	2,00 Ca
Green Tea	3	6,07 Ba	4,74 Bb	4,86 Bab	4,44 Ad
	7	6,65 Bb	6,30 Bb	6,41 Bc	4,49 Ac
	10	6,25 Bab	6,34 Bb	6,23 Bb	5,38 Ab
	14	6,26 Ba	5,03 Ba	6,23 Ba	4,82 Aa
Mint Tea	3	5,12 Aa	6,32 ABb	4,67 Aab	5,90 Bd
	7	5,98 Ab	5,70 ABb	5,77 Ac	5,77 Bc
	10	5,19 Aab	5,05 ABb	5,01 Ab	4,95 Bb
	14	5,37 Aa	4,97 Aba	4,97 Aa	2,98 Ba
Linden Tea	3	6,31 Ba	5,48 Ab	6,31 Cab	5,07 Ad
	7	6,50 Bb	5,61 Ab	6,90 Cc	4,79 Ac
	10	6,56 Bab	6,14 Ab	6,29 Cb	3,33 Ab
	14	6,12 Ba	4,01 Aa	5,86 Ca	2,22 Aa
Sage Tea	3	5,64 Aa	5,27 Bb	5,88 Bab	6,30 Dd
	7	6,22 Ab	6,01 Bb	6,19 Bc	6,13 Dc
	10	6,27 Aab	6,18 Bb	6,62 Bb	5,84 Db
	14	5,56 Aa	6,05 Ba	6,04 Ba	5,73 Da

\* Capital letter refers to the difference between tea varieties.

\*\* Lower case refers to the difference between fermentation days.

*Lactobacillus* number of black, green, and mint teas reached the highest value on the 7th day of fermentation. *Lactobacillus* number of linden, and sage teas reached the highest number on the 10th day of fermentation (Fig. 2). As a result of statistical analysis, the difference between the tea varieties in terms of lactobacilli numbers was found significant at the level of  $P < 0.01$  ( $F = 7,716^{**}$ ). The difference between fermentation days was also found significant at  $P < 0.01$  ( $F = 4,498^{**}$ ). Degirmencioglu et al. [6] prepared the

teas from white, green, black, oolong and pu'er tea leaves (100g / L sugar and 6g / L tea leaf, 100 mL / L fermented kombucha and SCOBY) at 30°C after 21 days fermentation time. In their study, there was a rapid increase in lactic acid bacteria numbers until the 3rd day of fermentation, and this increase continued until the 12th day of fermentation. The highest value in LAB numbers was determined as 5.80 log CFU/mL in green tea. Their results are similar to those of this study.

The *Lactococcus* number increased rapidly in all samples until the 3rd day of fermentation. *Lactococcus* numbers decreased in the kombucha samples prepared from black tea and mint tea after the 3rd day of fermentation and in the others after the 10th day of fermentation (Fig. 3). As a result of statistical analysis, the difference between the tea varieties in terms of *Lactococcus* numbers was found to be significant at the level of  $P < 0.05$  ( $F = 3.194^*$ ) and the difference between the fermentation days at the level of  $P < 0.01$  ( $F = 11.643^{**}$ ). Due to lactic acid they

produce, Lactic streptococci and lactobacilli can lower the pH to 4.5-4.3 and 3.5-3.2, respectively [22]. At low pH, lactic acid is in toxic form for most bacteria and yeasts. Highly produced acetic acid by the lactic acid bacteria interacts with the cell membrane. It can affect intracellular acidity and cause protein denaturation. The acidity constant of acetic acid is higher than that of lactic acid (lactic acid 3.08, acetic acid 4.75). Lactic acid increases the effect of acetic acid by lowering the pH of the medium [23]. Kılıç [24] stated that acetic acid is effective on *Saccharomyces* sp.

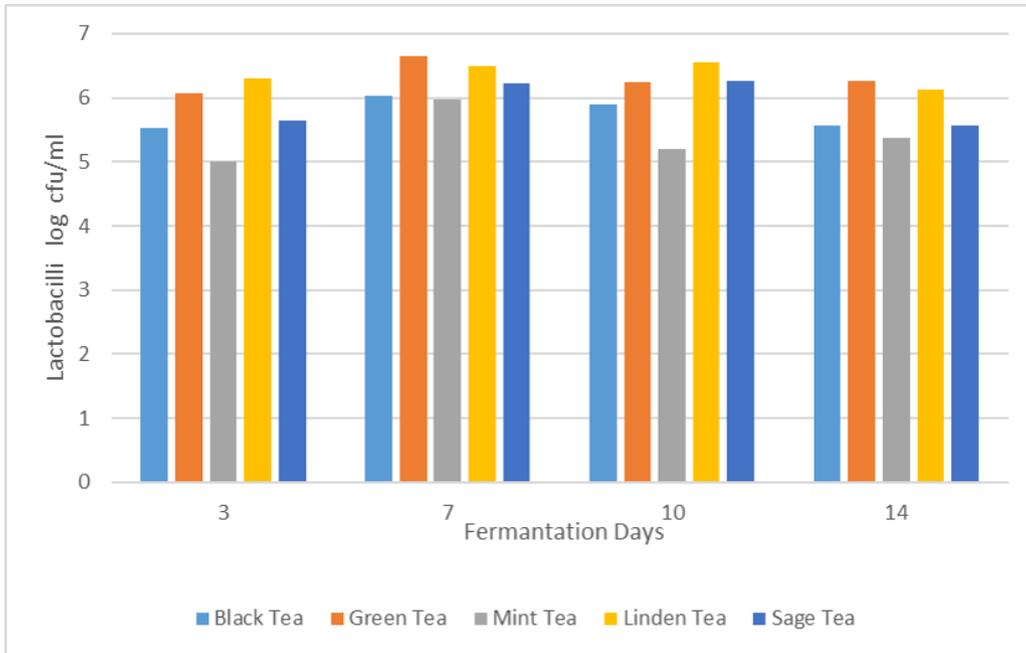


Figure 2: Changes of *Lactobacillus* counts in Kombucha samples during fermentation

