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BIOCHEMISTRY AND GENETICS OF ANIMALS

ВЛИЯНИЕ УСЛОВИЙ ХРАНЕНИЯ НА БИОХИМИЧЕСКИЙ СОСТАВ СОРТООБРАЗЦОВ МОРКОВИ

Агаев Ф.Н.
доктор философии по биологии, доцент, академик Международной Академии Аграрного образования, ведущий научный сотрудник
ORCID-0000-0002-3366-081X
Насибов Х.Н.
доктор философии по аграрным наукам, доцент, и.о. председателя правления
ORCID-0009-0005-4725-2154
Аскеров А.Т.
доктор философии по биологии, доцент, зампредседатель Правления по науке
ORCID-0009-0000-4995-3564
Махсудов Ш.М.
доктор философии по аграрным наукам, завотдел картофелеводства
ORCID-0009-0005-1509-1325
Мустафаев З.Х.
доктор философии по аграрным наукам, член-корр. Международной Академии Аграрного образования, старший научный сотрудник
ORCID-0009-0002-5608-4664
«Научно-исследовательский институт Овощеводства»
Публичное Юридическое лицо, Азербайджанской Республики, г.Баку

THE INFLUENCE OF STORAGE CONDITIONS OF THE BIOCHEMICAL COMPOSITION OF CARROT VARIETIES

Agayev F.,
Nasibov H.,
Asgerov A.,
Machsudov Sh.,
Mustafayev Z.
Baku, Republic of Azerbaijan
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Аннотация

Были исследованы изменения биохимического состава 6 образцах моркови (№1, №2, №2/1, №3, №4, №5), выращенной в открытом грунте сразу после сбора урожая, а также в течение 20 и 34 дней хранения при температуре 12 ± 1^0С и относительной влажности 75-80%. Установлено, что содержание сухого вещества в сортообразцах моркови сразу после сбора урожая варьировалось от 11,28 до 13,70%, содержание сахара – от 7,60 до 9,63%, экстрактивных веществ (всех веществ, растворенных в клеточном соке) - от 9,25 до 11,04 %, общей кислотности – от 0,052 до 0,11%, сахарокислотного индекса – от 70,46 до 185,19, а количество нитратов – от 38,9 до 56,6 мг/кг. Показано, что условия хранения оказывают положительное влияние на биохимический состав: после 34 дней хранения содержание сухого вещества в изученных образцах составило 12,88-14,83 % (повышение в 1,01-1,15 раза), содержание сахаров – 8,26-10,08 % (повышение в 1,01-1,28 раза), экстрактивных веществ – 9,72-11,6% (повышение в 1,04-1,20 раза). Повышение значения указанных показателей после хранения можно объяснить высыханием корнеплодов моркови, т.е. потерей воды. Условия хранения не оказали существенного влияния на количество нитратов. Следует отметить, что количество нитратов, накопившихся в корнеплодах моркови, было значительно ниже допустимого передела (250 мг/кг), установленного Министерством Здравоохранения Азербайджанской Республики для этого вида овощей (4,42-6,70 раза). Наибольшее содержание нитратов было зафиксировано в образцах №3 (51,4 мг/кг) и №4 (56,6 мг/кг) сразу после сбора урожая, а наименьшее – в образцах №2/1 (37,3 мг/кг) и №5 (38,3 мг/кг) после 34 дней хранения. Такое низкое накопление нитратов в корнеплодах моркови следует объяснять биологическими особенностями этого овощного растения.

Abstract

Changes in the biochemical composition of 6 carrot samples (№1, №2, №2/1, №3, №4, №5) grown in open ground immediately after harvesting as well as during 20 and 34 days of storage at a temperature of $12\pm1\ ^0$C and a relative humidity of 75-80 % were studied. It was found that the dry matter content in carrot varieties immediately after harvesting variety from 11,28 to 13,70%, sugar content – from 7,60 to 9,63 %, extractive substances (all substances dissolved in cell sap) – from 9,25 to 11,04 %, total acidity – from 0,052 to 0,11 %, sugar – acid index – from 70,46 to 185,19, and the amount of nitrates-from 38,9 to 56,6 mg/kg. it was shown that storage conditions have a positive effect on the biochemical composition: after 34 days of storage, the dry matter content in the studied samples was 12,88-14,83 % (an increase of 1,01-1,15 times), the sugar content was 8,26-10,08 % (an increase of 1,04-1,20 times), and extractive substances 9,72-11,60 % (an increase of 1,01-1,28 times). The increase in the values of these indicators after storage can be explained by the drying on carrot roots, i.e., the loss of water. Storage conditions did not significantly affect nitrate levels. It should be noted that the amount of nitrates accumulated in carrot roots was significantly lower than the permissible limit (250 mg/kg) established by the Ministry of Health of the Republic of Azerbaijan for this type of vegetable (4,42-6,70 times). The highest nitrate content was recorded in samples №3 (51,4 mg/kg) and №4 (56,6 mg/kg) immediately after harvest, and the lowest in samples №2/1 (37,3 mg/kg) and №5 (38,3 mg/kg) after 34 days of storage. Such low nitrate accumlation in carrot roots should be explained by the biological characteristics of this vegetable plant.

Ключевые слова: морковь, сортообразцы, биохимический состав, условия хранения, гибриды, открытый грунт.

Keywords: carrot, variety samples, biochemical composition, storage conditions, hybrids, open ground.

Введение.

Морковь занимет одно из ведущих мест среди овощных культур благодаря содержащимся в ней углеводам, витаминам, минералам и биологически активным соединениям. β – каротин, содержащийся в моркови, является предшественником витамина А (ретинола) и составляет более 50% всех каротиноидов, при этом его количество вдвое превышает количество α – каротина [1, с.89]. Поскольку биохимический состав моркови сильно зависит от срока хранения и условий, изучение этих факторов имеет актуальное значение. В зависимости от условий и сроков хранения происходит изменение уровня биологически активных веществ (каротина и витаминов), а также сахаров и других компонентов в моркови. Согласно литературным данным, независимо от условий хранения, количество каротина и витаминов в корнеплодах моркови со временем уменьшается из-за окисления и разложения. При этом уровень сахаров, экстрактивных веществ (всех веществ, растворенных в клеточном соке) и общая кислотность могут как увеличиваться, так и уменьшаться [2, с. 17-18]. Это зависит от биологических особенностей сортов моркови, условий хранения и исходного уровня сахаров, экстрактивных веществ. Установлено, что внесение азотных и фосфорных удобрений приводит к увеличению содержания сухих веществ в корнеплодах, но при этом происходит снижение сырой массы продукта во время хранения. Большинство исследователей отмечают, что оптимальными условиями хранения для длительного хранения корнеплодов моркови (более 40 дней) являются температуре 0^0C и влажность 95…98 % [3, с. 11; 4]. Наибольшее влияние на хранение оказывают условия выращивания корнеплодов. Хотя применение высоких доз удобрений и обильный полив повышают урожайность, они снижают их качество, транспортабельность и способность к хранению. По данным исследования А.Юровой, внесение удобрения в дозе $N_{64}P_{64}K_{64}$ под растения моркови увеличило количество сухого вещества на 10,5 % по сравнению с вариантом без удобрений (контроль) и содержание токсичных веществ – нитратов – в 3,61 раза [4]. Также наблюдалось некоторое увеличение количества общего сахара и каротина (в 1,10 и 1,57 раза соответственно), но даже при этом примененная доза удобрений значительно ухудшила транспортабельность и способность моркови к хранению.

Е.В.Янченко, Ю.Г.Михеев и другие изучали оценку способности к хранению и устойчивости к болезням современных сортов и гибридов столовой моркови, влияние их биохимических показателей на способности корнеплодов к хранению и степень поражения различными болезнями в процессе хранения, и установили, что образцы с высоким содержанием сухого вещества и сахаров обладают лучшей способностью к хранению и устойчивостью к серой гнили, белой гнили и альтернариозу [5, с.18; 6, с.35].

По мнению некоторых исследователей, все фрукты и овощи подвержены порче во время хранения по трем основным причинам: потеря влаги, изменения химического состава и метаболизма, а также гниение, вызванное патогенами. Относительная величина каждой из этих причин варьируется в зависимости от сорта и вида продукта. Поэтому необходимо сократить наиболее важные источники потерь при хранении любых овощей [7, с.29; 8, с.181]. С этой целью вышеупомянутые авторы обрабатывали морковь 0,2%-ным водным раствором пропионовой кислоты (ПК) один раз в 2 дня в течение хранения. После такой обработки количество сухого вещества и органических кислот увеличилось в 1,17 и 2,11 раза соответственно за первые тридцать дней хранения. Кроме того, обработка корнеплодов моркови водным раствором ПК способствовала сохранению их тургора, свежести и вкуса, а также не наблюдалось ухудшения качества из-за воздействия различных патогенов. В другой исследовательской работе С.В.Демченко отмечает, что разрушительные биохимические и микробиологические процессы, происходящие в корнеплодах во время хранения, замедляются действием 0,2%-ного водного раствора ПК, то есть эти процессы ингибируются [9, с. 26-27].

В своей диссертационной работе Р.Н.Обломий попытался усовершенствовать методы хранения моркови и установил, что в течение первых 30 дней хранения корнеплодов моркови при температуре 0 - $+2^0$C и влажности 90-98% количество сухого вещества и сахаров несколько увеличилось, но количество протопектинов и витаминов (С и β – каротин) уменьшилось [10, с. 15-16]. Он также показал, что несмотря на то, что свежая морковь практически не содержит оксикофеиновых кислот (хлорогеновой, кофейной кислот и их производных – производных феруловой и кофейной кислот), они образуются в условиях хранения, что в конечном итоге приводит к ухудшению вкуса и качества корнеплодов. Поскольку эти вещества имеют фенольную природу, из них могут синтезироваться горькие вещества [10, с. 17].

Исходя из вышеизложенного, можно заключить, что исследователи изучили условия хранения моркови в условиях холода и при высокой влажности, как и большинства других овощей, и пришли в выводу о необходимости соблюдения следующих условий для снижения потерь при хранении:

– строгое соблюдение технологии выращивания моркови;

– бережный сбор урожая, избегание повреждения корнеплодов;

– немедленное охлаждение урожая после сбора;

– избегание колебания температура в хранилищах;

– дезинфекция мест хранения и контейнеров.

Наше исследование посвящено биохимическим изменениям в моркови, хранившейся в течение 20 и 34 дней при температуре 12±1^{0}С и влажности 75-80%. В ходе исследования корнеплоды моркови опрыскивали водопроводной водой каждые два дня. Корнеплоды, поврежденные или пораженные болезнями во время хранения, выбрасывали (их количество не превышало 5 %).

Материал и методика.

Объектом исследования были гибриды сортообразцы моркови (гибриды №1, №2, №4 сортобразцы №2/1, №3, №5), взятые из генофонда публично-юридического лица «Научно-исследовательский Институт Овощеводства» (НИИО).

Посев семян моркови был произведен 30 июня на полях Апшеронской Экспериментальной станции НИИО (Апшеронский полуостров Азербайджанской Республики) по схеме 50х20 см, а уход за посевами осуществлялся по общепринятым методикам [11]. Уход за растений морковью включал 5-7 поливов (каждый раз и расчета 400-500 м^3), минеральное питание ($N_{60}P_{60}K_{110}$), 1-2 раза прореживания, борьбу с болезнями и вредителями, сорняками, а также рыхление почвы культиватором 1-2 раза [12, с. 816].

Биохимический состав корнеплодов моркови изучали непосредственно после сбора урожая, на 20-й и 35-й день хранения. Сухое вещество в корнеплодах определяли термостатно-весовым методом путем высушивания при 105^{0}С, количество сахаров – с помощью рефрактометра RA-130 (Корея), количество экстрактивных веществ – с помощью прибора RX-5000 CX (ATSGO – Япония), нитраты с помощью портативного нитратометра (SOEKS), а общую кислотность – методом титрования [13].

Результаты исследования и их обсуждение.

Результаты исследования показывают, что при кратковременном хранении корнеплодов моркови (30-35 дней) нет необходимости использовать традиционные методы хранения (хранение при 0…+1^{0}С и относительной влажности 90-98%, газовый режим). Для этого достаточно создать в помещении для хранения температуру 12±1^{0}С и влажность 75-80% зимой и весной. При хранении в этих условиях корнеплоды следует слегка опрыскивать водопроводной водой или, как указано в литературе, 0,2%-ным водным раствором пропионовой кислоты каждые 2 дня [7; 8; 9]. В процессе такого хранения на 20-й день количество сухого вещества в корнеплодах увеличивается в 1,01-1,084 раза, количество сахаров, - в 1,01-1,12 раза, количество экстрактивных веществ – в 1,01-1,07 раза, а уровень органических кислот – 1,14-1,39 раза (таблица). При этом, поскольку уровень кислотности в корнеплодах увеличивается больше, чем содержание сахаров, соотношение сахар-кислота (сахарокислотной индекс) значительно снижается (в 1,02-1,37 раза).

Таблица.

Изменчивость биохимических показателей в сортообразцах моркови в зависимости от различных сроков хранения

Генотипы	Сухое вещество, %	Сахара, %	Экстрактивные вещества, %	Общая кислотность, %	Сахарокислотной индекс	Нитраты, мг/кг
Сразу после сбора урожая						
Гибрид №1	13,08	8,58	11,0	0,070	122,57	38,9
№ 2/1	11,95	7,60	9,48	0,052	146,15	43,2
Гибрид №2	11,28	7,80	9,25	0,057	136,84	39,4
№ 3	13,70	9,63	11,04	0,052	185,19	51,4
Гибрид № 4 (7х3)	12,43	7,75	9,35	0,11	70,46	56,6
№5	12,80	8,17	9,67	0,11	74,27	49,7
20-й день хранения						
Гибрид №1	13,80	9,58	11,20	0,080	119,75	39,1
№ 2/1	12,43	8,04	9,76	0,072	111,67	44,2
Гибрид №2	12,33	8,26	9,86	0,077	107,27	38,6
№ 3	14,03	9,73	11,10	0,072	135,14	46,7
Гибрид № 4 (7х3)	12,68	7,90	9,45	0,14	56,43	45,6
№5	12,90	8,25	9,82	0,13	63,46	42,4
35-й день хранения						
Гибрид №1	14,20	10,08	11,60	0,090	112,0	39,5
№ 2/1	13,48	9,72	11,37	0,090	108,0	37,3
Гибрид №2	12,93	8,76	10,18	0,100	87,60	39,2
№ 3	14,83	9,76	11,21	0,090	108,44	41,3
Гибрид № 4 (7х3)	12,88	8,26	9,72	0,18	45,89	40,6
№5	12,95	8,98	9,93	0,16	56,13	38,3

Биохимические показатели, зафиксированные на 35-й день хранения, продолжают увеличиваться. Так, это увеличение сухого вещества, составляет 1,011-1,15 раза, сахаров – 1,014-1,28 раза, экстрактивных веществ – 1,04-1,20 раза, кислотности 1,29-1,75 раза, а снижение величина сахарокислотного индекса – 1,09-1,71 раза.

Следует отметить, что количество токсичных веществ – нитратов в исследованных генотипах было значительно ниже допустимого предела (250 мг/кг), установленного Министерством Здравоохранения Азербайджанской Республики для данного вида овощей. Однако в трех исследованных образцах - №1, №2/1 и №2 – содержание нитратов оставалось практически неизменным в течение 34 дней хранения, тогда как в остальных трех - №3, №4, №5 – их концентрация уменьшалась в 1,25-1,39 раза.

Таким образом, исследование показало, что наибольшее увеличение содержания сухого вещества, сахаров, экстрактивных веществ и органических кислот было зафиксировано у генотипов №2 и №2/1, а наибольшее снижение величина сахарокислотного индекса – у генотипов №2 и 3. Максимально уменьшение концентрация нитратов (в 1,39 раза) наблюдалось у генотипа №4.

Обсуждая полученную информацию на основе имеющейся литературы, можно заключить, что при краткосрочном хранении (30-35 дней) моркови не обязательно прибегать к традиционным режимам хранениям [7; 8; 9; 10]. Наиболее удобным и экономически эффективным методом является создание в хранилище температуры 12 ± 1^0C и относительной влажности 75-80% в зимний и ранневесенний периоды, а также достаточно опрыскивание корнеплодов обычной водопроводной водой каждые 2 дня. При этом корнеплоды не теряют свежести и сохраняют свои нормальные качества.

При хранении корнеплодов моркови при температуре 12 ± 1^0C и относительной влажности 75-80 %, увеличение количество сухого вещества, сахаров, экстрактивных веществ и органических кислот, снижение величина сахарокислотного индекса, сохранение неизменного количества нитратов в одних образцах и снижение их в других могут быть обусловлены биологическими особенностями исследуемых образцов и физиолого-биохимическими процессами, происходящими в условиях хранения.

Причинами увеличения содержания сухого вещества, сахаров, экстрактивных веществ, органических кислот (яблочная, лимонная и др.) и снижения величина сахарокислотного индекса в корнеплодах моркови могут быть следующие:

1) в процессе хранения в корнеплодах моркови продолжается дыхание, в ходе которого органиче-

ские вещества окисляются, и часть продуктов окисления используется для дыхания, а остальная часть остается в виде сухого вещества, включая сахара и органические кислоты, что приводит к увеличению их содержания;

2) в условиях хранения крахмал, содержащийся в корнеплодах моркови, может частично гидролизоваться до простых сахаров (моно – и дисахаридов), что в конечном итоге приводит к повышению содержания сахаров;

3) при хранении при температуре 12±1^{0}C и относительной влажности 75-80% из корнеплодов моркови испаряется вода, в результате чего может происходить увеличение сухого вещества за счет этого испарения;

4) при хранении при указанной температуре и относительной влажности нитраты в корнеплодах моркови не претерпевают существенных изменений, поскольку являются стабильными соединениями;

5) некоторое снижение концентрация нитратов в некоторых генотипах, вероятно, связано с использованием нитратов в качество источника азота в процессе дыхания, но поскольку этот процесс не считается доминирующим, он проявляется не у всех генотипов.

В дополнение ко всему вышесказанному следует отметить, что предлагаемый нами метод хранения подходит только для кратковременного хранения (до 35 дней). Так, на 40-й день хранения корнеплоды моркови почти 30 % вянут, сморщиваются, теряют тургор и товарные качества. Поэтому длительное хранение моркови (40 дней и более) более удобна проводить традиционным методом (0…+1^{0}C и 90-95 % относительной влажности), поскольку при более высокой температуре и более низкой влажности, чем оптимальная, процесс дыхания может быть более активным, в результате чего масса моркови может быстрее уменьшаться, а ее качество может ухудшаться. Но не следует забывать, что патогенные микроорганизмы быстрее развиваются при высокой влажности, и продукт быстро портится.

Заключение.

Наиболее благоприятные условия для кратковременного (34 дня) хранения корнеплодов моркови создаются при температуре 12±1^{0}C и относительной влажности 75-80 %. В результате физиолого-биохимических процессов, происходящих в корнеплодах моркови, хранящихся в таких условиях, их биохимический состав обогащается, количество токсичных веществ-нитратов, и значение сахарокислотного показателя снижается, что позволяет получить морковный продукт сбалансированного состава.

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CHEMISTRY

SOIL POLLUTION AROUND OIL REFINERIES WITH HEAVY METALS AND OIL PRODUCTS

Hasanov Kh.
Doctor of Chemistry Sciences, Professor, Western-Caspian University
Azerbaijan Medical University, SRC
Hasanzade T.
Western-Caspian University
Quliyeva N.
Doctor of Philosophy (PhD) in Chemistry Sciences, Western-Caspian University
Azizova A.
Doctor of Philosophy (PhD) in Chemistry Sciences, Azerbaijan Medical University
Kasımov Sh.
Doctor of Philosophy (PhD) in Chemistry Sciences, Azerbaijan Medical University
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Abstract

This paper examines soil pollution near the Heydar Aliyev Baku Oil Refinery (BOR). The concentrations of petroleum hydrocarbons and heavy metals (Pb, Cd, Cr, Ni, Cu, etc.) in the soil were determined, and their impact on the physicochemical properties of the soil was assessed. The main pollutants in the area are oil and petroleum products, heavy metals, and other contaminants. Research shows that the soils around the BOR are seriously contaminated with heavy metals and petroleum products due to emissions, spills, and improper waste management, which degrades their properties, disrupts the environment, and poses a threat to human health. The results indicate that soil pollution in areas adjacent to the BOR poses a high environmental risk and requires ongoing monitoring.

Keywords: oil refinery, oil-contaminated soils, petroleum hydrocarbons, heavy metals, environmental risk.

The objective of the study was to determine the actual soil condition within the Heydar Aliyev Baku Oil Refinery.

Introduction

The oil refining industry occupies a significant place in Azerbaijan's industrial sector. However, the lengthy process of oil refining leads to environmental pollution, particularly of the soil. The environmental problems that have arisen around the Baku oil refinery are of immediate scientific and practical importance. Soil pollution around oil refineries has been extensively studied, and it has been established that petroleum products disrupt the soil structure, and heavy metals reduce the biological activity of the soil, posing a threat to ecosystems [1,2].

Heavy metals, the main group of elements polluting soils, have been a pressing environmental issue for decades, as high concentrations of them have a toxic effect on soil chemistry and plants. Soil is the primary environment where heavy metals enter from the atmosphere and water. Plants in such soil absorb the heavy metals, and some of them subsequently end up in food. The main sources of heavy metal soil pollution are the ferrous and non-ferrous metallurgy, energy production, mining, and other industries [3,4].

Soil pollution with industrial toxicants occurs in industrial cities, where the primary source of harmful substances is atmospheric air [1, 3]. Pollutants contained in industrial emissions combine with water vapor and gradually settle to the surface soil layer. Unlike atmospheric air, soil exhibits persistent, long-term contamination with chemicals specific to a given industrial sector [5, 6]. Toxicants can dissolve and migrate into living organisms through the food chain.

A second pathway for heavy metal salts and petroleum products to enter the soil is through pipeline accidents or the gradual spread of oil sludge from oil fields. The main heavy metals are lead, cadmium, mercury, and arsenic. They become hazardous when oil sludge enters groundwater. Volatile fractions of petroleum are highly toxic to soil organisms, but their effects are short-lived. The heavy fractions are immobile and can create persistent contamination in the soil, causing destructuring. They disrupt moisture exchange, altering the hydrophysical properties and biological activity of the soil. Like pesticides, heavy metal salts accumulate in agricultural soils and subsequently migrate to plants. They enter the human body through the food chain via plant or animal products [7-11].

Materials and Methods

The study was conducted within a radius of 0–1.5 km from the Heydar Aliyev Baku Oil Refinery. Soil samples were collected from a depth of 0–20 cm and analyzed using infrared spectroscopy and atomic absorption analysis. Analysis methods include atomic absorption spectrometry. Soils can be cleaned of oil products using ultrasound, which disrupts the bonds between the soil and contaminants.

During 2024–2025, we collected 20 samples from the Heydar Aliyev Oil Refinery industrial zone and throughout the city. Sampling was conducted using the "envelope" method at a depth of 0–10 cm^3 in eight directions from the petrochemical complex: north (N), south (S), east (E), west (W), northwest (NW), northeast (NE), southwest (SW), and southeast (SE) [12–14]. Concentrations of industrial toxicants were determined at the Baku State University Environmental Pollution Monitoring Laboratory. The obtained values for chemicals in the soil were compared with previous soil studies conducted at the Heydar Aliyev Oil Refinery.

Results and discussion

Due to the rapid development of the oil and chemical industries and the intensification of agricultural production, land pollution occurs as a result of accidental or uncontrolled leaks during the production, transportation, use, storage, and disposal of substances, which has a negative impact on the environment. This pollution is represented by oil, petroleum products (hydrocarbons), agricultural pesticides, and chemical industry products [15, 16]. Oil and petroleum products are among the main environmental pollutants, which, along with other pollutants, threaten not only the normal functioning of various ecosystems but also human existence. The most significant environmental damage is caused by accidents on main and in-field pipelines. Fig.1

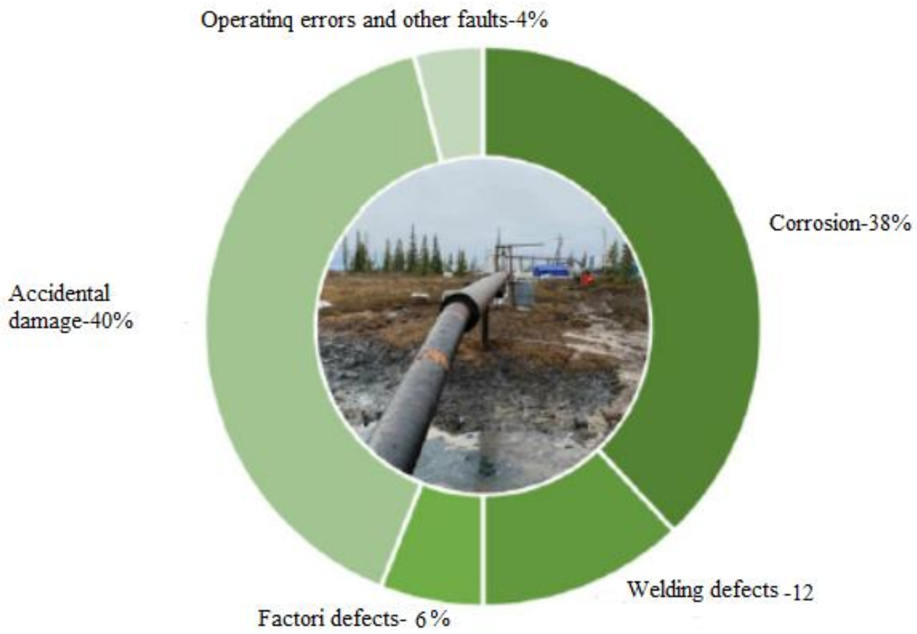

Fig.1. Main causes of oil leaks.

Among pollutants, heavy metals occupy a special place in terms of the scale of pollution and impact on biological objects. Heavy metals contained in industrial waste are emitted into the atmosphere and deposited on the soil surface. The bulk of heavy metals is firmly fixed in the 0-10 cm layer of natural soils and 0-20 cm of arable soils [17]. The soil type is mainly represented by ordinary chernozems and floodplain soils. The average pH was 7.4 units. The content of heavy metal salts in the soil on the territory of the Heydar Aliyev Oil Refinery is presented in Table 1.

Table 1.

Concentration of heavy metals in soil (mg/kg)

Metal	Near Zone	Middle Zone	Year
Pb	120 65	25 32	2024-2025
Cd	3.5 1.8	0.5 1.0	2024-2025
Ni	95 50	30 40	2024-2025
Zn	67 34	36 42	2024-2025
Cu	45 22	34 47	2024-2025
Sn	36 17	31 42	2024-2025

The results of the analysis of samples with excess of MAC (maximum permissible concentrations)1 MAC (approximate permissible concentration) are presented in Table 1. In 2025, the largest number of them were detected for cadmium in the zone with a radius of more than 1.5 km - 67% in the range from 1 MAC to 5 MAC and 10% more than 5 MAC, for copper - 19% more than 1 MAC, for nickel - 52% more than 1 MAC, for zinc - 57% more than 1 MAC. On the territory of the Heydar Aliyev Oil Refinery, excesses were detected only for cadmium, copper and zinc more than 1 MAC in 36%, 45% and 100%, respectively [5-7].

When analyzing the content of petroleum products in the soil in 2025, which amounted to 53–4854 mg/kg, in 88% of the collected samples there was an excess of the background value by 1.1–97.1 times. On average, the level of petroleum products in the study area exceeded the background by 12.7 times and was equal to 634.84 mg/kg. The maximum content of petroleum products was recorded in the buffer base of the oil refinery (4854 mg/kg, 97.08 F), which is lower than in 1999, when the average content of these impurities was observed at the level of 21 F, the maximum - 145 F. Extremely high pollution (more than 50 F) was observed in 4% of samples, high pollution (20–50 F) - in 10% of samples, soil pollution at the level of 2.0–18.9 F - in 56% of the collected samples. The detection of elevated levels of petroleum products in the soil is related to the location of numerous oil refining and petrochemical plants. Figure 2 shows an area contaminated with oil waste around an oil refinery. In 2025, soil contamination studies were conducted according to the same program as in 2024. The soil type remained unchanged. The average pH was 8.3.

Fig. 2. The plant area contaminated with oil waste.

When studying the content of heavy metal salts, no samples exceeding the MAC (APC) were found for each representative. The average concentration of cadmium and zinc slightly exceeded the background level and amounted to 1.02 F and 1.06 F, respectively. This is explained by the fact that over 9 years, colossal work has been done to modernize oil refining and petrochemical enterprises. This is also evidenced by a steady decrease in total emissions of harmful substances into the atmosphere of the Heydar Aliyev Oil Refinery from all stationary sources from 40.6 thousand tons in 2024 to 25.828 thousand tons in 2024. Unlike heavy metal salts, the content of petroleum products in the soil over the past 9 months increased from 634.84 mg / kg to 776.86 mg / kg. Table 2 shows the cases of exceeding background concentrations of petroleum products in the study area.

Table 2

Content of petroleum products in the soil of industrial zones of the Heydar Aliyev Baku Oil Refinery and in the city and their percentage exceeding background levels (in 2025, F = 50 mg/kg; in 2024, F = 38 mg/kg)

Year	Number of samples	Petroleum products				
		M ± m, mq/kq	Less 2 F	2-20 F	20-50 F	More 50 F
2024	10	634.84 ± 122.4	30	56	10	4
2025	10	776.86 ± 205.08	14	66	12	8

The maximum concentration of petroleum products was recorded in the industrial zone of the Heydar Aliyev Oil Refinery (8855.6 mg/kg, 233.04 F), which is almost twice as high as the maximum concentration recorded in 2024. Over the 9th month, the percentage of samples with extremely high contamination increased from 4% to 8%, and with high contamination – from 10% to 12%. There was also an increase in the number of samples with a level of 2–20 F from 56% to 66%. The change in the amount of petroleum hydrocarbons in the soil (graphical representation) depending on the distance is shown in Figure 3. The results show that the amount of petroleum hydrocarbons in areas located near the plant exceeds the norm and decreases with increasing distance. The increase in the concentration of petroleum products in the soil on the territory of the Heydar Aliyev Oil Refinery over the 9th month is associated not only with the activities of oil refining and petrochemical enterprises, but also with the increase in the number of motor vehic

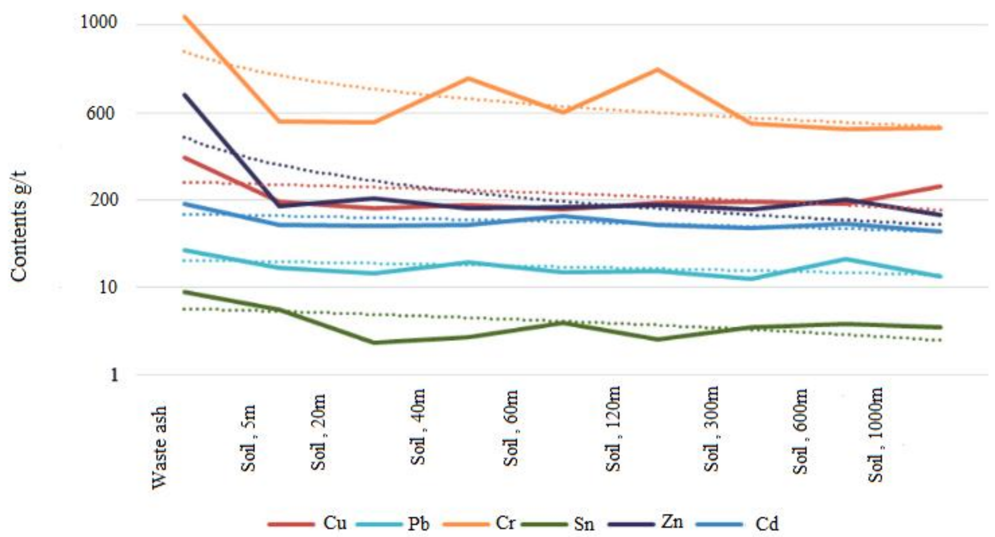

Fig.3.Changes in elemental content during removal from the plant.

In 2025, the average cadmium, copper, nickel, and lead concentrations did not exceed the MAC (MPC) for loamy soils and ranged from 0.2 to 0.7 MPC (MPC). The maximum cadmium concentration was observed at 0.4 MPC in the industrial zone of the Heydar Aliyev Oil Refinery. The maximum copper content was observed at 4 ODK in a zone with a radius of 1.1–1.5 km to the east. The maximum nickel concentration was also recorded at 3 ODK. Elevated lead levels were detected at 1 ODK in a zone with a radius of 0.1–1.5 km to the southeast. The average cadmium and zinc concentrations exceeded the ODK and were at 3.05 ODK and 1.27 ODK, respectively. The maximum cadmium content was recorded at 10 ODK in a zone with a radius of 1.1–1.5 km to the northeast, and the maximum zinc content was at 4.1 ODK in a zone with a radius of 0–1.0 km to the south. The average concentrations of cadmium, copper, nickel, lead, and zinc exceeded background levels and were 8.7 F, 5.62 F, 1.63 F, 1.33 F, and 3.98 F, respectively. The average cadmium level did not exceed background levels and was recorded at 0.52 F.

From 2024 to 2025, concentrations of heavy metal salts in the soil decreased both within the Heydar Aliyev Oil Refinery industrial zone and within the city limits. Significant differences were observed in the soil concentrations of cadmium, copper, lead, nickel, and zinc in 2025 and 2024, respectively. Soil contamination with petroleum products remained virtually unchanged over the study period; however, a greater shift in the percentage of samples exceeding background levels was observed in 2020 compared to 2025. Analysis revealed that the total amount of petroleum hydrocarbons in areas adjacent to the refinery exceeds the permissible limit by 2–4 times. High concentrations of heavy metals, such as Pb and Cd, were detected.

Conclusion

A soil study was conducted in 2024-2025 at the Heydar Aliyev Oil Refinery in Baku. Concentrations of heavy metal salts and petroleum products were determined within the industrial zone and throughout the city. The study revealed that, compared to 2024, heavy metal salt concentrations in the soil decreased in 2025, both within the plant's industrial zone and within the city limits. Significant differences were found in the soil concentrations of cadmium, copper, lead, nickel, and zinc in 2025. Unlike heavy metal salts, petroleum product concentrations in the soil have shown an upward trend over the past nine months. The highest concentration of petroleum products was found within the plant's industrial zone.

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THE PRESENCE OF RADIOACTIVE ISOTOPES IN ENVIRONMENTAL SOIL SAMPLE AND RADIOCHEMICAL SEPARATION OF ALPHA - EMITTING ISOTOPES AS PART OF THEIR DETERMINATION'S PROCEDURE

Daci B.,
Bylyku E.
Institute of Applied Nuclear Physics, University of Tirana, Albania
DOI: 10.5281/zenodo.18677683

Abstract

Radioactive isotopes are present in soil either naturally or due to human activities. The isotopes originated from the uranium and thorium decay chains, can modify soil properties, water quality, and potentially enter in the food chain. The most common naturally occurring radioactive isotopes are Uranium - 238, Thorium -232 and Potassium - 40. The natural radioactivity of the soil is determined from the mineral composition of the rocks. Rocks with high concentrations of uranium, thorium, and potassium will produce soils with higher radioactivity. Radioactive contamination can impact soil properties, potentially affecting plant growth and overall ecosystem health. The procedures for the determination of alpha emitting isotopes in soil, generally follow these two steps: 1. Sample preparation which includes dissolution (using a mixture of hydrofluoric and nitric acids to release the radioisotopes) and separation (using different techniques like coprecipitation, ion-exchange, liquid-liquid extraction, extraction chromatography) to isolate the specific alpha-emitting isotopes from the dissolved sample. 2. Alpha Spectrometry measurement (separated isotopes are deposited on a stainless-steel disk and measured using an alpha spectrometer). The aim of this paper is to describe in detail the procedure applied in the radiochemistry laboratory of the IANP for the sample preparation and separation of alpha emitters in environmental soil sample. This optimal procedure is the result of evaluating each step of the procedure performed in years in the laboratory.

Keywords: radiochemical preparation, alpha emitters, radioactive isotopes, separation technique.

Introduction

The vast majority detected on the earth is from the natural radioactivity from primordial origins [1,2]. Uranium in nature is one of the heaviest elements that exists mainly in the earth crust and its activity is found in soil, in water and/or in the earth-born materials [1,2]. Uranium is found as 238-U (99.2739 - 99.2752%), has occurred in many different rock types from sedimentary to volcanic and has been deposited on land by volcanic action [2]. Chemical conditions sometimes elevate the concentrations of uranium, and significantly occur in some substances such as phosphate rock deposits, minerals (such as lignite) and monazite sands in uranium-rich ores [3]. The redistribution of uranium in soil, rocks as well as in water is happening throughout the environment by wind, rain and geologic processes. Moreover, it can dissolve in the water to be consumed by any organism [2]. The mean concentration of 238U in the earth's crust varies from 0.5 to 5 ppm, and in granite it is 4 ppm [2].

The radioactive substance of thorium occurs naturally in the earth's crust in combination with other minerals such as silica. More than 99% of natural thorium exists in the form of thorium - 232 with a concentration range of 2 - 20 ppm [2,3]. Some rocks in underground mines contain more concentrated form of thorium. Natural weathering like wind and water action breaks these rocks and makes the thorium and all other components of the rocks to become a part of the soil. Moreover, the soil containing high amount of clay materials show higher contents of thorium [2]. The two natural isotopes of potassium 39K (93.2581%) and 41K (6.7302%) are needed for living species, however, the strong gamma radiation emitted from the primordial 40K causes various health hazards [1,2].

The radionuclides and their progenies are the principal contributor to the background radiation in our living environment. The different physio-chemical forms of these radionuclides have influenced their mobility and biological uptake. As for instance, uranium specially bonds to organic matter while potassium and thorium preferentially bond to clays, and hence these are more radioactive than the other sedimentary rocks [2,3].

Radioisotopes are of interest in environmental physics for several reasons:

- Environmental protection - the emitted radiation is potentially hazardous and therefore radioactivity levels in environmental media must be monitored and the consequences of contaminations have to be assessed [1].
- Tracing - as the detection limits can be very low, radioisotopes can be used successfully as tracers to monitor e.g., transport processes [4].
- Dating - due to the ubiquity and the wide range of half - life times of naturally occurring radioisotopes, they can be used for age determination [1].

Material and Methods

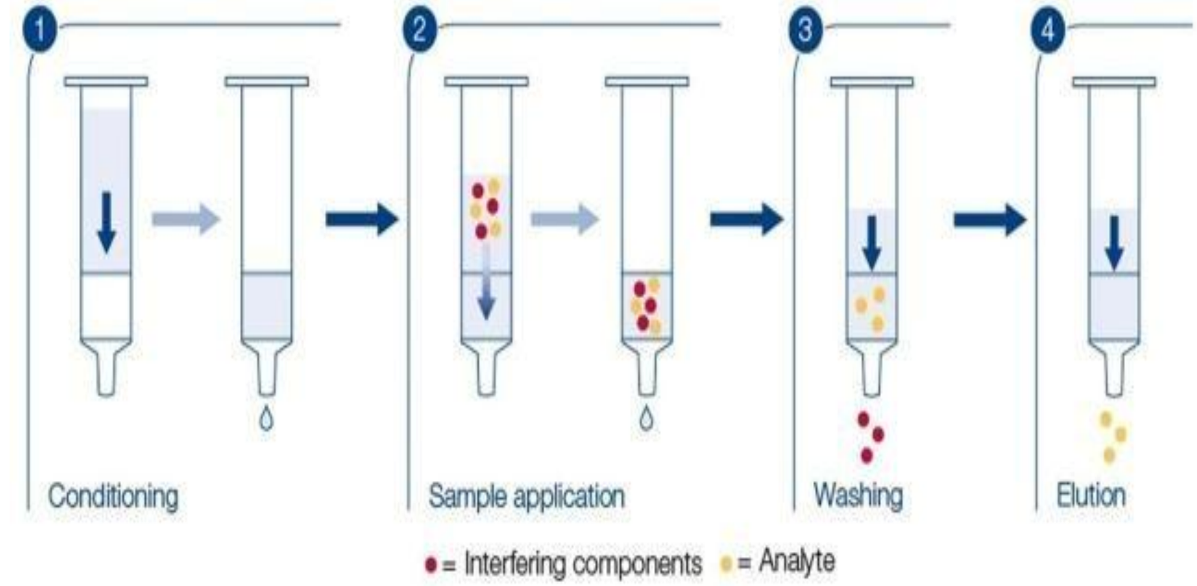
Analytical procedure for separation and quantification of 210Po, 241Am, Pu and U isotopes by extraction chromatography and alpha spectrometry is described as follows [5,6].

1. Sample preparation (dispensing and dissolution):

Dispense ~ 1g of the sediment to a 50 mL screw-cup centrifuge tube, record the sample weight, add 70.1Bq of 209Po, 243Am, 232U and 242Pu tracers and record the added weight of each tracer solutions. Add 20mL of concentration HNO_3 to dissolve the sediment and after dissolution evaporate to dryness and re dissolve in 15 mL of 0.1M HNO_3. For Calcium phosphate co-precipitation add 0.2mL of 30% H_2O_2 to ensure Po (IV), 1 mL 1.25M calcium nitrate (50 mg Ca) and 3 mL 3.2M ammonium hydrogen phosphate. Adjust the pH to pH 10 with concentrated ammonium hydroxide using a pink phenolphthalein end point. Centrifuge at 3500 rpm for 6 min, discard the supernatant, add 10mL of 8M HNO_3 / 3mL of 2M $AI(NO_3)_3$ to dissolve the precipitate and add 0.1mL of 30% H_2O_2 to ensure Po (IV) [5,6].

2. TRU/DGA separation:

For TRU/DGA cartridge separation, attach stacked TRU/DGA cartridges to the vacuum box loaded with 50mL test tubes, precondition the resin by passing 20mL of 8M HNO_3, load the sample to the top of the stacked cartridges, rinse with 10 mL of 8M HNO_3 to fix Am, Po, U, Pu on the resin and to remove matrix interferences. Then, rinse with 10 mL of 10M HNO_3 to transfer Po to the DGA and rinse the cartridge tandem with 15mL of 4M HCI to transfer Am to the DGA resin. Separate TRU from DGA cartridges, add clean reservoirs. Elute Pu from TRU as Pu (III) with 12 mL 3M HCI - 0.02M $TiCl_3$. Elute U from TRU with 15 mL 0.1M Ammonium oxalate. Elute Am from DGA with 12 mL 0.25M HCI. Elute Po from DGA with 15 mL 0.05M HNO_3 [5,6].



Results and Discussions

The optimal procedure described in the above section is the result of the many experiments performed in different conditions including all the steps of the procedure.

The results for the separation of alpha emitters (210Po, 241Am, Pu and U) are analyzed and discussed in detail and each step of the procedure that is performed in a different way to find optimal and good separation of each radioisotope.

Micro-precipitation of Plutonium

Add 10 mL of water to reduce the acid strength and 0.5 mL 30% H_20_2 to oxidize any that might be present to prevent uranium co-precipitation. After that add 50 ug Ce and 2 mL 28 M HF to form CeF_3. Wait 15 min and filter the solution using a 25 mm polypropylene Resolve filter. Rinse the filter with 5mL deionized water and 5mL ethanol. Dry the filter under a heat lamp for a couple of minutes.

Micro-precipitation of Uranium

Add 0.5 mL 10% $TiCI_3$ to reduce U(VI) to U(IV) and 50 ug Ce and 1 mL 28 M HF to form CeF_3. Wait 15 min and filter the solution using a 25 mm polypropylene Resolve filter. Rinse the filter with 5mL deionized water and 5mL ethanol. Dry the filter under a heat lamp for a couple of minutes.

Micro-precipitation of Americium

Add 0.2 mL of 30% H_2O_2 to oxidize any that might be present to prevent uranium co-precipitation and 50 ug Ce and 1 mL 28 M HF to form CeF_3. Wait 15 min and filter the solution using a 25 mm polypropylene Resolve filter. Rinse the filter with 5mL deionized water and 5mL ethanol. Dry the filter under a heat lamp for a couple of minutes.

Micro-precipitation of Polonium

Add 0.1mL of 30% H_20_2 to ensure Po (IV) and 100ug Bi (0.1mL of 1000ppm Bi standard in 2 % HNO_3). Adjust the pH adding 0.2mL of 3M NH_4OH (ammonia solution). Add 0.8mL of 3.2M $NH_4H_2PO_4$ to form $BiPO_4$ precipitate and mix well by shaking for a couple of minutes. Wait 15 min and filter the solution using a 25 mm polypropylene Resolve filter. Rinse the filter with 5mL deionized water and 5mL ethanol and dry the filter under a heat lamp for a couple of minutes.

Conclusions and Recommendations

In order to find a good correlation between water quality, used for drinking and hygienic purposes, and the milk quality, more extensive studies are necessary, including a big number of samples and farms to be taken into study as well as identification of specific microorganisms.

The studies allow determining the concentration and spread of radionuclides in the soil.

Contaminated soils treated with an acid solution of ions NO3-, PO4--- and K+, undergo a reduction of radioactivity up to 35%, after a series of washes which simulate one year's rainfall.

The capacity of the deepest soil layers to immobilize the radionuclides percolated from the superficial layers was also confirmed.

The migration of radionuclides towards deeper soil layers, following chemical treatments, and their subsequent stabilization reduces bioavailability in the uppermost soil horizon, preventing at the same time their transfer into the water-bearing stratum.

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ИЗУЧЕНИЕ ПРОЧНОСТИ СТРАНИЦ КНИГ, НАХОДЯЩИХСЯ В КНИГОХРАНИЛИЩАХ БИБЛИОТЕК, ПОСЛЕ ИХ ОБРАБОТКИ ОЗОНОМ. ПОДБОР КОНСТРУКЦИИ ОЗОНАТОРА ДЛЯ ЗАЩИТЫ КНИГОХРАНИЛИЩ БИБЛИОТЕК ОТ ГРИПКОВЫХ ЗАБОЛЕВАНИЙ

Татишвили Г.Д.
Член-кор. НАН Грузии., директор Института неорганической химии и электрохимии им. Р.Агладзе Грузия, Тбилиси
Чагелишвили В.В.
Д.т.н., главный научный сотрудник Института неорганической химии и электрохимии им. Р.Агладзе
Басиладзе Ц.М.
К.х.н., научный сотрудник лаборатории радиационной химиии
Шанидзе Г.В.
К.х.н., научный сотрудник лаборатории радиационной химии
Мамардашвили М.И.
К.х.н., научный сотрудник лаборатории радиационной химии
Квирквелия Н.М.
Научный сотрудник лаборатории радиационной химии
Табатадзе С.В.
Сотрудник Института неорганической химии и электрохимии

STUDYING THE STRENGTH OF THE BOOK PAGES IN THE LIBRARY'S STORAGE AFTER THE OZONE TREATMENT. SELECTION OF OZONATOR DESIGN TO PROTECT LIBRARY BOOK STORAGE ENVIRONMENTS FROM FUNGAL CONTAMINATION

Tatishvili G.
Corresponding Member of the Georgian Academy of Sciences. Director, R. Agladze Institute of Inorganic Chemistry and Electrochemistry Georgia, Tbilisi
Chagelishvili V.
Doqtore of Texnical Sciences, R.Agladze Institute of Inorganic Chemistry and Electrochemistry
Basiladze Ts.
Candidate of Chemical Sciences, Research worker of Laboratory of Radiation Chemistry.
Shanidze G.
Candidate of Chemical Sciences, Research worker of Laboratory of Radiation Chemistry.
Mamardashvili M.
Candidate of Chemical Sciences, Research worker of Laboratory of Radiation Chemistry
Kvirkvelia N.
Research worker of Laboratory of Radiation Chemistry.
Tabatadze S.
Colleague of Institute of Inorganic Chemistry and Electrochemistry
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Аннотация

Изучена возможность применения озона для очистки загрязнённых плесенью, вирусами, бактериями и различными другими микроорганизмами книг в хранилищах библиотек. Установлена оптимальная доза озона, которая очищает поверхность страниц от перечисленных факторов без видимых повреждений самой страницы.

Изучена прочность разных типов бумаг (книжных страниц-новых, старых, загрязнённых плесенью ., печатных белых и др.) после их обработки озоном. Это зависит от содержимости и структуры бумаг, которая возникает в процессе их производства. Изучение структуры осуществлялось с применением микроскопа, разрушительная сила измерялась в ньютонах.

В процессе работы исследовались страницы старых книг и белых печатных листов при обработке их озонированным воздухом различных концентраций.

Было установлено, что при применении озонатора, производительностью 0,32 г/час и соответствующей обработкой озоном образцов в течение 60 минут не наблюдалось разрушение поверхности и структуры при сравнении их с неозонированными образцами. При увеличении времени озонирования до 90 минут, уже при достижении этого времени, наблюдалось изменение поверхности и структуры, а разрушительная сила (разрыв) в сравнении с неозонированными образцами, была на 0,94 нт меньше у озонированных образцов страниц старых книг. При сравнении озонированных и неозонированных образцов обычных белых печатных листов разрушительная сила была на 0,77 нт меньше.

Изучена работа озонатора в закрытом помещении. Установлена необходимость добавления некоторых изменений для улучшения работы озонатора, из них особенно важных: удаление компрессора воздуха на значительное расстояние от ячейки озонатора; внесение конструктивных изменении в ячейку озонатора с целью упрощения и повышения эффективности его работы.

Abstract

The possibility of cleaning processes of books contaminated with mold, viruses, bacteria and other microorganisms has been studied. The optimal dose of ozone has been determined, which will clean the surface of the book page from mold, viruses, bacteria and other harmful microorganisms without damaging the surface of the book and its internal structure.

The strength of various types of paper (printing, book—new, old, mold-infested, etc.) when treated with ozone was studied. The paper's strength depends on the composition and structure of the paper, which is formed during the paper production process. The structure was studied using a microscope. The breaking force of the structure was measured in Newtons.

During the work period, studies were conducted on the processes occurring in old books and printing sheets under conditions of increased ozone concentration.

It was determined that using an ozonator with a capacity of 0.32 g/h and the optimal 60-minute dose of ozone did not change the arithmetic mean value of the sheet-breaking force in Newtons compared to non-ozonized samples. However, more highly ozonized (90 minutes) samples, when the surface and internal structure of the paper began to change at the moment of stretching and tearing, the value of the breaking force also varied compared to non-ozonized samples. In particular, in the case of the old book, the breaking force was reduced by 0.94 Newtons compared to non-ozonized samples. The process proceeded similarly in the case of white printing paper, with the breaking force value decreasing by 0.77 Newtons.

The operation of an ozonator in a closed space has been studied.

The need to make several changes to the ozonator design has been identified, the main ones being:

- *Moving the air compressor from the ozonator unit by a significant distance;*
- *Making structural changes to the ozonator cell to simplify and increase its efficiency.*

Ключевые слова: Озонатор, озон, книга, микроскоп, ньютон, конструкция, компрессор.

Keywords: Ozonizer, ozone, book, microscope, Newton, design, compressor.

Введение

Известно [лит. 1.], что при обработке озоном страниц старых книг, находящихся в книгохранилище одной из библиотек, с применени озонатора, производительностью 0,32 г/час и времени озонирования 60 мин., не наблюдалось изменение поверхности страниц и их структуры. С увеличением озонирования до 90 минут начиналось изменение структуры, а после 120 минут озонирования и поверхность и структура страниц полностью разрушалась. Возникла необхадимость иследования прочности самих страниц в тех же условиях. На начальном этапе изучалась прочность различных бумаг (печатных белых листов, страниц новых и старых книг, загрязнёнными плесенью и др.), что связано с показателями самой бумаги. Самыми значительным показателями являются плотность и пористость. Для различных бумаг плотность меняется в пределах 0,5 г/см^3 -1,2 г/см^3. Значение имеет также толщина бумаг, которая измеряется соответствующим прибором(мкм). Сила бумаги зависит от силы структуры самой бумаги, которая возникает в процессе производства. Сила, разрушающая структуру бумаги, измеряется в ньютонах. Известно, что сила бумаги определяется не силой волокна, а силами связи между ними. Например, гидрофобный агент (розин) уменьшает плотность бумаги, а гидрофильный агент(крахмал), наоборот увеличивает. Сила прочности бумаги измерялась прибором(рис.1).

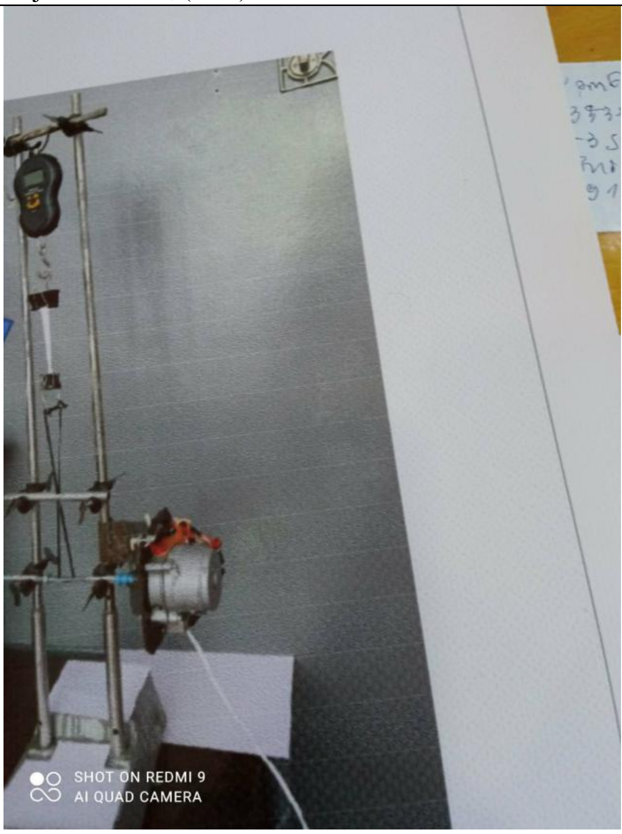

Рис. 1. Прибор для определения прочности бумаги.

Эксперимент

В процессе работы проводились исследования при обработке озоном в течение разного времени озонирования: старых книг и печатных листов, в частности, сохранения и изменения прочности использованной бумаги. Данные, полученненные в процессе растяжения и разрыва образцов во время проведения эксперимента, приведены в таблицах 1,2,3,4. С каждым образцом проводилось 6-7 измерений и определялось среднее аритметическое значение в ньютонах [лит.2]. Полученные данные указывают на то, что при озонировании в течение 60 минут с применением озонатора, производительностью 0,32 г/час, среднее арифметическое разрушительной силы (1,92 нт) не меняется в сравнении с неозонированными образцами. С увеличением времени озонирования(90 мин.), начинается изменение внутренной структури и поверхности[лит.1]. Полученные данные показывают, что для озонированных образцов, в частности, в случае страниц старых книг(таблица 3) значение разрушительной силы уменьшилось на 0,94 ньютона при сравнении с неозонированными образцами(таблица 1). Аналогичные данные получены в случае печатного листа(таблица 4), в частности, разрушительная сила уменьшилась на 0,77 нт, при сравнении с неозонированными образцами(таблица 2).

Определение прочности в неозонированных образцах

Страница старой книги. Образцы приготовлялись по специальной форме(полная длина 12 см, ширина 1 см, ширина головки 2 см).

Таблица 1

Вес образца, в гр	Разрушительная сила(F), в ньютонах
0.22	1.87
0.23	1.85
0.19	2.16
0.18	2.01
0.18	2.28
0.20	1.85
0.17	1.40
	Ср. 1.92

Белый печатный лист бумаги. Образцы приготовились по специальной форме(полная длина 12 см, ширина 1см, ширина головки 2 см).

Таблица 2

Вес образца, В гр	Разрушительная сила (F), в ньютонах
0.20	3.01
0.20	2.69
0.20	3.50
0.22	3.20
0.20	3.75
0.20	2.95
0.22	3.10
	Ср. 3.30

Определение прочности озонированных(в течение 90 мин.) образцов.

Страница старой книги. Образцы приготовились по специальной форме(полная длина 12 см, ширина 1 см, ширина головки 2 см)

Таблица 3

Вес образца, в гр	Разрушительная сила (F), в ньютонах
0.35	0.80
0.38	0.85
0.33	1.01
0.33	1.19
0.35	0. 91
0.31	1.06
0.31	1.06
	Ср. 0,98

Белый печатный лист бумаги. Образцы приготовились по специяльной форме(полная длина 12 см, ширина 1 см, ширина головки 2 см).

Таблица 4

Вес образца, в гр	Разрушительная сила(F), в ньютонах
0.27	2.13
0.33	2.60
0.36	2.10
0.33	2.90
0.29	2.60
0.33	2.70
0.33	2.70
	Ср. 2.53

Выводы

Установлено, что озонирование в течение 60 минут с применение озонатора, производительностью 0,32 г/час страниц старых книг или печатных листов не меняет среднее арифметическое значение разрушительной силы в ньютонах при сравнении с неозонированными образцами. При увеличении времени озонирования до 90 минут, когда начинается изменение поверхности и структуры бумаги, при растяжении и разрыве также изменяется значение разрушительной силы при сравнении с неозонированными образцами. В частности, в случае страниц старой книги разрушительная сила уменьшилась на 0,94 нт, при сравнении с неозонированными образцами. Аналогично протекает процесс в случае белого печатного листа, разрушительная сила уменьшилась на о,77 нт.

Для выполнения предаставленной работы возникла необходимость создания озонатора новой конструкциии в лабораторных условиях для защиты книгохранилищ библиотек от грибковых заболеваний.

После испытания работы озонатора в закрытом помещении понадобились некоторые изменения, из которых важними являются: 1. Удаление компрессора воздуха на значительное растояние от ячейки озонатора и 2. Внесение конструктивных изменений в ячейку озонирования с целью упрощения и повышения эффективности работы. Необходимость 1-го изменения вызвана тем, что в компрессор воздуха непосредственно вблизи ячейки озонатора, вместе с воздухом попадает выработанный озон. Как известно, рабочие детали компрессора, в большинстве случаев сделаны из резины, из стали и при работе в среде озона они часто выходят из строя из-за коррозии.

Для устранения этой причины компрессор должен находиться на значительном удалении от ячейки озонатора или в другом помещении и оттуда должна осуществляться подача выра ботанного воздуха в озонатор. С целью повышенния эффективности работы озонатора были исследованы указанные на рис. 2. четыре ячейка озонирования различных конструкций и схемы взаиморасположения их активныъх элементов. В первой и во второй ячейках зона озонирования(объёмная электрическая дуга) осуществляется между находящейся в центре кварцевой трубы из нержавеющей стали и внешней, намотанной на кварцевую трубу спиралью из нихромовой проволоки. Во второй ячейке число витков спирали в пять раз больше, чем в первой(5/1). В этих условиях озон получается как внутри кварцевой трубы, так и снаружи вокруг намотанной спиралью. Из -за высокой температуры внутри кварцевой трубы обратимая реакция $3O_2 \leftrightarrow 2O_3$ отклоняется влево. В обоих случаях, выработанный во внешней среде, озон должен распространяться в соседней низкотемпературной зоне без попадания в высокотемпературную зону для уменьшения перехода озона в кислород. Исходя из этого, увеличение снаружи витков спирали должно увеличить выход озона вокруг внешней спирали. В это же время увеличение витков способствует повышению температуры во внутренней зоне и переходу реакции обратно $2O_3$ --->$3O_2$.

В третым варианте ячейки узкая зона озонирования возникает между находящейся в конце центральной трубы диском из нержавеющей стали и расположенного вдоль кварцевой трубы узкополосового электрода. Когда эта зона минимально удалена от выхода ячейки, образующийся внутри и снаружи озон в оптимальном количестве попадает в нужную среду и служит поставленной цели.

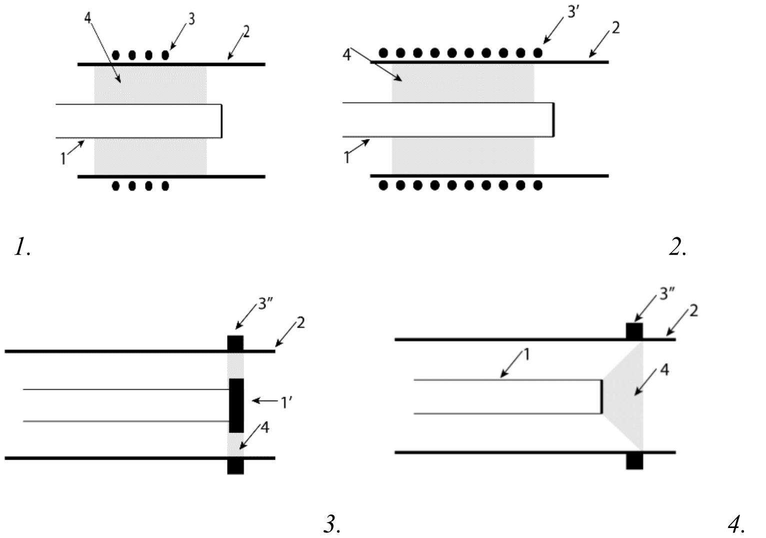

Рис. 2. Схемы основных предложенных ячеек озонирования.
1-центральный электрод из нержавеющей стали; 1'- центральный электрод в форме диска; 2- кварцевая труба; 3- внешний электрод со спираплью с четырьмя витками из нихромовой проволоки; 3'- внешний электрод со спираплью с 20-ю витками из нихромовой проволоки ; 3''- внешний электрод(один виток спирали проволоки из нихрома); 4- зона объёмной электрической дуги.

В четвёртом варианте конструкции ячейки электрическая дуга осуществляется непосредственно между концом центральной трубы и оптимально отдалённого внешнего узкополосового электрода. В этих условиях электрическая дуга принимает форму воронки. Такое расположение электродов на оптимальном удалении от конца кварцевой трубы определяет максимальное введение озона в нужную среду.

Тестирование всех четырёх конструкций осуществлялось с применением герметического цилиндрического сосуда, представленного на рис. 3.

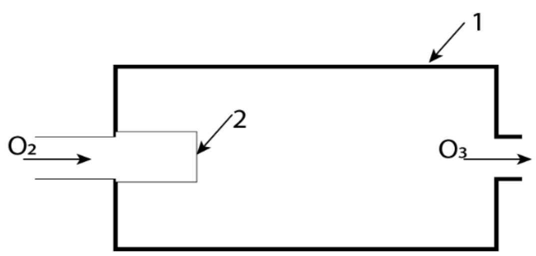

Рис.3. Схема устройства тестирования ячеек озонаторов. 1-герметичная камера, объемом 10000 см3, 2-ячейка озонирования, объёмом 100 см3..

Тестирование всех четырёх конструкций проводилось с использованием герметического цилиндрического сосуда, представленного на рис.3 в следующих условиях: объём сосуда двумя степенями превосходил объём ячеек; интенсивность подаваемого в ячейку воздуха составляла 300л/час. Приложенный потенциал на электроды во всех случаях равнялся 10 квольт. Продолжительность озонирования потока воздуха регулировалась с помощью реле времени и во всех случаях равнялось 2 минутам, относительность объёмов ячейки и сосуда, стабильность потока воздуха, продолжительность озонирования определяли идентивность условий испытания четырёх ячеек с условиями испытаемого объекта (книгохранилищ библиотек). Количество испытуемого озона определялось иодометрическим методом. Данные тестирования представлены в таблице 5.

Таблица 5

Данные количества иода, полученные при пропускании озонированного воздуха через 200 мл 0,1 N раствора KI.

Варианты конструкций	Количество затраченного 0,005 N раствора $Na_2S_2O_3$ (мл)	Количество выделяющего иода, N
1	23	5.10^{-4}
2	17	$4.\ 10^{-4}$
3	54	16.10^{-4}
4	54	16.10^{-4}

Отсюда можно сдалать вывод, что с точки зрения эффективности ячейки третьей и четвётвой конструкции практически идентичны и значительно превосходят остальные. Поэтому, предусматривая простоту конструкции, рекомендировано применение четвёртого варианта ячейки

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ETHNOLOGY

CONCEPTELE DE *IDENTITATE* ȘI *SĂRBĂTORI*, RAPORTATE LA DIASPORA ROMÂNEASCĂ

Krenek (Apostol) C.
Drd., Universitatea Oradea, România
Departamentul: Şcoala Doctorală de Ştiinţe Umaniste și Arte
Domeniul de studii: Filologie

IDENTITY AND FESTIVE PRACTICES CONNECTED TO THE ROMANIAN DIASPORA

Krenek (Apostol) C.
PhD Candidate, University of Oradea, Romania
Department: Doctoral School of Humanities and Arts
Field of Study: Philology
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Rezumat

Lucrarea de față face parte dintr-un studiu mai amplu, ce își propune să analizeze conceptele de identitate și sărbătoare, în raport cu diaspora românească, în contextul globalizării și al migrației. Multiculturalismul și interculturalitatea sunt evidente; de aceea o analiză a conceptului de *identitate*, ca aspect relevant al vieții sociale, culturale și cotidiene, este imperios necesară. Consider acest lucru deoarece asistăm la apariția unor comunități minoritare, etnice, cunoscute sub termenul generic de *diaspora*; care se raportează într-un mod special la identitate, pendulând permanent între două culturi (cea din țara natală și cea din țara de adopție). Există diverse forme de identitate: culturală, națională, istorică, publică, etnică, de opțiune, pozitivă/negativă, socială, profesională. Una dintre identitățile la care ne vom referi este *identitatea socială*, ce presupune apartenența individului la un anumit grup social și conștientizarea acestui aspect. O altă formă definitorie pentru orice om este *identitatea națională*, în construirea căreia un rol important îi revine memoriei sociale. Fiecare popor, un anumit grup social sau comunitar își revendică propria identitate, un rol definitoriu având-l limba maternă, raportarea la cult, dar și la tradiție, la valori. Ia naștere, în acest mod, *identitatea culturală*, cel mai important aspect al acesteia fiind limbajul, comunicarea. Un alt tip de identitate, ce are legătură directă cu migrația, este *identitatea de opțiune*; la care se adaugă o *identitate revendicativă,* specifică românilor emigranți apatrizi, *exilații, pribegii* de dinainte de Revoluția din 1989, contestatarii condițiilor de trai din propria țară. Deși fiecare resimte diferit ruperea de țară, cu toții experimentează *condiția străinului*.

Lucrarea ilustrează și noțiunea de *sărbătoare*, prezentând calendarul obiceiurilor și sărbătorilor românești – reminiscențe în unele comunități românești din diaspora. Opțiunea de a le studia este motivată de bogăția folclorului pe care românii l-au dus peste granițele țării, *l-au exportat.* Acestea, cuprinse în sărbătorile noastre, sunt asemenea unor verigi dintr-un lanț în care se îmbină armonios datini, obiceiuri, practici, ritualuri, credințe, în care se explică reciproc spiritul și materia. Ele au un *caracter unitar*, în ciuda micilor diferențe care apar, în funcție de regiunile țării din care au plecat românii aflați în diaspora. Sărbătorile tradiționale sunt mereu vii**,** chiar dacă unele dintre tradițiile aferente lor nu se conservă, ci se transformă: unele parțial, altele radical sau sunt compuse, după vechile scheme, și reinvestite cu funcții sau simboluri noi.

În concluzie, elementul popular stă la originea fiecărui popor în parte, îl definește ființial și identitar și tocmai de aceea, atunci când ne îndreptăm spre alte zări, el nu poate fi lăsat deoparte pentru că este adânc înrădăcinat în ființa românului, oriunde s-ar afla.

Abstract

This article is part of a broader study that aims to analyze the concepts of *identity* and *celebration* in relation to the Romanian diaspora, in the context of globalization and migration. Multiculturalism and interculturality make it evident that analyzing the concept of identity as a relevant aspect of social, cultural, and daily life is important. This necessity stems from the emergence of minority ethnic communities, commonly known as *diasporas*, which relate to identity in a particular way, constantly oscillating between two cultures: that of the country of origin and that of the host country. There are various forms of identity: cultural, national, historical, public, ethnic, elective, positive/negative, social, and professional. One of the identities addressed in this study is *social identity*, which involves an individual's belonging to a particular social group and awareness of that belonging. Another defining form for any individual is *national identity*, in the construction of which social memory plays an important role. Each person, as well as any social or community group, claims its own identity, the mother tongue, religious affiliation, tradition, and values playing a determining role. Language, or communication, is the primary factor in establishing *cultural identity*. Another type of identity directly related to migration is the *identity of choice*, complemented by *a revealing identity* specific to emigrants, Romanian exiles, and stateless displaced persons who were challenged by living conditions in their country of origin before the 1989 Revolution. Although each experiences the separation from their homeland differently, all share the *condition of strangeness*.

The article also illustrates the concept of *celebration* by presenting the calendar of Romanian customs and festivals as preserved in some communities of the Romanian diaspora. The decision to study these traditions is

motivated by the richness of folklore that Romanians have brought beyond the borders of the country. These elements, embodied in the Romanian celebrations, resemble links in a chain where customs, practices, rituals, and beliefs intertwine harmoniously, explaining each other's spirit and matter. They present a unitary character, despite minor differences that manifest themselves depending on the regions from which the Romanians of the diaspora come. Traditional festivals remain alive even if some of their associated customs are not preserved but transformed: some partially, others radically, or reconfigured according to older patterns and reinvested with new functions or symbols.

In conclusion, the folk element lies at the origin of every people, defining them existentially and identically. For this reason, when individuals move to other horizons, it cannot be left behind, because it is deeply rooted in Romanian being, wherever they are.

Cuvinte-cheie: identitate, sărbători, tradiții, diaspora, limba maternă.

Keywords: identity, festivals, traditions, diaspora, mother tongue.

In a modern world, characterized by diversity, promoting a society that tends toward globalization, in which multiculturalism and trans culturalism increasingly become commonplace, an analysis of the concept of *identity*, as a relevant aspect of social, cultural, and everyday life, becomes imperative. Globalization, which has generated extensive migratory movements, has led to the emergence of minority ethnic communities, generically known as *diasporas*, which relate to identity in a particular way, constantly oscillating between two cultures: that of the country of origin and that of the host country. It is generally accepted that identity exists in multiple forms: cultural, national, historical, public, ethnic, identity by choice, positive or negative identity, social identity, professional identity, and others. "The notion of *identity* is polysemic; it appears both in everyday language and in the vocabulary of psychology, psychoanalysis, and philosophy." [1] The present study proposes a minimal definition of several of these concepts, which serve the purpose of this work and will be developed further as required. One of the identities addressed here is *social identity*, defined as "the individual's awareness of belonging to a particular social group, together with the emotional and evaluative significance attached to that membership." [2] From this definition arise three essential coordinates: "individuals recognize that they belong to a specific group, experience this belonging emotionally, and assign value to their membership in that group." [3]

The authors of one of the foundational theories of social identity, Henri Tajfel and John C. Turner [4], argued that individuals generally seek a positive self-conception in order to maintain or increase self-esteem. However, certain social groups or categories to which one belongs may carry either positive or negative connotations, generating correspondingly positive or negative social identities. In this way, social groups contribute decisively to shaping an individual's social identity. When one's own group is evaluated in comparison with another group, through the comparison of attributes or values, a positive or negative difference may emerge. In the case of Romanians living beyond the country's borders, or those intending to emigrate, such a difference often appears as negative, associated with diminished prestige. Consequently, social identity becomes unsatisfactory, and individuals attempt to leave their group of origin, hoping to gain access elsewhere to a more positively valued group. Upon arrival in the host country, *as emigrants or foreigners,* they frequently encounter the same condition of negative social identity and "begin to act in ways intended to improve the status of their own group." [5] A situation of this kind is described by Gina Stoiciu in her book *Acasă. Cei plecați în lume*, where she reflects on the experience of Romanian emigrants in Montreal, Canada, beginning in the 1980. [6]

Another defining form of identity for any individual is *national identity*, in whose construction social memory plays a decisive role: "the notion of identity depends on memory and vice versa… Identity, that *hard core* of personality, is sustained by the recollection of how we related in the past to other people, to society, and to values." [7] We assume a particular identity based on what we consciously remember; voluntary recollections of the past shape the representations we hold about ourselves in the present. Every person, or even a particular social or community group, claims its own identity, perceived as *something sacred*. [8] If personal identity represents a set of qualities and flaws belonging to the same individual, and social identity refers to the specificity of a group in terms of gender, profession, religion, or social status, national identity occupies a different plane. As Chelcea argues, "national identity, like ethnic identity, constitutes *a fundamental identity group*: from the first days of life, the newborn begins reacting to stimuli from the surrounding world, especially to the presence of the mother, who herself belongs to a nationality, speaks a language, and follows a system of values, including religious ones. In acquiring the mother tongue, the candidate for humanity becomes fully human." [9]

In this way, *cultural identity* emerges, with language and communication as its central components. The importance of the mother tongue for national identity is therefore crucial, since "the mother tongue determines our human identity and nourishes our inner being." [10] From this perspective, another essential dimension of national identity, despite the coexistence with other religious denominations, remains Orthodoxy, particularly visible in Romanian diaspora communities. There, the church, and especially the Orthodox Church, plays a crucial role in preserving and affirming national identity. Thus, "both the mother tongue and religious affiliation may function as *poles around which national identity crystallizes.*" [11] From these derive, implicitly, the collective self-awareness of a nation or ethnic group.

Modern societies also *invent traditions*, and many historians argue that such practices attempt to establish continuity with the historical past. There is, however, a risk inherent in the invention of traditions when they imply a rupture from older practices. Invented traditions are often accompanied by *invented celebrations*, some belonging to contemporary or urban folklore. While *older traditions* are generally tied to ritual practices, social customs, and even superstitions, *invented* ones differ in form but frequently promote similar moral values, such as patriotism, loyalty, and duty. Among invented celebrations are those that mobilize the Romanian tricolor and national emblem, reflecting the *political symbolism* present in every nation. Within Romanian families abroad, in community associations, churches, or sporting events involving Romanian representatives, the national flag is almost always present. Such practices have generated celebrations such as *National Flag Day* (26 June), *Romanian Language Day* (31 August), *Romanian Culture Day, The Day of Romanians Everywhere* (25 May), *International Family Day, Grandparents' Day, United Nations Day*, and many others carrying symbolic meaning.

Returning to the concept of identity, we may mention a category directly linked to migration, namely *identity by choice*. Some researchers argue that, for any nation, history and the territory of the homeland become *objects of symbolic reverence*. The individual becomes fully human by assuming, throughout the process of socialization, the origin and history of the group into which they are born and within which they live. The past, recalled in memory, represents a durable source of identity and *a program for the present.* [12] When an individual, a group, or an entire population leaves its native territory and severs this connection," it loses the identity prescribed by birth and adopts an *identity by choice.*" [13] This situation is particularly relevant in the case of Romanian emigrants, especially the stateless, the *exiles, and the wanderers* before the 1989 Revolution. They fall into the category of individuals with a *vindictive identity* [14] generated by their opposition to the living conditions in their homeland. Most contested political power discreetly and tacitly, out of fear of repression, constructing in this way a *negative identity* that extended to a large part of Romanian society. The more courageous among them chose to leave the country in the hope of building a positive identity elsewhere. Many, however, encountered unexpected barriers, the most immediate and painful being the language barrier. These experiences are reflected in numerous accounts from members of the diaspora. Although each person experiences separation from the homeland differently, all confront the *condition of the foreigner*, which may appear as a form of dispossession of identity produced by *uprooting*. [15] For each individual, departure represents a unique experience. It is often perceived as an act of courage, an adventure of one's own life, a destiny consciously shaped and assumed, yet nostalgia and, frequently, loneliness inevitably make themselves felt. "Estrangement, initially experienced as isolation, gradually becomes an attentive observation of an unfamiliar world and a lucid observation of life itself. The paradox of choice is that one can never know whether the chosen path was the right one." [16] In order to understand this experience, the emigrant turns to memory, because *the first life becomes the past.* Chronological order is one thing, voluntary memory another; memory builds bridges within a multicultural world, since "identity and memory are not things we think about, but things with which we think." [17]

Within this context of preserving identity, Romanian folklore assumes an essential role, especially the calendar of customs and celebrations and their remnants within diaspora communities. The motivation to study the persistence of Romanian traditions abroad arises from the richness of folklore that Romanians took it across the country's borders, *exported it*, a term used by Flaviu Predescu, within the show *Romanian traditions in the Diaspora.* [18] The popular element stands at the origin of every people; it defines them both ontologically and in terms of identity, remaining inseparable from them regardless of where they move. As Cocchiara argues, "the discovery of the primitive and popular element is not an external act, but a given of our consciousness that provides new and original experiences." [19]

A history of peoples, and particularly of the Romanian people, necessarily includes a history of folklore, which constitutes an integral part of the history of civilization and culture. Folklore is a complex ensemble that incorporates customs, traditions, rituals, beliefs, and superstitions, a vast spectrum of popular life manifestations existing within civilizations. It represents the intersection of several disciplines, including philology, anthropology, ethnography, sociology, and psychology. Its unity derives from the heritage preserved, affirmed, promoted, and often recreated by each people. The concept of *people* itself refers to "A well-defined particularity that responds to certain ethical or spiritual interests towards which one's own actions and thoughts aim [...] is the expression of a certain vision of life, of some certain spiritual attitudes, of thought, of culture, of customs, of a civilization that presents itself with its own characteristics, specific, well structured. This is the very nature of folklore [...] The folk is always as history has created it: a history not only political, but a historical life in all its manifestations, from language to economy, from law to morals." [20]

The folk is first composed of individuals who pass through successive stages of life marked by key human moments: birth, marriage, and death. These transitions often involve shifts in social status or even movement between societies, and each transformation generates both profane and sacred reactions. Life events, past and present, define the human being, society, and its relationship with nature and the universe, all subject to ritual frameworks. *Tradition* crowns these processes, rooted deeply in the past yet constantly reflected in the present, and this is the domain studied by folklore. The promotion of Romanian traditions is also motivated by the desire to awaken national consciousness among Romanians wherever they may live. Preserving and transmitting these traditions safeguards not only ways of life but also forms of authentic Romanian artistic expression. They create bridges between people, between past and future, and between generations. "It cannot be denied that the study of folklore has always contributed to overcoming the spiritual and cultural boundaries of each people to reach towards the end the recognition of a wider community, the one that unites people with each other. The generous competition [...] eager to save everything that each person and each nation has most intimate starts, of course, from a national feeling [...] The very concept of Europe, the new concept of Europe, remains useless and empty, if it is not decisively introduced into the circle of those cultural and moral factors to whose creation it contributed folklore. Because folklore urged researchers to think in English, in German, in Russian, and in other languages, but at the same time urged them to think in European, according to an expression of Mrs. Stäel." [21]

This dynamic becomes evident when examining Romanian traditions carried beyond national borders. These traditions, embedded in celebrations, function as links in a chain where customs, practices, rituals, and beliefs intertwine harmoniously, mutually explaining the relationship between spirit and matter. They survive precisely because they respond to deeply rooted emotional structures within Romanian identity. The connection between Romanians and their homeland persists even among those who left in anger or disappointment. The bond remains internal, because “Transplanting traditions outside their native soil resembles inviting guests into a household after changing their clothes, while their essence remains intact.” [22] It can be noted, at the same time, that the *unitary character* of the traditions and customs of our people, despite the small differences that appear depending on the regions of the country from which the Romanian diaspora left: "The people have their songs and their customs, their stories, and their holidays [...] like the leaves of a tree that sinks its roots into the past, from where it draws the sap of the future." [23]

Anything that originates from the people and returns to them in forms they preserve and value may be considered *popular*, and celebrations belong to this sphere. *Popular traditions stand at the foundation of human existence*. [24] Traditional celebrations remain alive even when some associated practices are transformed or forgotten; common ritual forms continue to appear at crucial moments in human life, wherever *their bearers* migrate. Some traditions change partially, others radically, and some are recomposed according to older patterns and reinvested with new meanings or functions.

The Romanian ethnographer Simion Florea Marian presents, in his monumental ethnographic study *Romanian Celebrations* (original title: *Sărbătorile la români)*, a detailed portrait of the popular calendar. Divided into three volumes, the work is grounded in extensive documentation and focuses on *what Romanians themselves believe and say about their celebrations.* [25] Marian acknowledges that certain customs disappear while others replace them, yet insists that their study remains necessary for ethnographers, anthropologists, and historians alike. His monographic research includes both church celebrations and those considered pagan or unrelated to official religious practice but still respected by the people. Although many ancient celebrations have faded over time, certain rituals and beliefs have survived in adapted forms. “The celebrations to which Marian devotes the greatest attention are those that continue to hold strong resonance within Romanian communities worldwide, regardless of geographic location. Among the most significant within his study are the New Year and Easter cycles, which occupy the largest ritual and symbolic space.” [26]

Both in the conception of the ethnographer S. Fl. Marian, and in that of the Romanian people, the Christian holiday of Holy Easter is considered "the greatest, most important, most sacred and joyful holiday of the year." [27] It is known that it is a holiday celebrated in spring and this thing is not accidental at all because nature is also revived with Christ and with the triumph over death which the Savior brings. What draws attention in this study and is related to our approach regarding the reminiscences of traditional Romanian holidays in the diaspora, is that distinct note that is found in all chapters dedicated to major holidays, regarding the detailed presentation of manifestations that we find on the day of a certain holiday, which have continued until the days of our time, including in Romanian communities outside the country's borders. Some precede major holidays, others are held on the very day of the holiday, and others follow it. For example, in Holy Week, which precedes the great feast of the Resurrection of the Lord, people engage in household chores already established, such as: the so-called spring cleaning, which must be done at any cost before (the same thing happens on the occasion of Christmas and New Year, especially since the threshold of houses and churches will be trod by the heralds of the Nativity of the Lord: carolers, the Star, the Herod or *Viflaim*, the *Goat*, the *Buhai*); to which are added rituals indispensable for any housewife who respects herself, including: beautifying the house, baking the Easter bread, called *pasca*, painting the eggs and preparing the lamb. Some foods, considered ritual foods (for example: round or elongated cakes, those called old men or old women, pies, prosphora or the notorious Easter lamb) generate a true spirit of competition, which has been maintained among the diaspora, taking care to present and offer them for tasting to *foreigners* from the country of adoption, in the midst of which they live. Some of these have become small entrepreneurs and have even developed businesses that thrive around the holidays traditional consecrated, especially (the well-known Romanian stores that have appeared all over the world, especially where large communities of Romanians live); others prefer to procure from their homeland, directly from producers or from family members, as ingredients as natural as possible, which can bring to the holiday table the specific taste and smell of the holidays at home. A special place is occupied by egg painting (a ritual about which we find multiple meanings and explanations in the mentioned trilogy earlier).