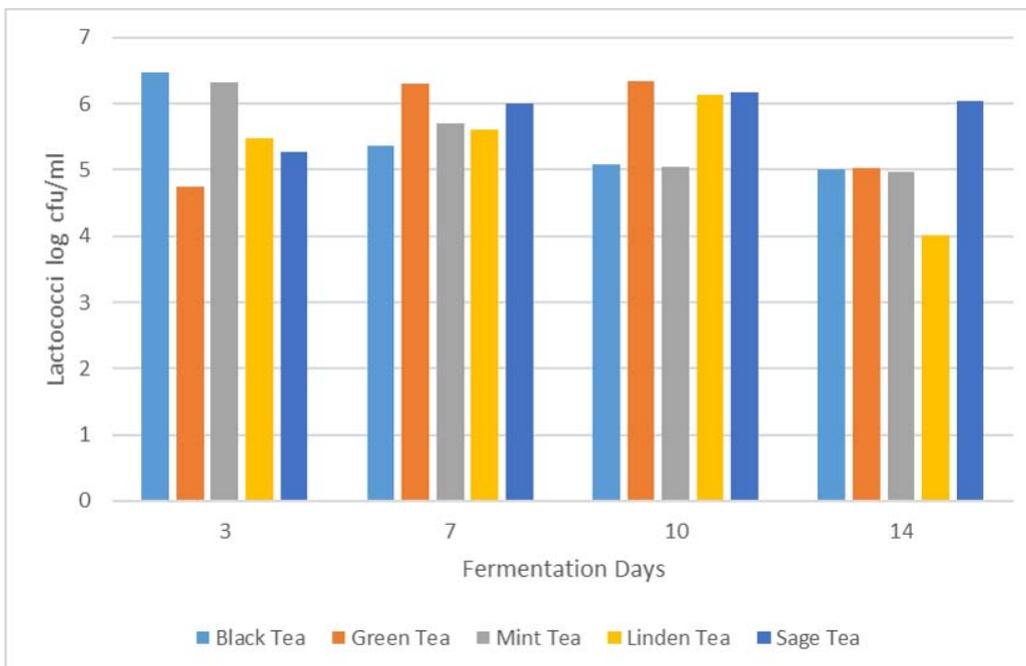


Figure 3: Changes of *Lactococcus* counts in kombucha samples during fermentation

The number of yeasts increased rapidly in all samples until the 3rd day of fermentation. Yeast numbers decreased after the 3rd day of fermentation in the sample prepared from black tea, and after the 7th day of fermentation in other tea samples (Fig. 4). As a result of statistical analysis, the difference between tea varieties and days in terms of yeast numbers was found to be significant at the level of  $P < 0.01$ . ( $F = 9,715^{**}$ ;  $F = 9,890^{**}$ ). In the study of Degirmencioglu et al. [6], the number of yeast in the green tea sample increased until the 12th day of fermentation, the number of yeast in the black tea sample was almost unchanged and decreased after the 12th day of fermentation. The yeast numbers in this study are similar to the yeast numbers in their study. The decrease in yeast numbers during fermentation may be due to a decrease in pH value. pH values decreased rapidly starting from the first days. These pH values are far below the pH value of yeasts that are effective in fermentation. However, it has shown that bacteria and yeasts in symbiotic culture can continue their activities. Yıkmiş and Tuğgüm [25] produced kombucha from black tea leaves (10g / L tea leaves, 10% sugar, and 10% pre-prepared compost tea) after a fermentation that lasted ten days at 24°C and stored at +4°C. The yeast count of this sample was 2.51 log CFU/mL on the 1st day of storage. That value is considerably lower in our study than the number of yeasts on the 10th day of fermentation of kombucha produced from black tea leaves. Jayabalan et al. [26] prepared kombucha from black tea leaves (1.2% black tea leaves, 10% sugar, 3% SCOBY, 10% fermented kombucha) at the end of fermentation (at 24°C) for 21 days. While the number of yeast was around  $45 \times 10^7$  in 7 days of fermentation, it reached  $47.5 \times 10^7$  in the 14th day of fermentation. Yeast number is higher than determined in our study. The reason for this difference may be the microflora in the cultures used. The number of yeasts in the kombucha produced from mint leaf was lower than that of the others on all days of fermentation. The reason for this may be an inhibitory effect of peppermint against certain yeasts. Schelz et al. [27] found that peppermint oil was very effective against *S. cerevisiae* 0425 52C and *S. cerevisiae* 0425  $\phi$  / 1 strains in their study.

Microbial interactions between *Saccharomyces* and non-*Saccharomyces* yeasts seem to be an advantageous option in mixed fermentation processing, having several benefits like avoiding the risks of a stuck fermentation, the addition of flavors and aromas allows the modification of undesired parameters, between others [28]. The interaction of yeasts in Kombucha causes the formation of the desired properties in the fermented product [30].

The dominant bacteria of Kombucha tea culture are acetic acid bacteria [29]. In this study, the number of acetic acid bacteria increased rapidly until the 3rd day of fermentation in all tea samples, and after the 3rd day of fermentation in samples produced from black,

peppermint, linden, and sage tea showed a regular decrease. In the sample produced from green tea, it increased until the 10th day of fermentation and then decreased (Fig. 5). As a result of statistical analysis, the difference between the tea varieties in terms of the number of acetic acid bacteria was found to be significant at the level of  $P < 0.01$  ( $F = 214,793^{**}$ ). Differences among fermentation days were also significant at the level of  $P < 0.01$  ( $F = 146.318^{**}$ ). In the study of Degirmencioglu et al. [6], the number of acetic acid bacteria increased rapidly until the 3rd day of fermentation, and the increase was slower until the 12th day. It was faster from the 12th to the 21st day of fermentation. In a study of Jayabalan et al. [26], while the number of acetic acid bacteria of the samples was around  $41 \times 10^4$  on the 7th day of fermentation, it increased to around  $45.5 \times 10^4$  on the 14th day of fermentation. In our study, the number of acetic acid bacteria decreased. Acetic acid bacteria show the best growth in the range of 25-30 °C. [30]. The optimum pH range for the development of acetic acid bacteria is 5.5-6.5. They can develop even at low pH depending on the presence of oxygen in the environment. Acetophilic ones can develop at pH 3.5, acetotolerant ones can develop between pH 3.5-6.5 [6]. In this study, since the pH fell below three after the 3rd day of fermentation, the number of acetic acid bacteria may decrease. The difference between our study and other researchers study may be the difference of the culture (SCOBY) used, the culture rate, the amount of sugar, the amount of tea leaf, the infusion time of the tea, and the fermentation conditions. Although other researchers added fermented kombucha in addition to SCOBY to the teas that will be produced, fermented kombucha was not used as a culture in this research.