It is worth noting that S. Fl. Marian, spreads beyond the Romanian space, making references to other ethnographic areas as well. Thus, he mentions that "the tradition of red eggs was also held by other peoples: Romans, Persians, Greeks, Gauls, Egyptians, Italians, Spaniards, as well as peoples from South America." [28] The erudite ethnographer also paid special attention to the legends about painted eggs, highlighting, thus, the folk art put in the service of respecting such customs; detailing aspects related to the color range used for *painting eggs*. Moreover, he also gave a speech at the Romanian Academy, a reception speech on the popular chromatic theme. Egg painting in a traditional , but also with methods that are more and more modern, remains a defining element for the feast of Holy Easter, in all Romanian communities around the globe, and the custom of inviting folk craftsmen skilled in the realization of this technique has already become a tradition, which the Romanians from diaspora presents with pride to the general public, invited to the various events occasioned by of this great Christian holiday. The feeling of national pride corresponds, however, from the most distant times, also this feeling of *Christian brotherhood* [29] that Romanians prove not only to their fellow countrymen, but also to all their fellow human beings, regardless of religion or nationality. What is notable to remember from the celebration of holidays is the way in which the Romanian has valued time, but also the way in which he combined what is sacred with what is profane, because this eminently religious holiday is accompanied by so many customs of not only a festive, but also a profane nature. S. Fl. Marian's trilogy "proposed, for the first time in our specialized literature, not only a conclusive image of a part of the Romanians' holidays, seen as a coherent whole, but also a definition of them..." [30]

The scholarly successor of S. FL. Marian (because he could not finalize the project of including, in their entirety, the holidays of the year) is Tudor Pamfile, who divided the holidays among Romanians into depending on the seasons, as follows: Summer holidays, among which are some that are preserved, are respected and celebrated by Romanians beyond the country's borders, some even being invested with new functions and symbols: Summer *Moșii* (memorial service), Pentecost Celebration, *Sânzienele*, Holy Apostles Peter and Paul, St. Ilie; Autumn holidays and Christmas Fast: Saint Mary – The Assumption of the Blessed Virgin Mary and The Birth of the Blessed Virgin Mary, Day of the Cross, Autumn All Souls' Day, Holy Archangels Michael and Gabriel, St. Andrew, St. Nicolae, *Ignatul* (pig slaughter). Separately, he treats Christmas, enumerating "the customs and beliefs that together make up the Christmas holiday." [31] Both days are regarded as significant, the traditions related to this period, elements of the specific ritual, customs, habits of this holiday cherished, among which: waiting for the holidays, cakes and sweet bread, father Christmas, the blessing the Christmas Eve table, caroling, Star o'caroling, *Vifleim* or *Irozii*; the Goat (the Turk), *Brezaia*; slaughtering the pigs; Christmas, autumn All Souls' Day, the Christmas Tree, and others. About the legendary person of Christmas speaks in Chapter VIII, mentioning in one of the two final chapters: "Christmas is the man who drove the mother of God out of his house in the hour of birth, but later, after birth repented and gave glory to God. This is what the legends tell us, which in their wide garb of prose can keep it clearer, something that cannot be asked of a carol, often out of the pen of a scholar [...] Christmas includes many customs, like Easter." [32]

Today it is quite difficult to assess how much of what is specifically Romanian, autochthonous, and authentic can still be found in the culture of the people. Despite the course of human evolution and the fact that Romanians have come to spread across the world and engage with an increasingly evident multiculturalism, the capacity of folkloric models to capture diverse social realities and to express them in varied forms persists. This endurance is due to the fact that each generation, in one way or another, inherits and carries forward the traditions of its people, particularly those centered on the major festivals of the annual cycle. No culture of a people exists alone, but coexists with other cultures, especially in this century in which borders are open and free movement is no longer just a beautiful dream; Romanian culture is not outside of that European, nor that of the universal, because artistic values circulate *in both directions.* [33] Based on these considerations, Constantin Eretescu compiles a classification of all aspects related to folk literature as a source of inspiration for written literature, gathering factual and classifying folklore, which is, at least in Romania, a syncretic phenomenon.

I consider this aspect important because it can serve as a starting point for comparative and conclusive research on how many of these traditions have evolved within Romanian diaspora communities, and which have disappeared, either through neglect or as a result of reinterpretation. Certainly, we can speak of a permanent recreation of them and not of a disappearance, with some exceptions. Moreover, referring to this aspect, namely the existence of an unquestionable connection between people, the ethnologist, anthropologist, and writer Constantin Eretescu remarked that: "The literary folklore of Romanians was formed in the context of their coexistence with other peoples. Differences in language have never hindered the migration of cultural values." [34]

We find that the folklore of customs is mostly preserved in modern society today and in Romanian communities everywhere, which is visible in the holidays throughout the year or in the crucial moments of human existence, wherever they may be, being updated in a sacred time. The ritual act is indispensable in the folklore of customs, and it reveals its syncretic character because, surprisingly or not, even today, in all corners of the world where Romanians live, certain ancient rituals are practiced, even if they are most often disguised under a new guise. Rituals differ not only from one historical era to another but also from the point of view of the meaning, functions they fulfill, or their motivation. The mentality of those who practice them has determined transformations of these, but these metamorphoses somehow confirm their perennity: "The contemporary form of unfolding of some customs is, therefore, the complex result of the successive modifications to which they have been subjected." [35]

On a similar note, trying to synthesize folklore to relate it to the latest realities, which are still preserved and received by folklorists, Romanian holiday calendars provide an admirable synthesis of the country's beliefs, customs, and traditions, key markers of national identity examined in depth in Professor Antoaneta Olteanu's monumental work, *Space and Time in Romanian Traditions*. We find here: Calendar of holidays with a fixed date, Calendar of mobile holidays, Calendar of seasons, Weekly calendar, Calendar of days and nights, and Lunar calendar. This work has relevance for our research because it includes a vast ethnological material, through which we are offered an updated version of all the holidays that we can find in the Romanian villages and, from here, carried to other horizons by our Romanians, more or less tributary to them, who have spread around the world and taken with them part of the wealth and beauty of Romanian folklore, many of them trying to create a piece of Romania where they are. The author offers" [...] a gradual presentation of the festive. In addition to traditions and customs, which synthetically provide the data best known, best preserved of the holiday, numerous magical practices are offered, which emphasize the active participation of people in the sacredness of the day." [36]

Thus, in the calendar of holidays with a fixed date, we find the winter holidays (starting with St. Andrew the Apostle's Day – which has been decreed in recent years as the Patron Saint of Romania, St. Nicholas, Christmas, New Year, Epiphany, and Saint John), with all the related traditions, are described in detail some of them exported and practiced beyond the country's borders, with Romanian carols holding a place of honor, without exception, and in some areas even *Viflaim* or *Irozii*, *Plugușorul*, *Capra* (or *Turca*), *Sorcova*; practiced in some diaspora communities or presented not only to Romanians, but also to the general public from the countries of adoption, through countless shows, festivals or parades initiated by generous people, the Church, various Associations, with the support of the Department for Romanians from Everywhere, the Embassies or other political or apolitical bodies and organizations, NGOs, etc.

All these represent *a unique form of art*, which we, as Romanians, have a duty to preserve, to promote and cultivate it further in the souls of the younger generations, especially among those born abroad, international children, who *evolve in a present without memories and without a past*. [37]

The aspects presented in this article constitute a first step in a broader study, which aims to highlight Romanian customs, habits, and traditions, in which there are values authentic to the Romanian people.

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MATERIALS SCIENCE AND MECHANICS OF MACHINES

DETERMINATION OF LOADING POWER OF FLEXIBLE WAVE TRANSMISSION WHEE

Aliyev B.
Baku Engineering University, PhD, Associate Professor, Department of Engineering Mechanics, Baku, Azerbaijan
Zarbaliyeva G.
Baku Engineering University, teacher, Department of Engineering and Mechanics, Baku, Azerbaijan
Aliyev S.
Baku Engineering University, Master's degree, Department of Engineering and Mechanics, Baku, Azerbaijan
Musayev E.
Baku Engineering University, Master's degree, Department of Engineering and Mechanics, Baku, Azerbaijan
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Abstract

Wave gear transmissions are mechanical transmissions that employ a flexible and rigid gear mesh, possessing significant features that determine their application areas. These features include a high gear ratio in a single stage, low transmission weight relative to the transmitted load, the ability to transmit motion through a sealed wall, and the presence of a flexible gear and a wave generator. Due to the specific nature of the transmission, the flexible gear is constantly deformed by the rotating wave generator, generating alternating stresses. The effect of alternating stresses on the flexible gear often leads to its fatigue failure. This article presents an analysis of the stresses acting in the flexible gear and discusses the dependencies for determining these stresses. These dependencies include correction factors that take into account the influence of the gear ring on the rigidity of the flexible gear, as well as the influence of the ratio of certain gear dimensions. These coefficients were obtained on the basis of experimental studies. As a result, an analysis was conducted of the dependence of the load-carrying capacity of flexible gears on their dimensions and the main determining factor—the thickness of the flexible gear under the rim.

Keywords: harmonic transmission, flexible gear, stress in the flexible gear, precision, and durability.

1. INTRODUCTION

For most harmonic transmissions (HPTs), the performance criteria are the fatigue resistance of the flexible gear and the ultimate load on the wave generator. To prevent fatigue failure of the gear, it is necessary to properly design it, determining its inner diameter based on the load—the transmitted torque. It is also necessary to correctly assign the remaining dimensions of the flexible gear, such as the rim dimensions, the shell thickness, the thickness of the gear under the rim, and others. In this case, it is necessary to consider not only the stresses arising in the flexible gear but also the load acting on the harmonic transmission generator, since exceeding the ultimate load leads to generator breakthrough and loss of transmission performance. When analyzing the performance of a wave gear transmission based on the fatigue resistance criterion of a flexible wheel The stresses caused by its deformation by the wave generator [1], [2] and the stresses arising from the load on the teeth [3], [4] are considered. A spatial model of the flexible sprocket, taking into account its interaction with the wave generator [5], [6], is also considered.

Based on numerous studies of the performance of the flexible sprocket [3], [4], [7], [8], [9], recommendations have been developed for determining the size of the flexible sprocket depending on the transmitted load. However, the influence of some parameters determining the load capacity of the flexible sprocket of the flexible sprocket has not been sufficiently considered. Such parameters primarily include the thickness of the flexible sprocket under the toothed rim, since it is this thickness that primarily determines both the magnitude of the stresses in the flexible sprocket of the flexible sprocket and the load on the wave generator.

II. PROBLEM STATEMENT

When designing a flexible sprocket of the flexible sprocket that meets fatigue resistance requirements, it is necessary to determine its design and specify the required dimensions. After this, it is necessary to determine the stresses acting in the flexible sprocket and analyze the dependence of these stresses on the transmitted load and the geometric parameters of the sprocket. Based on the analysis, recommendations can be made for wheel design.

For the flexible wheel design, we propose a flexible "cup" wheel (Fig. 1), as the most common and efficient. Figure 1 shows the design and main dimensions of the flexible wheel, as well as the load F applied by the wave generator.

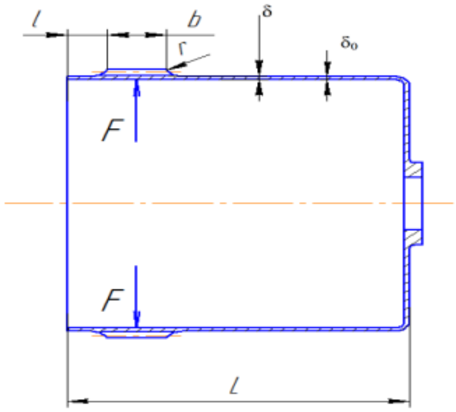

Fig. 1. Flexible Gear - Cup

When designing a flexible gear, its inner diameter is first determined based on the transmitted load [3]. Next, it is necessary to determine the stresses in the most critical area – the gear ring. These stresses depend on many factors affecting the fatigue resistance of the flexible gear. Therefore, correction factors that take these factors into account must be introduced into theoretical formulas for calculating stresses. The coefficients must be determined based on actual tests of flexible gears in an operating harmonic drive. To determine the coefficients, special fatigue resistance tests of flexible gears were conducted [2], [3]. After obtaining the coefficients and their dependence on the studied parameters of the flexible gear of the harmonic drive, it is necessary to determine the stresses in the flexible gear. The magnitude of these stresses must be analyzed based on the parameters that significantly influence their magnitude.

III. THEORY

During operation of a flexible gear, the following stresses arise in it:

– stresses σ h,c , arising in the flexible gear due to its deformation by the wave generator;

– stresses σ 3 arising in the running wheel from the load on the
teeth;

– stresses t τ arising in the wheel from the torque T.

The equivalent stresses are determined by the known relationship

$$\sigma = \sqrt{\left(\sigma_{h,x} + \sigma_3\right)^2 + 4\tau_n^2} \qquad (1)$$

To determine the stress magnitude δh.c using the stresses inδhгл in a smooth ring with a thickness δ1 equal to the thickness of the flexible gear under the ring gear, we introduce the correction factor

$$K_{h,zn} = \sigma_{h,c}/\sigma_{h,zn} \qquad (2)$$

where δhгл is the nominal stress in a smooth ring with a thickness under the ring gear of δ1. These stresses are determined using the known relationship

$$\sigma_{h,zn} = \frac{E\,\delta_l}{2}\,\frac{R-r}{(R+\delta_l/2)(r+\delta_l/2)} \qquad (3)$$

where E- is the modulus of elasticity of the material; δ_1 - is the thickness of the flexible gear under the rim; R - is the radius of the inner surface of the ring before deformation; r- is the radius of the inner surface of the deformed ring. The values of the coefficient Kh were determined using the relationship:

$$K_h = (\sigma - l)_h/(\sigma - l)_{hzn} \qquad (4)$$

where (σ-1)ngl is the fatigue limit of the smooth ring material, which was determined experimentally on smooth specimens; (σ-1)hgl is the fatigue limit of the flexible gear, which was determined by testing the gears without tooth loading, but only by deforming the gear with a wave generator [1], [2]. In these tests, the flexible gears were subjected only to the action of the generator without tooth loading. As a result of testing and processing of their results, the dependence of the coefficient Kh on the geometric parameters of the flexible gear was obtained

$$K_h = 9.57 - 1.44\frac{\delta_l}{m} - 3.68\frac{L}{R} - 0.29\frac{r_l}{R} - 5.58\frac{b}{R} + 0.62\frac{\delta_l L}{mR} + 3.19\frac{Lb}{RR} \qquad (5)$$

where m – is the engagement modulus; R - is the radius of the inner cylindrical surface of the flexible gear; δ_1 - is the thickness of the flexible gear under the gear rim; L - is the length of the flexible gear; b - is the width of the gear rim; r1 - is the transition radius from the gear rim to the smooth part.

The determination of stresses σ_3 arising in a flexible wheel from the load on the teeth was carried out using the nominal stresses σз.н and the clarifying coefficient Kмооб obtained as a result of experiments

$$\sigma_3 = K_{h,\delta}\,\sigma_{3,l} \qquad (6)$$

Nominal voltages σz.n. are determined, according to [3.7], by the dependence

$$\sigma_{3,n} = \mu\sqrt{\frac{\pi T \sin 2\alpha_c}{2m^2 Z^3 K_L K_z}}\,(h + 0.5\delta_l)\,\frac{\delta_l m}{\delta_l^2}\,K_y \qquad (7)$$

Where μ - is the coefficient for reducing the unevenness of load distribution across the gear rim width; T- is the transmitted torque; αg is the profile angle of the flexible gear tooth; C- is the specific tooth rigidity; m is the engagement modulus; Z - is the number of teeth; KL - is the ratio of the length L - of the flexible gear to its inner diameter; Kz - is the coefficient determining the proportion of teeth in engagement in one zone; h - is the tooth height; KJ- is the gear rim rigidity coefficient.

The clarifying coefficient Ktooth was obtained based on fatigue resistance tests of flexible gears. The flexible gears were tested in a running transmission under load. Flexible gears with an inner surface diameter of 80 mm were tested. Wheels with various combinations of geometric parameters were tested. After processing the test results, the coefficient Ktooth - was obtained.

$$K_{y\delta} = 0.21\frac{\delta_l}{m} + 7.84\frac{L}{R} + 28.44\frac{b}{R} - 2\frac{\delta_0}{\delta_l} - 0.616\frac{\delta_l L}{mR} - 16.25\frac{Lb}{RR} - 6.79 \quad (8)$$

According to [4], the nominal torsional stresses are defined as

$$\tau_{m,u} = \frac{T}{K_{p,2\pi}\,(R+\delta_l/2)^2\,\delta_2} \quad (9)$$

where Kкр is a coefficient that takes into account the number of teeth simultaneously in mesh. Similarly to the stresses from the tooth load, the maximum local shear stresses T,n τTn were determined from the action of torque:

$$\tau_{m,n} = K_m\,\tau_{m,u} \quad (10)$$

where the refinement coefficient Kt was determined experimentally, similar to the previous refinement coefficients. Its value is determined as:

$$K_m = 18.21 + 0.72\frac{\delta_l}{m} - 8.94\frac{L}{R} - 43.05\frac{b}{R} + 1.2\frac{r}{R} + 22.95\frac{Lb}{RR} \quad (11)$$

After substituting the stress values into formula (1), we obtain:

$$\sigma = \sqrt{\left(\sigma_{h,z}K_h + \sigma_{3,u}K_3\right)^2 + 4\left(\tau_{m,u}K_m\right)^2} \quad (12)$$

IV. EXPERIMENTAL RESULTS

Based on the obtained dependencies, the maximum stresses in the flexible wheel ring gear area were calculated. These dependencies use clarifying coefficients obtained from previously conducted experimental studies. Flexible wheels with the following parameters were considered in the calculations: the parameters of the flexible wheels under consideration (d = 80 mm; L = 80 mm; b = 16 mm). Various values of the flexible wheel thickness δ1 under the ring gear were also considered. The calculation results are shown in Figure 2; the δ1 values used in the calculations are listed in Table 1.

Table 1

Flexible wheel thickness δ1

№ кривой	1	2	3	4	5	6	7	8	9
δ_l, мм	0.583	0.729	0.875	1.02	1.167	1.313	1.459	1.705	1.75

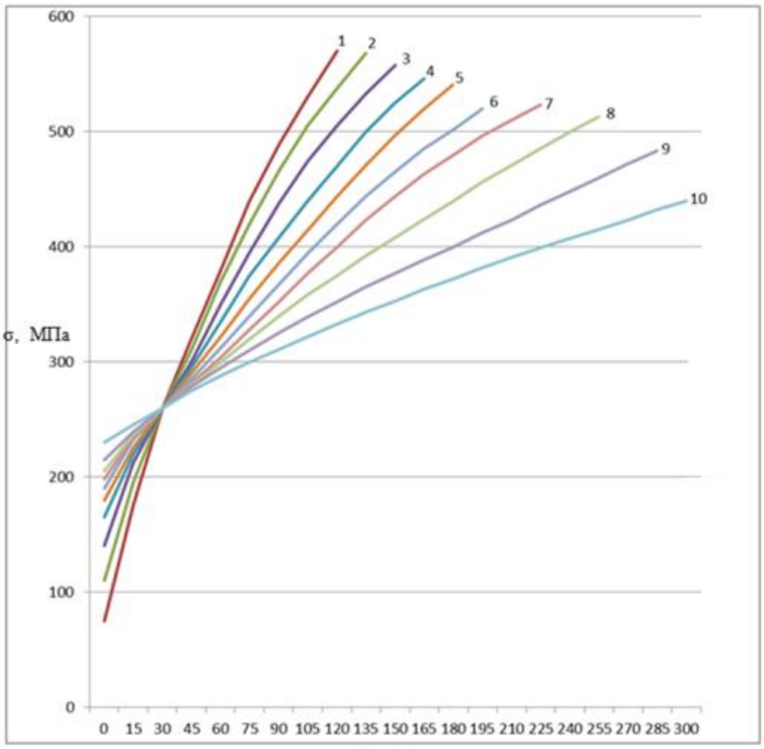

Fig. 2. Stresses in the Flexible Gear

V. CONCLUSIONS

Analysis of the obtained results allows us to draw conclusions that define recommendations for the design of flexible gears for VZP.

1. The most significant influence on stresses in the flexible gear is the thickness δ1 of the flexible gear under the ring gear.

2. In a transmission with the adopted parameters (d = 80 mm; L = 80 mm; b = 16 mm), with a load of up to 30 Nm, it is preferable to adopt the minimum values

for the thickness δ1, and with a load of over 30 Nm, it is preferable to adopt the largest possible values for the thickness δ1 (see Table 1).

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PARADIGMS OF APPLICATION OF BUSINESS INTELLIGENCE IN SMALL AND MEDIUM-SIZED ENTERPRISES IN SERBIA

Denić N.
Faculty of Sciences and Mathematics
University of Priština, Kosovska Mitrovica,
https://orcid.org/0000-0003-2584-259X
Bogdanić D.
Faculty of Information Technologies,
Alfa BK University, Belgrade, Serbia,
https://orcid.org/0009-0008-1152-159
Carević M.M.
Faculty of Mathematics and Computer Sciences,
Belgrade, Serbia,
https://orcid.org/0000-0001-6458-2044
Mehmedi S.
Faculty of Finance, Banking and Audit,
Alfa BK University, Belgrade, Serbia,
https://orcid.org/0009-0006-0129-7995
Milić S.
Faculty of Information Technologies,
Alfa BK University, Belgrade, Serbia,
https://orcid.org/0009-0005-1491-263X
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Abstract

Today's times bring new and rapid changes in the business environment every day, to which small and medium-sized enterprises should adapt as soon as possible, often on the fly. With the development of new information technologies of artificial and business intelligence in the 20th and 21st centuries, everything becomes dependent on the availability of information and thus on investments in innovations and new technologies, not only in technological but also in business development. In the theoretical part of the research, based on the results of eminent world authors in this field, the concepts, terms, functions and methods of business intelligence are explained, from the aspect of business optimization and improvement of business decision-making. In this regard, we investigate the theoretical basis of business intelligence and a possible practical demonstration of the implementation of these systems in SMEs in Serbia. The aim of the research is a qualitative, studious analysis of the advantages and disadvantages, as well as the possibilities of applying new business intelligence technologies and approaches in SME operations in Serbia, in the conditions of the global economic crisis and recession, with the aim of optimizing and improving operations, i.e. survival in the increasingly open world market. The empirical part will present the results of research conducted in practice, through the classification and statistical performance of small and medium-sized enterprises in Serbia, then the areas in which the application of business intelligence has yielded the best results will be presented, and finally the effects of its application in specific companies in Serbia. In this context, it can be said that for the purposes of the research, the ever-present growing need for the use of business intelligence methods, techniques and tools from the aspect of improving and optimizing company operations, as well as computer-supported methods and methodologies for decision-making in companies, has been studiously analyzed. The theoretical and practical parts of the work are interconnected and in constant interaction.

Keywords: Small and medium enterprises, business intelligence, artificial intelligence.

Field: Technical and technological sciences

1. INTRODUCTION

Companies in Serbia today operate in an extremely uncertain and volatile environment with an extremely high level of uncertainty and the inability to predict the future. The latest research shows that employers in Serbia are often fighting the crisis by laying off workers and freezing wages[7]. In this regard, there are also certain differences between the size of business entities, as the data shows that compared to the small and medium-sized enterprise sector (hereinafter referred to as SMEs), large companies record productivity at a significantly higher level (in 2021 by 58.8%, in 2022 by 53.6% and in 2023 by 59.5% above the SME average). Research in practice shows that SMEs are under increasing pressure to survive in an increasingly competitive market and in this sense they find a solution in the application of new sophisticated technologies such as artificial and business intelligence, although until recently this was characteristic of large companies[11]. Representative research in the world shows that almost half of the respondents (47%) stated that their company had already laid off workers, while 46% stated that their salaries had been frozen. Furthermore, 36% of the respondents stated that the companies where they work had frozen financing for new projects, 33% that salaries had been reduced, while 32% of the respondents stated that they had cut education costs [2]. In this context, research indicates the importance and crucial importance of analyzing business data and information.

2. THEORETICAL BASICS OF SMALL AND MEDIUM-SIZED ENTERPRISES

Business practice in the world shows that micro, small and medium-sized enterprises are considered one of the leading forces of economic development because they represent the most efficient segment of the economy in almost all countries of the world. The results of the Republic of Serbia's Statistical Office indicate the importance and significance of small and medium-sized enterprises in Serbia, illustrating this with basic indicators - that these enterprises account for 99.8% of the total number of enterprises in the non-financial sector[24]. In this context, it is estimated that the total economic activity in the Republic of Serbia in 2025, measured by the real movement of gross domestic product (GDP), recorded a growth of 2.0% compared to 2024. Similar data are in the world where the largest number of enterprises registered in the territory of the European Union are small and medium-sized enterprises, it is estimated that 99% of enterprises, out of over 200 million enterprises, 93% of which are the smallest, so-called micro-enterprises, which have up to ten employees. Precise data according to the latest data from the Statistical Office of the Republic of Serbia show that out of a total of 110,287 enterprises in the Republic of Serbia, in 2023 there were: 94,078 micro (85.3 percent), 12,613 small (11.4 percent), 2,953 medium (2.7 percent) and 643 large enterprises (0.6 percent). According to available data, more than 940,000 workers are employed in SMEs, which is 67.2% of the total number of employees in the non-financial sector and 43.2% of the total number of employees[24]. One of the most appropriate ways to create a competitive advantage for SMEs in Serbia, in the current conditions of the global economic crisis and recession, is the concept of business intelligence[12]. In this regard, the current application of business intelligence methods, techniques and tools is justified, i.e. the demand for accurate, timely and useful information in SMEs is extremely high[13]. The following figure 1 shows statistics of companies in the Republic of Serbia.

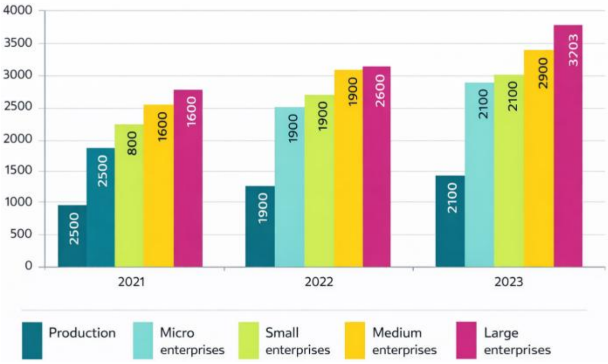

Table 1. Classification of companies by size in Serbia 2

As can be seen, whether they are complete or customized business intelligence solutions, they bring corresponding improvements in market positioning and competitiveness, as well as better, new ways of managing information and knowledge.

3. THEORETICAL BASIS OF BUSINESS INTELLIGENCE

The relevant literature states that business intelligence is the ability of an organization to understand and use data to improve its operations or to use existing data, information, and knowledge within the company [21]. This is supported by the opinions of Turban et al (2021), who emphasize that business intelligence is "an umbrella term that combines and defines tools, databases, analytical tools, applications, and methodologies"[26]. Similarly, Kimball and Ross define business intelligence as an umbrella term to describe "concepts and methods for improving business decision-making with the help of evidence-based support systems"[17]. However, practical results show that for the application of business intelligence to be effective, appropriate IT knowledge and competencies are necessary. In this context, Chao and Chandra (2012) conducted a survey of 217 small manufacturers and financial services organizations in the USA and found that the level of IT knowledge of the owners is a key predictor of IT strategic positioning, as well as the adoption of business intelligence[3]. The literature states that the goal of introducing business intelligence is to support and improve business decision-making processes in companies [4]. In essence, business intelligence is the process of collecting data and information that, after appropriate processing, becomes knowledge[25]. In general, it can be said that business intelligence is a general term that describes the use of internal and external sources of information in companies, in a way that facilitates making better decisions[17]. Based on the above, the conclusion is that business intelligence produces knowledge that is the basis for optimizing and improving business and making better business decisions. The definition presented by Gartner emphasizes that this is a term that includes applications, infrastructure, which enable analysis and access to information in order to improve and optimize business, processes, decisions and performance[14]. One of the most complete definitions of business intelligence can be found on the IBM website: “Business intelligence is the collection, management, analysis and sharing of information to gain insights that can be used to make better decisions. The famous author Howson (2013) defines business intelligence as a technology that enables people from all levels of the enterprise and business systems to access, interact and process data for business management, in order to improve their work, discover new opportunities and work more efficiently[15]. In this regard, it can be said that business intelligence is the process of collecting significant internal and external data and transforming it into information and useful new knowledge needed by SMEs to improve their business and make business decisions[1]. Based on the evolution of the relevant literature, the following can be distinguished as the main tools and techniques of business intelligence:

- ✓ Data warehouses - data storage in a way that enables the satisfaction of numerous analytical needs.
- ✓ ETL tools (eng. Extraction, Transformation, Load) - tools for extracting and normalizing data. Data sources reside in or out of numerous databases, and in both cases the data must be recognized as relevant and extracted from its existing location into the system for transfer or transformation.
- ✓ OLAP (eng. On-line Analytical Processing) - enable data in the warehouse to be analyzed in multiple dimensions, which expands the metrics by which users value information.
- ✓ Data mining (eng. Data Mining) - an unconventional way of finding hidden patterns or rules in large data sets that can be of great advantage and importance.
- ✓ Business reporting - visualization via business portals, balanced scorecards, digital dashboards.
- ✓ Monitoring of basic performance indicators - KPI (eng. Key Performance Indicators)
- ✓ Monitoring of business activities - BPM (eng. Business Process Management)

Eminent authors define a data warehouse as a subjectively oriented, integrated, time-varying, non-normalized and consistent set of data for analytical decision support [27]. The next factor is the so-called. ETL process, which is one of the most complex and commonly used data preparation techniques for business intelligence purposes. The goal of the ETL process is to select, clean and integrate data from various sources into the data warehouse, so this process is the basis of the business intelligence process. On average, 70% of the total time spent on the implementation of a business intelligence system is spent on the ETL process itself [17], with the cause of the problem most often being poor quality of the data source, which unequivocally indicates the importance of the quality of business data and information. This is confirmed by the authors who state that the emphasis of the ETL process consists of sub-selection, cleaning, unification and delivery of data in a dimensional data model. The next factor is the so-called. OLAP tools, the use of which in data warehouses is in the function of more transparent and clear information. However, the results in practice show that despite this, it is noticeable that due to the large amount of data, business analysts work very hard, slowly and often inefficiently. It is estimated that today companies receive huge amounts of business data from internal and external sources, of which they barely manage to use about 5 to 10%. This is supported by the latest research by well-known authors, which indicates that a typical company has 90% of the necessary data and information, necessary for efficient business operations, but effectively uses only 10% of the available data and information[19][20]. In this direction, the role and importance of tools for discovering knowledge in data are reflected, which instead of analysts automatically analyze data and display results. Data mining tools are essentially a kind of alternative in the search for business information, where the amount of input data is enormous, and the necessary business information is hidden and very difficult to access. This is exactly what a quality business intelligence system will provide to the manager, and this can be achieved if the data obtained from such systems is used in the best possible way. However, the results in practice show that although business intelligence is often mentioned in SMEs in Serbia today, unfortunately the business discipline is still used negligibly little.

4. RESEARCH METHODOLOGY

The methods used in this research work include the use of standard scientific methods such as analysis, synthesis, comparison, generalization, description, induction and deduction, compilation, and methods of proof. In this context, it can be said that a research framework was applied that combines different research methods, thus including quantitative and qualitative research methods [23].

5. RESULTS

Another in a series of studies, which indicates the enormous growth of the amount of data, is a study conducted by Gartner, where 47% of respondents qualified the growth of business data among the three biggest challenges of modern management[14]. The results of the study show that the application of advanced techniques; ETL, OLAP, DM, DW, and the introduction of intelligent information systems in SMEs raises business to a higher level, which enables efficient monitoring of business processes. The problems of managers in companies are noticeable and significant because, according to research, about 54% of business users cannot find the necessary information, 43% are not sure whether the information they receive is accurate, while 77% claim that bad decisions are made solely due to a lack of information. According to the results of representative research by individual authors Kielstra, the most important attributes of information needed for decision-making are: quality (65%), completeness (18%), timeliness (13%), and price (5%) [16]. The well-known expert Eppler emphasizes that for SMEs today the quality of information is crucial, not the quantity. An example from practice shows that thanks to the successful implementation of OLAP functionality in the analyzed company "Lipovica", the management came to the conclusion that in a period of 5 years it is possible to expand capacities by 24% and redistribute planting and cutting material, which would bring a total profit of 48% compared to the current period [8]. This is complemented by the opinions that can be seen in the following figure 2 that company managers clearly want to shift their focus from data collection to the use of data in business optimization and more efficient business decision-making.

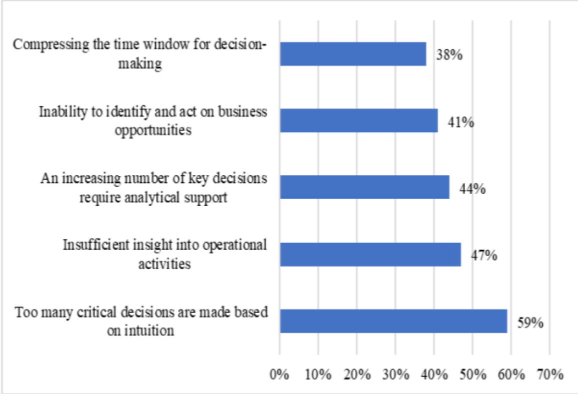

Fig. 2. The main pressures for the use of business intelligence in SME 2

5. DISCUSSION OF RESULTS

Research indicates that the best business intelligence model in times of economic crisis and recession is one that will help SMEs achieve a competitive advantage, while being inexpensive[9]. For this purpose, OSBI (Open Source Business Intelligence) has been increasingly discussed recently. Implementation projects, or rather the introduction of business intelligence into companies, are extremely demanding and complex. However, despite the fact that the latest research in the world indicates that, for example, out of 43 American companies that participated in the research, 46% achieved 100% or less return on investment, 34% between 101% and 1000%, and 20% around 1001% and more, they are still not applied to the necessary and sufficient extent in SMEs in Serbia. It is important to note that not all data warehouses are suitable for business intelligence, just as not all business intelligence applications require data warehouses[10]. However, according to some surveys, more than 90% of larger and successful companies in Europe use some form of data storage and business intelligence, while in Serbia it is still less than 10%. However, in practice, there are certain obstacles to the widespread use of business intelligence, such as research cited by Davenport and Ronanki (2018), which emphasizes that despite the recognized benefits, the lack of professional knowledge and trust in intelligent systems remain the most common obstacles to the application of business or artificial intelligence in business, or in the process of business decision-making and management with the aim of improving business[6]. Considering that according to research, more than 70% end either with deadlines being exceeded or inefficient, the authors Olszak and Ziemba (2012) consider the so-called critical success factors for establishing business intelligence in SMEs, which highlight common features of obstacles such as: financial, organizational-cultural and IT barriers within the company[22]. If the above figures are presented as a payback period for the invested funds, the situation is as follows: 49% of companies recovered the funds invested in a business intelligence project in one year or less, 32% in a period of one to three years, 19% in three or more years. The results of research in the world indicate that a typical business intelligence project has an average return of over 430%. According to available data, this year, according to the readiness index for the implementation of business or artificial intelligence, Serbia ranked 39th out of a total of 195 assessed economies worldwide, which places it among the top 20 percent of the most prepared economies at the global level. Research shows that business intelligence functionally affects the improvement of the operations of small and medium-sized business systems, forming a positive attitude towards the effects of the application of intelligent systems for decision support in the company (Figure 3).

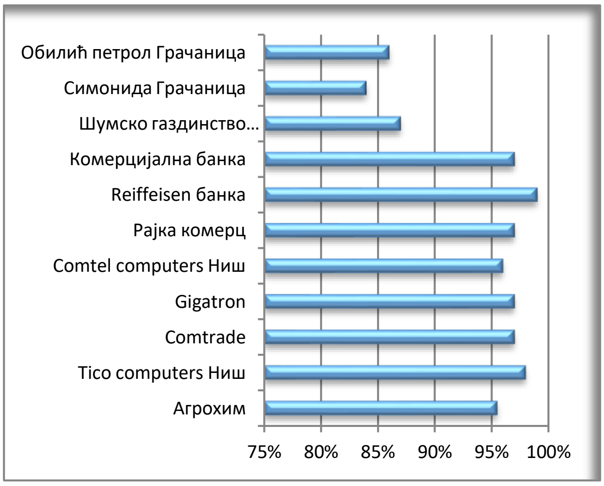

Fig. 3. The main pressures for the use of business intelligence in SME 2

The largest application of business intelligence in Serbia was recorded in the information, communication and professional sectors, where 62% of companies use business or artificial intelligence [28]. According to Eurostat data, only 8% of companies in Europe used business or artificial intelligence in their operations in 2023, and Serbia is only at an estimated 2% of applications.

6. CONCLUSIONS

The research shows that SMEs account for over 50 percent of Serbia's exports, which further indicates the relevance and importance of this research. The research results indicate that the use of business intelligence will result in business success only if business intelligence users regularly develop business and decision-making processes, recognize their needs, help in their modeling and monitor the completion of the project, as well as actively participate in the implementation of new business intelligence components. In this regard, access to information and its processing into relevant knowledge is of great importance for a company of any size. The basic concept of the research is guided by the idea that by synthesizing modern IT methods and techniques: ETL, OLAP, DW and Data Mining through the practical application of business intelligence concepts, tools and techniques, a new high-quality information system for SMEs can be developed that improves work at the operational level, and primarily makes it easier for top management to make the right business decisions important for the survival and development of SMEs in Serbia. To successfully adapt to the ever-changing market, SMEs must understand what changes are taking place and how this can affect their business. The results of thorough research indicate that the greatest contribution to business efficiency is quick insight into a large amount of data and shortening the time to access information. In last year's report, Serbia ranked 57th in terms of readiness for the implementation of business intelligence, or artificial intelligence. The research shows that the benefits of implementing a business intelligence project include centralized knowledge, improved decision-making processes, systematization and recognition of opportunities, better implementation of business processes, greater productivity and competitiveness.

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MATHEMATICS

THE INTEGRATİON OF MATHEMATİCS AND COMPUTER SCİENCE: FOUNDATİONS, APPLİCATİONS, AND FUTURE DİRECTİONS

Aliyeva G.
Sheki Branch of ADPU, head teacher
https://orcid.org/0000-0002-6613-8227
DOI: 10.5281/zenodo.18677777

Abstract

The integration of mathematics and computer science constitutes a fundamental pillar of modern scientific and technological development. Mathematics provides formal structures, abstract reasoning, and theoretical models, while computer science translates these models into computational processes through algorithms, programming paradigms, and system architectures. This close relationship enables the design, analysis, and optimization of complex computational systems.

This article examines the mathematical foundations underlying computer science, including discrete mathematics, linear algebra, probability theory, logic, and numerical analysis. It further explores how these mathematical tools are applied in key computational domains such as artificial intelligence, machine learning, cryptography, data science, scientific computing, and computer graphics. Particular attention is given to algorithmic thinking and optimization, highlighting how mathematical rigor contributes to efficiency, correctness, and scalability in computational solutions.

In addition, the paper discusses emerging research directions, including quantum computing, explainable artificial intelligence, and computational mathematics, emphasizing the growing importance of interdisciplinary approaches. By demonstrating the deep interdependence between mathematics and computer science, this study underscores the necessity of integrated education and research to address increasingly complex real-world problems and to drive future innovation.

Keywords: Mathematics and Computer Science; Algorithms; Discrete Mathematics; Linear Algebra; Artificial Intelligence; Machine Learning; Optimization; Computational Modeling.

1. Introduction

Mathematics and computer science are two closely related disciplines whose interaction has fundamentally shaped the evolution of modern science and technology. Mathematics offers a formal language for abstraction, logical reasoning, and theoretical modeling, while computer science focuses on the representation, processing, and automation of information through computational systems. The integration of these fields has enabled the systematic analysis of complex problems and the development of efficient, reliable, and scalable computational solutions.

Historically, the relationship between mathematics and computation predates the emergence of modern computers. Early algorithmic concepts can be traced back to classical mathematical procedures, such as Euclid's algorithm, which demonstrated that abstract reasoning could be transformed into a step-by-step computational process. With the advent of digital computers in the twentieth century, mathematical logic, number theory, and discrete structures became essential components of computer science, forming the theoretical basis for programming languages, automata theory, and complexity analysis.

In contemporary research, the boundaries between mathematics and computer science have become increasingly blurred. Fields such as artificial intelligence, machine learning, cryptography, and data science rely heavily on mathematical models, including linear algebra, probability theory, optimization, and statistical inference. At the same time, advances in computer science have enabled the practical implementation and large-scale experimentation of mathematical theories, allowing researchers to solve problems that were previously intractable using analytical methods alone. Furthermore, mathematical rigor plays a critical role in ensuring the correctness and reliability of computational systems. Formal methods, based on logic and set theory, are used to verify algorithms, software, and hardware designs, reducing errors in safety-critical applications such as healthcare, finance, and aerospace systems. Algorithmic efficiency, often evaluated through mathematical complexity analysis, has also become a key concern in the era of big data and high-performance computing.

The growing demand for interdisciplinary approaches has highlighted the importance of integrating mathematics and computer science in both education and research. Modern scientific challenges—ranging from climate modeling and bioinformatics to cybersecurity and intelligent systems—require a deep understanding of mathematical principles alongside strong computational skills. This integration not only enhances problem-solving capabilities but also fosters innovation by enabling researchers to bridge theory and practice. This article aims to provide a comprehensive overview of the integration between mathematics and computer science. It discusses the mathematical foundations that underpin computational theory, examines key application areas where this integration is most evident, and outlines emerging trends that are shaping future research. By emphasizing the mutual dependence of these disciplines, the study seeks to demonstrate why their continued collaboration is essential for addressing increasingly complex real-world problems.

2. Mathematical Foundations of Computer Science

The theoretical foundations of computer science are deeply rooted in several core areas of mathematics. These mathematical disciplines provide the formal structures and analytical tools required to model computation, analyze algorithms, and ensure the correctness and efficiency of computational systems. Without mathematical rigor, many of the fundamental concepts in computer science would lack precision and reliability.

2.1 Discrete Mathematics and Combinatorial Structures

Discrete mathematics forms the backbone of theoretical computer science. Since digital computers operate on discrete data, structures such as graphs, trees, sets, and finite automata play a central role in algorithm design and analysis. Graph theory, for example, is essential for modeling networks, communication systems, and social interactions, while combinatorics enables the enumeration and optimization of possible configurations in complex systems.

Combinatorial analysis is particularly important in algorithmic complexity theory, where the growth rate of computational resources is examined as input size increases. Techniques such as recurrence relations and asymptotic analysis allow researchers to classify algorithms according to their time and space complexity, providing a mathematical basis for comparing efficiency and scalability.

2.2 Linear Algebra and Vector Spaces

Linear algebra is a foundational component of many modern computational methods. Vector spaces, matrices, and linear transformations provide compact representations of large-scale data and enable efficient numerical computation. In computer graphics and computer vision, linear algebra is used to model geometric transformations, projections, and rotations. In machine learning, matrix operations form the core of neural network training, dimensionality reduction, and optimization algorithms.

Eigenvalues, eigenvectors, and matrix decompositions play a crucial role in data analysis and signal processing, allowing complex systems to be analyzed through simpler, orthogonal components. The computational efficiency of linear algebraic operations has therefore become a central concern in high-performance computing and large-scale data processing.

2.3 Probability Theory and Statistics

Probability theory and statistics provide the mathematical framework for modeling uncertainty and randomness in computational systems. These tools are indispensable in areas such as machine learning, artificial intelligence, and data science, where algorithms must operate on incomplete, noisy, or stochastic data.

Statistical inference enables the estimation of model parameters from observed data, while probabilistic models such as Bayesian networks and Markov processes allow complex dependencies to be represented and analyzed. Randomized algorithms, which incorporate probabilistic decision-making, often achieve improved efficiency or simplicity compared to deterministic approaches, highlighting the practical importance of probabilistic reasoning in computer science.

2.4 Logic, Set Theory, and Formal Methods

Mathematical logic and set theory form the conceptual foundation of computation and programming languages. Propositional and predicate logic are used to define formal semantics, specify program behavior, and verify correctness. Automata theory, which studies abstract machines and formal languages, relies heavily on logical and set-theoretic principles to model computation. Formal methods apply logical reasoning to the verification and validation of software and hardware systems. Techniques such as model checking and theorem proving ensure that systems adhere to specified properties, making them particularly valuable in safety-critical applications where errors can have severe consequences.

2.5 Numerical Analysis and Computational Mathematics

Numerical analysis addresses the problem of approximating solutions to mathematical models that cannot be solved analytically. Many real-world phenomena—such as fluid dynamics, climate systems, and biological processes—are described by continuous mathematical equations whose exact solutions are computationally infeasible. Through numerical methods, including iterative solvers and discretization techniques, these problems can be transformed into computationally tractable forms. The study of stability, convergence, and error propagation ensures that numerical solutions remain accurate and reliable, emphasizing the importance of mathematical analysis in computational simulations.

2.6 Optimization and Mathematical Modeling

Optimization theory provides essential tools for improving performance and efficiency in computational systems. Problems in resource allocation, scheduling, machine learning, and network design are often formulated as optimization tasks, where the objective is to minimize cost or maximize performance under given constraints.

Mathematical modeling enables complex real-world problems to be expressed in a formal, analyzable form. By combining optimization techniques with computational algorithms, researchers can derive solutions that are both theoretically sound and practically effective.

3. Applications of Mathematics in Computer Science

The integration of mathematics and computer science finds its most tangible expression in a wide range of practical and theoretical applications. Mathematical models not only guide the design of computational systems but also provide the analytical tools necessary for evaluating their performance, reliability, and limitations. This section examines key application domains where mathematical principles are essential to modern computing.

3.1 Artificial Intelligence and Machine Learning

Artificial intelligence (AI) and machine learning (ML) are among the most prominent areas demonstrating the synergy between mathematics and computer science. At the core of many learning algorithms lie mathematical concepts such as linear algebra, probability theory, optimization, and statistics. Neural networks, for example, rely on matrix operations, gradient-based optimization methods, and nonlinear functions to model complex patterns in data.

Statistical learning theory provides a rigorous framework for understanding generalization, overfitting, and model complexity. Optimization algorithms, including gradient descent and its variants, enable the efficient training of large-scale models. Without mathematical analysis, the interpretability, stability, and performance of AI systems would remain largely empirical and unreliable.

3.2 Cryptography and Information Security

Cryptography represents a direct application of abstract mathematics to practical computational problems. Modern cryptographic systems depend on number theory, algebraic structures, and computational complexity to ensure data confidentiality, integrity, and authenticity. Public-key cryptography, for instance, is based on mathematically hard problems such as integer factorization and discrete logarithms.

Mathematical proofs play a critical role in evaluating the security of cryptographic protocols, allowing researchers to formally reason about potential vulnerabilities. As digital communication continues to expand, the mathematical foundations of cryptography remain essential for maintaining trust and security in computational infrastructures.

3.3 Data Science and Big Data Analytics

Data science combines statistical modeling, mathematical analysis, and computational techniques to extract meaningful insights from large and complex datasets. Linear regression, clustering, dimensionality reduction, and probabilistic modeling all rely on mathematical foundations to ensure accurate and interpretable results. As datasets grow in size and complexity, mathematical methods enable efficient data representation and scalable computation. Techniques such as matrix factorization and statistical inference help manage high-dimensional data, making mathematics an indispensable component of modern data-driven decision-making systems.

3.4 Scientific Computing and Simulation

Scientific computing applies computational methods to solve mathematically formulated problems arising in science and engineering. Differential equations, numerical linear algebra, and optimization techniques are used to model physical, chemical, and biological systems. Through numerical simulations, researchers can study complex phenomena that are difficult or impossible to observe experimentally.

Mathematical analysis ensures the stability and accuracy of these simulations, while computer science provides the algorithms and hardware architectures required for large-scale computation. This collaboration has led to significant advancements in fields such as climate modeling, biomedical engineering, and materials science.

3.5 Computer Graphics, Vision, and Visualization

Computer graphics and computer vision heavily depend on geometric modeling, linear algebra, and optimization. Mathematical representations of shapes, transformations, and lighting enable the generation of realistic visual environments. In computer vision, mathematical models are used to interpret and analyze visual data, supporting applications such as object recognition and autonomous systems.

Visualization techniques further bridge mathematics and computation by transforming abstract data into interpretable visual forms. These methods enhance understanding and decision-making across scientific and industrial domains.

3.6 Algorithm Design and Computational Optimization

Algorithm design represents a direct manifestation of mathematical thinking in computer science. Mathematical analysis is used to prove correctness, evaluate efficiency, and optimize performance. Techniques from graph theory, combinatorics, and optimization enable the development of algorithms capable of solving large-scale and complex problems efficiently.

Optimization-based algorithms are widely applied in logistics, network routing, scheduling, and machine learning. By combining theoretical analysis with computational implementation, mathematics ensures that algorithms are both effective and reliable.

4. Emerging Trends and Future Directions

The continuous evolution of computational technologies has further intensified the integration of mathematics and computer science. Emerging research areas increasingly rely on advanced mathematical theories to address new computational challenges. This section highlights key trends that are shaping the future of this interdisciplinary field.

4.1 Quantum Computing

Quantum computing represents a paradigm shift in computation, relying heavily on mathematical concepts such as linear algebra, complex vector spaces, probability amplitudes, and group theory. Quantum algorithms exploit quantum mechanical properties to achieve computational advantages over classical algorithms for certain problem classes.

The development of quantum error correction, complexity analysis of quantum algorithms, and formal models of quantum computation demonstrates the growing importance of mathematical rigor in this emerging field. As quantum hardware matures, the role of mathematical abstraction in algorithm design and verification will become increasingly critical.

4.2 Explainable and Trustworthy Artificial Intelligence

As artificial intelligence systems become more pervasive, the demand for transparency, interpretability, and reliability has increased. Explainable Artificial Intelligence (XAI) seeks to provide mathematically grounded explanations for model decisions, enabling users to understand and trust complex computational systems.

Mathematical tools such as optimization theory, information theory, and statistical analysis play a vital role in developing interpretable models. Formal verification methods are also being explored to ensure that

AI systems behave consistently and ethically, particularly in high-stakes domains such as healthcare and finance.

4.3 Computational Mathematics and Automated Reasoning

Advances in computational mathematics and automated reasoning have expanded the capabilities of computer-assisted mathematical discovery. Symbolic computation systems and automated theorem provers use logical inference and algebraic methods to verify proofs and explore new mathematical structures.

These developments not only enhance mathematical research but also improve software verification and algorithm correctness. The increasing automation of reasoning processes illustrates the deepening interaction between mathematical logic and computational techniques.

4.4 Interdisciplinary Modeling and Complex Systems

Modern scientific problems often involve complex systems that span multiple domains, including physics, biology, economics, and social sciences. Mathematical modeling combined with computational simulation enables researchers to analyze such systems at scale.

Techniques from nonlinear dynamics, graph theory, and stochastic modeling are increasingly used to capture interactions within complex systems. The integration of mathematics and computer science in interdisciplinary research is expected to play a central role in addressing global challenges such as climate change, public health, and sustainable development.

5. Emerging Trends and Future Directions

The rapid advancement of computational technologies has led to increasingly complex systems that challenge traditional theoretical and practical frameworks. As a result, the integration of mathematics and computer science is evolving beyond foundational applications toward more sophisticated and abstract research paradigms. Emerging trends in this interdisciplinary domain emphasize not only computational power but also mathematical interpretability, reliability, and theoretical guarantees.

5.1 Quantum and Post-Classical Computation

Quantum computing represents a fundamental departure from classical computational models, requiring entirely new mathematical formulations. Concepts from linear algebra, Hilbert spaces, complex probability amplitudes, and group theory form the basis of quantum algorithms and quantum information theory. Unlike classical computation, quantum computation introduces superposition and entanglement, which necessitate rigorous mathematical frameworks to ensure correctness and stability.

In parallel, post-classical cryptographic systems, including lattice-based and code-based cryptography, are gaining prominence as responses to quantum threats. These systems rely on advanced algebraic and geometric structures, highlighting the continued relevance of deep mathematical research in securing future computational infrastructures.

5.2 Theoretical Foundations of Artificial Intelligence

As artificial intelligence systems increase in complexity and autonomy, understanding their theoretical behavior has become a major research priority. Mathematical frameworks such as statistical learning theory, information theory, and optimization provide insights into generalization, convergence, and robustness of learning algorithms.

Future research is expected to focus on bridging the gap between empirical performance and theoretical guarantees. Topics such as explainability, fairness, and robustness require mathematically grounded definitions and proofs. The integration of formal methods with machine learning models is emerging as a promising direction for ensuring reliable and trustworthy AI systems.

5.3 Automated Reasoning and Formal Verification

Automated reasoning and formal verification are becoming increasingly important as software and hardware systems grow in scale and complexity. Mathematical logic, type theory, and category theory are being incorporated into programming language design and verification tools to provide stronger correctness guarantees.

Future developments in this area aim to reduce the gap between theoretical verification methods and practical software engineering. By automating proof generation and verification, these approaches seek to make mathematically rigorous correctness checks feasible for real-world systems, particularly in safety-critical and mission-critical applications.

5.4 Computational Modeling of Complex and Adaptive Systems

The study of complex and adaptive systems represents another significant direction for future research. Such systems are characterized by nonlinear interactions, emergent behavior, and uncertainty, requiring advanced mathematical modeling techniques combined with large-scale computation.

Graph theory, dynamical systems, and stochastic processes are increasingly used to model networks in biology, social sciences, and economics. Computational simulations based on these models enable researchers to explore system dynamics that are analytically intractable, reinforcing the importance of mathematical abstraction in computational experimentation.

5.5 Education, Interdisciplinarity, and Research Integration

The future of mathematics and computer science integration is also shaped by educational and institutional developments. Interdisciplinary curricula that emphasize both mathematical rigor and computational implementation are essential for training researchers capable of addressing complex scientific challenges.

Collaborative research environments that bridge theoretical mathematics, computer science, and applied domains are expected to accelerate innovation. As computational problems become increasingly abstract and large-scale, the demand for professionals fluent in both mathematical theory and computational practice will continue to grow.

6. Conclusion

The integration of mathematics and computer science has become an indispensable driver of contemporary scientific and technological progress. Far from being separate disciplines, these fields form a unified intellectual framework in which mathematical abstraction provides theoretical rigor, while computational methods enable practical realization and large-scale experimentation. This synergy has transformed the way complex problems are formulated, analyzed, and solved across a wide range of domains.

Throughout this study, the mathematical foundations underlying computer science—such as discrete mathematics, linear algebra, probability theory, logic, numerical analysis, and optimization—have been examined alongside their applications in artificial intelligence, cryptography, data science, scientific computing, and emerging computational paradigms. These examples demonstrate that mathematical reasoning is not merely supportive but essential for ensuring correctness, efficiency, interpretability, and scalability in modern computational systems.

Looking forward, emerging trends such as quantum computing, explainable and trustworthy artificial intelligence, automated reasoning, and the computational modeling of complex systems further reinforce the need for deeper mathematical integration. As computational systems grow increasingly autonomous and influential, mathematically grounded approaches will play a critical role in guaranteeing reliability, transparency, and ethical responsibility.

In conclusion, the continued integration of mathematics and computer science is vital for addressing the theoretical and practical challenges of the digital age. Strengthening this relationship through interdisciplinary research and education will not only advance fundamental knowledge but also enable the development of robust, intelligent, and socially responsible computational technologies.

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NEUROBIOLOGY

THE ASSOCIATION BETWEEN VITAMIN B DEFICIENCY AND COGNITIVE IMPAIRMENT AMONG ELDERLY PATIENTS WITH ALZHEIMER'S AND VASCULAR DEMENTIA

Valkova M.
MD, PhD
University Hospital "Sofiamed", Sofia, Bulgaria
DOI: 10.5281/zenodo.18677797

Abstract

Vitamin B 12 deficiency (VitB12def.) is frequent among elderly patients. The aim of our study was to examine the effect of Vit.B12def. on cognitive decline among patients with cognitive impairment due to Alzheimer's disease (AD), small vessels disease (SVD) and mixed (vascular and Alzheimer's) dementia (MD).

Material and methods: We examined 49 patients with Vit.B12def. (on average age of 77.76±6.41 years, 18 males and 31 females, 17 with AD, 13 with SVD and 19 with MD) and 97 patients with normal Vit.B12 levels (on average age of 76.07±7.97, 28 males and 66 females, 21 with AD, 43 with SVD and 33 with MD) twice (with interval of 2 years) via Mini Mental State Examination (MMSE), Isaac's Set Test (IST), Literal fluency Test (LFT), Clock Drawing Test (CDT), 10 Words, Digit Symbol Substitution test (DSST 90sec), Digit Span Test (DST forward and backward) and 21 Hamilton Depression Scale. All results were interpreted at 95% confidential level.

Results: Regression analysis showed not linear but square root associations between Vit.B12 level and recognition. CDT, DST forward and DSST, exponential correlations between Vit.B12 and recognition at the second examination and reciprocal correlation with IST at the second examination.

Conclusions: Vit.B12def. is with high prevalence among elderly with AD, SVD and MD. It might lead to additional domain specific cognitive decline (executive functioning, hippocampal memory and visual-special abilities). The association between the levels of Vit.B12 and cognitive performances is non-linear, mostly square root. Patients with such dementias should be examined for Vit.B12def. and should be adequately treated.

Keywords: cognitive impairment, Vitamin B 12 deficiency, Alzheimer's disease, small vessel disease, mixed dementia.

Introduction:

Vitamin B 12 deficiency (VitB12 def.) is frequent among elderly and it is associated with reversible cognitive impairments and dementia (5). Recent studies suggest direct association between VitB12def. and increased risk for developing Alzheimer's disease (7,8), although others question such causality (4). VitB12def. leads to increase of serum homocysteine, which also might cause some cognitive impairments (7). It is also associated with small vessel disease (9).

Vitamin B12 is powerful antioxidant, that cleans super-oxide from mitochondria and cytoplasm and is protective agent from oxidative stress, induced by different factors including methionine, homocysteine and inflammation (7,10). It is of essential importance for cellular energetic processes, myelination and synthesis of brain neurotransmitters (3,7). It also plays important role in the synthesis of fats and nucleic acids and participates in synaptogenesis and nerve cell metabolism (7). Vit.B12def. leads to increased deposition of beta amyloid at the specific brain areas in mice models (7). Animal models also show that Vitamin B12 decreases amyloid proteotoxicity (6) and inhibits alpha-beta fibrillation and deposition of amyloid into amyloid plaques (2).

The aim of our study was to examine the effect of Vit.B12def. on cognitive decline among patients with cognitive impairment due to Alzheimer's disease (AD), small vessels disease (SVD) and mixed (vascular and Alzheimer's) dementia (MD).

Material and methods: Patients with Vit.B12def. showed poor results on recognition, CDT, DST forward and DSST.

We examined 49 patients with Vit.B12def. (on average age of 77.76±6.41 years, 18 males and 31 females, 17 with AD, 13 with SVD and 19 with MD) and 97 patients with normal Vit.B12 levels (on average age of 76.07±7.97, 28 males and 66 females, 21 with AD, 43 with SVD and 33 with MD). The inclusion criteria of the study were 1. Age ≥ 60 years; 2. Confirmed by neuropsychologist cognitive impairment at ≥2 cognitive domains; 3. Confirmed on the basis of history, neurological and somatic examination, laboratory data and imaging study diagnosis of AD or SVD or MD; 4. All patients with Vit.B12def. were treated with Vitamin B12 orally or with muscular injections; 5. No additional causes for anemia of any kind; 6. Lack of other neurological diseases such as trauma, brain tumors, neuroinfections, demyelinating diseases or epilepsy; 7. Lack of decompensation of coexisted somatic diseases during the study; 8. Lack of psychiatric diseases, except of mild depression or anxiety; 9. Lack of treatment or usage of benzodiazepines, modafinile acetate, hallucinogens and other psychoactive drugs, except for low dosages of Quetiapine (≤50mg/d), Pregabaline (≤150mg/d), Gabaneural (≤600mg/d), Hydroxyzine (≤25mg/d) or antidepressants; 10. Lack of alcohol abuse or usage of forbidden substances; 11. Signed informed consent.

After clinical interview and confirmation of the diagnosis, the patients were examined via the following neuropsychological battery: Mini Mental State Examination (MMSE), Isaac's Set Test (IST for verbal fluency), Literal fluency Test (LFT; variant M-O-H-A in Bulgarian, 1 minute for every letter), Clock Drawing

Test (CDT), 10 Words Test (for working memory, delayed recall and recognition (10/20words), Bulgarian variant), Digit Symbol Substitution test (DSST 90sec), Digit Span Test (DST forward and backward) and 21 Hamilton Depression Scale (HDS). All patients with HDS above 12 points were excluded.

The same neuropsychological battery was used 2 years after the first examination.

The statistical analysis was done via parametric and non-parametric tests as ANOVA, MANOVA, Man-Whitney and Kruskal-Wallis test statistics and simple regression analysis via SPSS 20.0 and Statgraphics 20.0. All results were interpreted at 95% confidential level (p 0.05).

Results:

1. Demographics and laboratory data

We presented the demographic data of our patients at table 1. 34% of our patients had Vit.B12def. Patients with and without Vit.B12def. were at similar age and had similar formal education and the groups could be compared. However, we found that Vit.B12 deficiency was more frequent at men than women.

2. The association between Vit.B12def. and cognitive functioning.

We failed to find statistical significant difference on MMSE, short term memory, delayed recall, IST, LFT and DST backward between patients with and without Vit.B12def. ($p>0.05$). Patients with Vit.B12def. showed poor results on recognition, CDT, DST forward and DSST, although we failed to find additional decline on these scales during the period of the study (see table 2).

The data from the regression analysis was summarized at table 3. We failed to find any association between Vit.B12 levels and MMSE, LFT, 10WT (except for recognition) and DST backward ($p>0.05$). Regression analysis showed not linear but square root associations between Vit.B12 level and recognition. CDT, DST forward and DSST, exponential correlations between Vit.B12 and recognition at the second examination and reciprocal correlation with IST at the second examination (see table 3).

Discussion:

Vit.B12def is relatively frequent among our patients. More than 1/3 of them had such deficiency. According to Allen et al. (2009) the prevalence of Vit.B12def. among elderly is more than 20%, but in some countries it is up to 40%, more often among people with marginal status. Patients with Vit.B12def. show poorer performance on scales, that measure attention, hippocampal memory (recognition) and visual-spatial abilities. It is suggested that Vit.B12def. is associated with executive dysfunctions and memory decline, although authors obtain different domain specific cognitive changes (11,12). Such changes remain constant and don't improve with therapy, which suggested constant fronto-temporo-subcortical dysfunction, associated with Vit.B12deficiency, as also suggested other authors (9,11,12). Other cognitive impairments improve over time with the application of specific therapy (5). Because of the high prevalence of Vit.B12def. and it potential role for additional cognitive decline, we suggest that every elderly patient with AD, SVD or MD should be additionally examined for Vit.B12def. and should be adequately treated.

The regression analysis shows non liner model of correlation between the level of Vit.B12 and cognitive impairments (speed of informational processing, recognition, visual-spatial abilities and attention). However, during the period of the study we haven't found any additional decline on examined scales. We should note that all patients with Vit.B12def. were treated with oral or muscular Vit.B12. The correlation coefficients obtained were low. Although these facts, we might say that Vit.B12 deficiency is associated with constant fronto-subcortical changes and hippocampal dysfunction. It may not play role for individual global cognitive functioning but can change his quality of life and decision making and might play important role for the velocity of cognitive decline in elderly. However, according to our data treatment with Vit.B12 in these cases might prevent from additional cognitive decline, associated with Vit.B12def.

Limitations of the study: We examined a relatively small sample of patients for a relatively short period of time. Moreover, all our patients with Vit.B12def. were adequately treated so we don't have untreated control subjects because of ethical and medical purposes.

Conclusions: Vit.B12def. is with high prevalence among elderly with AD, SVD and MD. It might lead to additional domain specific cognitive decline (executive functioning, hippocampal memory and visual-special abilities). The association between the levels of Vit.B12 and cognitive performances is non-linear, mostly square root. Patients with such dementias should be examined for Vit.B12def. and should be adequately treated.

Table 1.

Demographic and laboratory data

	AD	SVD	MD	Total	Age (years)	M:F	Education B:M:H	Vit.B12(pmol/l)
Patients with normal levels of Vitamin B12	21	43	33	97	76.07±7.97	28:66	9:53:32	277.55±61.97 (Med 234.5)
Patients with Vit.B12def.	17	13	19	49	77.76±6.41	18:31	3:29:17	109.02±47.07 (Med. 101.0)
P=					>0.05	0.0038	>0.05	0.0001
Total	38	56	52	146	76.71±7.47	48:98	12:83:51	202.65±50.06
Legend: AD – Alzheimer's disease, SVD – small vessels disease; MD – mixed dementia; M:F- male:female ratio; Education B:M:H – patients with basic, with middle and with high formal education								

Table 2.

Associations between Vit.B12def. and cognitive performances.

	Averages or medians of patients without Vit.B12def. vs with Vit.B12def.	p=
Recognition 1 (w.)	17.00±2.26 vs 15.94±3.24	0.0251
Recognition 2 (w.)	15.87±3.10 vs 14.58±3.87	0.0331
Decline of recognition (w.)	NA	>0.05
CDT 1 (errors)	0.0 vs 1.0	0.0203*
CDT 2 (errors)	1.0 vs 2.0	0.0144
Increase of the total number of errors on CDT	NA	>0.05
DST forward 1 (p.)	NA	>0.05
DST forward 2 (p.)	5.73±1.58 vs 5.11±1.57	0.0314
Decline of DST forwards (p.)	NA	>0.05
DSST 1 (p.)	30.05±12.76 vs 24.55±13.93	0.0256
DSST 2 (p.)	25.5 vs 17.0	0.0369*
Decline of DSST (p.)	NA	>0.05
Legend: CDT – Clock drawing Test; DST – Digit Span Test; DSST – Digit Symbol Substitution Test		

Table 3.

Regression analysis on the influence of serum Vit.B12 level on cognitive functioning.

The impact of absolute level of Vit.B12 (pmol/l; x) on y:	rr; model	p=
IST1 (p.)	NA	p>0.05
IST2 (p.)	0.17; reciprocal	p=0.0465
Decline of IST (p.)	NA	p>0.05
Recognition 1 (w.)	-0.19; square root	p=0.0223
Recognition 2 (w.)	-0.19; exponential	p=0.0272
Decline of recognition (w.)	NA	p>0.05
CDT 1 (errors)	0.20; square root	p=0.0185
CDT 2 (errors)	NA	p>0.05
Increasing of errors on CDT.	NA	p>0.05
DST forward 1 (p.)	NA	p>0.05
DST forward 2 (p.)	-0.18; square root	p=0.0308
Decline of DST forward (p.).	NA	p>0.05
DSST 1 (p.)	-0.22; square root	p=0.0109
DSST 2 (p.)	-0.21; square root	p=0.0158
Decline of DSST (p.).	NA	p>0.05
Legend: IST – Isaac's Set Test, CDT – Clock Drawing Test, DST – Digit Span Test; DSST – Digit Symbol Substitution Test. rr – correlation coefficient		

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NORMAL AND PATHOLOGICAL PHYSIOLOGY

ГЕМОДИНАМИЧЕСКОЙ ПЕРЕСТРОЙКЕ СОСУДОВ РЕПРОУКТИВНЫХ ОРГАНОВ У ЖЕНЩИН ПРИ НЕКОТОРЫХ ПАТОЛОГИЧЕСКИХ ПРОЦЕССАХ

Асанбекова С.Х.,
Соискатель кафедры анатомии человека имени Я.А. Рахимова ГОУ «ТГМУ имени Абуали ибни Сино»
Кодирова Ф.А.,
соискатель кафедры анатомии человека имени Я. А. Рахимова Таджикского государственного медицинского университета имени Абуали ибни Сино,
Курбонов С.
Док. мед. наук, профессор кафедры анатомии человека имени Я.А. Рахимова ГОУ «ТГМУ имени Абуали ибни Сино»

HEMODYNAMIC RESTRUCTURING OF THE VESSELS OF REPRODUCTIVE ORGANS IN WOMEN WITH CERTAIN PATHOLOGICAL PROCESSES

Asanbekova S.,
The applicant of the Department of Human anatomy named after. Y.A. Rakhimov SEI Avicenna Tajik State Medical University
Qodirova F.,
applicant of the department of Human anatomy named by Ya.A. Rakhimov Avicenna Tajik State Medical University
Kurbonov S.
Doctor of medical sciences, professor of the Department of Human anatomy named after. Y.A. Rakhimov SEI Avicenna Tajik State Medical University
DOI: 10.5281/zenodo.18677814

Аннотация

Сосудистая система и тканевая структура маточной трубы и эндометрия характеризиются высокой пластичностью – способностью перестраивается к разнообразным приспособительным перестройкам стенки сосудов, а тканевые структуры при меняющихся условиях гемодинамики подвергаются гиперплазии с последующей редукцией в соответствии с меняющимися условиями функционирования органов при трубной беременности и гиперпластические процессы эндометрия

Abstract

The vascular system and tissue structure of the fallopian tube and endometrium are characterized by high plasticity - the ability to rebuild itself to various adaptive restructuring processes of the vascular wall, and structure of the tissues under the changing of hemodynamic conditions undergo hyperplasia with subsequent reduction in accordance with the changing conditions of organ which functions during tubal pregnancy and hyperplastic processes of the endometrium.

Ключевые слова: маточная труба, эндометрия, перестройка сосуды, внематочная беременность, гиперпластические процессы.

Keywords: fallopian tube, endometrium, vascular restructuring, ectopic pregnancy, hyperplastic processes.

The aim of the study. The purpose of this study was to study the hemodynamic restructuring of the vessels of the reproductive organs in women during certain pathological processes.

Materials and methods of research. A morphological study was performed on 27 women who underwent surgery for tubal pregnancy (TP) using the laparoscopic method. Prospective uterine examination (diagnostic curettage) of 33 reproductive-age patients with hyperplastic pathological processes without malignancies. Sections were stained using standard histological methods. Statistical analysis was performed using the Statistica 6.0 application package, with averaged data calculated using the "M ± m" calculation.

Research results and their discussion. The main components of the female reproductive organ are the uterus, fallopian tubes, ovaries and their appendages. With age-related and pathological changes playing a significant role is played by compensatory and structural changes of walls and nutrient vessels of the organ. It should be noted that to date, pathomorphological changes in the structure of the walls of the fallopian tube vessels in patients with TP remain poorly studied [1-2].

In connection with the development of new directions in the accurate diagnosis of diseases of the internal genital organs of women of reproductive age, there is a need for a detailed study of the compensatory mechanisms of the vessels of the fallopian tubes and uterus in TP and hyperplastic processes in women of reproductive age and the development of effective diagnostic methods.

The results of these studies may not only provide an opportunity to understand the inadequacy of the study of the morphogenesis of this disease, but also resolve the issue of diagnosis and justification of the rational scope of surgical intervention in patients with this pathology.

The blood supply to the uterus and fallopian tubes is provided primarily by the uterine arteries and, to some extent, by the ovarian artery. These arteries run perpendicular to the organ axis along the lateral margins of the uterus and longitudinally along the oviduct, and are located beneath the serosa. Morphometric analysis shows that tubal pregnancies are characterized by the presence of a dilated fallopian tube. The length of the fallopian tubes varied from 7 to 11 cm, averaging 9.0 ± 0.3 cm. At the same time, an increase in the thickness of the fallopian tube was observed, with a diameter ranging from 2.0 to 4.3 cm. A study of pathological changes in the fallopian tube wall during tubal pregnancies after laparoscopic surgery revealed that the organ undergoes changes in all layers of the fallopian tube. In the wall of the organ, structural morphological changes and vascular reorganizations mainly depend on the location of the invasion of the fertilized egg; this process is often localized in the myosalpinx and rarely in the subserous layer of the oviduct wall, creating the possibility of perforation of the organ wall in the invasion zone or promoting the development of adhesions with adjacent organs [3].

The morphological picture of the ectopic pregnancy revealed the presence of elements of the fertilized egg and trophoblastic tissue in the dilated fallopian tube, hemodynamic shifts, hemorrhage, edema of the connective tissue membrane, and, frequently, chorionic villi growing into the folds of the mucosa and muscular membranes. Histological examination of serial sections of the fallopian tube in the area of fertilized egg implantation revealed a decrease in the number of chorionic villi, characterized by hyalinosis of the endosalpinx, myosalpinx, serous layer (perisalpinx), and mesosalpinx, resembling chronic nonspecific productive salpingitis. It was established that progressive changes occur in the area of fertilized egg implantation during tubal pregnancy. The serous layer of the oviduct, involved in the pathological process, underwent significant pathomorphological and compensatory vascular changes.

Tissue edema was accompanied by breakdown of the mesothelium layer and hemodynamic disturbances within the organ system, characterized by dilation and engorgement of blood vessels, particularly the venous components of the microcirculatory system. Destructive pathological changes in the tissue and cellular structures of the organ's serous layer (mesothelium, limiting membrane, superficial and deep cribriform layers of collagen and elastic fibers) were also detected. These changes led to thickening of the serous membrane due to swelling and edema of the connective tissue layer. Compared to the control group, collagen fibers increased in number. In large areas of the serous membrane of the fallopian tube, the mesothelium was thickened and shed, and the mesothelial cells became swollen, edematous, and deformed. The walls of some microvascular vessels were thickened due to collagen proliferation, clearly indicating the transformation of a chronic, productive, infiltrative inflammatory process. The most compensatory changes were noted in the capillaries located beneath the mesothelium, including edema, endothelial cell damage, microthrombosis, and changes in arteriole-arteriolar and arteriole-venular anastomoses. The venular-arteriolar index in this oviductal membrane with TP was 1.29 versus 1.14 in the comparison group, and the arteriole-venular index was 0.6 versus 0.75 in the comparison group, a 15.5% decrease.

In our study, we sought not only to present information on the normal characteristics of vascular-tissue relationships in the uterus but also to identify specific criteria for certain hyperplastic pathological processes. Given the highly diverse pathomorphology of the uterus, we decided to trace the patterns of microcirculatory bed transformations in some of the most frequently encountered clinical processes: endometritis, endometrial polyps, and endometrial hyperplasia. Endometritis is a prominent representative of a group of acute inflammatory diseases and, for many years, was mistakenly considered a clinically insignificant pathology in cases of asymptomatic inflammation. Studying hemodynamics in the uterine wall in various forms of hyperplastic processes will contribute to the development and improvement of methods for the differential diagnosis of endometrial hyperplastic processes in reproductive age [4-5].

It is known that hyperplastic processes in the endometrium of the uterus are characterized by hyper vascularization of its wall, the cause of which is considered to be venous or arterial plethora [6-7].

The studied material showed that during the inflammatory diseases of the uterus, hyperplastic processes and restructuring of all components of the microcirculatory bed of the organ occur. All intraorgan vessels undergo adaptive and pathological changes. Adaptive transformations of terminal vessels occur in a morphofunctional sequence, characterized by the mobilization of reserves, multiplication of blood flow pathways, and hemodynamics. An increase in the capacity of the microcirculatory bed is observed due to the filling of all exchange vessels and the growth of the capillary network, the appearance of tortuosity, and an increase in vascular parameters. Arterioles with a diameter of 18.4 ± 1.3 μm and precapillaries in places are dilated to 15.1 ± 0.9 μm, and capillaries – 11.3 ± 1.1 μm, postcapillaries – 24.6 ± 1.4 μm, venules and arteriolovenular anastomoses are dilated, the venular-arteriolar index increases from 1.23 to 1.45, and the athero-venular coefficient from 0.53 to 0.65. The network of blood capillaries of the mucous membrane is represented by capillaries of folds and capillaries surrounding the glands. Under the influence of the inflammatory process in the intraorgan system of the mucous membrane, a violation of the permeability of capillaries and vessels occurs. The venous capillary network is highly developed and many times exceeds the arterial bed. The walls of dilated arterioles and venules, compared to control vessels, have fewer rows of smooth muscle cells, which are spaced more widely. Functional disturbances in the microvascular bed trigger the development of pathohistological changes in the uterine mucosa and determine their transformation [6]. Mucosal folds are enlarged, glands are dilated, and very deep folds can be seen in cross-sections. The number of glands in the mucosa is significantly greater than in the control group, and the glands rarely have the appearance of deep tubular sacs.

Hyperplastic processes are observed in the stroma of the uterine mucosa, with increased lymphohistiocytic infiltration around capillaries, glands, and in the connective tissue of the uterine base. During removal of endometrial polyps, histological examination revealed the presence of glandular and glandular-fibrous polyps, most commonly.

Along with the aforementioned adaptive mechanisms, we have identified destructive changes in individual components of the microcirculatory bed, particularly in the venous section, indicating functional failure of the vascular organ system. This may be due to the disease's duration—more than 5 years.

Conclusion. The vascular system and tissue structure of the fallopian tube and endometrium are characterized by high plasticity - the ability to rebuild itself to various adaptive restructuring processes of the vascular wall, and structure of the tissues under the changing of hemodynamic conditions undergo hyperplasia with subsequent reduction in accordance with the changing conditions of organ which functions during tubal pregnancy and hyperplastic processes of the endometrium.Consequently, the functional significance of microvessels determines their structure, which obviously should be taken into account when conducting various diagnostic and therapeutic procedures.

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MULTIMODAL PREOPERATIVE DIAGNOSIS AND THE EVOLUTION OF SURGICAL TREATMENT OPTIONS IN PECTUS EXCVATUM

Sîrbu I.,
PMSI Institute of Mother and Child „Natalia Gheorghiu" National Scientific and Practical Center for Pediatric Surgery
„Nicolae Testemițanu" State University of Medicine and Pharmacy
Șavga N.N.,
„Nicolae Testemițanu" State University of Medicine and Pharmacy
Babuci S.
PMSI Institute of Mother and Child „Natalia Gheorghiu " National Scientific and Practical Center for Pediatric Surgery
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Abstract

Pectus excavatum (PE) is the most common congenital thoracic deformity, often leading to functional and psychological impairments. Accurate preoperative diagnosis is essential for selecting the optimal surgical strategy, with multimodal imaging playing a crucial role. This review explores the evolution of diagnostic methods, including radiography, computed tomography, magnetic resonance imaging, and echocardiography, highlighting their importance in assessing thoracic indices, asymmetry, and cardiopulmonary impact. Additionally, the article traces the history of PE surgical treatment, from early invasive techniques to modern minimally invasive approaches such as the Nuss procedure and hybrid techniques. The advantages, limitations, and complications associated with each surgical method are discussed, emphasizing the need for individualized treatment plans. While significant progress has been made in refining diagnostic and surgical techniques, further research is required to optimize patient outcomes and reduce postoperative complications.

Keywords: Pectus excavatum, Historical review, Thoracic surgery.

Pectus excavatum (PE) is one of the most common types of thoracic deformities, with an incidence of 1:400 births, with a prevailing male gender (4:1), which can influence the development of serious consequences, including scoliosis, heart displacement, the reduction of lung volume, etc. [1].

Preoperative imaging in patients with pectus excavatum is the key diagnostic option, and it is also irreplaceable in guiding the treatment [2]. Chest radiography allows visualization and assessment of the degree of chest wall deformation, leftward shift of the cardiac silhouette, hidden right cardiac border, narrowing of the mediastinum, and inclined anterior ribs. Plain chest radiography can determine different thoracic indices, such as the Welch index, the vertebral index, the xiphoid manubrium corporal index, the Haller index, the correction index, but is not an appropriate option in assessing thoracic asymmetry or sternal torsion [3].

In patients with PE, computed tomography allows the determination of several thoracic indices, which help to assess the severity of the chest wall deformity and to determine the surgical strategy and the selection of the type and size of implants to be used. It should be considered that three-dimensional reconstructions are essential for these decisions, and chest CT scans should be performed at the end of expiration to measure the most severe thoracic indices under conditions similar to those observed by the surgeon in the operating room - the patient being relaxed during expiration [4].

The thoracic index is a formula used to identify or quantify a thoracic deformity or to assess the severity of the defect, the sternal characteristics, the deformity and the impact of PE on the cardiopulmonary function of the patients and to define further treatment strategies. There is no definition, classification or consensus in the literature where the thoracic index is the gold standard.

The pectus index (PI) is the greatest lateral distance of the chest wall relative to the smallest anteroposterior distance between the most depressed point of the chest wall and the vertebral body. Haller J.A. et al. (1987) indicated that a pectus index > 3.25 was present in all patients undergoing surgery, while in patients with mild pectus excavatum who did not undergo surgery, in children and adolescents included in the control group, this index was <3.25 in all cases. Thus, the authors concluded that the pectus index can be a useful adjacent tool in the objective evaluation of children and adolescents presenting for possible surgical treatment for the pectus excavatum deformity [5]. The significance of the Haller index indicates the ratio between the width of the rib cage and the deepest point of the sternal depression, being the most frequently used index in assessing the severity of PE. In healthy individuals, the Haller index varies between 2.0 and 3.0. However, according to data from recent literature, an index of 3.25 as a cut-off point for surgical intervention is no longer a good discriminator and has no conclusive relationship with the aesthetic problems observed. Meanwhile, the Haller index has other limitations and includes variations in the shape of the chest/age/gender/breathing, lack of assessment of asymmetry and cardiac compression [6, 7, 8].

It has been noticed that minimally invasive repair of pectus excavatum is associated with a high complication rate, which exponentially increases with age and a high Haller index, the principle being exposed in the classification proposed by Clavien-Dindo, where several degrees of this index are described [9].