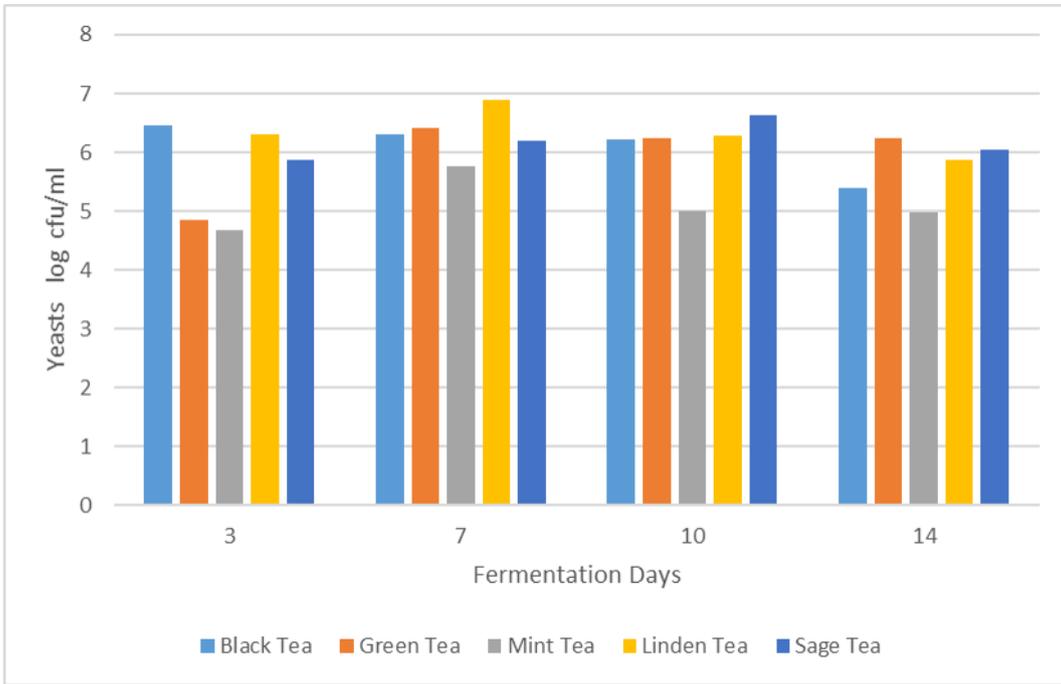


Figure 4: Changes of yeast counts in kombucha samples during fermentation

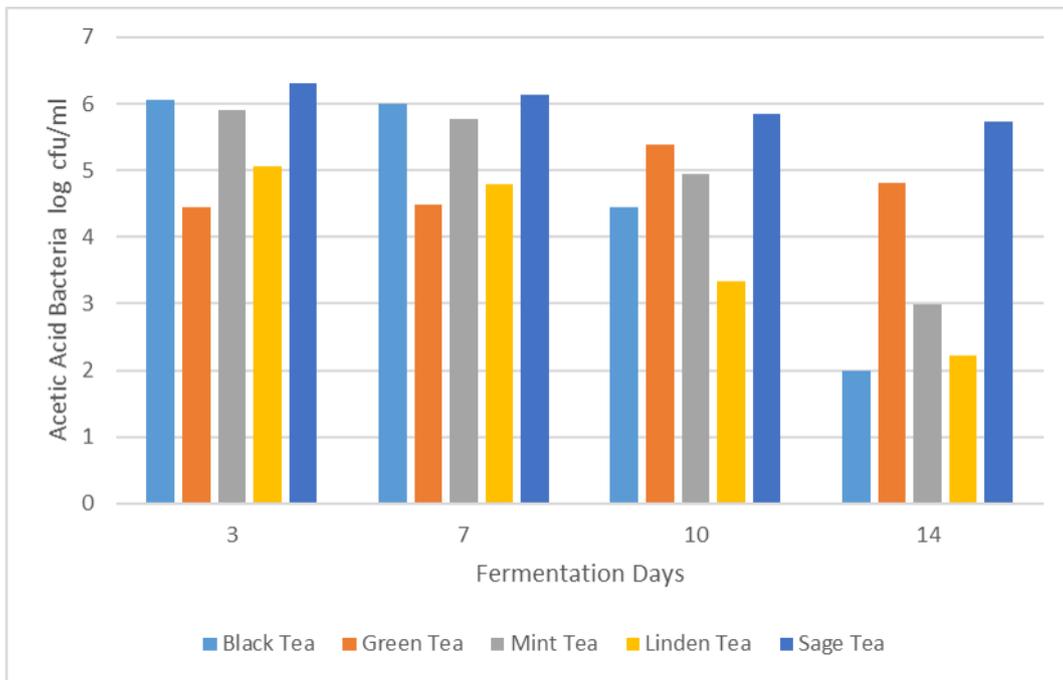


Figure 5: Changes of acetic acid bacteria counts in kombucha samples during fermentation

The kombucha fermentation process leads to the formation of a floating biofilm on the surface of the growth medium due to the activity of certain strains of acetic acid bacteria [31] (*Acetobacter aceti*, *Acetobacter pasteurianus*, *Acetobacter xylinoides*, *Bacterium gluconicum*, and *Gluconobacter oxydans*) [8]. It has been reported that the variety in the composition of yeast composition of Kombucha may be due to

geographic, climatic and cultural conditions as well as local cross-contamination of yeasts and fungi or possible cross-contamination between cultures [7,32].

In this study, the masses of biofilms formed in the kombuchas produced from black, green, mint, linden, and sage teas were determined as 43.85, 20.70, 7.44, 4.64, and 3.90g at the end of fermentation, respectively (Figure 6,7). The effect of peppermint,

linden, and sage on the growth and activity of some microorganisms may have affected biomass formation. The weight of the biomass formed in the kombuchas

obtained from these plants is less than the weight of the biomass in the kombuchas obtained from black and green teas.



Figure 6: Biofilms formed in the kombuchas and kombuchas produced from black, green, mint, linden and sage teas at the end of fermentation

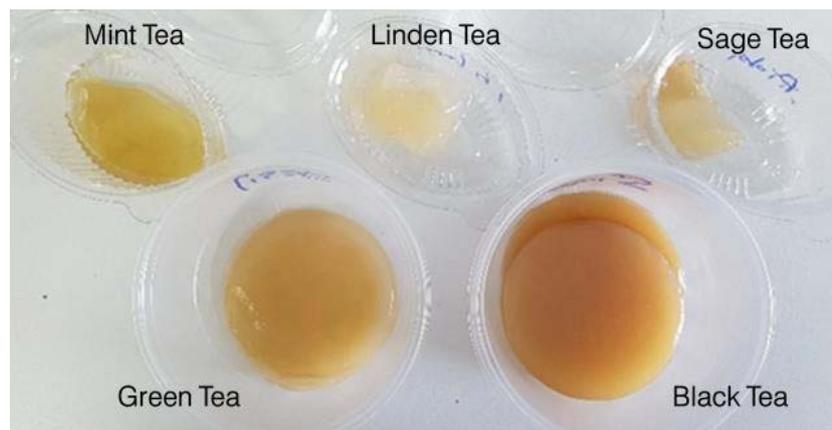


Figure 7: Biofilms formed in the kombuchas at the end of fermentation

#### IV. CONCLUSION

The number of *Lactobacillus* in the kombucha produced from green tea and linden was higher than that of other samples in all days of fermentation. While *Lactococcus* numbers in the kombucha samples produced from black tea and mint continuously decrease during fermentation, *Lactococcus* numbers in the other tea samples increased until the 10th day of fermentation and then decreased. While the yeast number of the kombucha produced from green tea, mint and linden was highest on the 7th day of fermentation, it was the highest on the 10th day of fermentation in the kombucha produced from sage. Acetic acid bacteria increased in only the green tea until the 10th day of

fermentation and then decreased. Their number in other tea samples decreased from the 3rd to the 14th day of fermentation. Different herbal teas can be used to produce kombucha with enhanced functional properties. Researching the functional properties of these teas and publishing the results will enlighten the producers and consumers.

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## An Automated Locking System to Prevent Backflow of Blood in an Intravenous Setup

By Janaki Moorthy, Keerthana Karunakaran  
& Shree Vidhya Senthil Kumar

**Abstract-** Intravenous (IV) therapy is a standard method of treatment in hospitals and clinics. However, the intravenous infusion system has its drawbacks, one of them being the reverse flow of blood back into the IV tube. The difference in pressure between the drip chamber and the venous pressure causes the reverse flow. To address the above issue, hospitals use a blood pressure cuff tied on the same arm where the infusion is given and, this cuff is inflated when backflow occurs. However, this technique requires constant monitoring which is difficult when the number of patients have to be monitored simultaneously. Although several automatic systems have been developed to make the monitoring of intravenous infusions easier for both clinicians and patients alike, there hasn't been a system specifically designed to address this issue by locking the tube. In this paper, we propose a valve-controlled locking system aimed at preventing backflow using a load cell, a Hx711 amplifier module, a microprocessor and a solenoid valve. This system is simple and cost-effective making it accessible even in poor resource locations.

**Keywords:** *intravenous tube, drip chamber, backflow, load cell, solenoidal valve, automatic locking.*

**GJRE-J Classification:** FOR Code: 091599



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# An Automated Locking System to Prevent Backflow of Blood in an Intravenous Setup

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## I. INTRODUCTION

Intravenous infusion is a form of therapy where fluids are infused into the body through the veins [1]. It is the standard method of treatment for individuals in whom food or medication cannot be administered orally. It is commonly used in chemotherapy, to reduce electrolyte imbalance to manage dehydration, fever and anemia [1], [2]. It is usually administered in the upper limbs due to an increased risk of thrombophlebitis during line placement in the lower limbs [3].

An intravenous (IV) setup consists of drip bottle, drip chamber, a capillary tube and a roller clamp. The drip bottle is suspended from a stand at a height from the patient. The drip chamber is connected to the bottle at its mouth. The roller clamp facilitates regulation of flow rate which is measured in drops per unit time. The fluid in the drip chamber reaches the patients' vein as a result of the pressure difference between the drip chamber and the patients' venous pressure [2], [4]. Once the volume of liquid in the bottle goes below a certain level, the pressure is reversed causing backflow of blood into the capillary tube which has several adverse effects such as blockage of tube, loss of blood, swelling, infection, hypothermia [5] and blood leakage [6]. Another severe effect is air embolism [7] which can

result in reduced cardiac output and in extreme cases cause death.

To prevent backflow, a manual method is being adapted in hospitals wherein a blood pressure cuff is tied on the upper arm and the catheter is passed beneath the cuff. The cuff is inflated when necessary, causing constriction of the lumen thus preventing backflow [8]. Although this method is quite simple and has not been proven to have any adverse effects, it requires constant monitoring by clinicians. Apart from backflow, intravenous therapy also requires tremendous effort on the part of the nurses not to mention continuous surveillance of the patients' status [9] which is difficult to do in poor resource locations.

In recent years, several methods [1], [2], [4-17] have been developed to make the process of monitoring intravenous infusion easier both for the patients and clinicians. These include alarm-based systems [1], [2], [5], [10], warning systems based on RFID technology [9], [11], optical detection [12], one-way valves [13], [14], flow sensors [15] and wireless sensors [16], [17]. Although several similar techniques have been developed, none of them are aimed at prevention of backflow [5]. In this paper, we have proposed an automated locking system which effectively prevents the backflow of blood into the catheter.

## II. LITERATURE SURVEY

Several studies have been conducted and techniques developed to make the management of intravenous infusions easier. Across the studies, the various methods that have been used are listed below:

- a) Alarm based systems
- b) RFID based systems
- c) Optical detection
- d) Flow sensors
- e) One-way valves
- f) Wireless sensors

### a) Alarm based systems

Several studies [1], [2], [5], [10] have proposed an intravenous infusion monitoring and alarm-based system. Jianwen et al. used a photoelectric sensor technology and signal processing system to display and monitor the velocity of the fluid and also to indicate the blockage or end of an infusion process using an alarm. The hardware system consists of an infrared detection

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unit, SCM processing unit, data display module, sound and light alarm module, the locking module and wireless communication modules [10], [11].

In a study conducted by Shelishya et al., the system consists of slotted interrupter modules which are IR sensors used to monitor the flow of fluid in an IV tube. The sensor output is then given to an analog to digital convertor. This ADC output is then fetched by a microcontroller which is programmed to activate a voice module to alert the nurse on the end or blockage of an infusion process [5], [11].