Degree	Haller Index (cm)
1	3,0 – 3,9
II	4,0 – 4,9
III	5,0 – 5,9
IV	$\geq$6,0

The second thoracic index that should be included in CT reports is *the correction index*, considered to be a more appropriate criterion in recommending surgical correction, suggested in 2011. In the authors' opinion, this index is very simple to measure, it is easy to reproduce, and represents a very accurate measure that clearly differentiates patients with pectus excavatum from those without the disease. Only at a correction index equal to 10%, the defect should become sufficiently visible to establish the diagnosis. The authors recommend turning to surgical correction of PE for patients with a CI ≥ 28%, this value correlating with the long-accepted standard (HI ≥ 3.25) [10, 11].

The asymmetry index (AI) = 1- (the greatest antero-posterior distance of the left chest wall)/ (the greatest antero-posterior distance of the right chest wall), or the ratio of the depth of the left and right chest during inspiration and expiration. In healthy individuals, this index ranges from -0.05 to +0.05. The chest wall is considered "asymmetrical" if the asymmetry index is <–0.05 (the left side of the chest is more convex) or >0.05 (the right side of the chest is more convex) [12].

The flatness index (FI) was originally suggested by Kim H.C. et al. (2008) for the purpose of assessing depression. In that respect, the eccentricity index (EI), the circularity index (CI) and the rotation index (RI) were developed to assess asymmetry. The ratio of the length between the major axis and the minor axis of an ellipse can represent the degree of flatness of the ellipse. Using this characteristic, the authors proposed the evaluation of a *flatness index*. To calculate this index, the index calculation algorithm finds an ellipse, using the nonlinear least squares fitting method from the extracted inner boundary coordinates of the chest wall. Subsequently, the length of the major axis (Lm) and the length of the minor axis (Ln) of the ellipse are calculated (Fig. 1): FI = 1 - Ln/Lm [13]. The authors also suggested calculating the following indices:

- *The eccentricity index* (EI) = L_f/L_m;
- *The circularity index* (CI) = L_r/L_m;

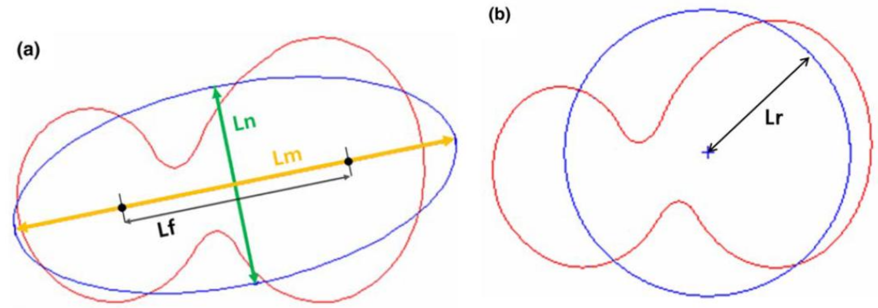

Fig. 1. a) Elements for calculating EI, FI and RI: red line of the chest wall, ellipse marked with blue line extracted with the curve fitting method, Lm - length of the major axis of the ellipse, Ln - length of the minor axis of the ellipse, Lf - distance between two focal points of the ellipse; b) Elements for calculating CI: red line indicates the chest wall, blue line indicates the circle extracted by the curve fitting method, length Lr - radius of the circle (according to Kim H.C. et al., 2008).

The sternal torsion angle (STA) is the angle between the sternum and a horizontal line.

A positive value indicates counter-clockwise rotation of the sternum, and a negative value indicates clockwise rotation. *The Louis angle (AoL)* is the angle between the manubrium and the body of the sternum in the sagittal plane [14].

Computed tomography is the gold standard in the evaluation of the chest in children with PE, but exposure to ionizing radiation remains a concern because children are more sensitive to ionizing radiation. Both inspiratory and expiratory CT have been shown to have a large impact on the assessment of chest motion, with end-expiratory PE assessment leading to an additional number of surgical candidates compared to end-inspiratory assessment alone [15]. Computed tomography is useful in the diagnosis of PE, providing a qualitative assessment of the severity of the chest wall deformity [16]. Considering that standard CT and MRI examinations require breath-holding maneuvers, little is known about chest wall motion in patients with PE under free breathing conditions. So far, static axial cross-sections of the chest at the deepest point of the funnel have been used to determine the degree of pathology. However, the phase of the respiratory cycle used to calculate the indices is not standardized, although there is evidence that HI and CI change during breathing. A variation in the degree of breathing is likely, especially in children and adolescents, even if a specific phase of breathing is preselected [17]. MRI imaging offers the option to detect and measure chest deformities without radiation, while ultra-fast MRI allows morphometric measurements at different stages of the respiratory cycle [18].

The spirometry results in patients with PE are typically 10% to 20% lower than the population average, and these values are statistically and clinically significant. In addition to altered respiratory biomechanics and some changes in pulmonary function, this chest wall malformation may exert direct compression on the underlying right heart chambers, leading to various morphological and functional cardiac changes, documented in some studies using echocardiography and cardiac MRI [19].

Common and stress Doppler echocardiography (stress echo) are used in order to demonstrate external cardiac compression (especially of the right ventricle) and its dynamics during rest and stress (exercise), manifested by a reduction in tricuspid annulus diameter and tricuspid/mitral annulus width ratio, a fixed tricuspid valve area at rest and stress, and an increased tricuspid diastolic gradient. It is also important to explore the presence of signs of diastolic dysfunction not only of the right ventricle but also of the left, also assessing the presence of paradoxical septal motion. Therefore, stress echocardiography is necessary to be performed in order to exclude ischemic heart disease or, to a much lesser extent, for other indications, such as valvular heart disease, the exclusion of stress-induced regional wall motion abnormalities [4, 20].

All patients with significant pectus excavatum should undergo an echocardiogram, especially those who are being considered for surgery. Pathological electrocardiographic findings are frequently observed in patients with PE. Observational studies have found several abnormal ECG deviations in patients with PE, such as: P wave abnormalities, right QRS axis deviation, right bundle branch block, T wave inversion, ST segment elevation. It is assumed that these ECG changes are secondary to anatomical distortion, rotation and compression of the heart due to rib cage deformity, mitral valve prolapse or aortic root dilatation, which may require long-term monitoring. However, little is still known about postoperative ECG changes and the association between ECG changes and exercise testing. [21, 22].

The history of the surgical correction of PE starts at the beginning of the 20th century with the works of Meyer L. (1911) and Sauerbruch E.F. (1927). Over the next four decades, some methods were reported by Brown A.L. (1939), Lester C.W. (1946) and others. During this timespan, the suggested surgical therapies were based on the resection of the deformed costal cartilages and sternum, while cutting mediastinal and diaphragmatic adnexa, and/or external traction [23].

More than 80 different surgery types and their modifications for the correction of PE have been described in the literature, of which two types of surgeries are the most widespread: the one first described by Ravitch M.M. (1949), who proposed costochondral osteotomy and the minimally invasive surgery suggested by Nuss D. (1998), which consisted of a temporary implantation of a metal bar aimed to modify the curvature of the anterior chest wall [24, 25].

In 1949, Ravitch M.M., based on the detailed review of Ochsner and DeBakey (1939), the patient series presented by Lincoln Brown (1940) and the publications of Sweet R.H. (1944) and Lester C.W. (1946) operated on 8 children with PE aged 2 to 10 years. In 7 cases there were no complications, the author achieved excellent results, and one child died due to a fulminant infection. Based on the analysis performed, the author concluded that pectus excavatum is a progressive congenital deformity of the sternum and costal cartilages, which can be satisfactorily corrected by surgery. The younger the patient, the greater the probability of resulting in a completely normal thoracic contour. Surgery is indicated for the removal of a cosmetic defect that represents a social handicap, for the correction of a skeletal deformity, and for the improvement of cardiac or pulmonary symptoms. Early surgery is important as a prevention of the progression of symptoms and signs. The deformed portions of all involved costal cartilages on both sides are resected. The xiphosternal joint and substernal ligament are divided and the body of the sternum isolated except for its attachment to the manubrium. A transverse osteotomy at the superior margin of the defect allows the sternum to be raised to the corrected position, which is maintained by silk sutures woven into the bone. No external traction is used and no type of cast or other support is required. [26].

In 1965, Ravitch M.M. reaffirmed his basic principles of the operation - subperichondrial excision of all the deformed cartilages, complete release of the sternum by division of the xiphoid and intercostal fascicles, transverse sternal osteotomy, and the absence of external fixation. The author is suggesting a modifying element, which consists in oblique division of the lowermost normal cartilage, which allows osteotomy of the sternum with a space higher than before, and this osteotomy is now always performed on the posterior surface of the sternum. Occasionally, internal fixation or support is used, especially in adolescents or adults with long sternal structures [27].

The subsequent half-century of thoracic surgery was dominated by the technique suggested by Ravitch, which became the gold standard for surgical treatment of pectus excavatum worldwide for that period [28], although several modifications were proposed [29, 30, 31], including modifications designed to maintain the corrected position of the sternum by using a metal support [32, 33]. However, performing the procedure in infants and preschool children resulted in postoperative damage to the growth centers, leading to the development of acquired asphyxiating chondrodystrophy. Therefore, pediatricians were the first to recognize the problem and the number of referrals for pectus excavatum repair decreased significantly during this period [34, 35].

In severe and recurrent types of PE, Robicsek F. (1978) suggested a correction method, which consisted of sternal mobilization, transverse osteotomy, parasternal resection of the costal cartilages (a modified Ravitch procedure), followed by the placement of Marlex prosthetic material behind the sternum and suturing this mesh to the peripheral stumps of the resected ribs, the use of the mesh being intended to support the floating sternum [36]. The modification proposed by Dailey J.F. (1952) consisted of stabilizing the corrected position of the sternum by using an autologous scythe graft [37]. These methods of pectus excavatum repair have been advocated for some time by several authors with relatively satisfactory early results, even though there was a risk for the appearance of the chest wall to alter over time. [38].

In 1970, Wada J, et al. published a study in which they presented the results of 271 surgeries performed on patients with PE using the "sterno-turnover" procedure, which consists of separating the sternum from the mediastinal tissue by blunt dissection, the ribs or costal cartilages and intercostal muscles are transected bilaterally at the level of the costal arches along the edge of the deformity, with the deformed sternum being then elevated, with both internal mammary arteries ligated and sectioned. After the sternum is sectioned and removed en bloc, thoracoplasty is resorted to by the method of inverting the sternum with its fixation with steel wire and each costal cartilage or rib is sutured with silk to the adjacent cartilage. Since the surgical results obtained in cases using the sterno-turnover procedure were not satisfactory, the authors also resorted to costoplasty, which provided that the ribs were straightened through multiple partial incisions or wedge resections and then reattached anteriorly to the sternum to form a new and elevated costal arch [39]. The so-called turnover operation for pectus excavatum was disappointing due to postoperative complications, such as fistula formation with necrosis of the bones and muscles. For this reason, Taguchi T.K. et al. (1975) developed a new sternal turnover operation with preservation of the bilateral internal mammary vessels, the surgical intervention being useful for patients over 15 years of age [40].

Some modifications have been suggested in severe cases of PE associated with Marfan syndrome, Javangula K.C. et al. (2006) proposed the use of a “sternal lodge” with 2 wide strips of Gortex patch as an alternative to a metal bar [41], and in cases of PE and annuloaortic ectasia, Kawamura T. et al. (2011) reported an open approach by partial sternotomy and sterno-costochondroplasty to divide and refix the right and left ribs, which was advantageous in partially immobilizing the sternum so that the right ribs could be opened to expose the deviated mediastinum [42].

Buchwald J. et al. (2020) suggested a modification of the Ravitch procedure, the difference being that the ends of the resected cartilages are blade-shaped to allow them to be inserted into previously prepared wedge-shaped depressions, which are located on both edges of the sternum. The correction technique proposed by the authors does not require the use of additional sternal support, and the good long-term results make the procedure suitable and acceptable in the treatment of anterior chest wall deformity in children and adolescents [43].

Over the recent decades, the Nuss procedure has gained wide acceptance in the surgical correction of patients diagnosed with PE [44]. According to Nuss D., Kelly R.E. (2010), the minimally invasive repair proposed by Nuss D. can be successfully performed in patients aged between 1 and over 50 years, the ideal age being before puberty because at this age the thorax is still malleable, the support bar is adjusted in length during puberty, and the recovery time is short, with a low incidence of relapses. Excellent results and a short recovery time have been recorded in patients under 8 years of age, but because the support bar is removed before puberty, which is a period of growth spurt, there is a potential for relapse. However, in cases where significant cardiac and/or pulmonary compression is noted, early repair is warranted, but the bar should be left in situ for 3 years. The family should also be informed that the patient may require a second bar placement either at the time of removal of the first bar or if a longer bar is required [45].

Specific inclusion criteria, originally established for the Nuss procedure and relevant to patient selection, include two or more of the following: 1) A computed tomography (Haller) index greater than 3.25 or correction index of 10% or greater in association with cardiac or pulmonary compression; 2) Pulmonary function test results clearly showing restrictive and/or obstructive insufficiency; 3) Cardiologic evaluation showing cardiac compression, displacement, mitral valve prolapse, murmur, or conduction abnormalities; 4) Documenting the progression of the deformity with advancing age in association with the development or worsening of physiological symptoms (i.e., shortness of breath, lack of endurance, exercise intolerance, palpitations, and chest pain); 5) Psycho-social effects. The optimal age range for pectus excavatum repair appears to be between 10 and 14 years, when the chest wall is still malleable [46, 47].

The procedure developed by D. Nass et al. (1998), who first published the results of the treatment of patients operated on with pectus excavatum over a period of 10 years, consists of using an original surgical technique based on the “extension” of the costal cartilages due to their elasticity against the background of dysplasia using a metal plate inserted retrosternal. In the opinion of the authors, the minimally invasive technical procedure proposed by them has some obvious advantages, such as: 1) the lack of anterior incision of the chest wall, does not require extensive dissection and detachment of the musculo-fascial component of the anterior chest wall and the lack of resection of the costal cartilages or sternal osteotomy; 2) short operating time, minimal blood loss and early return to full activity; 3) long-term normal thoracic resistance, expansion, flexibility and elasticity; and 4) excellent long-term cosmetic result [48]. With excellent cosmetic results, this minimally invasive procedure has quickly become the standard of care for the treatment of children and adolescents with PE [47]. Although minimally invasive correction has been successfully performed in patients from 1 to over 50 years of age, according to D. Nuss, the ideal age for this intervention is just before puberty, because at that age the chest is malleable, the support bar is fixed during the pubertal growth spurt, the recovery time is short, and the incidence of relapse is low. Patients younger than 8 years of age, including those aged 3-6 years, have an excellent result and a short recovery time, but because the support bar is removed before the pubertal growth spurt, there is a potential for relapse. However, if a younger patient has significant cardiac and/or pulmonary compression, early repair is warranted, but the bar should be left in situ for 3 years, and the family should be informed that the patient may require a second bar placement when a longer bar is needed [45, 48]. Park H.J. et al. (2012) found that routine early repair of pectus excavatum in patients older than 3 years is safe and effective.

Currenty, several significant changes have been made to the technical procedure that Nuss originally patented, which led to the creation of “hybrid” methods, which can not only compete with the original method, but in some respects even surpass it [50, 51, 52, 53]. The original procedure proposed by Donald Nuss was performed without the aid of thoracoscopy, later this technique was modified to be performed with the help of a thoracoscope as part of measures to improve the safety of the intervention [54, 55], this modification having the potential to reduce the risk of cardiac complications without increasing the rate of minor complications [56]. In 2014, Dawn E. Jaroszewski modified the Nuss procedure, describing an original technique for forced mechanical elevation of the sternum (sternal retraction) with expansion of the retrosternal space and facilitating blunt dissection of the anterior mediastinum in severe cases of pectus excavatum and safe passage of the metal bar, using a special "crane" device and a metal suture tied to the sternum without the need for endoscopic guidance [57]. Subsequently, the advantage of using the sternal retraction technique was confirmed by several authors [58, 59]. Rygl M. et al. (2014) used a technical innovation using a semiflexible thoracoscope and hook-lift of the sternum, reducing the risk of cardiac injury [60], and Haecker F.M. et al. (2019) used a vacuum bell to lift the sternum [61].

In the standard Nuss procedure for pectus excavatum, the costal arch is often lifted together with the sternum, resulting in unevenness of the lower chest. Postoperative protrusion of the costal arch can be prevented by the original change suggested by Nagasao T. et al. (2023), which involves separating the seventh costal cartilage from the sternum. Wu L. et al. (2024), in order to ensure sufficient sternal elevation, suggested horizontal separation of the sternum after rotating the metal bar, which also contributes to reducing postoperative pain [62, 63].

Even though the Nuss procedure is considered minimally invasive, some technical problems have been noticed, the most important of which is the challenge of mediastinal manipulation in a severely sunken sternum, and the precordial elevation may cause some intraoperative adverse events, such as rib fracture. The overall incidence of minor and major complications after this procedure ranges between 2-20%, the real incidence of life-threatening complications and mortality being unknown, since the total number of procedures performed worldwide is unknown [64]. Some fatal complications have been described during the Nuss procedure, after the procedure itself, and during removal of the metal bar after certain amounts of time, such as pneumothorax, hemothorax, pleural effusions, cardiac perforation, etc [55, 64]. Metal allergy is found in 2.7% and 3.1% of patients, manifesting as rash, erythema, granuloma, postoperative wound problems, or pleural effusion [65]. The surgical technique, patient age, severity and asymmetry of the pectus, previous chest surgery, and surgeon experience play a decisive role in the overall incidence of such complications [66]. In 2017, Masai K. et al. developed a combined Ravitch and Nuss technique for the treatment of severe PE, which involves three steps: 1) the severely depressed portion of the costal cartilage is transected; 2) the sternum is stabilized with pectus bars, and 3) the anterior chest wall is then reconstructed. Mercedes incisions are cut in the deepest part of the thorax. After mobilization of the pectoralis and rectus muscles, the deformed costal cartilages are exposed. Then, bilaterally, the ribs from the third or fourth to the seventh costal cartilage junction were disconnected from the adjacent sternum. The bilateral internal mammary arteries were preserved. According to the original Ravitch procedure, transverse sternal osteotomy at the level of the third rib can be used if necessary. With the dissection of the costal cartilage of the bilateral ribs, the buried sternum developed increased mobility (part of the Ravitch procedure). After mobilization of the sternum, the Nuss procedure was performed. Under the control of a thoracoscope, the inserter was safely positioned under the sternum. Subsequently, a titanium pectus bar was passed through the mediastinum under the reconstructed sternum and then rotated 180 degrees to stabilize the anterior chest wall. Because the cut ends of the costal cartilages protruded approximately 1–2 cm due to the elevation of the anterior chest wall, it was necessary to resect the edge of the costal cartilages to level the anterior wall of the rib cage, after which the edge of the costal cartilage and the sternum were sutured using surgical metal wires or sutures [67]. Some combined techniques have been suggested for the repair of asymmetrical cases of pectus excavatum, such as the procedure proposed by Kuyama H. et al. (2021), which involves chondrotomy of the depressed and deformed costal cartilage to elevate the depressed part, combined with the Nuss procedure or the technique presented by Okuyama H. et al. (2021), which provides for thoracoscopic excision of the costal cartilage combined with the Nuss procedure [68, 69].

Therefore, even with protocols with promising preliminary results, in order to improve the successe rates of the surgical correction of patients with pectus excavatum, the need for additional studies with the evaluation of long-term results is imposed [70]. Several meta-analyses have been reported in the specialty literature, which aimed to comparatively evaluate the effectiveness of the Ravitch and Nuss surgical procedures in the repair of pectus excavatum [71, 72, 73]. The comparative analysis presented by the authors could not definitively suggest a preference for any of the surgical method of pectus excavatum repair [74]. The Nuss procedure was associated with a shorter operative time and diminished blood loss compared with the Ravitch procedure, while the postoperative length of hospital stay was similar. No difference was observed between the procedures in terms of overall complication rates, while the rates of reoperation due to rod migration or persistent deformity, postoperative pneumothorax, and hemothorax were higher in the Nuss group than in the Ravitch group [75].

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THE ROLE OF ARTERIAL HYPERTENSION ON COGNITIVE DECLINE OF ELDERLY PATIENTS WITH ALZHEIMER'S AND VASCULAR COGNITIVE IMPAIRMENT

Valkova M.
MD, PhD
University Hospital "Sofiamed", Sofia, Bulgaria
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Abstract

Arterial hypertension (AH) and cognitive impairments frequently coexist among elderly. The aim of our study was to examine the association between AH and cognitive decline among elderly patients with Alzheimer's disease (AD), Vascular cognitive impairment (VCI) and mixed (AD and VCI) cognitive impairment (MD).

Material and methods: We examined 100 patients with AH (on average age of 76.72±7.59 years, 28 males and 72 females, 24 with AD, 38 with VCI and 38 with MD) and 46 patients without AH (on average age of 76.67±7.28 years, 20 males and 26 females, 14 with AD, 18 with VCI and 14 with MD) twice (with interval of 2 years) with the following neuropsychological battery: Mini Mental State Examination (MMSE), Isaac's Set Test (IST for verbal fluency), Literal fluency Test (LFT; variant M-O-H-A in Bulgarian, 1 minute for every letter), Clock Drawing Test (CDT), 10 Words Test (for working memory, delayed recall and recognition (10/20words), Bulgarian variant), Digit Symbol Substitution test (DSST 90sec), Digit Span Test (DST forward and backward) and 21 Hamilton Depression Scale (HDS).

Results: AH itself was not associated with additional cognitive decline. Its role is modified by other factors such as duration of AH, the age of onset of AH, its control and coexistence of more than 4 other vascular risk factors.

Conclusions: The existence of AH itself has no negative effects on cognitive functions. However, its impact on cognition is modified by other important factors such as longer duration and poor control of AH and coexistence of other vascular risk factors.

Keywords: arterial hypertension, Alzheimer's, vascular cognitive impairment, mixed dementia.

The association between arterial hypertension (AH) and cognitive impairment among elderly is complex and disputable (1,4,7). The role of AH on cognitive decline is possibly modified by other important additional factors such as socio-economic factors, gender, race and ethnicity, existence of other comorbidities (diabetes mellitus type 2, obesity, kidney failure, heart failure, etc.) and the age of onset and control of AH (1,3, 4,5,6,7). The exact mechanism of influence of AH on cognitive function is unknown. It is suggested that it causes maladaptation of brain vascular system on abnormal arterial pressure and vascular remodeling (4,7). The high pressure at the distal part of the brain microcirculation promotes oxidative stress in endothelium cells and increased production of oxygen radicals in mitochondria. AH causes increasing of blood – brain barrier permeability leading to subsequent endothelial impairment, changes of extracellular matrix, damages of pericytes and activation of metal proteases (4,7). The ageing additionally exacerbates AH by inducing microvascular and blood-brain barrier damage (7). The blood-brain barrier damage causes neuroinflammation, synapses loss and neurodegeneration. Moreover, AH is associated with accumulation of beta amyloid and increasing of tau phosphorylation (7).

The aim of our study was to examine the association between AH and cognitive decline among elderly patients with Alzheimer's disease (AD), Vascular cognitive impairment (VCI) and mixed (AD and VCI) cognitive impairment (MD).

Material and methods: We examined 100 patients with AH (on average age of 76.72±7.59 years, 28 males and 72 females, 24 with AD, 38 with VCI and 38 with MD) and 46 patients without AH (on average age of 76.67±7.28 years, 20 males and 26 females, 14 with AD, 18 with VCI and 14 with MD). The inclusion criteria of our study were 1. Age>60 years; 2. Diagnosis of cognitive impairment at the onset of the study confirmed by neuropsychological examination and confirmed diagnosis of AD, VCI or MD on the basis of clinical examination, imaging and laboratory data; 3. Lack of other neurological diseases such as trauma, brain tumors, neuroinfections, demyelinating diseases or epilepsy; 4. Lack of decompensation of coexisted somatic diseases during the study; 5. Lack of psychiatric diseases, except of mild depression or anxiety; 6. Lack of treatment or usage of benzodiazepines, modafinile acetate, hallucinogens and other psychoactive drugs, except for low dosages of Quetiapine (≤50mg/d), Pregabaline (≤150mg/d), Gabaneural (≤600mg/d), Hydroxyzine (≤25mg/d) or antidepressants; 7. Lack of alcohol abuse or usage of forbidden substances; 8. For patients with AH, its duration should be minimum 5 years; 9. Signed informed consent.

After clinical interview and confirmation of diagnosis, the patients were examined via Mini Mental State Examination (MMSE), Isaac's Set Test (IST for verbal fluency), Literal fluency Test (LFT; variant M-O-H-A in Bulgarian, 1 minute for every letter), Clock Drawing Test (CDT), 10 Words Test (for working memory, delayed recall and recognition (10/20words), Bulgarian variant), Digit Symbol Substitution test (DSST 90sec), Digit Span Test (DST forward and backward) and 21 Hamilton Depression Scale (HDS). All patients with HDS above 12 points were excluded.

The patients were examined with the same neuropsychological battery 2 years after the first examination.

The statistical analysis was done via parametric and non-parametric tests as ANOVA, MANOVA, Man-Whitney and Kruskal-Wallis test statistics and simple regression analysis via SPSS 20.0 and Statgraphics 20.0. All results were interpreted at 95% confidential level (p 0.05).

Results:

1. Demographic and clinical data

The demographic data is presented at table 1. Most of our patients were elderly women with additional vascular risk factors (Diabetes mellitus or Insulin resistance, Dyslipidemia, Atrial Fibrillation, Heart failure, Chronic Ischemic Heart Disease, Carotid Atherosclerosis, Kidney Failure or Chronic Obstructory Pulmonary Disease). Among them prevailed the group of patients with VCI, followed by MD and AD. Patients with and without AH had similar demographics and similar additional comorbidities so they could be statistically compared.

The additional data, concerning the characteristics of arterial hypertension is presented at table 2. Most of AH patients had good or moderate control of their blood pressure, although about one fourth of them had poor control. About 1/3 of AH patients had 0 or 1 additional vascular risk factor, 1/3 had 2 to 4 and 1/3 had more than 4 of them.

2. Association between AH and cognitive decline

AH was not associated with additional cognitive decline among all examined patients (p>0.05). Patients with AD and AH had significantly better results on overall cognitive performance, measured by MMSE and slightly better performance on LFT than patients with AD without AH, although there were no differences at other scales (see table 3). Patients with VCI and AH had slightly better results on MMSE than those without AH, but there were no statistical significant differences at other scales. There were no associations between the existence of AH and cognitive functioning on examined scales among patients with MD.

3. The impact of other factors on cognitive performances of patients with AH

3.1 Duration of AH

There was statistically significant association between the duration of AH and cognitive decline – see table 4. Patients with longer AH duration had lower test results on all cognitive scales and moreover they showed severer cognitive decline for 2-year period of the study.

3.2. Early and middle age of onset and late age of onset of AH

Patients with middle and early onset of AH showed lower results on all cognitive scales vs patients with late onset AH (see table 5). Patients with early and middle onset AH showed more severe decline on MMSE, short term verbal memory, recognition (hippocampal memory) and DSST vs those with late onset disease.

3.3. The role of AH control. Patients with good AH control had significantly better results on cognitive scales. They showed mild or no decline during the time of the study (see table 6).

Patients with moderate control showed worse results on MMSE, IST, LFT, short term memory, delayed recall and DSST compared with those with good control. Those differences were relatively small. There were no differences on cognitive performances between patients with good and moderate control on recognition, CDT and DST.

Patients with poor control had worst results on almost all cognitive scales and they also showed severest decline during the time of the study.

3.4. The role of additional vascular risk factors.

Patients with 0-1 and 2-4 risk factors had similar performances (see table 7). However, those with >4 additional vascular risk factors had poor results on all tests. They also had severest decline on almost all examined scales except for delayed recall and CDT.

Discussion:

AH and dementia frequently coexist in elderly. 68% of our sample had AH, which was most frequent among patients with MD. We failed to find statistically significant differences on cognitive performances of our general sample according to the existence of AH. However, patients with AH showed slightly better MMSE and LFT test performances than those without in AD group, although we failed to find any additional positive effect of AH on cognitive performances on other scales or improvement of any cognitive domain during the period of the study. Patients with VCI and AH also showed better MMSE results vs those without AH, although we also failed to find any additional improvement during the study or associations between AH and examined cognitive functions. So according to our data we might say that the existence of AH hasn't negative effect on cognitive functions of elderly and might eventually has some mild positive effects among patients with AD and VCI. Some other authors also suggest that late onset AH could have some positive effects on cognition in elderly with already developed cognitive impairments and dementia (2,5,10).

The duration of AH is associated with poor cognitive performances at all examined scales and increased cognitive decline among our patients. And although this factor is modified by ageing, it prevails the effect of ageing itself. Zhu et al. (2025) obtained that AH is associated with "more rapid declines in global cognition, orientation, and attention and calculation abilities over time". The duration is also modified by another important factor – the age of onset of AH. We found that patients with AH onset at early and middle life showed significantly lower results and increased decline on all cognitive domains than those with late onset AH. Some authors suggest that middle life hypertension is strongly associated with cognitive impairments and rapid cognitive decline at elderly, but late onset AH shows less impact and even may have some positive effects on cognition (2,5,10). However, according to Zhu and al. (2025) late onset hypertension also leads to accelerated cognitive decline, although not immediately after the onset of AH.

One of the most important modifying factors for the association between AH and cognitive impairment is its control (2,8,10). Patients with good control show significantly better results on all cognitive scales than those with moderate or poor control, having mild (verbal fluency, short term memory and attention) or no additional decline (at overall cognitive performance, recognition and CDT) over the time of the study. Those with moderate control show slightly poor cognitive performances and more rapid cognitive decline than those with good control. The group of patients with poor control show the worst results and the rapidest decline of almost all cognitive domains. According to us the control of AH is one of the key risk factors for sparing the cognition of elderly with dementia. It can modify the influence of factors such as ageing, age of onset and duration of AH.

The effect of AH on cognition is modified also by the coexistence of other vascular risk factors, that also lead to microvascular brain changes and additional loss of the vascular ability to adapt to high blood pressure (2,5,10). With increasing the number of additional vascular risk factors, we also obtain statistically significant additional cognitive decline at almost all examined cognitive domains, including short term and hippocampal memory and executive functions (working memory, processing speed and attention). Patients with coincidence of middle life onset AH, poor AH control and vascular risk factors >4 had worst results and rapidest decline even for the short period of follow up (2 years).

Conclusions: AH and cognitive impairments frequently coexist in elderly. The existence of AH itself has no negative effects on cognitive functions. However, its impact on cognition is modified by other important factors such as longer duration and poor control of AH and coexistence of other vascular risk factors.

Limitations of the study: The study was conducted among relatively small sample of patients, followed up for relatively short period of time (2 years).

Informed consent: Each respondent who agreed to participate in the survey signed two copies of an informed consent form; one copy was retained at the Neurology Clinic, where it was saved. For participants who were otherwise vulnerable, informed consent was obtained from a legal guardian.

Table 1.

Demographics and additional vascular risk factors.

	Patients without AH	Patients with AH
N=	46	100
Age (y)	76.67±7.28	76.72±7.59
Sex (Male:Female)	20:26	28:72
Formal education (Basic:Middle:High)	2:30:14	10:53:37
Patients with AD	14	24
Patients with VCI	18	38
Patients with MCI	14	38
Additional vascular risk factors*		
0-1	12	32
2-3	20	32
>4	14	37
Legend: AD – Alzheimer's disease, VCI – vascular cognitive impairment, MCI – mixed cognitive impairment' * Additional vascular risk factors – Diabetes mellitus or insulin resistance (confirmed by endocrinologist), Dyslipidemia, Atrial Fibrillation; Heart failure; Chronic Ischemic Heart Disease (confirmed by cardiologist); Carotid atherosclerosis (confirmed by Doppler examination); Kidney failure (confirmed by nephrologist or laboratory data); Chronic Obstructory Pulmonary Disease (confirmed by pulmologist)		

Table 2.

Characteristics of AH

Total number of patients with AH	100
Number of patients with AH development at middle or early ages (<55 y)	47
Number of patients with AH development at late age (>55 y)	54
Duration of AH (y.)	21.90±6.27
Patients with Good control of AH	39
Patients with Moderate control of AH	38
Patients with Poor control of AH	24
Legend: AH – arterial hypertension; Good control – arterial pressure below 140/80mmHg (<130/80 in diabetics), lack of hypertension crises or severe hypotension episodes. Moderate control – arterial pressure at most of the time below 140/80, existence of below 4 crises of hypertension >160/80mmHg or hypotension monthly. Poor control – not fulfill the criteria for good or satisfactory control of blood pressure	

Table 3.

Association between AH and Cognitive functions.

	Overall	AD	VCI	MCI
Patients without AH (1)	46	14	18	14
Patients with AH (2)	100	24	38	38
The association between AH and:				
MMSE 1 (p.)	p>0.05	p=0.0128 Median (1) 20 Median (2) 25	p>0.05	p>0.05
MMSE 2 (p.)	p>0.05	p=0.0133 Median (1) 17.5 Median (2) 23.0	p=0.0428 Median (1) 24 Median (2) 26	p>0.05
Decrease of MMSE (p.)	p>0.05	p>0.05	p>0.05	p>0.05
IST 1 (p.)	p>0.05	p>0.05	p>0.05	p>0.05
IST 2 (p.)	p>0.05	p>0.05	p>0.05	p>0.05
Decrease of IST (p.	p>0.05	p>0.05	p>0.05	p>0.05
LFT 1 (p.)	p>0.05	p=0.0102 Median (1) 12.5 Median (2) 20	p>0.05	p>0.05
LFT 2 (p.)	p>0.05	p>0.05	p>0.05	p>0.05
Decrease of LFT (p.)	p>0.05	p>0.05	p>0.05	p>0.05
Legend: MMSE – Mini Mental State Examination, IST – Isaac's Set Test, LFT – Literal Fluency Test 1- at the onset of the study, 2 – at the 2rd year after the onset AD – Alzheimer's disease VCI – vascular cognitive impairment MCI – Mixed cognitive impairment				

Table 4.

Association between the duration of arterial hypertension and cognitive impairment.

The association between the duration of AH and	Rr	p=
MMSE1 (p.)	-0.71	0.0001
MMSE2 (p.)	-0.79	0.0001
Decline of MMSE (p)	**-0.39**	**0.0001**
IST1 (p)	-0.51	0.0001
IST2 (p)	-0.59	0.0001
IST decline (p)	**-0.23**	**0.0200**
LFT 1 (p.)	-0.47	0.0001
LFT 2 (p.)	-0.54	0.0001
Decline of LFT (p.)	**-0.24**	**0.0253**
10WT – STM 1 (w.)	-0.53	0.0001
10 WT – STM 2 (w.)	-0.64	0.0001
Decline of 10WT-STM (w.)	**-0.37**	**0.0002**
10 WT – DR 1 (w.)	-0.42	0.0001
10 WT – DR 2 (w.)	-0.48	0.0001
Decline of 10WT-DR (w.)	**-0.42**	**0.0001**
Recognition 1	-0.42	0.0001
Recognition 2	-0.52	0.0001
Decline of recognition	**-0.30**	**0.0025**
CDT 1 (errors)	0.42	0.0001
CDT 2 (errors)	0.55	0.0001
Increasing of errors on CDT	**0.21**	**0.0424**
DST forward 1 (p.)	-0.45	0.0001
DST forward 2 (p.)	-0.56	0.0001
Decline of DST forward	**-0.27**	**0.0098**
DST backward 1 (p.)	-0.41	0.0001
DST backward 2 (p.)	-0.61	0.0001
Decline of DST backward	**-0.26**	**0.0110**
DSST 1 (p.)	-0.58	0.0001
DSST 2 (p.)	-0.70	0.0001
Decline of DSST	**-0.47**	**0.0001**

Legend: rr – coefficient of correlation; MMSE – Mini Mental State Examination; IST Isaac's Set Test; LFT – literal fluency test; 10 WT – STM – the average result of 5 trials for immediate response on 10 words test; 10 WT – DR – the 5 min delayed recall on 10WT; CDT – Clock Drawing Test; DST – Digit Span Test; DSST – Digit Symbol substitution test; AH – arterial hypertension

Table 5.

The association between early/middle onset and late onset AH on cognitive performance.

	Early and middle AH onset (average)	Late onset AH (average)	p=
MMSE1 (p.)	21.38	26.87	0.0001
MMSE2 (p.)	18.85	26.48	0.0001
Decline of MMSE (p)	**-2.49**	**-0.45**	**0.0005**
IST1 (p)	25.65	33.37	0.0001
IST2 (p)	23.17	32.46	0.0001
IST decline (p)	**NA**	**NA**	**>0.05**
LFT 1 (p.)	19.95	25.81	0.0025
LFT 2 (p.)	15.35	23.19	0.0003
Decline of LFT (p.)	**NA**	**NA**	**>0.05**
10WT – STM 1 (w.)	4.37	5.61	0.0001
10 WT – STM 2 (w.)	3.67	5.31	0.0001
Decline of 10WT-STM (w.)	**-0.68**	**-0.32**	**0.0172**
10 WT – DR 1 (w.)	2.16	3.91	0.0001
10 WT – DR 2 (w.)	1.28	3.43	0.0001
Decline of 10WT-DR (w.)	**NA**	**NA**	**p>0.05**
Recognition 1	16.04	17.40	0.0030
Recognition 2	13.96	16.85	0.0001
Decline of recognition	**-2.04**	**-0.62**	**0.0018**
CDT 1 (errors)	2.26	0.86	0.0007
CDT 2 (errors)	2.87	1.10	0.0001
Increasing of errors on CDT	**NA**	**NA**	**p>0.05**
DST forward 1 (p.)	5.70	6.33	0.0256
DST forward 2 (p.)	4.93	5.90	0.0030
Decline of DST forward	**NA**	**NA**	**p>0.05**
DST backward 1 (p.)	2.23	3.98	0.0158
DST backward 2 (p.)	2.288	3.51	0.0001
Decline of DST backward	**NA**	**NA**	**p>0.05**
DSST 1 (p.)	21.90	32.66	0.0001
DSST 2 (p.)	16.25	30.31	0.0001
Decline of DSST	**-4.95**	**-1.96**	**0.0048**

Legend: MMSE – Mini Mental State Examination; IST Isaac's Set Test; LFT – literal fluency test; 10 WT – STM – the average result of 5 trials for immediate response on 10 words test; 10 WT – DR – the 5 min delayed recall on 10WT; CDT – Clock Drawing Test; DST – Digit Span Test; DSST – Digit Symbol substitution test; AH – arterial hypertension

Table 6.

The role of AH control on cognitive performances.

	Good control of blood pressure (Median)	Moderate control of blood pressure (Median)	Poor control of blood pressure (Median)	P
MMSE1 (p.)	27	25	19	0.0001
MMSE2 (p.)	28	23	15	0.0001
Decline of MMSE (p)	**0**	**-1**	**-3.5**	**0.0001**
IST1 (p)	34	32	24	0.0002
IST2 (p)	34	29	19	0.0001
IST decline (p)	**-1**	**-2**	**-3**	**0.0226**
LFT 1 (p.)	24	25	17	0.0392
LFT 2 (p.)	21	20	12	0.0011
Decline of LFT (p.)	**-1**	**-2**	**-6**	**0.0287**
10WT – STM 1 (w.)	5.6	5	4.2	0.0003
10 WT – STM 2 (w.)	5.5	4	3	0.0001
Decline of 10WT-STM (w.)	**-0.2**	**-0.2**	**-0.6**	**0.0003**
10 WT – DR 1 (w.)	4	3	2	0.0034
10 WT – DR 2 (w.)	4	2	0	0.0001
Decline of 10WT-DR (w.)	**0**	**-1**	**0**	**0.0180**
Recognition 1	17	17	16	0.0297
Recognition 2	17	16	12	0.0001
Decline of recognition	**0**	**0**	**-2**	**0.0005**
CDT 1 (errors)	0	0	3	0.0021
CDT 2 (errors)	0	1	4	0.0001
Increasing of errors on CDT	**NA**	**NA**	**NA**	**p>0.05**
DST forward 1 (p.)	NA	NA	NA	p>0.05
DST forward 2 (p.)	6	6	4	0.0007
Decline of DST forward	**0**	**0**	**-1**	**0.0340**
DST backward 1 (p.)	4	4	3	0.0336
DST backward 2 (p.)	3	3	2	0.0001
Decline of DST backward	**0**	**0**	**-2**	**0.0084**
DSST 1 (p.)	31	31.5	17	0.0043
DSST 2 (p.)	31	25	10	0.0001
Decline of DSST	**-1.5**	**3**	**7**	**0.0009**
Legend: MMSE – Mini Mental State Examination; IST Isaac's Set Test; LFT – literal fluency test; 10 WT – STM – the average result of 5 trials for immediate response on 10 words test; 10 WT – DR – the 5 min delayed recall on 10WT; CDT – Clock Drawing Test; DST – Digit Span Test; DSST – Digit Symbol substitution test; AH – arterial hypertension				

Table 7.

The role of additional risk factors on cognition.