Bhavaasar et al. emphasize intravenous liquid monitoring and alarm system using load cell as well as heart beat sensors. This method lowers the chance of heart attacks and reduces the complications in IV therapy by monitoring the level of the liquid in the IV bag when the level drops below the set point and by sensing air bubbles formed in the catheter [1], [11].

Raghavendra et al. designed a system for detecting variations in light transmission between a LED and a photodiode placed around the drip chamber. This device displays the drip flow rate and also has an alarm system which indicates the deviation from the pre-set value [2], [11].

#### b) *RFID based systems*

RFID system uses tracker tag system, these tags consist of electronically stored information and the passive tag collects information from the nearby available RFID reader. In this technique the major components are load cell of s-type, drip bag weight scale, RFID/NFC tag reader, 6502microcontroller system. The load cell transforms the tension pulled by a drip bag, to weak electrical signal. Then the electrical signal is amplified and is filled into a 16-bit A/D converter. Finally, the tension is converted into 2-byte digital weight data. The two-byte data and five-byte RFIF data are packed as a data packet which is transmitted via UDP protocol to a data collector module of IV infusion monitoring system [9]. The RFID tag is designed and attached on the bag of intravenous drip. The tag is disabled when the bag is not empty because liquid contained [11].

Sometimes LAN (Local Area Network) has been used in the process of data transmission. Active tags have local power source and it may operate hundreds of meters away from the RFID reader [12].

#### c) *Optical detection*

Here the system to be monitored is stimulated through an appropriate electromagnetic signal, typically a step-like voltage pulse, which is propagated through a probe, any impedance variation will cause the partial reflection of the propagating signal through a probe. Any impedance variation will cause the partial reflection of the propagating signal. The analysis of the reflection coefficient in time-domain,  $\rho$ , allows the retrieval of the dielectric characteristics of the material under test, as

well as of its quantitative parameters, such as in the case of the level of liquid materials [11], [13].

While considering the case of the liquid sample having a certain level, at the air-to-liquid interface an impedance change occurs, due to the difference in dielectric permittivity. Therefore, the measured reflection coefficient shows a significant variation which may be used to individuate the air to liquid interface. Here the non-invasive probe is made of two strip electrodes, attached on an external surface of a container in which the medical liquid is contained. The ad-hoc probe configuration was realized through two adhesive copper strips with a width of 3 mm and a mutual distance of 3 mm [11], [13].

#### d) *Flow sensors*

The piezoresistive flow rate sensor inspired by the hair cell sensor found in the fish lateral line system has been composed and fabricated. The sensor has been bonded with a 3D printed fixture and they have been integrated on an intravenous tube. The responses of the sensor with respect to flow rates between 100ml/h and 500 mL/h are noted. The flow rate has been tested using an experimental set up and it is controlled by peristaltic pump. The sensor shows both transient phase and stable phase responses [11], [16].

#### e) *One-way valves*

One-way valves or non-return valves (NRV's) are valves that are used across several medical devices as a means to prevent backflow in intravenous infusions and as a means of preventing contamination of the patients' fluids with the infusion fluids [14],[15]. These valves are specially designed allow only a designated direction of flow (DDF) [15] and can usually withstand high levels of reverse pressure before failing [14]. However, two studies [14],[15] conducted on these valves have indicated that they cannot be relied upon as a means of prevention of backflow or as infection control.

Ellger et al. [15] conducted a study on five different models of NRVs and tested them for rising levels of pressure against DDF and migration of micro-organisms proximal to the valve. As an outcome of the study, 40% of the NRVs' resulted in backflow in instance of rising pressure against DDF and 30% of samples showed migration of micro-organisms near the valve. It was thereby concluded that NRV's are not a reliable method of prevention of backflow or contamination of fluids. Another study conducted by Nandy et al. [14] to test the levels of cross-contamination in one-way valves used 5 models of valves against 3 different infusions passed against the direction of flow. Leakage occurred in several models of valves against direction of flow. The conclusion was that one-way valves are not reliable for prevention of contamination in case of backflow [11].

#### f) *Wireless sensors*

Wireless sensors have been incorporated into monitoring systems for intravenous infusion monitoring. Zhang et al. [18] developed a monitoring system which involved a monitoring sensor which was incorporated at an end of the infusion tube. The sensor collects signals on the progress of the infusion. The sink node is deployed at a PC in the nurses' station from where the infusion status can be monitored. The monitor software on the PC is used to generate alarms and to process signals. It also provides information on the medicine administered, the volume, the drop velocity [11].

Bustamante et al. [17] devised a system to detect any occlusions in the catheter or to detect when the catheter is empty and reduces the need for clinical intervention. It consists of a sensor, a radio module for low consumption, a feeding module to give an alert in case of low battery and a microprocessor. The sensor used is an optical sensor which is used to detect the dripping of fluid in the tube. The microprocessor receives the signal from the sensor and determines if the infusion is dripping or not and generates signals accordingly [11].

In the above studies, methods have been developed to facilitate easier monitoring but in all these systems, an alert is given whenever the flow rate varies or level of fluid in the reservoir falls below the desired range and a nurse has to manually rectify the issue. In this paper, we have discussed a valve-controlled locking system that automatically locks the IV tube based on a preset value of the bottle weight [11].

### III. VALVE-CONTROLLED LOCKING SYSTEM

The system has been designed in such a way to keep it as simple and cost-effective as possible. The setup primarily consists of a load cell, an amplifier module, a solenoid valve, and microcontroller. The load cell records the weight of the bottle, and the amplifier module strengthens the signal. The microcontroller reads the signal generated by the amplifier and accordingly controls the solenoid valve interfaced with it. The system design is as given in Figure 1.

The overall setup of the proposed system is as given in Figure 2. A load cell is present, from which the IV bottle is suspended. Based on the tension generated by it, the load cell produces an electric signal, which is equal to the weight of the IV bottle. Although, this signal is too feeble to be read by a microcontroller, hence it needs to be boosted. The amplification has been done with an Hx711 module, which is often used in tandem with a load cell. The amplified signal is then read by a microprocessor, which in turn controls a solenoid valve incorporated into the IV tubing. If the value read by the microcontroller goes below a critical point, the solenoid valve is turned on and locks the tube, thereby preventing backflow.

The software platform used is the Arduino IDE. A single control program monitors the weight of the IV bag. The flow of the program is as given in Figure 3 below. The output of Hx711 is monitored continuously in a loop. By default, the value of the solenoid pin is set to HIGH and is on. Once the weight of the bottle falls below the threshold point (e.g., 10 grams), the solenoid pin value is set to LOW and is switched off, thus effectively locking the IV tube.