	Patients with 0 or1 additional risk factors (median)	Patients with 2-4 additional risk factors (median)	Patients with >4 additional risk factors (median)	P
MMSE1 (p.)	28	26	21	0.0001
MMSE2 (p.)	28	25	18	0.0001
Decline of MMSE (p)	**0**	**-0.5**	**3.0**	**0.0001**
IST1 (p)	36	32	24	0.0001
IST2 (p)	36	30	21	0.0001
IST decline (p)	**-1**	**-1**	**-3**	**0.0057**
LFT 1 (p.)	25	26	17	0.0024
LFT 2 (p.)	21	24	12	0.0001
Decline of LFT (p.)	**-1**	**-1**	**-6**	**0.0042**
10WT – STM 1 (w.)	5.6	5	4.1	0.0001
10 WT – STM 2 (w.)	5.6	4.8	3.0	0.0001
Decline of 10WT-STM (w.)	**-0.2**	**-0.2**	**-0.8**	**0.0001**
10 WT – DR 1 (w.)	5	3	2	0.0001
10 WT – DR 2 (w.)	4	2	0	0.0001
Decline of 10WT-DR (w.)	**NA**	**NA**	**NA**	**p>0.05**
Recognition 1	18	17	16	0.0079
Recognition 2	17	17	14	0.0001
Decline of recognition	**0**	**0**	**-2**	**0.0002**
CDT 1 (errors)	0	0	1	0.0092
CDT 2 (errors)	0	1	4	0.0001
Increasing of errors on CDT	**NA**	**NA**	**NA**	**p>0.05**
DST forward 1 (p.)	6	6	5	0.0094
DST forward 2 (p.)	6	6	4	0.0001
Decline of DST forward	**0**	**0**	**-1**	**0.0002**
DST backward 1 (p.)	4	4	3	0.0096
DST backward 2 (p.)	3.5	3	2	0.0001
Decline of DST backward	**0**	**0**	**-1**	**0.0054**
DSST 1 (p.)	38	31	18	0.0001
DSST 2 (p.)	36	25	10	0.0001
Decline of DSST	**-1**	**-2.5**	**-6.5**	**0.0001**
Legend: MMSE – Mini Mental State Examination; IST Isaac's Set Test; LFT – literal fluency test; 10 WT – STM – the average result of 5 trials for immediate response on 10 words test; 10 WT – DR – the 5 min delayed recall on 10WT; CDT – Clock Drawing Test; DST – Digit Span Test; DSST – Digit Symbol substitution test; AH – arterial hypertension				

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PARASITOLOGICAL SCIENCES

LEYŞMANİOZ TÖRƏDİCİLƏRİNİN *İN VİTRO* KULTURASINA TƏRKİBİNDƏ EMBRİONAL DANA ZƏRDABI (FBS) OLMAYAN QİDALI MÜHİTLƏRİN TƏSİRİNİN ÖYRƏNİLMİSİ

Əliyeva Ş.N.
V.Y. Axundov adına Elmi-Tədqiqat Tibbi Profilaktika İnstitutu
Bakı, Azərbaycan
biologiya üzrə fəlsəfə doktoru
https://orcid.org/0009-0006-6971-4679
Hüseynova F.H.
V.Y. Axundov adına Elmi-Tədqiqat Tibbi Profilaktika İnstitutu
tibb üzrə fəlsəfə doktoru
https://orcid.org/0009-0009-6805-2302
Eyvazlı S.N.
V.Y. Axundov adına Elmi-Tədqiqat Tibbi Profilaktika İnstitutu
https://orcid.org/0009-0005-5045-3176
Məsimova İ.A.
V.Y. Axundov adına Elmi-Tədqiqat Tibbi Profilaktika İnstitutu
https://orcid.org/0009-0004-5507-3650
Abbaslı A.S.
V.Y. Axundov adına Elmi-Tədqiqat Tibbi Profilaktika İnstitutu
https://orcid.org/0009-0004-9617-3199

STUDY OF THE EFFECT OF SERUM (FBS)-FREE MEDIA ON THE CULTIVATION OF *LEISHMANIA* PROMASTIGOTES *IN VITRO*

Aliyeva Sh.
The V.Akhundov Scientific Research Medical Preventive Institute
Baku, Azerbaijan
PhD in biological sciences
https://orcid.org/0009-0006-6971-4679
Huseynova F.
The V.Akhundov Scientific Research Medical Preventive Institute
PhD in medical sciences
https://orcid.org/0009-0009-6805-2302
Eyvazli S.
The V.Akhundov Scientific Research Medical Preventive Institute
https://orcid.org/0009-0005-5045-3176
Masimova I.
The V.Akhundov Scientific Research Medical Preventive Institute
https://orcid.org/0009-0004-5507-3650
Abbasli A.
The V.Akhundov Scientific Research Medical Preventive Institute
https://orcid.org/0009-0004-9617-3199
DOI: 10.5281/zenodo.18677865

Xülasə

Leyşmanioz qlobal, ağır, transmissiv, parazitar xəstəlikdir. Xəstəlik dünyanın 98 ölkəsində geniş yayılmışdır və hər il təqribən 0,7-1 milyon insanın xəstələnməsinə və 26,000-65,000 insanın ölümünə səbəb olur. *Leishmania* cinsinin qamçılı protozoaları leyşmaniozun törədicisi hesab olunur. Bu xəstəliklə effektiv mübarizə aparmaq, dərmanlar və peyvənd hazırlamaq üçün törədicilərin *in vitro* uzunmüddətli kulturasını əldə etmək lazımdır. Peyvəndin yaradılması üçün əsas tələb böyük həcmdə promastiqot istehsalıdır. Hazırda buna imkan verə biləcək optimal qidalı mühitin yaradılması mühüm problemdir. *Leishmania* parazitləri üçün istifadə edilən müxtəlif növ qidalı mühitlər var ki, bunlar əsasən bahalı əlavə olan embrional dana zərdabı tələb edir. Tropik və subtropik ölkələrin leyşmanioz yayılmış bəzi bölgələrində zərdabın əldə edilməsi müəyyən problemlər törədir. Bundan başqa zərdabda kontaminasiya riski də var. Yuxarıda qeyd olunan problemləri azaltmaq üçün qidalı mühitin tərkibindəki zərdabın digər komponentlərlə əvəz edilməsinə dair bir sıra tədqiqatlar aparılmışdır. Bu tədqiqatların nəticələri göstərmişdi ki, *Leishmania* parazitləri müxtəlif zərdabsız mühitlərdə, zərdab əlavə edilmiş mühitlərdə olduğu kimi inkişaf edib çoxala bilir.

Abstract
Leishmaniasis is a global transmissible parasitic disease. The disease is widespread in 98 countries worldwide, with an annual incidence of approximately 0,7–1 million people and 26,000–65,000 deaths. Flagellated protozoa of the genus Leishmania are the causative agents of leishmaniasis. To effectively combat this disease, to create drugs and a vaccine, it is necessary to obtain a long-term culture of pathogens in vitro. The main requirement for creating a vaccine is the production of a large volume of promastigotes. At present, creating an optimal medium that would support this condition is a significant challenge. There are different types of media used for Leishmania, which mostly require fetal bovine serum as an expensive supplement. Availability of serum is a problem in some parts of tropical and subtropical countries involved in leishmaniasis. There is also a risk of various contaminants in this serum. Several studies have been conducted to replace fetal bovine serum in the culture medium with various other components to reduce the above-mentioned problems. The results of these studies showed that the Leishmania parasite was able to grow and survive in various serum-free media as well as in serum-supplemented media.
Açar sözlər: *in vitro* kultivasiya, *Leishmania* promastiqotları, zərdabsız medium, *L.major*, *L.tarentolae*.
Keywords: *in vitro* cultivation, *Leishmania* promastigotes, serum-free medium, *L.major*, *L.tarentolae*.

Giriş

Leyşmanioz qlobal, ağır, transmissiv, parazitar xəstəlik olub, törədicisi obliqat hüceyrədaxili *Leishmania* parazitləridir. Parazit məməli sahibinə, *Phlebotomine* cinsinə aid yoluxmuş dişi hünülərin qan sorma zamanı dişləməsi ilə metasiklik formada ötürülür. Xəstəlik tropik və subtropik zonalarda yerləşən 98 ölkədə geniş yayılmışdır. Dünyada hər il təxminən 0,7-1 milyon insan bu xəstəliklə yoluxur, 26,000-65,000 ölüm halı müşahidə olunur. 350 milyon insan yoluxma riski altındadır (WHO, 2020).

Bu xəstəliklə effektiv mübarizə aparmaq, yeni dərman preparatları və peyvənd hazırlamaq üçün törədicilərin *in vitro* uzunmüddətli kulturasını əldə etmək lazımdır. Son onilliklərdə *Leishmania* parazitinin kultivasiyası üçün müxtəlif qidalı mühitlərdən istifadə edilmişdir ki, bunlar iki əsas qrupa bölünür: yarıbərk ikifazalı mühitlər və maye monofazalı mühitlər. Bu qidalı mühitlər (RPMI-1640, M199, BHI və NNN, həmçinin Schneider's Drosophila) hüceyrə bölünməsini stimullaşdırmaq və *Leishmania* promastiqotlarının uzunmüddətli inkişafını dəstəkləmək üçün müvafiq miqdarda qan və ya FBS (embrional dana zərdabı) ilə zənginləşdirilməlidir.

FBS parazitin *in vitro* davamlı saxlanılması və çoxalması üçün vacib olan hormonlar, vitaminlər, nəqliyyat zülalları, adgeziya faktorları, boy faktorları kimi çoxlu sayda komponentləri ehtiva edir (Van der Valk, 2004). FBS kimi bahalı komponentin istifadəsi müəyyən problemlər yaradır və həmçinin çirklənmə riskini artırır (Brunner, 2010). Beləliklə, heyvan zərdabının başqa, etibarlı bir əlavə ilə əvəz edilməsi tələb olunur (Gstraunthaler, 2003).

Hüceyrələrin zərdabsız qidalı mühitlərdə kultivasiyasının əhəmiyyəti indi geniş müzakirə edilir. *Leishmania* parazitlərinin zərdabsız kultivasiyası iqtisadi cəhətdən səmərəlidir və parazitlərin genişmiqyaslı istehsalına imkan yaradır. İndiyə qədər heyvan mənşəli maddələr (Muniaraj, 2007), soya zülalının izolyatı (Sidana, 2018), pepton və müxtəlif ekstraktların qarışığı (Van der Valk, 2004 və Sharief, 2008), həmçinin bəzi xüsusi serumsuz mühitlər (Ali, 1998) kimi müxtəlif maddələr hazırlamaqla FBS üçün uyğun əvəzediciləri tapmaq məqsədilə bir neçə cəhd edilmişdir.

Abdalla Hassan Sharief və həmkarları tərəfindən aparılan araşdırmada (Sharief, 2008) zərdabdan və ya qandan istifadə etmədən *Leishmania* promastiqotlarının ilkin təcrid edilməsi və sonrakı kultivasiyası üçün sadə tərkibli qidalı mühit təsvir edilmişdir. *Leishmania* promastiqotlarının kultivasiyası üçün, bahalı FBS-ni əvəzləyən ucuz, asanlıqla əldə olunan inqrediyentlərdən ibarət nisbətən sadə medium (CML) təsvir edilmişdir. Bu mediumda parazitlərin inkişaf sürəti zərdablı RPMİ-1640 qidalı mühitindəki kimi olmuşdur. CML-də çoxaldılan *Leishmania* promastiqotları J774 makrofaq hüceyrə xəttində sınaqdan keçirildikdə orta və yüksək dərəcədə yoluxuculuq nümayiş etdirmişdi. Yeni modifikasiya olunmuş qidalı mühitdə saxlanılmış *Leishmania* ştammları ilə RPMI-1640 mühitində yetişdirilənlər arasında yoluxuculuq və replikativ potensial baxımından əhəmiyyətli fərqlər müşahidə edilməmişdir. Asan hazırlanması və ani istifadəsi, münasib qiyməti, inqrediyentlərin əlçatanlığı və 30-45 günü əhatə edən uzun saxlama müddəti sayəsində yeni CML mediumu digər iki fazalı və ya maye mühitləri asanlıqla əvəz edə bilər. CML mühitində parazitlərin normal inkişaf etməsi faktı bu mediuma digərləri ilə müqayisədə üstünlük verir. 8 həftəlik fasiləsiz kultivasiyada *L.donovani* və *L.major* promastiqotları həm RPMI-1640, həm də CML mühitində sürətli çoxalma nümayiş etdirmişdi. Promastiqotların inkişafı kulturanın 6-cı həftəsində pik həddə çatmış, qısa müddət ərzində sabit qalmış, 8-ci həftədə azalmışdı. İlk altı həftə ərzində CML və RPMI-1640 qidalı mühitlərində *Leishmania* izolyatlarının inkişafı eyni olmuşdur.

Ali S.A. və həmkarlarının tədqiqatında (Ali, 1998) *Leishmania* promastiqotlarının *in vitro* uğurlu kultivasiyası üçün embrional dana zərdabı (FBS) ehtiva etməyən yarı sintetik, avtoklavlana bilən maye mühit təsvir edilmişdir. Parazitlər 10% FBS və 2% məməli urinası əlavə edilmiş 199 qidalı mühitində kultivasiya edilmiş və onların inkişafı tərkibində FBS olmayan eyni mühitdəki inkişafla müqayisə edilmişdir. Zərdabsız yarı sintetik mediumda parazit artımı zərdablı 199 qidalı mühitinə nisbətən bir qədər yaxşı olmuşdur.

Santarem N. və həmkarları (Santarem, 2014) qeyd edir ki, *Leishmania* promastiqotları üçün ideal qidalı mühit hünülərin orqanizmində həyat tsikli keçən promastiqotların əsas xüsusiyyətlərini (morfologiya və yoluxuculuq qabiliyyəti) təmin etməlidir. Tədqiqatçılar parazitlərin morfologiyası, həyatilik və yoluxuculuq qabiliyyətini təhlil etmişlər. Onlar sadə, zərdabsız qidalı mühit (cRPMI) hazırlamışlar. Müxtəlif mühitlərdə saxlanılan parazitlər fərqli bioloji xüsusiyyətlər, *in vitro* və *in vivo* fərqli yoluxuculuq qabiliyyəti nümayiş etdirmişlər. cRPMI mediumu promastiqotların *in vitro* kultivasiyası üçün istifadə olunan zərdablı, ənənəvi qidalı mühitə nisbətən daha ucuz başa gəlmişdir. Həmçinin qeyd olunmuşdur ki, parazitlərin laboratoriya şəraitində kultivasiyası üçün cRPMI mediumu daha uyğundur. Belə ki, bu medium kultivasiya zamanı parazitin virulentliyinin itməsinin müəyyən qədər qarşısını alır.

Digər tədqiqatçılar da (Habibzadeh, 2021) leyşmanioza qarşı peyvənd yaratmaq məqsədilə həyata keçirilən parazit kultivasiyası üçün yeni bir serumsuz medium hazırlamağı hədəfləmişlər.

Müxtəlif Leishmania növləri arasında *L.tarentolae* kərtənkələlərin parazitidir və insanlar üçün patogen deyildir. Bu parazit öz xüsusiyyətlərinə görə rekombinant zülalların istehsalı üçün mühüm vasitə kimi təklif edilmişdir. Onun bir sıra digər üstünlükləri də var: kultura mühitində 6-10 saatlıq qısa generasiya müddəti, qidalı maddələrə az tələbat, yüksək inkişaf sürəti (Klatt, 2019). *L.tarentolae* leyşmanioza qarşı təhlükəsiz və effektiv peyvənd hazırlanması üçün yüksək potensiala malikdir.

Hazırkı tədqiat işində CSFM adlı sadə, monofazlı, zərdabsız qidalı mühit hazırlanmışdır. Bu medium *Leishmania*-nın patogen forması (*L.major*) və peyvənd hədəfi kimi Ppsp15-EGFP ifraz edən qeyri-patogen rekombinant *L.tarentolae*-nın kultivasiyası üçün təklif edilmişdir. Üç növ *L.tarentolae* istifadə edilmişdir: yabani tip *L.tarentolae* Tar II (ATCC 30.267); *L.tarentolae* -EGFP və rekombinant *L.tarentolae* - PpSP15-EGFP, həmçinin yabani tipli *L.major* ştammı (MRHO/IR/75/ER). Birinci mərhələdə promastiqotlar inaktivləşdirilmiş FBS əlavə edilmiş M199 qidalı mühitində 26°C temperaturda saxlanılmışdı. M199 mühiti standart mühit kimi təqdim edilmişdir. PpSP15-EGFP ifraz edən rekombinant *L.tarentolae* və yabanı tipli *L.major* zərdabsız (CSFM) və zərdab əlavə olunmuş qidalı mühitlərdə becərilmiş və hər iki mühitdə parazitlərin inkişaf sürəti, zülal ekspressiyası və yoluxuculuğu müqayisə edilmişdir. Rekombinant *L.tarentolae* -PpSP15-EGFP parazitinin CSFM və 5% FBS-li M199 qidalı mühitlərində inkişaf sürəti müqayisə edilmişdir. Müəyyən edilmişdir ki, CSFM mühiti 5% FBS-li M199 mediumu kimi *L.tarentolae* - PpSP15-EGFP parazitinin inkişafını dəstəkləyə bilər. İnokulədən sonrakı 2-3 gün ərzində bir qədər əhəmiyyətli fərq olsa da ($p < 0.05$) digər günlərdə inkişaf tempi oxşar olmuş və əhəmiyyətli fərqlər aşkar edilməmişdir ($p > 0.05$). Kultivasiya zamanı hər gün parazitlərin hərəkətliliyinin mikroskopik müşahidəsi aparılmışdı. Bu nəticələr CSFM mühitinin *L.tarentolae* -PpSP15-EGFP parazitinin çoxalmasını dəstəkləmək qabiliyyətini təsvir edir.

Beləliklə, bu tədqiqatda CSFM adlı yeni, zərdabsız qidalı mühit, *L.tarentolae* -PpSP15-EGFP və yabanı tipli *L.major* parazitlərinin kultivasiyası üçün istifadə olunan 5% FBS-li M199 ilə müqayisə edilmişdir. Aşkar edilmişdir ki, CSFM qidalı mühitində *L.tarentolae* -PpSP15-EGFP promastiqotlarının tipik görünüşü 5% FBS-li M199 mediumundakı kimi olmuşdur. CSFM mühitində *L.major* promastiqotlarının artım sürəti 5% FBS-li M199 mediumundakı çoxalma sürəti ilə təqribi oxşar idi ($p > 0.05$). Bu işdə tədqiqtçılar FBS-i iqtisadi cəhətdən daha sərfəli əlavələrlə əvəz etməyi məqsəd qoymuşlar. Bu, *L.tarentolae*-PpSP15-EGFP parazitinin peyvənd məqsədli kultivasiyası üçün çox əhəmiyyətlidir. Zərdabı əvəz edə biləcək əlavələri müəyyənləşdirmək üçün *Leishmania* parazitinin qida tələbatı öyrənilmişdi. Aşkar edilmişdi ki, triptofan, fenilalanin, arginin, leysin, lizin, valin, serin, histidin, tirozin və treonin aminturşuları *Leishmania* promastiqotlarının fasiləsiz kultivasiyası üçün çox vacibdir (Nayak, 2018). Həmçinin məlumdur ki, hem müxtəlif *Leishmania* növlərində oksidləşdirici metabolizm, oksigenin saxlanması və daşınması, siqnal ötürülməsində kritik tənzimləyici komponent kimi çıxış edən, nəticədə parazitlərin böyüməsinə və sağ qalmasına təsir edən mühüm biomolekuldur. Artıq sübut edilmişdir ki, *Leishmania* paraziti və digər ibtidailər, məsələn, tripanosomatidlər metabolik qüsura malikdir və bu molekulu sintez etmək üçün lazımi fermentlərə malik deyillər. Buna görə də ətraf mühitdən hemin alınması zəruridir (Laranjeira-Silva, 2020). *Leishmania* parazitinin tələb etdiyi digər qida maddələrinə nikotin turşusu, fol turşusu, biotin, tiamin, riboflavin və pantotenat kimi vitaminlər daxildir (Santarem, 2014).

İmmunoblotinq testi göstərmişdi ki, CSFM mühitində saxlanılan *L.tarentolae* -PpSP15-EGFP promastiqotlarında PpSP15-EGFP zülalının ekspressiya profili molekulyar çəki və nisbi intensivlik baxımından zərdabla zənginləşdirilmiş qidalı mühitindəki nəticələrə oxşardır. Bu nəticələr aydın şəkildə nümayiş etdirir ki, *L.tarentolae* -PpSP15-EGFP parazitləri CSFM mühitində inkişaf edib çoxala bilirlər. Tədqiqat həmçinin CSFM mühitində saxlanılan parazitin, zərdablı M199 mediumunda saxlanılan parazit kimi BALB/c siçanlarını yoluxdurmaq qabiliyyətinə malik olduğunu nümayiş etdirdi. Həmçinin yaxmalar hər iki mühitdə saxlanılan *L.major* promastiqotlarının normal morfoloji xüsusiyyətlərə malik olduğunu göstərdi. Parazit sıxlığının ölçülməsi, ətrafların yastıqcıqlarındakı lezyonlar və ödem hər iki qidalı mühitdə *L.major* promastiqotlarının infektivlik gücünü göstərdi. Bu nəticələr açıq şəkildə nümayiş etdirdi ki, CSFM mühitindən digər qida maddələri ilə əvəz edilməsi səbəbindən FBS-nin çıxarılması parazitə *in vivo* yoluxuculuq səviyyəsində heç bir təsir göstərməmişdir.

Bütövlükdə, bu məlumatlar təsdiq edir ki, CSFM mühiti, tərkibindəki əvəz olunan və olunmayan amin turşuları, vitaminlər, yüksək qlükoza faizi və digər qida maddələrinə görə həm *L.tarentolae* -PpSP15-EGFP, həm də vəhşi tipli *L.major*-un inkişafını və yoluxuculuğunu dəstəkləyə bilir. Bu medium peyvənd və terapevtik məqsədlərlə *Leishmania* parazitlərinin kütləvi istehsalı üçün istifadə edilə bilər. CSFM *Leishmania* parazitlərinin kultivasiyasında zərdablı mediumlarını əvəz edə bilər.

Nəticə

Bu tədqiqatlar göstərir ki, *Leishmania* promastiqotlarının *in vitro* kultivasiyası üçün daha ucuz zərdabsız qidalı mühitlər istifadə edilə bilər. Kultura mühitindən FBS-nin çıxarılması parazitə *in vivo* yoluxuculuq səviyyəsində təsir göstərmir.

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PEDAGOGY

MODERN TRANSPORTATİON SYSTEMS OPERATİON SERVİCES: TECHNOLOGİCAL TRANSFORMATİON AND ECONOMİC EFFİCİENCY

Ibrahimova S.
Sheki branch of the Azerbaijan State Pedagogical University
Honored Teacher, Senior Lecturer
https://orcid.org/0000-0002-8944-3611
DOI: 10.5281/zenodo.18677875

Abstract

The article analyzes the current state, technological transformation and strategic role of transport vehicle operation services, which are the main driving force of the modern economy. The research study examines the specific features of road, rail, water, air and pipeline transport, their integrated operation and innovative approaches applied in the operation process. The impact of increasing the operational efficiency of vehicles on the country's GDP, environmental safety and social well-being is scientifically substantiated. The article identifies prospects for digitalization and the application of "green technologies" in the transport sector.

Keywords: Transport operation, technical service, logistics, national economy, telematics systems, road transport, railway, multimodal transport, intelligent transport systems, energy efficiency.

Interpretation of generalizations formed on the basis of research materials.

In the modern global economy, the transport sector is the backbone of the logistics chain, and the efficiency of this sector directly depends on the quality of transport vehicle operation services. Vehicle operation refers not only to their movement, but also to complex processes such as maintenance, repair, diagnostics, and resource management. The main goal of operation services today is to maintain the maximum level of vehicle performance, while minimizing operating costs and ensuring environmental safety. Technological development, especially digitalization and the introduction of artificial intelligence, has led to fundamental changes in the operation strategies of transport vehicles. The previously applied "repair after failure" approach is now giving way to the "predictive maintenance" model. Within the framework of this model, data is collected in real time from the engine, transmission, and other critical nodes of the vehicle through sensors and telematics systems. The collected big data is processed by analytical algorithms, and the probability of potential failures is determined in advance. This prevents unexpected vehicle downtime and optimizes the logistics of spare parts. [5; 16]

Another important factor determining the quality of service in the operation of transport vehicles is the intellectualization of the technical service infrastructure. Modern service centers are equipped with high-precision diagnostic equipment, minimizing errors caused by the human factor. Energy efficiency in the operation process is also of particular relevance. The increase in the share of vehicles powered by alternative energy sources (electric and hybrid) in the fleet is fundamentally changing the structure of maintenance services. Although the presence of fewer moving parts in electric vehicles compared to vehicles with internal combustion engines extends the maintenance interval, it brings new service areas to the fore, such as battery management systems and software updates. At the same time, compliance with environmental standards and keeping the toxicity of exhaust gases under control are important conditions in the operation of transport vehicles.

Among the economic factors affecting the efficiency of maintenance services, the analysis of "life cycle costs" occupies a special place. This approach involves the optimization of all costs from the purchase of a vehicle to its disposal, including fuel, lubricants, spare parts and service. Scientific studies show that a properly organized maintenance service can increase the useful life of a vehicle by 20-30%. As a result, the future development of maintenance services for transport vehicles will be closely related to the integration of autonomous control systems, the "Internet of Things" and green technologies. The application of scientifically based approaches in this area, in addition to ensuring the sustainability of transport systems, directly serves to increase economic efficiency and reduce negative impacts on the environment. [2; 34]

The transport system is the main driving force of the economic independence of each state and the dynamic development of the national economy. This system, providing inter-sectoral connections, plays a decisive role in the delivery of raw materials from the point of extraction to processing plants, and finished products to the consumer. [5; 73] In modern times, transport types are divided into several main groups according to their technical characteristics and areas of application, each of which has its own place in the national economy. Each branch of the transport system performs specific functions in the national economy, and the technical and economic indicators of each of them are different. Below I present information about each of these transport types:

1. Railway Transport

Railway transport is the most efficient means of transporting heavy industrial cargo (oil, coal, ore, construction materials) over long distances. Its importance in the national economy lies in the low cost of transportation and its regular operation regardless of weather conditions. The mass transportation of large-volume cargo falls precisely on this sector.


Railway transport plays a crucial role in the development of heavy industry. This type of transport allows thousands of tons of cargo to be transported by a single train over long distances (1000 km or more) with minimal energy consumption. [7; 112]

Economic importance: The cost of transportation is several times lower than road transport. This ensures that the price of inexpensive but bulky cargo, especially coal, ore, and grain, remains affordable for the end consumer.

Feature: Minimal dependence on climatic conditions ensures the accuracy of schedules, which is critical for "just-in-time" production models. [6; 91]

Railway transport is one of the most important achievements of mankind since the industrial revolution and is of strategic importance for the sustainable development of the modern national economy. This type of transport is a unique system that ensures the delivery of especially large and heavy cargo (oil, coal, construction materials, ore, agricultural products) over intercontinental distances at the lowest cost. The greatest advantage of railways is in its technical and economic indicators; the minimal friction force when moving on rails allows one locomotive to pull dozens of wagons with thousands of tons of cargo. This reduces the cost of transportation several times compared to road transport and minimizes the negative impact of transport on the environment. From an ecological point of view, railway transport is a key element of "green logistics", since electrified railway lines sharply reduce the emission of harmful gases into the atmosphere. [1; 104]

In modern times, railway transport is in the stage of a radical technological transformation. The introduction of high-speed trains allows it to compete with air transport in passenger transportation, creating more favorable conditions in terms of time and comfort at distances of 500-1000 km. In freight transportation, containerization and multimodal transportation models have increased the flexibility of the railway. Thanks to intelligent control systems and automated dispatch control, the safety of train movement and schedule accuracy have been brought to an absolute level. The "East-West" and "North-South" international transport corridors, in which Azerbaijan participates, also emphasize the geopolitical importance of this area; since railways serve to accelerate global trade by connecting countries in a single economic chain. [7; 68]

For human life, railway transport also means mass mobility and safety. Statistics show that railways are the type of transport with the lowest risk of accidents. Intercity and suburban electric trains are indispensable in solving the problem of traffic jams in large megacities and in the mobility of the population as a workforce. In the future, the introduction of "Maglev" (magnetic levitation) technologies and digital "smart wagons" will make railway transport even faster and more efficient, turning it into the most stable and reliable pillar of the national economy in the coming decades.

2. Road Transport

This type of transport is distinguished by its high maneuverability and the principle of "door-to-door" delivery. It is indispensable in the national economy for short and medium-distance transportation, especially in the distribution of agricultural products and perishable goods. It is precisely motor transport that ensures the flexibility of the economy. Motor transport, being an integral part of modern civilization, has deeply penetrated almost every sphere of human life - from social activity to psychological and physical well-being. Its role is not only to move from one point to another, but also to determine the quality of life and the degree of freedom. Motor transport is the most dynamic and ubiquitous sector of the national economy. It performs the function of "capillaries" connecting all other types of transport. [11; 77]

Economic importance: The development of small and medium-sized businesses directly depends on this area. The delivery of products from warehouses to stores, as well as the satisfaction of individual needs, is carried out precisely by cars.

Innovations: Currently, work is underway on electrification of trucks and autonomous control systems, which in the future could reduce logistics costs by 30-40%. [6; 148] The main scientific criterion that distinguishes road transport from other types is flexibility and adaptability. From a technical point of view, this type of transport is the only system that provides "direct" delivery of cargo, which eliminates intermediate loading and unloading operations. [1; 68]



Modern scientific research is focused on increasing the useful work coefficient of internal combustion engines (ICE) or replacing them with alternative energy (electricity, hydrogen). The automobile has given man one of the greatest blessings - personal control over time and space. Regardless of public transport schedules, an individual can move at any time and in any direction. This is a key factor preventing social isolation, especially for people living in remote and isolated areas. The automobile has overcome the distance barrier between the city and the countryside, expanding people's choices for work, education and leisure. The most critical role of automobile transport for human life is operational services. [10; 48] Emergency medical services, firefighting and police services reach the scene of an accident within seconds thanks to special-purpose vehicles. Modern resuscitation vehicles (reanimobiles) perform the function of a kind of "operating room on wheels" on the way to the hospital, saving millions of lives every year. Automobile transport unites a huge workforce. Drivers, mechanics, engineers, and logistics specialists support their families through this industry. Also, the "door-to-door" delivery of food, clothing, and medicines that we use in our daily lives (courier services) makes people's lives easier, freeing them up for other important tasks. [8; 42]

The scientific development of modern automobile transportation is associated with Intelligent Transportation Systems. These systems use GPS, sensors, and Artificial Intelligence algorithms to perform the following functions:

The aim is to reduce the risk of accidents to zero by having cars exchange information with each other and with road infrastructure (traffic lights, signs).

The biggest "negative cost" of motor transport in the national economy is environmental pollution. Scientific analysis shows that a significant part of global carbon emissions falls on this sector. The transition to electric vehicles is not only ecological, but also a revolution in terms of operation. The mechanical simplicity of electric motors (fewer friction parts) significantly reduces maintenance costs. Motor transport creates a multiplier effect in the economy. That is, investment in this sector indirectly leads to the development of other sectors: [4; 56]

Acceleration of trade turnover: Shortening the time for product delivery from the producer to the consumer leads to the release of working capital. Roadside services, gas stations and logistics centers increase employment in the regions. The loss-free and quick delivery of farm products to the market directly depends on the quality of road transport. Road transport is not just a means of transport, but a complex technological ecosystem. In the future, the development of this sector will be in the direction of "green energy" and fully autonomous management (pilotless transport). This transition will allow human labor in the national economy to be minimized and transport safety to be raised to an absolute level.

3. Sea and Water Transport

The bulk of international trade is carried out by sea. This type of transport is the cheapest way to establish intercontinental economic relations. In particular, huge tankers and container ships are the main link in the global logistics chain. Approximately 80-90% of world trade turnover falls on sea transport. This is the main means of ensuring the integration of economies on a planetary scale.

Economic importance: Thanks to the containerization revolution, maritime transport has made it incredibly cheap to transport goods to distant continents. The cost of bringing a container from China to Europe is often less than the cost of distributing the same goods domestically.

Service area: Ports have become huge logistics centers, creating thousands of jobs. [5; 118]

Sea and river transport, in addition to being the oldest means of movement and trade of mankind, are the foundation of the modern global economy. This type of transport, taking on about 90% of world trade turnover, has become the most important means of intercontinental economic integration. The importance of water transport in the national economy is explained by its huge cargo carrying capacity and the fact that the cost of transportation is many times lower than that of other types of transport. [11; 49] In particular, sea transport has no competitors in the delivery of oil, gas, grain, ore and mass consumer goods (in containers) over long distances. Modern container ships can carry tens of thousands of tons of cargo in one trip, which directly affects the reduction of prices of goods in the global market and their accessibility to everyone.

River transport plays a special role in domestic transportation and in the economic revival of landlocked regions. Transportation through major rivers and canals is considered the most ecological and cheap way to supply heavy industrial enterprises with raw materials. [10; 202] The development of water transport also leads to the creation of huge port infrastructure and logistics centers, which means thousands of new jobs and rapid development of coastal regions. In modern times, maritime transport is transitioning to "smart port" technologies and unmanned ship management systems. At the same time, the transition of ships to environmentally friendly fuels (for example, liquefied natural gas or ammonia) has become a scientific priority to protect the ecosystem of the world's oceans. In terms of human life, maritime transport is also a guarantee of global food security; the fact that the bulk of the world's grain and fertilizer trade is carried out by sea serves to provide food for billions of people.

4. Air Transport

The main advantage of air transport is speed. It is used to transport valuable cargo, medicines and high-tech equipment that require urgent delivery for the national economy. It is also the first in terms of time saving in long-distance passenger transport. Although air transport is more expensive than other types, it is indispensable when the time factor is decisive.

Economic importance: It accelerates the introduction of electronics, optics, and other high-value goods to the global market. For example, air logistics makes it possible for a new smartphone model to go on sale in all the world's capitals on the same day.

Strategic role: It is the only option for delivering medical aid, humanitarian cargo, and emergency spare parts. [2; 49]

Air transport is considered a symbol of speed, high technology and global accessibility in the modern world. This type of transport, unlike all other means, has the ability to overcome distances and geographical barriers (mountains, oceans, deserts) in the shortest possible time. The main mission of air transport in the national economy is to provide services in areas where the time factor is decisive. Air logistics is indispensable, especially in the delivery of high-value goods, electronic components, pharmaceuticals and perishable products to international markets. For example, in modern medicine, organ transplantation or urgent vaccine delivery directly depends on the speed of aviation, which makes air transport a strategic area from a humanitarian point of view.

From an economic point of view, air transport is the mainstay of global tourism and business communications. The integration of production chains located in different parts of the world with each other is possible precisely thanks to the rapid circulation of specialists and documents provided by air. Modern aircraft - cargo and passenger aircraft - are considered the pinnacle of engineering science. Aerodynamic solutions and engine technologies applied in this field are aimed at increasing fuel efficiency and minimizing carbon dioxide emissions into the atmosphere. Currently, aviation science is working on the introduction of biofuels and the creation of electric aircraft within the framework of the "green flights" concept. [3; 52]

Modern airports, which form the infrastructure of air transport, are not just runways, but huge economic centers. These centers are ecosystems where thousands of people work, high-level security systems and automated logistics management are applied. The role of air transport in human life is also associated with the expansion of worldviews and the acceleration of intercultural dialogue; the ability to move to a completely different climate and culture in a few hours has fundamentally changed the concept of mobility of mankind. The development of unmanned aerial vehicles (drones) indicates that in the near future air transport will also revolutionize small intra-city cargo transportation.

5. Pipeline Transportation

Pipeline Transport is specialized for the transportation of specific types of cargo, such as liquid (oil) and gaseous resources. It is the cheapest and most sustainable type of transport that ensures the energy security of the economy. It creates a direct and uninterrupted line between production regions and consumption centers. Although this type of transport is invisible, it is the "blood vessel" system of modern industry. Unlike other types of transport, there is no moving vehicle here, the cargo itself moves under pressure inside the pipe.

Economic importance: Provides the highest safety and lowest cost in the transportation of oil, water, and gas. Without pipelines, transporting oil by tanker or railcar would increase the cost of energy resources several times.

Sustainability: It provides uninterrupted supply 24/7, as it is free from human factors and traffic accidents. [6; 73]

Pipeline transport is considered the "blood vessel system" of modern industry and the energy sector. This type of transport is fundamentally different from others, since there is no moving vehicle here; the cargo itself moves inside the pipes under high pressure. The role of pipelines in the national economy is determined, first of all, by the uninterrupted delivery of energy carriers (crude oil, natural gas, petroleum products) from production points to processing plants and end consumers. [8;451] This system provides the highest economic efficiency in the transportation of liquid and gaseous cargoes. Thus, the cost of transportation by pipeline is approximately 3-5 times cheaper than rail transport and ten times cheaper than road transport. This cheapness has a direct impact on the final price of fuel and energy resources, reducing production costs in all sectors of the industry.

The scientific and technical advantages of pipeline transport are that it is completely independent of climatic conditions and operates 24/7, that is, continuously. The "empty trips" encountered in other types of transport (for example, a tanker or wagon returning empty after unloading) do not exist here, which allows for the most efficient use of resources. Modern pipelines are high-tech complexes; they are made of special corrosion-resistant steel materials and equipped with complex pump-compressor stations. Management is fully automated, and pressure, temperature and the possibility of leakage at each point of the pipeline are monitored in real time through SCADA systems. This type of transport is of particular strategic importance for Azerbaijan. Projects such as the Baku-Tbilisi-Ceyhan (BTC) and the Southern Gas Corridor (TANAP/TAP) not only strengthen the country's economic sovereignty, but also play an important role in Europe's energy security. [5; 82]

From the point of view of human life and ecology, pipeline transport is the safest type of transport. The movement of hydrocarbons through pipes on land or under the sea minimizes the risks of accidents and fires that may arise during their transportation by road or rail. At the same time, since pipelines are located underground or on the seabed, they do not disrupt the structure of the landscape and create conditions for large areas to remain free from transport infrastructure. In the future, scientific development in this field will be in the direction of transporting "green hydrogen"; adapting existing gas pipelines to hydrogen transportation will be the main factor accelerating humanity's transition to environmentally friendly energy.

Main Functions of the Transportation System in the National Economy:

Production coordination: Establishes cooperative relationships between enterprises. Acceleration of product turnover: The rapid arrival of goods to the sales market increases the speed of capital turnover.

Regional development: The presence of road infrastructure leads to the integration of remote regions into the economy.

Defense ability: It is the basis of the country's security and strategic resource management. [10; 8]

As you can see, transportation is not just a service sector, but the lifeblood of the entire economy. The weakening of any type of transportation can lead to stagnation in the entire national economy.

Conclusion: The conducted analyses show that the operation services of transport vehicles do not only have a technical support function, but are also a direct guarantor of economic stability and global trade turnover. In modern times, integration (multimodal transportation) rather than competition between transport modes has come to the fore. For the efficient functioning of the national economy, the integration of these transport modes in a multimodal (combination of several transport modes) manner is important. This allows for the creation of a "single transport network", which directly stimulates the growth of the country's gross domestic product (GDP). Based on the obtained scientific results, we can say that:

Digitalization: The application of the "Internet of Things" (IoT) and Artificial Intelligence minimizes transportation operating costs and reduces the risk of accidents.

Ecological Transition: The transition to electric and hydrogen technologies in road and rail transport is inevitable for sustainable development.

Economic Effect: Properly organized maintenance service extends the life of a vehicle and increases the rate of capital turnover in the national economy.

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NEW APPROACHES TO ASSESSING ORAL COMMUNICATION IN PROJECT ASSIGNMENTS IN FOREIGN LANGUAGE TEACHING AT THE UNIVERSITY

Lysytska O.,
PhD, Associate Professor
Associate Professor of Foreign Language Department
Yaroslav Mudryi National Law University
Ukraine, Kharkiv
Romantsova Ya.
PhD, Associate Professor
Associate Professor of Foreign Language Department
Yaroslav Mudryi National Law University
Ukraine, Kharkiv
DOI: 10.5281/zenodo.18677887

Abstract

The article substantiates a process-oriented model for assessing oral foreign language communication of first-year university students during poster presentation projects in the context of active AI use. Based on diagnostic, formative, and summative assessment stages, the model shifts focus from the final product to the dynamics of communicative competence development. Quantitative results demonstrate positive growth across all criteria, particularly interactivity and communicative strategies, confirming the effectiveness and validity of process-based assessment in project-oriented language learning.

Keywords: oral communication, foreign language assessment, process-oriented assessment, formative assessment, project-based learning, poster presentation, communicative competence, artificial intelligence in education.

Introduction

In the context of the transformation of higher education and the active introduction of digital technologies, the problem of assessing oral foreign language communication is becoming particularly relevant. Modern methods of teaching foreign languages are focused on competency-based, communicative, and project-oriented approaches, within which oral speech is considered not as a reproduction of language forms, but as a means of solving academic and professional tasks (Council of Europe, 2020).

Project assignments, in particular poster presentations, are widely used in university teaching of a foreign language at the initial stages of study, including the first year. They allow combining the development of language skills with the formation of the skills of cooperation, critical thinking, and public speaking (Council of Europe, 2020). At the same time, practice shows that the assessment of such tasks, as before, is often focused on the final result - the final oral performance or visual product.