#### a) *Hardware description*

##### i. *Load cell*

To calculate the weight of the IV bottle, a load cell has been used. Here the load cell module has been used to convert it to analog data and sends it to the microcontroller [19]. A load cell is a sensor that can detect the amount of tension applied to it by the object suspended from it and generates an electric signal [20]. The capacity of load cells varies from 400g to 40 kg. For this system, to enable higher accuracy as far as the weight of the IV bottle/bag is concerned, a load cell of capacity 500g is used, as shown in Figure 4.

In this system, the IV bottle is suspended from the load cell. The load cell has a parameter called calibration factor, which determines the stability and accuracy of the recorded measurements, and this value has to be set accordingly.

##### ii. *Hx711 amplifier module*

The Hx711 amplifier module, as shown in Figure 5, is used in combination with the load cell and integrates directly with the microcontroller.

The signal generated by the load cell is weak and cannot be read by a microcontroller directly. Hence, it requires amplification, and this is where the Hx711 module comes into the picture. It also plays the role of an analog-digital converter, transforming the analog signal received from the two-weight sensors to a digital one, which is sent to the microcontroller [21]. The amplifier module passes the strengthened signal to the microcontroller for further processing.

##### iii. *Microcontroller*

The microcontroller is the integration point for all the hardware components and the controlling factor for the valve. In this setup, the Arduino microcontroller is used for interfacing with the sensors and with the solenoid valve, as shown in Figures 6 and 7. The Arduino Uno is a microcontroller board based on the ATmega328P datasheet. It has almost 14 digital input/output pins (of which six can be utilized as PWM outputs), six analog inputs, an ICSP header, a 16 MHz quartz crystal, a power jack, a USB connection and a reset button [8].

The Arduino contains features that are needed to assist the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. It is easy to work with

and can interface with a variety of sensors and is cost-effective when compared with other controllers. It also has a reasonably low operating voltage and hence optimizes power consumption. The microcontroller reads the signal from the amplifier module, which is equal to the weight of the IV bag. If the value decreases below a certain set point, the microcontroller turns the solenoid valve on and locks the IV tube.

#### iv. Solenoid valve

The solenoid valve is an electromechanical device that is used in this setup to lock the tube when the appropriate situation arises. This valve has an electric coil known as solenoid with a ferromagnetic plunger. When the valve is switched on, the electric current passing through the coil creates a magnetic field. The plunger is pulled towards the center of the coil, causing it to open. When the solenoid valve is closed, it needs to be offered a lowered current to maintain the valve pull-in state. This not only reduces energy consumption and calorific value but also decreases the turn-off time and improves the turn-off response [22].

Solenoid valves are available in operating voltages of 5, 12, and 24, 110, and 220 volts. For this system, a 12-volt valve has been used. The solenoid valve was chosen not only due to its' wide variety of applications in the medical device industry such as in oxygen concentrators, drug-delivery systems, and dialysis machines to control blood flow but also due to a list of other benefits including energy efficiency, lightweight and compact nature, cost-effectiveness and reliability.

## IV. RESULT ANALYSIS

For the result analysis, several repeat tests have been done for this system. A random sample of the results collected is shown in the table. Starting from the maximum volume condition, measurements related to the decrease in the level of the liquid were also recorded. The set point for the weight of the IV bag was set at 35 grams for a bottle of capacity 500 ml. While the weight stays above the set point, the valve remains unlocked. As soon as the weight of the IV bag falls below 35 grams, the valve locks the tube.

Table 1: Experiment results

Level in IV bag (ml)	Recorded weight of the IV bag (g)	Solenoid status
100	103.32	ON
75	77.86	ON
55	57.76	ON
35	37.44	ON
30	33.89	OFF
20	23.33	OFF
10	13.45	OFF
0	3.23	OFF

The critical level at which the tube is locked was set based on the levels of liquid used in previous

studies[23], [24], [25], [26] which focused on raising an alarm to alert the nursing staff when the level of liquid went below a certain critical value. One study [24] set the threshold value as 70 ml since the level of liquid at which the IV bag is replaced is between 50 to 100 ml. Setting such a midpoint value makes it easier for the clinician to replace the bag before backflow occurs. Another study [25], the critical value was set at 50 ml for the first alert and in this was missed, another alert was sent when the level of the liquid reached 30 ml. Another study [26] conducted with an IV bottle of capacity 500 ml sent an alert when the level dropped to 250 ml and an emergency alert when the level dropped to 50 ml. However, the studies cited above focused primarily on sending alerts, but in this system, the focus is on automatic locking. Hence, to minimize the wastage of liquids while simultaneously preventing backflow, the critical level of the system was set at 35 grams.

## V. CONCLUSION

The system proposed in this paper can be implemented in various settings, both in clinics as well at home. The system is both simple and cost-effective. Although several techniques have been developed in the past, these systems only address issues related to monitoring flow rate and raising the alarm in the event of any risk of backflow, but none of them could effectively prevent the backflow of blood in the IV tube since no system incorporated any kind of locking mechanism. Given the above observations, the implementation of this system would result in a considerable improvement in the management of patients on intravenous therapy. The future work involves the incorporation of an alarm system to indicate the status of the solenoid valve and a sensor to control the rate of infusion along with application to notify the clinician when the IV bottle becomes empty and to indicate variations in the set rate of infusion.