The situation is complicated by the widespread use of artificial intelligence tools by students, which questions the validity of assessment focused exclusively on the product of activity. In this regard, there is a need to rethink approaches to assessing oral project tasks and move the emphasis from the final result to the process of educational communication, which includes discussion, planning, oral interaction and phased preparation of the speech and presentation.

In this situation the assessment of the aspects of educational activity that cannot be fully automated is of the particular importance: oral interaction, communicative strategies, participation in discussions, argumentation, the ability to respond to questions and adapt the text to the audience.

In this respect, the purpose of this study is to describe and substantiate a process-oriented model of assessing oral communication within the framework of preparing a poster presentation, in which the object of assessment is not only the final speech, but also the dynamics of the development of communicative competence at different stages of project work, starting from discussing the idea and planning the content to rehearsals and final presentation of the poster.

The article proposes a multi-stage model for assessing oral communication of first-year students, which includes diagnostic, formative, and summative stages and is based on the principles of formative and criterion-based assessment.

Literature review

The issue of assessing oral communicative competence in higher education is at the center of attention of modern foreign language teaching methodology. Scientific research of recent decades emphasizes the need to move from traditional summative control to formative and authentic assessment, focused on the learning process and the development of communicative skills.

Formative assessment in language education. Formative assessment occupies a central place in modern theory and practice of language education. Unlike summative control, focused on fixing the final result, formative assessment is aimed at supporting the learning process and developing students' communicative skills (Pinto-Llorente & Izquierdo-Álvarez, 2024). Studies emphasize that regular, dialogic feedback contributes to the conscious development of oral speech, increases students' motivation and forms their autonomy (Winstone & Carless, 2019).

In the context of oral communication assessment, formative assessment is implemented through observations, analytical rubrics, self-assessment and peer assessment, which allows recording students' progress over time, and not just the level of language proficiency at a specific moment (Fulcher, 2015). Thus, oral communication is viewed as a developing skill, and assessment as an integral part of the learning process (Pinto-Llorente & Izquierdo-Álvarez, 2024).

Formative assessment is viewed in the scientific literature as a tool for developing competences, and not just as a means of setting a final score (Wiliam, 2011; Harding & Kremmel, 2016; Winstone & Carless, 2019; Panadero et al., 2018).

Assessment of oral communication and the CEFR. The Common European Framework of Reference for Languages (CEFR) has significantly influenced modern approaches to the assessment of oral communication in higher education. The CEFR offers descriptors of speech that focus on the functional use of language in real-life communicative situations, including interaction, spontaneity and pragmatic adequacy (Council of Europe, 2020).

Current research emphasizes the need to interpret CEFR levels not as static categories, but as guidelines for the process-based assessment of oral language development (Fan & Yan, 2020). In project tasks, CEFR descriptors are used as a basis for developing analytical criteria that allow assessing student participation in discussions, presentations, and collaborative work (Brooks, 2009; Galaczi et al., 2011). This approach increases the transparency of assessment and its relevance to the real communicative tasks of university education.

The conclusions from these sources allow us to state that modern assessment of communication takes into account the student's activity in the dialogue, his participation in interaction and adaptive response, and not only the final product of the utterance (Council of Europe, 2020; Brooks, 2009; Galaczi et al., 2011).

Project-based and task-based learning as an assessment context. Project-based learning and task-based language teaching are considered in modern literature as the optimal context for assessing oral communication. Project tasks create authentic communicative situations in which oral speech is used as a means to achieve a common goal, and not as an object of isolated testing (Beckett & Miller, 2020).

Within the framework of project activities, assessment of oral communication is integrated and includes presentations, group discussions, negotiations and reflection. Researchers note that it is in such conditions that formative assessment is most effective, as it allows taking into account the interactive and social aspects of speech, as well as developing students' strategic and sociolinguistic competence (O'Dowd & O'Rourke, 2019).

Scientific publications on competency-based and project-based approaches emphasize that it is oral communication in the process of activity that is key to the development of communicative competence (Beckett & Miller, 2020; Stoller, 2006).

Assessment in the context of digitalization and the use of AI. The digitalization of higher education and the active implementation of artificial intelligence tools are significantly changing approaches to assessing language skills. However, modern research indicates the limited capabilities of AI in assessing oral communication, especially in terms of interactivity, pragmatics, and contextual interpretation of utterances (Selwyn, 2023).

Although automated systems are able to analyze individual speech parameters (e.g. pronunciation or pace), they do not fully reflect communicative competence as a socially and situationally conditioned skill (Stoynoff & Chapelle, 2021). A theoretical review of communicative competence in AI conditions emphasizes that modern communication skills go beyond traditional tests, requiring the assessment of real-life interaction and the use of digital tools (Poole & Mackworth, 2023). In this regard, oral communication in project tasks is considered the most valid object of assessment, requiring teacher participation and the use of formative, human-centered approaches. The British Council notes in its analytical material that AI is transforming the assessment of oral speech, including interactive tasks, adaptive feedback and analysis of speech activity (British Council, 2025).

Researchers emphasize that in the AI era, the importance of speaking as an indicator of real language proficiency is not decreasing, but, on the contrary, increasing (Fan & Yan, 2020).

In AI scientific sources, it is noted that oral communication is becoming a key valid area of assessment, as AI environments require flexibility, interaction and adaptation, which are difficult to measure through traditional methods (Selwyn, 2023; Holmes et al., 2019).

In this context, oral communication and process-based assessment are seen as key tools for ensuring academic integrity and the authenticity of learning outcomes (Ajjawi & Boud, 2017; Bearman et al., 2020).

Methods

The study has a quasi-experimental design using quantitative methods of analysis and elements of a pedagogical experiment. The aim of the study is to verify the effectiveness of a process-oriented model of assessing oral communication of first-year university students during the preparation of a poster presentation in a foreign language in conditions of active use of digital tools and elements of artificial intelligence.

The subject of the study is the dynamics of the development of oral communication of students during staged (diagnostic-formative-summative) assessment.

Study participants

The experiment was participated in by 48 first-year students of the law specialty of Yaroslav Mudryi National Law University, who study a foreign language at level B2 according to the CEFR. The students were united in 12 small project groups of 3–5 people to perform a joint task of preparing a poster presentation.

Data collection tools

The following tools were used to collect empirical data: 1) an analytical multilevel analytical scale (analytic rubric) for assessing oral communication, developed taking into account the CEFR descriptors (Companion Volume) and adapted to the tasks of project-based learning and the poster presentation format. It included six criteria: communicative clarity; organization of oral expression; lexical and grammatical adequacy; interactivity; use of communicative strategies; academic and ethical correctness (taking into account the use of AI); 2) an oral communication portfolio, which includes oral tasks, written speech plans and working notes of students; 3) teacher observation, structured according to the developed criteria.

Each criterion was assessed on a scale of 1 to 4. The scores reflected the degree of development of each component of communicative competence and showed a progression from elementary to more autonomous and conscious use of oral speech in an academic context (1 - elementary proficiency; requires significant support; 2 - basic proficiency; understands and expresses simple ideas, errors do not interfere with communication; 3 - confident use; ideas are coherent, partially adapts to the audience; 4 - autonomous, accurate, and coherent use of the skill).

The analytical nature of the rubric provided for separate assessment of individual components of oral communication, which made it possible to track the dynamics of the development of each aspect of communicative competence at the diagnostic, formative, and summative stages of project work.

The rubric was used as a teaching assessment tool, and was also used in self-assessment and peer assessment procedures, which corresponded to the principles of assessment formation and contributed to the development of students' educational autonomy.

The Analytic Scale included the following criteria:

1) *communicative clarity* (clarity and accuracy of expression of thought, logical coherence of the statement, use of adaptive strategies in response to audience questions);

2) *organization of oral expression* (structuring of the speech, presence of a clear introduction, main part and conclusions, logical transitions between semantic blocks, compliance with the rules);

3) *lexical and grammatical adequacy* (diversity and relevance of vocabulary, grammatical correctness, pronunciation and intonation accuracy);

4) *interactivity* (ability to maintain the audience's attention, ask clarifying questions, adequately respond to listeners' requests and effectively manage the time of the speech);

5) *use of communicative strategies* (ability to perform the roles of project leader, discussion moderator and speaker, as well as to effectively cooperate in a team);

6) *academic and ethical correctness* (compliance with the norms of academic communication, correct presentation of sources and results of work, responsible and conscious use of artificial intelligence tools).

Research Procedure

The study was conducted over one training module (4 weeks) and included three consecutive assessment stages: diagnostic, formative, and summative.

At ***the diagnostic stage***, students performed a 2–3 minute mini-presentation, which included a summary of the key ideas of the poster and answers to the teacher's questions. This format allowed determining the initial level of oral communicative competence. An example of a mini-presentation prepared by a group of students is presented in *Figure 1*.

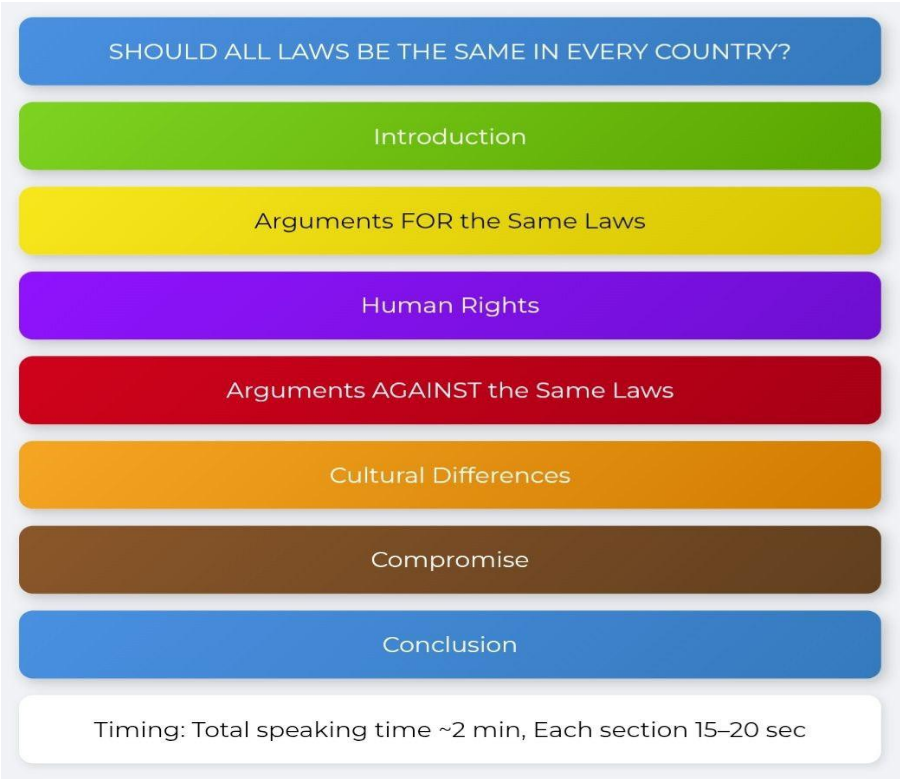

Figure 1. Slide of a mini-presentation at the diagnostic level of the study

The formative stage covered the process of preparing a poster presentation and included group discussions, rehearsals of oral fragments, and reflective written reports. Assessment at this stage was formative in nature and was aimed at supporting the development of oral communication and students' awareness of the criteria for their successful performance. A detailed plan of the students' presentation is presented in *Figure 2*.

Oral Presentation Plan (5–7 minutes)

"SHOULD ALL LAWS BE THE SAME IN EVERY COUNTRY?"

Section	Time	Key Ideas	Presentation Text
Title	10 sec	Topic introduction	*Today I will talk about whether all laws should be the same in every country.*
Introduction	50–60 sec	• Laws organize social life • Different legal systems	*Laws organize social life and help maintain order. However, legal systems are different in each country. This raises the question of whether laws should be the same everywhere or different.*
Arguments FOR the Same Laws	1–1.5 min	• Equal rights for all • International cooperation • Strong human rights protection	*Supporters of the same laws argue that they ensure equal rights for all people. Common laws can improve international cooperation and strengthen human rights protection. This is especially important in a globalized world.*
Human Rights	1–1.5 min	• Universal basic rights • Life, freedom, dignity • Global agreements	*Human rights are often considered universal. Basic rights such as life, freedom, and human dignity should be protected everywhere. Many countries support these rights through international agreements.*
Arguments AGAINST the Same Laws	1–1.5 min	• Different cultures • Religious values • Political & economic differences	*Opponents believe that the same laws cannot work everywhere. Countries have different cultures, religions, and political or economic systems, which strongly influence their laws.*
Cultural Differences	50–60 sec	• National identity • One size doesn't fit all • Respecting traditions	*Laws are closely connected to national identity. One legal system does not fit all countries, so traditions and cultural values must be respected.*
Compromise	40–50 sec	• Universal core laws • Flexible national laws • Global & local balance	*A possible compromise is to have universal core laws, especially for human rights, while allowing countries to adapt their national laws to local conditions.*
Conclusion	30–40 sec	• Not all laws should be the same • Universal principles • Diversity is effective	*In conclusion, not all laws should be the same. Universal principles are important, but legal diversity can be more effective. A balance between global values and national traditions is the best solution.*

Figure 2. Slide of an oral presentation plan at the formative level of the study

At ***the summative stage***, students presented a final poster presentation lasting 5-7 minutes with oral support and answers to questions from the audience. The final presentation was a full-fledged extended presentation using a poster or slides and demonstrating all components of interactive interaction. Assessment was carried out according to the same criteria, which ensured data compatibility at all stages of the study. An example of a final presentation poster is presented in *Figure 3*.

Figure 3. Final poster presentation at the summative stage of the study

Quantitative analysis included calculation of mean values (M) for each criterion and comparative analysis of results at three stages of preparation and evaluation.

Student participation in the study was voluntary. All materials were used exclusively for research purposes in compliance with the principles of confidentiality and academic integrity. Students were informed about the objectives of the study, evaluation criteria and permissible forms of use of artificial intelligence tools.

Research Results

Quantitative analysis of the research results was aimed at identifying the dynamics of the development of students' oral communicative competence in the process of project-based learning using poster presentation. The assessment was carried out at the diagnostic, formative, and summative stages using six criteria of the analytical multilevel scale. For each criterion, the average values (M) were calculated.

As presented in *Table 1*, at the diagnostic stage, the average indicators for all criteria ranged from 2.0 to 2.6 points. The lowest values were recorded for the criteria of interactivity and use of communicative strategies, which indicate the limited experience of students in managing oral interaction and performing various communicative roles in an academic context.

At the formative stage, a steady increase in indicators was observed for all criteria. The most positive dynamics was recorded for the criteria of interactivity and the use of communicative strategies, which indicates the high effectiveness of process-oriented forms of learning (group discussions, rehearsals, role-playing) in the development of these components of communicative competence.

At the summative stage, the average indicators for most criteria remained in the range of 2.9–3.3 points. At the same time, a slight decrease was recorded for the criteria of interactivity and the use of communicative strategies compared to the formative stage, which may be due to the increased cognitive load of the final speech and focusing of students on the content and structuring of the presentation.

Table 1

Average values (M) according to the criteria of oral communicative competence at different stages of assessment (n = 48)

Criteria	**Diagnostic stage (M)**	**Formative stage (M)**	**Summative stage (M)**	Growth (%)
Communicative clarity	2,8	3,4	3,9	+39%
Speech organization	2,6	3,3	3,8	+46%
Lexical and grammatical correctness	3,0	3,5	3,9	+30%
Interactivity	2,4	3,2	3,7	+54%
Communicative strategies	2,5	3,3	3,8	+52%
Academic and ethical correctness (including AI)	2,9	3,6	4,1	+41%

As shown in *Table 1*, for all criteria, there is an increase in average scores from the diagnostic to the summative stage, which indicates a positive impact of process-oriented assessment on the development of students' oral communication.

The most pronounced dynamics is recorded for the interactivity criterion (increase +54%). At the diagnostic stage, this indicator had the lowest average value (M = 2.4), which reflected the limited ability of students to interact with the audience, ask clarifying questions and respond to communicative requests. By the summative stage, the average score increased to M = 3.7, which indicates the development of interactive skills in the process of group work, rehearsals and feedback.

A comparable positive dynamics is observed for the criterion of using communicative strategies (increase +52%). The increase in indicators according to this criterion reflects the formation of students' ability to consciously perform various communicative roles in project activities (speaker, moderator, discussion participant). This confirms the importance of procedural stages of project preparation, which are rarely taken into account in traditional assessment.

The indicators of oral expression organization also show significant growth (+46%). If at the diagnostic stage students often presented information fragmentarily and without a clear structure (M = 2.6), then by the final presentation most participants were able to logically build a speech with a clear introduction, main part and conclusion (M = 3.8). This indicates the development of speech planning and structuring skills during phased project work.

According to the criterion of communicative clarity, an increase of 39% was recorded, which indicates the coherence of statements and the ability to adapt speech to the audience. It should be noted that the improvement of this indicator occurred gradually and was due, in our opinion, to formative feedback in the form of rehearsals and discussions with the teacher at the stage of project preparation.

Relatively less pronounced growth is observed according to the criterion of lexical and grammatical adequacy (+30%). However, the increase in the average score from M = 3.0 to M = 3.9 indicates a more appropriate and conscious use of language tools in oral academic communication.

Special attention is paid to the criterion of academic and ethical correctness (taking into account the use of AI), for which an increase of +41% was recorded. The results show that the inclusion of this criterion in the analytical rubric contributed to the formation of a more responsible attitude among students towards the use of artificial intelligence tools. At the summative stage, students more often demonstrated the conscious use of AI as an auxiliary tool, rather than a source of ready-made oral formulations.

Additional analysis of individual trajectories of students was aimed at identifying temporal differences in the manifestation of interactive and strategic components of oral communication, which is demonstrated in *Table 2*. Comparison of the results of the formative and summative stages showed that all participants in the study (n = 48) demonstrated a high level of final oral performance. At the same time, 13 students (27%) had high indicators according to the criteria of interactivity and use of communicative strategies (M ≥ 3.5) already at the formative stage, while the remaining students had a similar level of these components mainly at the summative stage. This indicates differences in the time of formation and demonstration of communicative skills and confirms the importance of procedural assessment for identifying individual dynamics of oral communication development.

Table 2

Time distribution of achieving a high level of interactive and strategic skills

Student group	**Number of students**	**Percentage (%)**
High level at the formative stage (M ≥ 3.5)	13	27
High level achieved primarily at the summative stage	35	73
Total	**48**	**100**

The obtained data demonstrate that the use of an analytical rubric and the inclusion of a formative assessment stage allow us to record the development of interactive and strategic components of oral communication, which are not always fully reflected in the results of the final presentation. This confirms the limitations of an assessment based solely on summative indicators and emphasizes the validity of a procedurally oriented approach to assessing oral communication in project-based learning.

Discussion of the results

Analysis of data obtained at the diagnostic, formative and summative stages indicates a positive dynamics of the development of oral communicative competence of first-year students. The most noticeable changes were observed in the increase in clarity and coherence of oral statements, increased confidence in oral explanation of the content of the poster, as well as more active participation of students in group discussions.

Students who demonstrated fragmentary oral speech at the diagnostic stage were mostly able to logically present the main ideas of the project by the time of final presentation, relying on visual material and their own oral comments, rather than on the memorized text.

The results of observations and analysis of reflective materials show that formative assessment has become a significant factor in the development of oral communication. Regular feedback contributed to more successful speech, the correction of mistakes in the process of preparation and the reduction of anxiety before public speaking. The practice of self-assessment and mutual assessment allowed students to critically reflect on their own role in the project and the level of their oral communicative activity. Formative assessment can be considered important for the development of interactive and strategic aspects of speech. The preparation process increases the objectivity and validity of the final assessment, especially in conditions of active use of artificial intelligence tools.

Comparison of formative assessment data with the results of the final poster presentation confirms the reasonableness of shifting the emphasis from the product to the process of preparation, especially in conditions of active use of AI. Oral presentation and discussion allowed to reveal the real level of understanding of the content of the project, which increased the validity and correctness of the assessment and reduced the risk of formal performance of the task.

Limitations

This study has a number of limitations that should be considered when interpreting the results.

First, the study was conducted within a single educational module and included a limited number of first-year students studying a foreign language at level B2. This limits the possibility of generalizing the findings to other levels of language training, educational contexts and disciplines.

Second, the assessment of oral communication relied mostly on the expert opinion of the teacher, which has the risk of being subjective, despite the use of analytical criteria and descriptors.

These limitations identify areas for further research, including expanding the sample, involving control groups and developing mechanisms to increase the reliability and objectivity of oral assessment.

Conclusion

The results of the study confirm that the process-oriented assessment model contributes to increasing the objectivity and transparency of the assessment of oral communication of first-year students, the development of their educational autonomy and a more complete accounting of real communicative activity in the conditions of project-based learning.

The proposed model allows you to shift the emphasis from formal control of the final product to the assessment of the process of forming oral communicative competence, which is especially important in the conditions of the widespread use of artificial intelligence tools. Multi-stage assessment, which includes diagnostic, formative, and summative stages, provides a more valid idea of the development of oral speech and meets modern methodological and ethical requirements of higher education.

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ІНТЕГРАЦІЯ ЦИФРОВИХ ІНСТРУМЕНТІВ В ОСВІТНІ КОМПОНЕТИ МАТЕМАТИЧНОГО ЦИКЛУ У ЗВО

Цись Я.
Асистент кафедри математики та інформатики ДЗ «Луганський національний університет імені Тараса Шевченка», Лубни, Україна
https://*orcid.org/0000-0003-1383-4111*

INTEGRATION OF DIGITAL TOOLS INTO THE EDUCATIONAL COMPONENTS OF THE MATHEMATICS CYCLE IN HIGHER EDUCATION INSTITUTIONS

Tsys Y.
Assistant of the Department of Mathematics and Informatics Luhansk Taras Shevchenko National University,
Lubny, Ukraine
https://orcid.org/0000-0003-1383-4111
DOI: 10.5281/zenodo.18677896

Анотація

У статті розглянуто особливості інтеграції цифрових інструментів освітні компоненти математичного циклу у закладах вищої освіти. Акцент зроблено на підвищенні якості навчання, розвитку математичної та цифрової компетентностей здобувачів, а також створенні інтерактивного освітнього середовища на основі сучасних технологій.

Abstract

The article examines the specific features of integrating digital tools into the educational components of the mathematics cycle in higher education institutions. The focus is placed on improving the quality of learning, developing students' mathematical and digital competencies, and creating an interactive educational environment based on modern technologies.

Ключові слова: цифрові інструменти; цифрова компетентність; інтерактивне навчання; освітні технології; цифровізація освіти.

Keywords: digital tools; higher education institutions; digital competence; interactive learning; educational technologies; digitalization of education.

Актуальність проблеми

Актуальність інтеграції цифрових інструментів в освітні компоненти математичного циклу у закладах вищої освіти зумовлена глибокими змінами, що відбуваються у сучасному освітньому просторі під впливом цифрової трансформації. Математична підготовка традиційно вимагає високого рівня абстракції, точності та логічного мислення, а тому потребує інструментів, здатних забезпечити наочність, динамічність і доступність складних понять. Використання цифрових технологій – від систем комп'ютерної алгебри та динамічних математичних середовищ до інтерактивних платформ моделювання й аналітичних сервісів – відкриває нові можливості для поглибленого опрацювання матеріалу, індивідуалізації навчання та розвитку дослідницьких навичок здобувачів.

У контексті модернізації вищої освіти цифрові інструменти стають не лише допоміжним ресурсом, а й необхідною умовою формування цифрової та математичної компетентностей, що визначені ключовими у сучасних професійних стандартах [11] . Вони сприяють переходу від репродуктивних форм навчання до інтерактивних, проблемно-орієнтованих і практико-спрямованих підходів, що відповідають потребам ринку праці та вимогам STEM-освіти. Крім того, цифровізація математичних дисциплін забезпечує можливість оперативного зворотного зв'язку, адаптивного оцінювання, дистанційної взаємодії та створення гнучкого освітнього середовища, здатного швидко реагувати на виклики часу.

Таким чином, інтеграція цифрових інструментів у математичний цикл є важливим чинником підвищення якості освіти, розвитку інноваційної культури викладання та підготовки конкурентоспроможних фахівців, здатних ефективно працювати в умовах цифрової економіки.

Аналіз публікацій

Проблематика інтеграції цифрових інструментів у навчальні дисципліни математичного циклу активно висвітлюється у працях як українських, так і зарубіжних дослідників. Значний внесок у розвиток теоретичних і методичних засад цифровізації математичної освіти зробили М. Жалдак [1], Ю. Триус [2], С. Семеріков [3], О. Співаковський [4], які у своїх роботах обґрунтовують необхідність використання комп'ютерно орієнтованих методичних систем, динамічних математичних середовищ та електронних освітніх ресурсів у підготовці здобувачів.

Зокрема, М. І. Жалдак [1] підкреслює роль інформаційно-комунікаційних технологій у формуванні математичної компетентності та обґрунтовує методичні підходи до використання комп'ютерної візуалізації у вищій школі. Ю. В. Триус [2] досліджує можливості систем комп'ютерної математики (Maple, Mathematica) та електронних навчальних середовищ для організації інтерактивного навчання математичних дисциплін. С. О. Семеріков [3] та співавтори аналізують потенціал хмарних сервісів, мобільних застосунків і змішаного навчання для модернізації математичної підготовки здобувачів технічних спеціальностей.

Серед зарубіжних дослідників значну увагу привертають роботи M. Hohenwarter [5], автора та дослідника середовища GeoGebra, який у своїх публікаціях демонструє ефективність динамічної математики для розвитку візуального мислення та дослідницьких навичок здобувачів. D. Tall [6] та D. Kaput [7] аналізують вплив цифрових технологій на формування математичних понять і когнітивні процеси у здобувачів. J. Borwein [8] та K. Devlin [9] підкреслюють роль комп'ютерних інструментів у сучасних математичних дослідженнях і навчанні, акцентуючи на зміні характеру математичної діяльності під впливом цифровізації.

Окремий напрям становлять дослідження, присвячені цифровій компетентності викладачів. У працях L. Mishra [10] та M. Koehler [10] (модель TPACK) обґрунтовується необхідність поєднання педагогічних, технологічних і предметних знань для ефективної інтеграції цифрових інструментів у викладання математики. A. Redecker [11] та експерти Європейської комісії у рамках моделі DigCompEdu визначають компетентнісний підхід до цифрової педагогіки, що є релевантним для підготовки викладачів математичних дисциплін.

Таким чином, аналіз наукових джерел свідчить, що питання цифровізації математичної освіти розглядається у широкому контексті: від методичних аспектів використання динамічних математичних середовищ і систем комп'ютерної алгебри до формування цифрової компетентності викладачів та здобувачів. Дослідження провідних учених підтверджують, що цифрові інструменти є ключовим чинником модернізації математичної підготовки у ЗВО та потребують системного методичного й організаційного забезпечення.

Мета роботи

Метою роботи є всебічне обґрунтування підходів до інтеграції цифрових інструментів в освітні компоненти математичного циклу у закладах вищої освіти, спрямованих на підвищення ефективності та якості навчального процесу. Передбачається визначити педагогічні та методичні засади використання сучасних цифрових ресурсів, окреслити їхній потенціал для розвитку математичної, цифрової та дослідницької компетентностей здобувачів, а також обґрунтувати умови, за яких цифрові технології сприятимуть модернізації змісту, форм і методів навчання математики у ЗВО.

Виклад основного матеріалу досліджень

Інтеграція цифрових інструментів у навчальні дисципліни математичного циклу передбачає не лише використання окремих технологічних рішень, а й формування цілісної цифрової дидактичної системи, у якій кожен інструмент виконує чітко визначену функцію. Така система забезпечує багаторівневу підтримку навчального процесу: від пояснення нового матеріалу до організації самостійної роботи, контролю знань і реалізації проєктної діяльності. Важливо, що цифрові технології дозволяють поєднати абстрактний характер математичних понять із можливістю їх наочної, динамічної та інтерактивної репрезентації, що значно підвищує якість засвоєння.

На етапі пояснення нового матеріалу ключову роль відіграють динамічні математичні середовища GeoGebra та Desmos. Їх використання дає змогу перейти від статичних зображень до інтерактивних моделей, у яких здобувач може самостійно змінювати параметри, спостерігати за поведінкою функцій, аналізувати вплив коефіцієнтів на форму графіка, досліджувати геометричні перетворення. Такий підхід сприяє формуванню інтуїтивного розуміння математичних закономірностей, що є особливо важливим у курсах математичного аналізу, аналітичної геометрії та дискретної математики. Використання динамічних моделей також дозволяє викладачеві оперативно реагувати на труднощі здобувачів, демонструвати альтернативні способи розв'язання задач, пояснювати складні поняття через візуальні аналогії.

Під час практичних занять доцільно застосовувати MATLAB, Maple та Wolfram Alpha, які забезпечують виконання складних символьних і числових обчислень, моделювання математичних процесів, аналіз даних і перевірку гіпотез. Ці інструменти дозволяють здобувачам працювати з реалістичними задачами, що потребують значних обчислювальних ресурсів, і зосереджуватися не на технічних операціях, а на змістовному аналізі результатів. Наприклад, у Maple можна досліджувати поведінку розв'язків диференціальних рівнянь, у MATLAB моделювати динамічні системи, у Wolfram Alpha швидко перевіряти правильність обчислень або будувати складні графіки. Такий підхід формує дослідницькі навички, уміння працювати з математичними моделями та інтерпретувати результати, що є важливою складовою професійної компетентності майбутніх фахівців.

Організація самостійної роботи здобувачів значною мірою залежить від можливостей LMS-платформ Moodle і Google Classroom. Вони забезпечують доступ до відеолекцій, інтерактивних завдань, тестів з автоматичною перевіркою, електронних тренажерів, що дозволяє здобувачам працювати у власному темпі та отримувати миттєвий зворотний зв'язок. LMS також підтримують адаптивне навчання: система може пропонувати додаткові матеріали тим, хто потребує повторення, або складніші завдання здобувачам із високим рівнем підготовки. Це сприяє індивідуалізації навчального процесу та формуванню навичок самоорганізації, що є важливими складовими цифрової компетентності.

У проєктній діяльності ефективним є використання хмарних сервісів Google Docs, Sheets і Slides, які забезпечують можливість спільної роботи над математичними задачами, аналітичними звітами та дослідницькими проєктами. Здобувачі можуть одночасно редагувати документи, коментувати розв'язання, обговорювати різні підходи, аналізувати дані, будувати графіки та моделі. Поєднання хмарних сервісів із математичними пакетами дозволяє створювати комплексні проєкти, що включають обчислення, моделювання, інтерпретацію результатів і презентацію висновків. Такий формат сприяє розвитку комунікаційних навичок, уміння працювати в команді, критично мислити та застосовувати математичні методи до реальних задач.

Для контролю знань і рефлексії навчального процесу доцільно використовувати інтерактивні платформи Kahoot, Quizizz і Mentimeter, а також аналітичні інструменти LMS. Вони дозволяють швидко оцінити рівень засвоєння матеріалу, виявити типові помилки, визначити теми, що потребують додаткового опрацювання. Гейміфіковані формати Kahoot і Quizizz підвищують мотивацію здобувачів, знижують тривожність, пов’язану з оцінюванням, і сприяють активній участі навіть тих, хто зазвичай не проявляє ініціативи. Mentimeter забезпечує можливість збору відкритих відповідей, ранжування варіантів, створення хмари слів, що є ефективним інструментом для рефлексії та обговорення складних тем.

Важливою умовою ефективної інтеграції цифрових інструментів є готовність викладача до проєктування цифрового освітнього середовища. Це передбачає не лише володіння технічними навичками, а й уміння методично обґрунтовувати вибір інструментів, поєднувати їх із традиційними методами навчання, забезпечувати педагогічний супровід і підтримку здобувачів. Не менш важливою є наявність технічної інфраструктури, доступу до інтернету та цифрових пристроїв, що гарантує рівні можливості для всіх учасників освітнього процесу.

Таким чином, інтеграція цифрових інструментів в освітні компоненти математичного циклу забезпечує комплексну модернізацію освітнього процесу, підвищує його наочність, гнучкість і практичну спрямованість, сприяє розвитку математичної, цифрової та дослідницької компетентностей здобувачів. Цифрові технології не лише підсилюють традиційні методи навчання, а й створюють умови для формування нового типу математичної освіти, орієнтованої на потреби сучасного цифрового суспільства.

Висновки

Узагальнюючи, можна стверджувати, що якісно підібраний цифровий інструментарій для навчальних дисциплін математичного циклу виконує комплекс взаємопов’язаних функцій: організаційно-управлінську (Moodle, Google Classroom), когнітивно-візуалізаційну та дослідницьку (GeoGebra, Desmos, Wolfram Alpha, MATLAB, Maple), комунікативно-колаборативну (Google Docs, Sheets, Slides), мотиваційно-контрольну (Kahoot, Quizizz, Mentimeter) та комунікаційно-підтримувальну (Zoom, Google Meet, MS Teams). Їх інтеграція не зводиться до механічного додавання окремих сервісів у навчальний процес, а передбачає цілеспрямоване проєктування цифрового освітнього середовища, у якому кожен інструмент використовується відповідно до дидактичної мети, змісту теми, рівня підготовленості здобувачів. Такий підхід дозволяє не лише підвищити якість математичної підготовки, а й сформувати в здобувачів здатність ефективно працювати з цифровими ресурсами, критично оцінювати результати обчислень і моделювання, застосовувати математику для розв’язання реальних задач у контексті сучасної цифрової економіки.

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PHILOLOGY

NEW APPROACHES IN THE STUDY OF VERB CATEGORIES IN FRENCH AND AZERBAIJANI LANGUAGES

Aliyeva H.
Doctoral Student at Nakhchivan State University
https://orcid.org/0009-0003-2035-4252
DOI: 10.5281/zenodo.18677904

Abstract

This article presents a comparative study of verb categories in French and Azerbaijani, introducing new methodological approaches in language instruction. The morphological and syntactic structures of verb systems are analyzed in the context of tense, person, and conjugation categories. The aim is to identify similarities and differences between these two languages from distinct language families, and to propose more effective and inclusive education-oriented teaching strategies.

The study also examines how these approaches affect students' language skills development and overall quality of life. Among the new methods are contextual learning, interactive grammar applications, and reflective teaching techniques applied in bilingual environments. The results show that functional and context-based grammar instruction improves learners' ability to use the language in daily life and creates equal opportunities in the educational process.

This research offers practical recommendations for both language teachers and policy makers, while also contributing to the UN Sustainable Development Goals, particularly inclusive education and quality of life.

Keywords: inclusive education, quality of life, equal access, learning opportunities, innovation, lifelong learning.

1. Introduction

This article explores new approaches to the study of verb categories in French and Azerbaijani languages, focusing on their structural and functional characteristics. As members of two distinct language families—Romance and Turkic—French and Azerbaijani exhibit fundamentally different grammatical systems, particularly in the domain of verb morphology and syntax. French, being a fusional language, conveys grammatical meanings through inflections, stem changes, and auxiliary verbs, resulting in complex verb forms. In contrast, Azerbaijani, as an agglutinative language, forms grammatical categories primarily through the linear addition of suffixes to the verb root, allowing for greater morphological transparency.

The article adopts a contrastive linguistic perspective to examine categories such as tense, mood, aspect, voice, and person, and how these are constructed and used in both languages. Additionally, it considers pedagogical implications for bilingual learners and proposes innovative teaching methods that integrate contextual grammar instruction, inclusive education practices, and digital tools. This research contributes to both theoretical linguistics and applied language teaching, aiming to enhance cross-linguistic understanding and support more effective language acquisition strategies in multilingual educational settings. The study is also aligned with global educational priorities such as sustainable development and quality education.

Research question (s)

2. Review of the literature

Since French and Azerbaijani belong to different language families, their verb systems differ significantly in both structure and function. Azerbaijani, as a member of the Turkic language family, is agglutinative—meaning that suffixes are added to the root of a word to create meaning. French, on the other hand, belongs to the Romance language group and is primarily inflectional, where grammatical forms of verbs are expressed through changes in the root and the use of endings. This structural difference has a strong impact on how the categories of tense, person, mood, and aspect are presented and learned.

In Azerbaijani, verbs are conjugated in both simple and analytic forms. The tense category is divided into three main parts: past, present, and future. These tenses are mostly expressed through suffixes attached to the verb root or stem. For example, in the forms "yazdı" (wrote), "yazır" (is writing), and "yazacaq" (will write), the meaning of the verb is clearly conveyed through tense suffixes. The person category is also expressed through suffixes, often making personal pronouns unnecessary, as the suffix itself indicates the subject. Additionally, moods such as imperative, indicative, and optative add various modal and functional nuances to the meaning of the verb. This structure helps students better understand the logical and systematic nature of grammar, which is particularly useful for delivering quality education [https://unesdoc.unesco.org/ark:/48223/pf0000373718].

In French, verb categories have a more complex structure. Verbs are divided into three groups: Group I ending in -er, Group II ending in -ir, and the irregular verbs in Group III. Verb forms change quickly according to tense and person, and in many cases, compound tenses are formed using auxiliary verbs (avoir and être). The tense system is more extensive, including présent (present), passé composé (perfect), imparfait (imperfect), futur simple (simple future), plus-que-parfait (pluperfect), among others. The formation and use of these tenses may pose additional challenges for learners, as proper usage often depends on both form and context. In French, verbs change according to person with specific endings, and the use of subject pronouns is necessary. For instance, forms like "je parle" (I speak) and "ils parleront" (they will speak) must include pronouns.

When comparing the two, it is important to note that while the categories of tense and person are central in both languages, the methods of expression differ. Azerbaijani presents these categories more simply through suffixes, while French involves various changes and exceptions in grammatical forms. These differences can present both challenges and opportunities for learners by contributing to the development of linguistic thinking.

This structural comparison plays a crucial role for teachers in planning instructional strategies and ensuring equal access for students. Emphasizing the functional characteristics of verbs in both languages and applying a contextual approach can enhance learning opportunities and foster a more inclusive educational environment. This approach not only improves students' language proficiency but also lays the foundation for an effective teaching model that enhances their overall quality of life [Y. A. Korkmaz, 2005, p. 147–152].

Table 1

Comparison table of verb categories: Azerbaijani vs. French

Category	Azerbaijani language	French language
Language family	Turkic language (agglutinative)	Romance language (fusional/flexional)
Verb stem	Stays constant; grammatical meaning added via suffixes	Can change, especially in irregular verbs
Tenses	Past, present, future	Présent, passé composé, imparfait, futur simple, plus-que-parfait, etc.
Tense Formation	Formed with suffixes (e.g., yazdı, yazır, yazacaq)	Verb endings + auxiliary verbs (e.g., j'ai parlé, nous parlerons)
Person markers	Person suffixes; pronouns often omitted	Each person has a distinct ending; pronouns are always used
Verb moods	Indicative, imperative, wish, conditional	Indicatif, impératif, subjonctif, conditionnel
Verb types	Main, auxiliary, participle, infinitive	Transitive, intransitive, reflexive, auxiliaries (avoir, être)
Conjugation system	Simple and consistent, based on suffixes	Complex with many rules and exceptions
Verb groups	Not divided into groups	Divided into 3 groups: 1st (-er), 2nd (-ir), 3rd (irregular)
Difficulty level	Moderate – relies on linear suffix addition	High – due to number of tenses and irregularities
Recommended teaching approach	Context-based learning, focus on suffix patterns	Use of conjugation tables, sentence examples, tense-based exercises

The Azerbaijani and French languages belong to different language families, which is clearly reflected in the structure and use of their verb systems. Despite these differences, there are also some notable similarities. In both languages, the verb is a core part of speech that expresses actions, states, or processes and typically functions as the predicate of a sentence. Verbs in both Azerbaijani and French change according to tense (past, present, future), person (first, second, third), and mood (indicative, imperative, conditional, etc.). In addition, both languages use auxiliary verbs to form compound tenses — "olmaq" in Azerbaijani and "avoir" or "être" in French. Furthermore, both systems include non-finite verb forms such as infinitives (e.g., yazmaq / parler), participles, and verbal adverbs, which are used to form complex sentence structures.

The most striking differences lie in the morphological structure of the languages. Azerbaijani is an agglutinative language, meaning grammatical categories are expressed by adding suffixes to a stable verb root in a linear and consistent order. This creates a logical and transparent verb system that is relatively easy to learn and predict. In contrast, French is a fusional (inflectional) language, where the verb endings change according to tense and person, and the verb root itself may also change, especially in irregular verbs. This often requires learners to memorize multiple forms and conjugation tables, making the learning process more complex.

In Azerbaijani, personal markers are added to the verb, so subject pronouns are usually not necessary. For example, the verb gedirəm (I am going) already indicates the subject through the suffix -əm. In French, subject pronouns are mandatory because verb endings alone are not always sufficient to identify the subject—e.g., je vais (I go), tu vas (you go), il va (he goes).

When it comes to tenses, Azerbaijani has three primary tenses—past, present, and future—which are formed by adding specific suffixes to the verb root. French, on the other hand, has a more complex tense system including both simple and compound tenses such as présent, passé composé, imparfait, futur simple, plus-que-parfait, and others. These tenses often require the use of auxiliary verbs and follow distinct conjugation patterns depending on the verb group [https://www.coe.int/en/web/common-european-framework-reference-languag].