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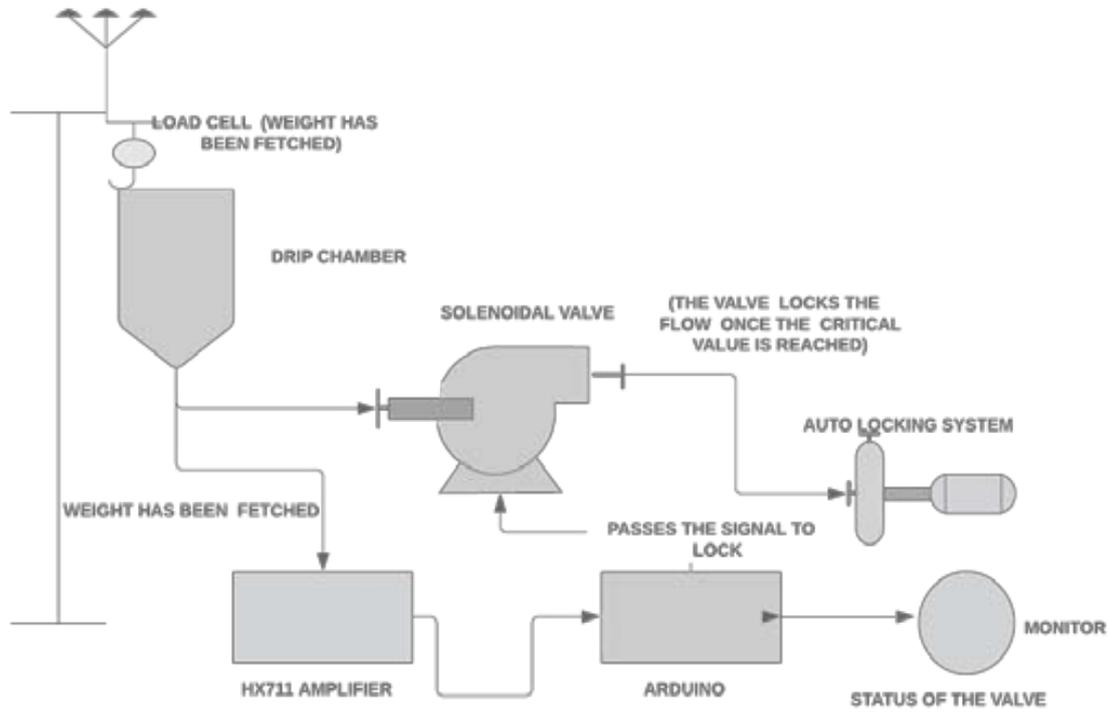


Figure 1: Architecture diagram of proposed system

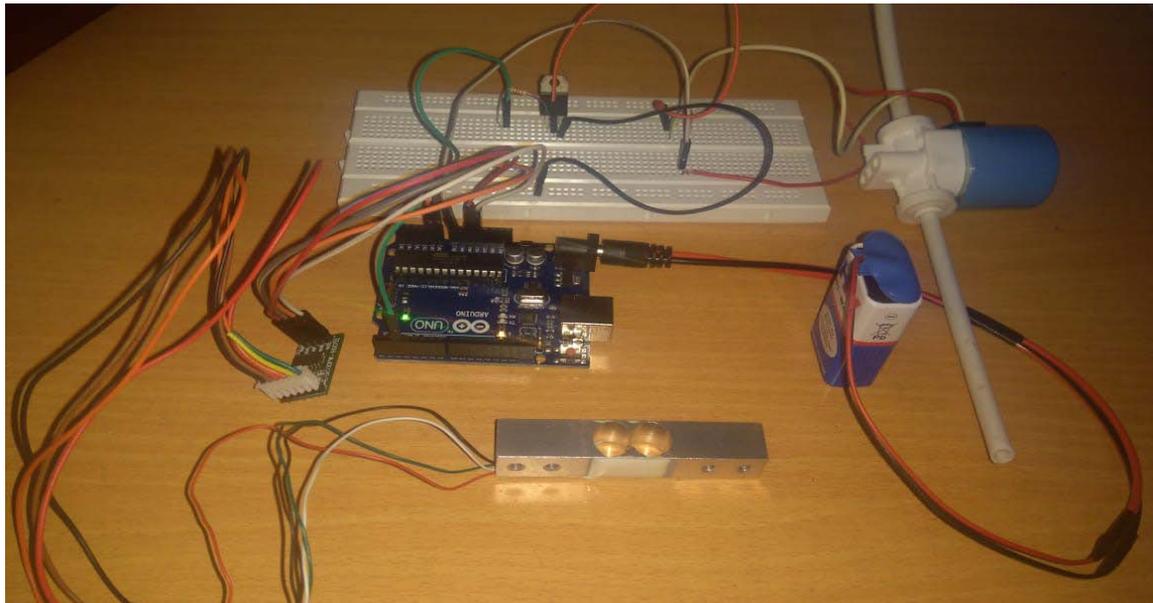


Figure 2: Setup of the proposed system

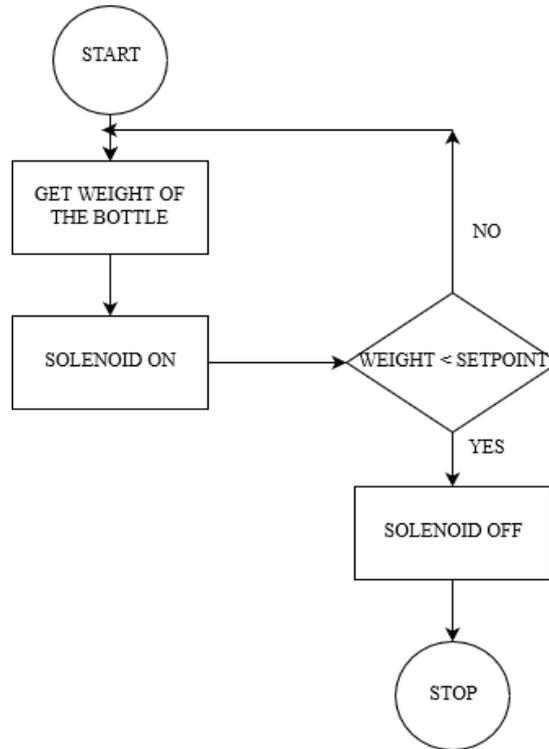


Figure 3: Flowchart of the control program

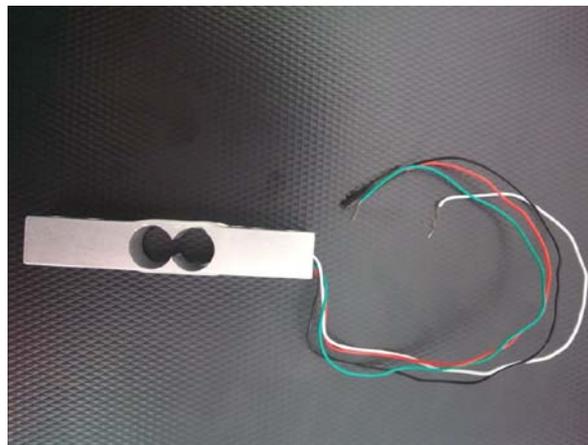


Figure 4: Load Cell

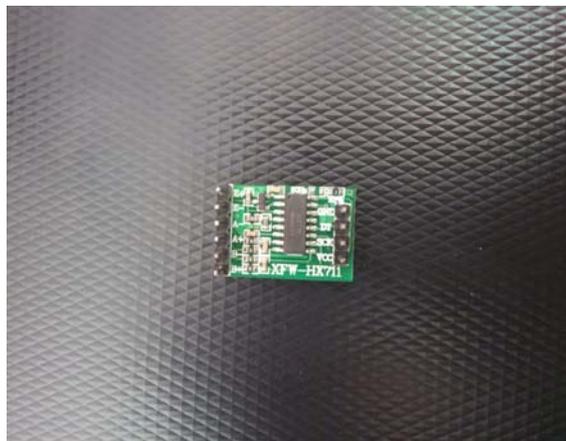


Figure 5: Hx711 amplifier module

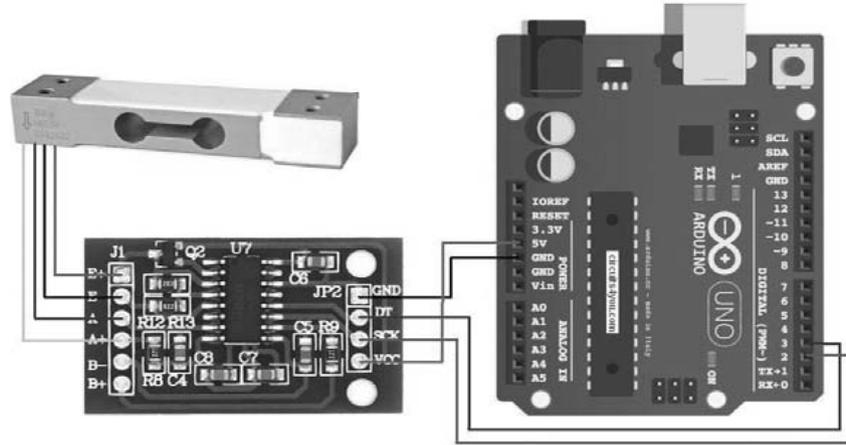


Figure 6: Interfacing load cell and Hx711 amplifier module with Arduino microcontroller

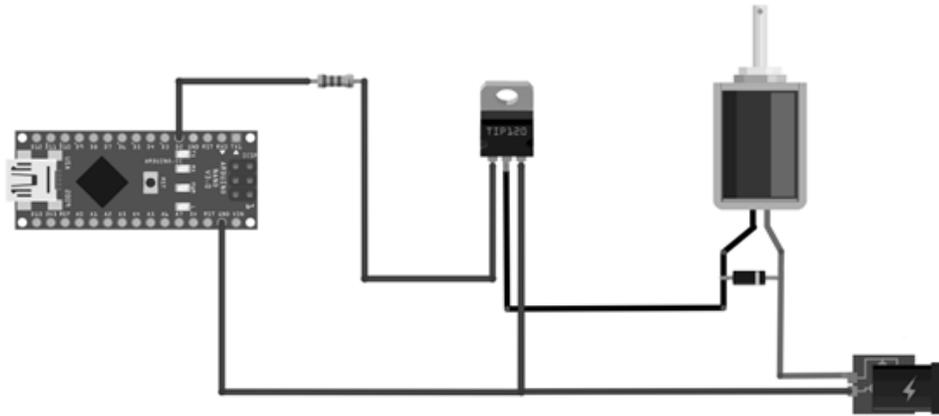


Figure 7: Interfacing solenoid valve with Arduino microcontroller

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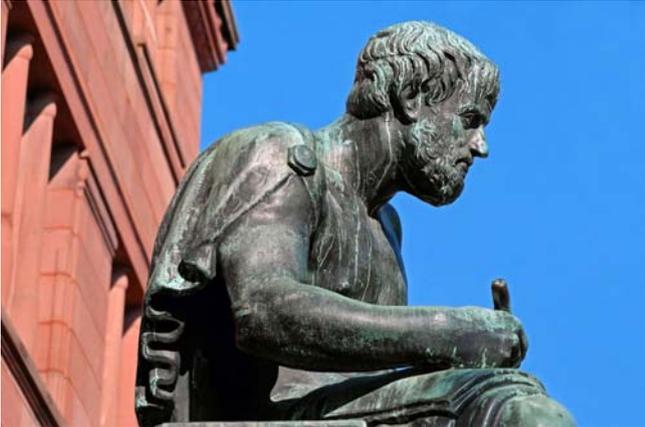
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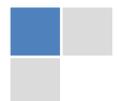
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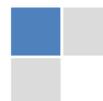
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**10. Use proper verb tense:** Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

**11. Pick a good study spot:** Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

**12. Know what you know:** Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

**13. Use good grammar:** Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

**14. Arrangement of information:** Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

**15. Never start at the last minute:** Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

**16. Multitasking in research is not good:** Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

**17. Never copy others' work:** Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

**18. Go to seminars:** Attend seminars if the topic is relevant to your research area. Utilize all your resources.

**19. Refresh your mind after intervals:** Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

**20. Think technically:** Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.



**21. Adding unnecessary information:** Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

**22. Report concluded results:** Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

**23. Upon conclusion:** Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium through which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

## INFORMAL GUIDELINES OF RESEARCH PAPER WRITING

### **Key points to remember:**

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

### **Final points:**

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

*The introduction:* This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

### **The discussion section:**

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

### **General style:**

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

**To make a paper clear:** Adhere to recommended page limits.

### *Mistakes to avoid:*

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.

- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

#### **Title page:**

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

**Abstract:** This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

*Reason for writing the article—theory, overall issue, purpose.*

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

#### **Approach:**

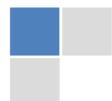
- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

#### **Introduction:**

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

*The following approach can create a valuable beginning:*

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.



**Approach:**

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

**Procedures (methods and materials):**

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

**Materials:**

*Materials may be reported in part of a section or else they may be recognized along with your measures.*

**Methods:**

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

**Approach:**

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

**What to keep away from:**

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

**Results:**

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.



**Content:**

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

**What to stay away from:**

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

**Approach:**

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

**Figures and tables:**

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

**Discussion:**

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.



**Approach:**

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

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	A-B	C-D	E-F
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<i>Introduction</i>	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
<i>Methods and Procedures</i>	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
<i>Result</i>	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
<i>Discussion</i>	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
<i>References</i>	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring



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