Verb grouping is another point of difference. Azerbaijani verbs are not divided into formal conjugation groups. French verbs, however, fall into three main groups based on their infinitive endings: the first group (-er), the second group (-ir), and the third group (irregular verbs). Each group follows different conjugation rules, and third-group verbs tend to have multiple irregularities.

These differences highlight the importance of using appropriate teaching strategies. The logical and regular nature of Azerbaijani verbs makes them suitable for step-by-step, rule-based instruction. French verbs, due to their complexity and exceptions, benefit from contextual teaching methods, conjugation tables, and repetitive practice. Understanding these similarities and differences allows educators to design more effective and inclusive teaching approaches that promote quality education, equal access, and better learning opportunities for all language learners [S.D. Krashen, 1982, p. 78–81].

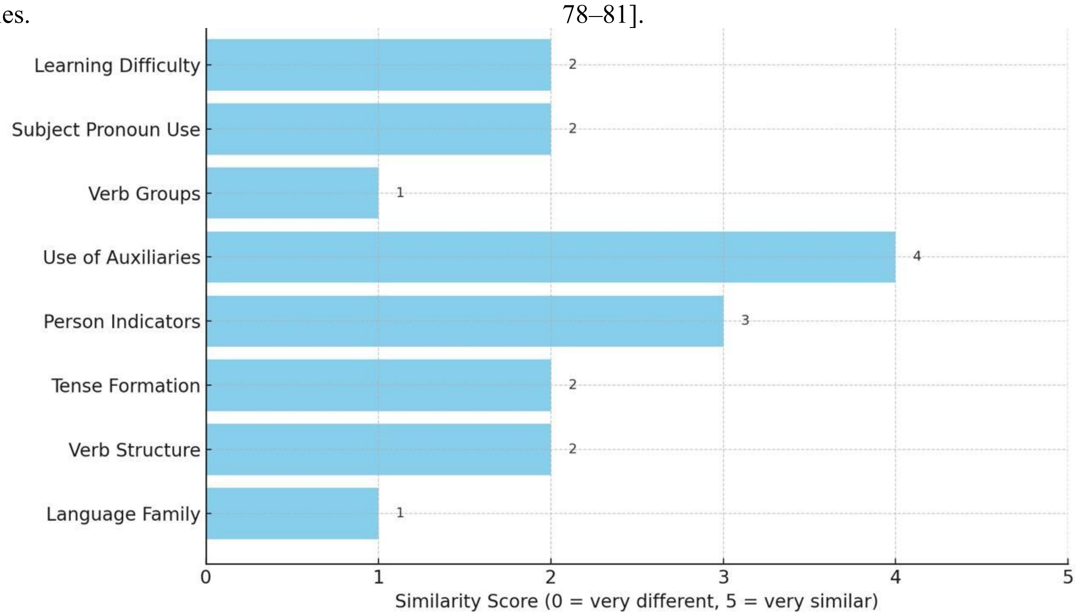

Figure 1. Similarity of verb categories: Azerbaijani vs. French

In modern language education—especially in the context of foreign and second language learning—traditional grammar-based methods are gradually being replaced by functional and communicative approaches. Among these, contextual teaching plays a particularly important role. Contextual teaching refers to learning language through real-life situations, everyday communication, and practical contexts. It enables students to internalize the language not only theoretically, but also in real-life usage.

When teaching the verb systems of Azerbaijani and French, contextual approaches allow students to relate grammatical rules to meaningful situations instead of memorizing them in isolation [J. Cummins, 2000, s. 99–103]. For example, learning the future tense through sentences like "sabah kinoya gedəcəyəm" or "je vais au cinéma demain" helps learners understand both the structure and how it is applied in a daily context. In this way, language becomes more meaningful and memorable.

One of the major advantages of contextual teaching is its alignment with inclusive and personalized learning. Students from different social, cultural, and educational backgrounds can engage with the material in a way that connects to their own experiences. This approach promotes equal access to education, helps reduce inequalities, and contributes to the goal of quality education for all.

The contextual method fosters functional literacy and real communication skills. Verb forms and tenses are not just presented through tables, but also through dialogues, scenarios, role-plays, and project-based tasks. This makes learning more engaging and increases learners' motivation to use the language actively.

Contextual teaching places the learner and their real-world experience at the center of the educational process. It ensures the development of not only grammatical knowledge but also practical communication, critical thinking, and cultural awareness. For these reasons, the application of contextual methods in Azerbaijani and French language teaching should be regarded as a key component of inclusive and sustainable teaching strategies [R.M. Quliyev, 2010, p. 85–90].

Table 2.

Comparison: traditional vs. contextual language teaching

Feature	Traditional teaching	Contextual teaching
Teaching focus	Grammar rules and memorization	Language use in real situations
Learning environment	Textbook-centered, rigid	Flexible, student-centered
Content delivery	Lectures, drills, rule explanation	Dialogues, tasks, real scenarios
Student role	Passive listener	Active participant
Teacher role	Knowledge transmitter	Facilitator and guide
Assessment type	Written tests on grammar	Performance-based, formative
Skills developed	Grammatical accuracy	Communication, critical thinking
Inclusivity level	Low	High
Connection to real life	Minimal	Strong

In modern education, language learning is no longer limited to textbooks and teacher-led grammar explanations on the board. With the integration of technology into pedagogy, interactive grammar applications have become an essential part of language acquisition. These tools make grammar more than just a set of rules to memorize—they turn it into a practical, usable skill. For students learning structurally different languages like Azerbaijani and French, interactive tools provide inclusive, personalized, and functional learning opportunities. These approaches enhance not only language proficiency but also overall quality of life by empowering learners with real-world communication skills.

Azerbaijani, as an agglutinative language, forms verbs through the linear addition of suffixes (e.g., gedəcəyəm, oxuyurdu, yazarsan). In contrast, French is a fusional language in which both the verb root and endings change depending on tense and person (e.g., je vais, tu iras, ils sont partis). These structural differences require different teaching strategies—an area where interactive grammar platforms are especially beneficial.

For French, the large number of tenses and irregular verbs can be overwhelming for learners. However, applications like Conjuguemos, Wordwall, and Quizlet allow students to practice verb forms in context by choosing the correct conjugation, filling in missing endings, or correcting grammar mistakes—all with instant feedback. In Azerbaijani, platforms such as Live Worksheets, Educandy, or custom teacher-made tasks can help reinforce tense and mood suffixes through interactive, hands-on activities [A.G. Banguoğlu, 2000, p. 95–98].

One of the greatest advantages of interactive grammar tools is their role in promoting equal access to learning. Students learning either French or Azerbaijani may come from diverse backgrounds, regions, or learning levels. Interactive platforms allow them to engage with content anytime and anywhere, without relying solely on classroom instruction. This contributes to reducing inequalities in education by ensuring that every student—regardless of their location or resources—can participate fully in the learning process.

Interactive grammar tools strongly support inclusion. These tools can be adapted for various learning styles—visual, auditory, and kinesthetic—making them suitable for a wide range of learners. Students not only read but also hear, interact with, and even speak the target language as they engage with grammar exercises. For example, a student learning the past tense in French might listen to an audio clip of il a parlé, match it with an image, and then complete a sentence with the correct form. Similarly, in Azerbaijani, a student might say aloud a verb like oxuyurdu, complete it in a sentence, and reinforce it through drag-and-drop exercises.

Research and classroom practice show that students using interactive grammar platforms make faster and more sustained progress. These methods enhance student engagement, foster a sense of ownership, and support self-assessment. As a result, students gain not only grammatical accuracy but also functional communication skills and cultural competence, both of which are vital in real-life use of language.

The use of interactive grammar applications in teaching Azerbaijani and French directly supports the goals of quality education and inclusive teaching. These technologies transform learning from a passive experience into an active, student-centered process that equips learners with real-world skills. They help to democratize education by providing equal learning opportunities for all and make language acquisition more accessible, engaging, and effective in both local and global contexts [M.H. Vəliyev, 2012, p. 112–115].

Table 3.

Comparison: Traditional grammar teaching vs. ınteractive grammar applications

Aspect	Traditional grammar teaching	Interactive grammar applications
Learning style support	Mainly visual, limited flexibility	Supports visual, auditory, kinesthetic learners
Accessibility	Limited to classroom time	Available anytime, anywhere
Adaptability to levels	One-size-fits-all approach	Adaptive and personalized
Engagement	Low to moderate	High (gamified, dynamic content)
Feedback speed	Delayed (via teacher review)	Instant, real-time feedback
Suitability for french	Partial – relies heavily on memorization	Strong – contextual and varied practice
Suitability for azerbaijani	Basic – limited interactive methods	Strong – suffix pattern recognition, instant drills
Supports ınclusion	Low	High
Contributes to SDGs	Minimal	Strong alignment (SDG 4: Quality Education, SDG 10: Reduced Inequalities)

In the evolving landscape of 21st-century education, the role of the teacher has shifted from being a transmitter of knowledge to a facilitator of thinking and learning. One of the most impactful methodologies that supports this shift is reflective teaching—a process that involves consciously analyzing teaching and learning experiences to improve future outcomes. In the context of language instruction, particularly for linguistically diverse and structurally distinct languages such as Azerbaijani and French, reflective teaching holds transformative potential. It serves as a bridge between student-centered learning, individual cognitive development, and inclusive pedagogy, aligning strongly with global goals such as SDG 4 (Quality Education) and SDG 10 (Reduced Inequalities).

Reflective teaching finds its roots in constructivist and experiential learning theories. Thinkers such as John Dewey, Donald Schön, and David Kolb emphasized that learners construct knowledge best when they reflect on their experiences. According to Dewey, "We do not learn from experience… we learn from reflecting on experience." This principle is especially crucial in language learning, where students are constantly processing new rules, cultural norms, and communicative strategies.

Reflective teaching is not limited to self-observation—it requires intentional inquiry: What happened? Why did it happen? What can be improved? It involves students and teachers engaging in metacognition (thinking about thinking), which increases awareness of one's learning processes, patterns, and needs.

Teaching Azerbaijani and French side by side brings a unique set of pedagogical complexities. Azerbaijani, as an agglutinative language, constructs meaning through the linear addition of suffixes. Verb tenses, moods, and aspects are built through consistent morphological patterns (e.g., gedirəm, getdi, gedəcək). In contrast, French is a fusional language, where verb roots often change irregularly, and tenses may require auxiliary verbs (e.g., je vais, nous sommes allés, ils avaient parlé) [M. Haspelmath, 2002, p. 154–157].

These structural differences necessitate differentiated instruction and context-sensitive strategies. Reflective teaching provides a framework through which both students and teachers can identify linguistic barriers, adapt instruction accordingly, and document learning growth over time.

For students, reflection fosters learning autonomy. After completing a task in Azerbaijani, a learner might reflect: "Did I use the correct suffix for the future tense?", "Why did I confuse getdi and gedəcək?" Similarly, a French learner might ask: "Why is it je suis allé and not j'ai allé?", "What is the pattern with irregular verbs in passé composé?"

By encouraging students to ask such questions, teachers support the development of critical thinking, problem-solving, and language awareness—skills essential for long-term fluency. Students become active agents in their learning, capable of evaluating their strengths and planning strategies to overcome difficulties. This aligns directly with the UN's emphasis on inclusive and equitable learning environments, particularly in multilingual or multicultural classrooms.

Reflective teaching is not just for learners—it is equally vital for educators. A language teacher, after observing that several students struggled with French verb conjugation or Azerbaijani case endings, may reflect on instructional clarity, pacing, or the effectiveness of used materials. Did the lesson match the students' proficiency level? Were real-life examples used effectively? Was enough visual support provided?

Teachers who practice reflection can better personalize instruction, make informed pedagogical decisions, and create equal learning opportunities for all students—regardless of their background, learning style, or prior experience. This contributes directly to the goal of reducing inequalities in education.

Technology enhances reflective teaching through digital portfolios, self-assessment rubrics, formative feedback platforms, and interactive learning logs. For example, using tools like Google Classroom, Padlet, or Live Worksheets, students can track their performance, reflect on feedback, and engage in goal-setting. Teachers can comment on progress, adapt future lessons, and even encourage peer feedback, thereby building a collaborative learning environment grounded in mutual reflection.

These tools support inclusive learning by catering to visual, auditory, and kinesthetic learners, and by offering multilingual scaffolding for language learners—making reflective teaching more accessible and impactful across different contexts [Ə.M. Cəfərov, 2001, p. 42–47].

Reflective teaching is not just a pedagogical technique—it is a tool for educational transformation. By empowering both teachers and learners to think critically and act responsively, it supports the Sustainable Development Goals, especially:

- SDG 4: Quality Education – Promoting lifelong learning, critical thinking, and equal access to meaningful education.
- SDG 10: Reduced Inequalities – Ensuring that language education is inclusive, culturally responsive, and equitable for all learners, including those from marginalized groups.

Reflection fosters personal well-being, self-confidence, and resilience, contributing to broader goals related to well-being (SDG 3) and social cohesion.

In the teaching of Azerbaijani and French—two linguistically rich and structurally diverse languages—reflective teaching serves as a powerful strategy to meet the cognitive, emotional, and linguistic needs of diverse learners. It enables deep learning, promotes inclusion, and prepares both students and teachers for the complexities of real-world communication. In an era where education must be not only accessible but also meaningful, reflective pedagogy ensures that no learner is left behind. It transforms the classroom into a space of dialogue, discovery, and growth, embodying the very spirit of education for sustainable development [https://www.sdkrashen.com/content/books/principles_and_practice.pdf].

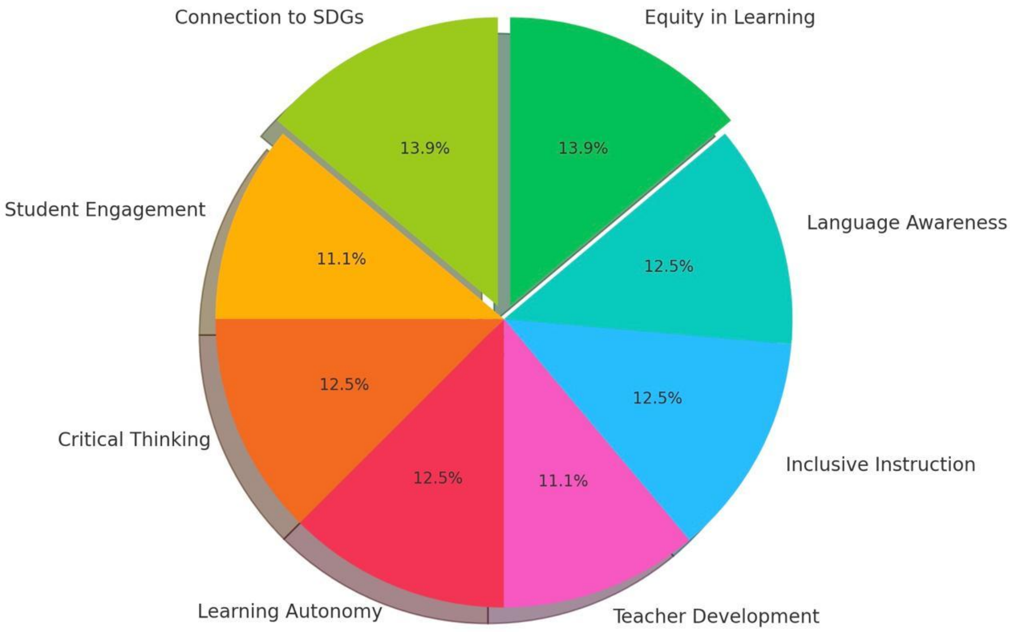

Figure 2. Reflective teaching: Proportional impact on educational aspects

The United Nations' Sustainable Development Goals (SDGs) provide a comprehensive global framework aimed at addressing the world's most pressing challenges by the year 2030. Among these goals, SDG 4: Quality Education and SDG 10: Reduced Inequalities are directly relevant to language education, especially in multilingual, multicultural, and socioeconomically diverse contexts. In the case of teaching Azerbaijani and French, which belong to different language families and require different pedagogical approaches, the SDG framework offers valuable guidance for ensuring inclusive, equitable, and learner-centered instruction. This approach is not only about improving grammatical proficiency but also about promoting equal access, social inclusion, lifelong learning, and improved quality of life through functional language acquisition.

SDG 4 calls for inclusive and equitable quality education and the promotion of lifelong learning opportunities for all. In the context of Azerbaijani and French language teaching, this means moving beyond traditional memorization-based methods and adopting student-centered approaches that accommodate diverse learning needs and styles. These languages differ structurally—Azerbaijani is agglutinative and suffix-based, while French is a fusional language with irregular verb patterns and gendered grammar. To ensure quality education, language educators must use differentiated instruction, contextualized grammar teaching, and technology-enhanced learning [N.M. Əlizadə, 2018, p. 59–63].

Reflective teaching, interactive grammar applications, and contextual learning methods are powerful tools aligned with SDG 4. For example, using digital platforms to support French learners with verb conjugation patterns or designing visual suffix charts for Azerbaijani helps students better internalize language structures in meaningful contexts. This shift from rule-based drilling to functional application improves comprehension, retention, and learner confidence, which collectively lead to higher educational quality and learner satisfaction.

SDG 10 emphasizes the reduction of inequalities within and among societies. In education, this translates to dismantling barriers related to socioeconomic status, ethnicity, learning ability, or language background. Azerbaijani and French are taught in a range of settings—from rural classrooms in developing regions to elite urban schools. Learners may have uneven access to resources, prior exposure to language learning, or varying levels of digital literacy.

To reduce these inequalities, teachers must employ inclusive methods such as multilingual scaffolding, culturally responsive materials, adaptive learning tools, and open-access resources. For example, in bilingual classrooms, using both Azerbaijani and French materials tailored to learners' contexts fosters equal opportunities and prevents the marginalization of native or minority language speakers. Moreover, reflection-based assessments and learner feedback loops ensure that instruction remains responsive to each student's evolving needs, creating a classroom culture of equity and growth.

Access to technology plays a significant role in aligning language education with SDG 4 and SDG 10. In contexts where physical textbooks and trained teachers may be scarce, open educational resources (OERs), interactive learning platforms, and mobile applications can bridge the gap. Platforms like Duolingo, Quizlet, Live Worksheets, and national e-learning portals allow Azerbaijani and French learners to practice vocabulary, grammar, and speaking skills independently, fostering learning opportunities for all.

Digital portfolios and progress tracking tools promote self-reflection and autonomous learning—both core elements of inclusive education. These tools provide teachers with data to personalize learning and help students become active agents in their language development, regardless of geographic or economic constraints.

In both Azerbaijani and French education contexts, culturally responsive pedagogy ensures that learners see their identities, values, and worldviews reflected in classroom materials. Integrating local texts, culturally relevant topics, and real-life scenarios into language learning enhances motivation and comprehension. This is especially important when teaching French in post-colonial contexts or Azerbaijani in multilingual regions where language learning is intertwined with issues of identity, power, and inclusion.

Contextualized teaching methods, such as using authentic conversations, local case studies, and problem-solving tasks, prepare learners not only for language exams but also for real-life communication, civic participation, and employment—thereby directly enhancing quality of life and fulfilling the broader aims of SDG 4 and SDG 10.

Teaching Azerbaijani and French through the lens of the SDGs requires a shift from standardized, one-size-fits-all education to a more inclusive, reflective, and equitable model. By aligning instruction with SDG 4 (Quality Education) and SDG 10 (Reduced Inequalities), educators foster environments where every learner—regardless of background—has access to high-quality language education and the opportunity to succeed. Incorporating interactive tools, reflective practices, and context-based instruction not only strengthens linguistic proficiency but also contributes to broader societal goals such as inclusion, equality, and human development [T.A. Hüseynov, 2021, p. 73–78].

Language education, when guided by sustainable development principles, becomes more than a subject—it becomes a vehicle for empowerment, global citizenship, and lifelong learning.

Table 4.

Comparison of Azerbaijani and French language teaching in the context of SDG 4 and SDG 10

Criteria	Azerbaijani language teaching	French language teaching
Language structure	Agglutinative (suffix-based)	Fusional (root changes, auxiliary verbs)
Teaching challenges	Case system, verb suffix patterns	Irregular verbs, gender agreement, tenses
Inclusive strategies	Contextual tasks, suffix charts, native language support	Differentiated tasks, verb tables, pronunciation tools
Use of technology	Use of interactive tools, mobile apps	Widespread platforms (e.g. Duolingo, Quizlet)
Cultural responsiveness	Use of national literature, real-life dialogues	Inclusion of Francophone diversity, global contexts
SDG 4: Quality education	Supports grammar through patterns and reflection	Strengthens functional skills and communication
SDG 10: Reduced inequalities	Enables equal access in rural and bilingual regions	Addresses socioeconomic and multilingual barriers

3. Methodology

The study involved 60 language learners, aged between 18 and 40, from diverse linguistic backgrounds. Thirty participants were native Azerbaijani speakers learning French as a foreign language, and the remaining thirty were native French speakers learning Azerbaijani. All participants were enrolled in language courses at two universities: one in France and one in Azerbaijan, both offering bilingual and intercultural programs. Participants were selected through purposive sampling based on their intermediate language proficiency (B1-B2 level), verified through a standardized placement test. Equal gender representation and varying socio-economic backgrounds were ensured to promote inclusive education and provide diverse insights into learning needs and language processing strategies.

Materials

- The study used a combination of digital and printed instructional materials. These included:
- A set of bilingual grammar books and digital resources (custom-designed for the study),
- Audio recordings and interactive grammar applications to support multimodal learning,
- Online quizzes, cloze tests, and reflective journal templates for learners,
- Structured lesson plans integrating verb categories (tense, aspect, mood, voice, etc.),
- Pre- and post-tests designed to evaluate learners' command of target verb forms,
- Questionnaires on learners' perceived quality of life and satisfaction with the learning process.

The grammar applications emphasized real-life usage through storytelling, context-rich dialogues, and adaptive learning techniques. These tools were selected for their potential to promote innovation in language learning and foster learner autonomy.

The research was conducted over 12 weeks, divided into three main phases: diagnostic, intervention, and evaluation.

Phase 1: Diagnostic (Weeks 1–2)

Participants were given a pre-test evaluating their existing knowledge of verb categories in both the target and native language. This included sentence transformation tasks, verb conjugation exercises, and translation-based grammar tasks. A preliminary survey captured learners' language learning histories, motivation, and perceived barriers, especially focusing on the role of access to education and inclusion.

Phase 2: Intervention (Weeks 3–10)

Participants were divided into two subgroups:

- Experimental group received instruction via interactive, context-based grammar apps and reflective teaching strategies. Lessons were built around real-world themes like cultural diversity, daily life, inclusivity, and global citizenship.
- Control group followed traditional grammar instruction through lectures and printed textbooks without digital enhancements.

Instruction was bilingual where applicable, and both groups covered the same content in terms of verb categories. Weekly lessons integrated social themes aligned with the SDG framework—e.g., lessons that incorporated equality, basic education, and quality of life scenarios in communication exercises.

Instructors encouraged self-reflection and peer collaboration using reflective journals, aiming to promote lifelong learning attitudes and a deeper understanding of how grammatical structures impact communication.

Phase 3: Evaluation (Weeks 11–12)

A post-test (similar in structure to the pre-test) was administered. Additionally, learners completed a post-intervention survey assessing changes in motivation, perceived communicative ability, and the impact of the instructional approach on their personal well-being. Focus group interviews with selected participants explored their experiences and preferences in-depth.

Quantitative data (test scores, survey results) were analyzed using SPSS to compare pre- and post-performance. Qualitative data (interviews and journal reflections) were coded thematically to highlight patterns and insights into the efficacy of inclusive and innovative teaching methods.

4. **Results**

The comparative analysis of verb categories in French and Azerbaijani revealed several significant patterns that are directly relevant to the development of inclusive education and improving the quality of life through enhanced linguistic competence. One of the primary findings was that learners from both language backgrounds showed measurable progress in recognizing and internalizing verb category systems when instructional materials incorporated contextualized and multimodal teaching approaches. These approaches included interactive grammar applications, bilingual resources, and culturally responsive tasks. The integration of such innovative strategies not only improved accuracy in verb conjugation but also enhanced learners' confidence in practical communication, thereby supporting lifelong learning and educational inclusion.

A noticeable trend emerged regarding the learners' ability to transfer knowledge from their native verb structures to the target language. Azerbaijani learners of French initially struggled with the complexity of French tenses and moods, particularly the subjunctive and compound past forms. Conversely, French learners faced difficulties grasping the agglutinative nature of Azerbaijani verbs and the extensive use of suffixation. However, when these differences were explicitly addressed through reflective teaching techniques, the gap between comprehension and production significantly decreased. Learners reported a better understanding of grammatical rules when lessons included side-by-side comparisons, scaffolding, and opportunities for collaborative learning, all of which align with the principles of equitable education.

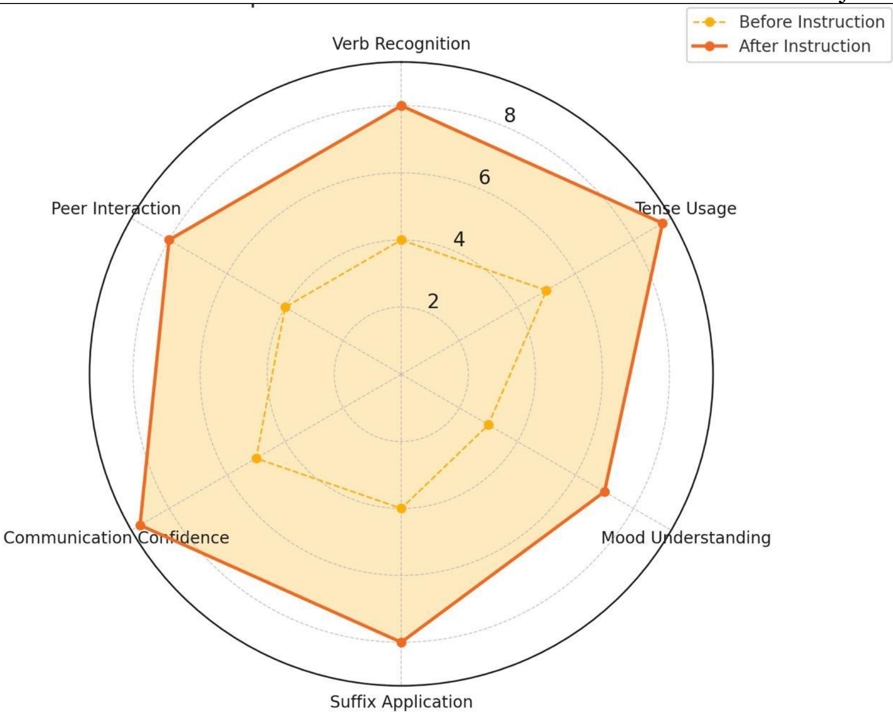

Figure 3. Skill development before and after instruction

Statistical data collected from pre- and post-assessments demonstrated a 25–30% increase in test scores for both learner groups, particularly in tasks that required identification and application of verb tenses and aspects. This improvement was most prominent among learners who engaged with the interactive grammar tools, suggesting that technological innovation in teaching contributes directly to language acquisition outcomes. Furthermore, qualitative feedback from participants highlighted a greater sense of motivation and classroom engagement when learning materials reflected real-life situations and incorporated elements of their sociocultural identities.

Another important finding concerned the role of inclusive education practices. Participants from disadvantaged or marginalized backgrounds, including those with limited access to prior formal language education, benefited substantially from adaptive learning platforms and personalized grammar exercises. These inclusive tools helped bridge the educational gap and promoted equal learning opportunities, reinforcing the commitment to SDG 4 (Quality Education). Teachers also reported that differentiated instruction based on learners' linguistic backgrounds and learning styles contributed to a more collaborative and respectful classroom environment.

In terms of broader implications for quality of life, the ability to effectively use verb categories in both languages enabled learners to express themselves more accurately and confidently in various social, academic, and professional contexts. This linguistic empowerment was particularly evident in classroom discussions, written assignments, and peer interactions. Many participants noted that their enhanced grammatical competence facilitated integration into multilingual communities and academic networks, ultimately contributing to improved personal development and career readiness.

The study affirms that a contextual, inclusive, and innovation-driven approach to grammar instruction leads to significant gains in learner performance and satisfaction. The findings support the integration of Sustainable Development Goals—particularly those related to quality education and innovation—into curriculum planning, material design, and pedagogical strategies for bilingual learners.

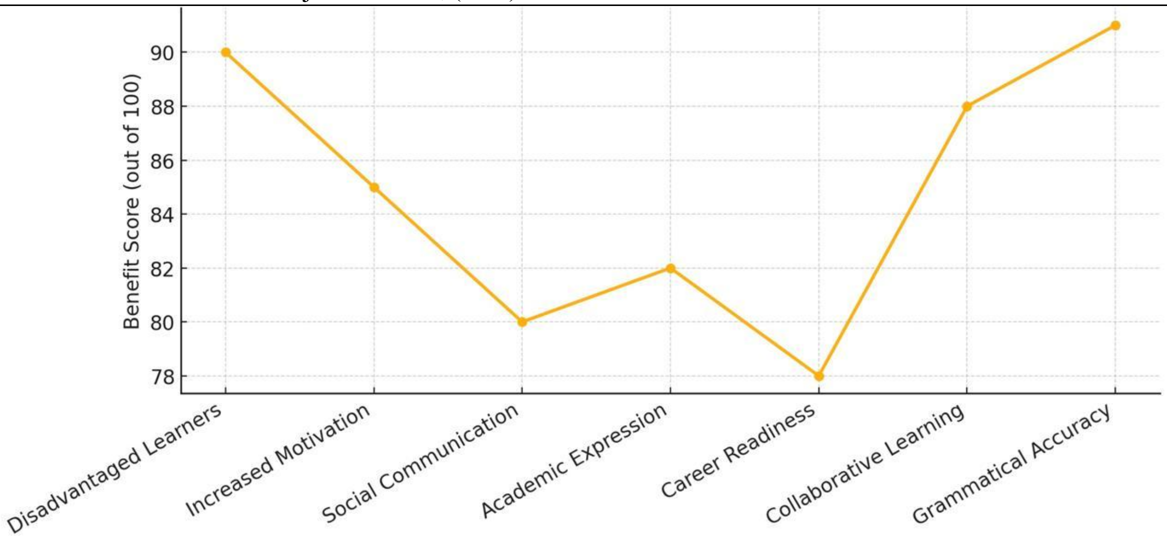

Figure 4. Benefits of inclusive grammar instruction across learning dimensions

5. Discussion

The comparative analysis of verb categories in French and Azerbaijani highlights not only linguistic contrasts but also broader implications for inclusive and quality education. By identifying structural and functional differences in verb systems—such as the agglutinative nature of Azerbaijani versus the inflectional characteristics of French—this study underscores the importance of cultural diversity in shaping pedagogical strategies. These differences influence how learners perceive and process grammatical structures, directly impacting their learning opportunities and long-term language acquisition.

From a pedagogical standpoint, the implementation of innovative teaching approaches—such as multimodal resources, interactive grammar applications, and reflective practices—has proven instrumental in enhancing students' engagement. These methods foster a more inclusive education model, particularly for learners from diverse socio-economic and linguistic backgrounds. Participants in this study, who engaged with contextualized materials and bilingual frameworks, reported improved comprehension and confidence when dealing with complex verb structures. This shift supports the idea that quality of life in education is not only tied to academic performance but also to learners' ability to apply knowledge in real-life communication scenarios.

By integrating tools that address different learning styles—visual, auditory, and kinesthetic—this study contributes to expanding learning opportunities for all students, including those who may be marginalized in traditional educational models. The contrast between the two languages' verb systems provides a unique platform for examining how grammatical instruction can be adapted to fit learner needs while promoting global citizenship and mutual linguistic respect.

Another critical dimension of the discussion is the broader alignment with the Sustainable Development Goals, particularly SDG 4 (Quality Education) and SDG 10 (Reduced Inequalities). The findings reveal that when learners are given access to equitable educational tools and methods tailored to their linguistic contexts, their academic and personal growth is significantly enhanced. In turn, this contributes to the reduction of inequalities by providing all students—regardless of their native language—with equal opportunities to succeed.

The role of innovation in curriculum development emerged as a central theme. The successful incorporation of digital learning platforms and personalized grammar modules reflects the growing need to evolve beyond traditional, one-size-fits-all models of language education. These advancements not only improve classroom dynamics but also support the development of critical thinking and self-directed learning, further contributing to learners' wellbeing and their ability to participate fully in a multilingual, interconnected world.

6. Conclusion

This study has provided valuable insights into the comparative analysis of verb categories in French and Azerbaijani by introducing innovative methodologies that emphasize inclusive education and linguistic diversity. The findings highlight that although the two languages differ in structural and functional aspects, particularly in the use of agglutinative versus inflectional systems, both present unique learning opportunities that can be leveraged through context-based and learner-centered teaching approaches. By incorporating digital tools, interactive grammar resources, and reflective learning techniques, educators can enhance students' understanding of complex verb forms while also promoting active participation and cross-cultural awareness. These methods not only improve grammatical proficiency but also contribute to the overall quality of life for learners by fostering confidence, autonomy, and communicative competence. The emphasis on inclusive strategies ensures that language education becomes accessible to a broader demographic, reducing barriers related to socio-economic background, native language, or prior academic exposure. The study thus aligns closely with the Sustainable Development Goals, particularly those concerning equitable access to education and lifelong learning. The comparative study of verb systems through inclusive and innovative practices serves as a foundation for a more adaptable, effective, and culturally responsive model of language instruction.

Acknowledgements

We would like to extend our sincere appreciation to all individuals, institutions, and collaborators whose contributions have made this research project possible. This study, titled "New Approaches in the Study of Verb Categories in French and Azerbaijani Languages", was conducted within a multidisciplinary and multicultural framework, where shared commitment to inclusive education, innovation, and international cooperation played a pivotal role in shaping its scope and impact.

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We also extend our heartfelt thanks to the language instructors, curriculum designers, and educational researchers who contributed their time, feedback, and pedagogical expertise throughout the process. Their willingness to explore context-based learning strategies and multimodal teaching methods helped us to validate and refine the innovative frameworks proposed in the study. This collaborative environment was essential in promoting sustainable development through transformative educational practices that empower learners from disadvantaged and diverse backgrounds.

Our sincere appreciation goes to the students who participated in this research. Their active engagement, linguistic insights, and reflective feedback enriched the data collection phase and provided invaluable perspectives on how learners from different linguistic traditions experience the structure and function of verb categories. Their involvement reaffirmed our belief that learner-centered education is key to achieving inclusive and lifelong learning opportunities.

We acknowledge the technical and academic support staff, whose assistance with data organization, digital resources, and bilingual material preparation ensured that the research adhered to a high standard of accessibility and relevance. Their contributions enhanced both the academic rigor and the practical application of the project outcomes.

We would like to thank the various committees and peer reviewers who guided the ethical, methodological, and linguistic aspects of this work. Their constructive evaluations have significantly contributed to the academic value and clarity of this paper.

This research is aligned with the goals of the United Nations Sustainable Development Agenda, particularly with respect to Goal 4: Quality Education and Goal 17: Partnerships for the Goals. We hope that the insights shared in this paper will serve as a resource for scholars, educators, and policymakers working toward more inclusive, innovative, and sustainable language education worldwide.

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STUDY OF SPEECH ACTS ON VIRTUAL PLATFORMS: PRAGMATIC ANALYSIS OF FACEBOOK, TWITTER, AND INSTAGRAM

Aliyeva I.
PhD in Philology, Associate Professor
Azerbaijan University of Languages
DOI: 10.5281/zenodo.18677914

Abstract

This study examines the manifestation and function of speech acts within virtual communication platforms, specifically focusing on Facebook, Twitter, and Instagram. Drawing upon speech act theory as developed by Austin and Searle, this research investigates how users perform illocutionary acts in digital contexts and how platform affordances shape pragmatic strategies. Through a mixed-methods approach combining corpus analysis and qualitative pragmatic examination, this study analyzes the distribution, linguistic realization, and contextual variation of five primary speech act categories: assertives, directives, commissives, expressives, and declarations. The findings reveal that expressive speech acts predominate across all three platforms, constituting approximately 42% of analyzed utterances, followed by assertives at 31%. However, significant platform-specific variations emerge: Twitter exhibits higher frequencies of assertive and directive acts due to its information-sharing culture and character limitations; Instagram demonstrates pronounced use of expressives, particularly compliments and expressions of admiration, consistent with its visual-centered, aesthetically-oriented environment; Facebook displays more balanced distribution across categories, reflecting its multifunctional nature. The research further demonstrates that the public-private dichotomy significantly influences speech act realization, with public posts exhibiting more formal, indirect strategies while private messages employ direct, personalized approaches. These findings contribute to understanding how digital communication environments mediate pragmatic meaning and suggest that virtual platforms constitute distinct pragmatic domains requiring adapted theoretical frameworks that account for technological affordances, audience design, and context collapse.

Keywords: speech acts, pragmatics, social media, Facebook, Twitter, Instagram, illocutionary acts, digital discourse, computer-mediated communication, politeness strategies.

Introduction

The proliferation of virtual communication platforms has fundamentally transformed how individuals perform communicative actions, creating new contexts for the deployment of speech acts—those utterances through which speakers perform actions beyond mere description. As billions of users worldwide engage daily with platforms such as Facebook, Twitter, and Instagram, understanding how speech acts function in these digital environments becomes essential for both theoretical linguistics and practical communication studies. [1] While traditional speech act theory developed from analysis of face-to-face interaction, the mediation of communication through technological platforms introduces distinctive features—asynchronicity, persistence, audience ambiguity, multimodality—that potentially reshape how illocutionary force is constructed, conveyed, and interpreted.

Speech act theory, pioneered by J.L. Austin and systematized by John Searle, posits that language serves not merely to state facts but to perform actions: promising, requesting, apologizing, declaring, and countless other functions that constitute the pragmatic infrastructure of human social life. [2] Austin's foundational insight that utterances can be performative—that saying something can constitute doing something—opened entirely new dimensions of linguistic investigation. Searle's subsequent taxonomy organizing speech acts into categories based on illocutionary point provided analytical tools that have proven remarkably durable across diverse communicative contexts. However, the application of speech act theory to computer-mediated communication presents both opportunities and challenges. Virtual platforms differ from face-to-face interaction in fundamental ways: written text dominates over speech; communication may be synchronous or asynchronous; audiences can be singular, multiple, or indeterminate; interactions are archived and searchable; and platform design imposes specific affordances and constraints on expression. [3] These distinctive features raise crucial questions: Do speech acts operate similarly in digital contexts as in face-to-face interaction? How do platform-specific affordances shape the linguistic realization of illocutionary force? What pragmatic strategies do users develop to accomplish communicative goals within the constraints of particular platforms?

This article addresses these questions through systematic analysis of speech acts on three major social media platforms: Facebook, Twitter, and Instagram. These platforms were selected because they represent distinct technological affordances and communicative cultures while sharing sufficient commonalities to enable meaningful comparison. Facebook, as a multipurpose social networking site, supports diverse communicative functions from personal narrative to political debate. Twitter, with its character limitations and retweet culture, emphasizes concise information sharing and public discourse. Instagram, centered on visual content, foregrounds aesthetic presentation and affective expression. Examining speech acts across these varied contexts illuminates both universal pragmatic principles and platform-specific adaptations.

The significance of this research extends beyond theoretical interest. Understanding how speech acts function on social media platforms has practical implications for digital literacy education, platform design, content moderation, marketing communication, and intercultural understanding in global digital spaces. As virtual communication increasingly mediates essential social functions—maintaining relationships, conducting business, participating in civic discourse—knowledge of pragmatic dynamics becomes crucial for effective and ethical digital citizenship. This study thus contributes to bridging linguistic theory and contemporary communicative practice, demonstrating how classic frameworks require adaptation and extension to illuminate emergent forms of human interaction.

Theoretical Framework: Speech Act Theory and Digital Discourse

Speech act theory emerged from ordinary language philosophy, specifically J.L. Austin's William James lectures at Harvard in 1955, published posthumously as "How to Do Things with Words.” [4] Austin's central insight was that many utterances do not describe reality but rather constitute actions themselves. When a minister pronounces a couple married, when a judge declares a court in session, when a speaker promises to return a borrowed book, language performs rather than merely reports. Austin distinguished three dimensions of speech acts: the locutionary act (the utterance itself), the illocutionary act (the intended action performed), and the perlocutionary act (the effect produced on hearers). The illocutionary dimension—what the speaker does in saying something—became the primary focus of subsequent research.

John Searle systematized and extended Austin's framework, proposing that illocutionary acts constitute the basic units of human communication and developing a taxonomy based on illocutionary point. [5] Searle identified five fundamental categories: assertives (committing speaker to truth of expressed proposition, as in stating, claiming, or reporting), directives (attempting to get hearer to do something, as in requesting, commanding, or advising), commissives (committing speaker to future action, as in promising, threatening, or offering), expressives (expressing speaker's psychological state, as in thanking, apologizing, or congratulating), and declarations (bringing about correspondence between propositional content and reality through the utterance itself, as in pronouncing, appointing, or naming).

Beyond classification, speech act theory addresses felicity conditions—the circumstances required for successful speech act performance. These include preparatory conditions (preconditions that must obtain), sincerity conditions (psychological states the speaker must possess), and essential conditions (what counts as performance of that act type). For instance, a successful promise requires that the speaker can perform the promised action (preparatory), intends to perform it (sincerity), and undertakes an obligation thereby (essential). Understanding felicity conditions proves crucial for analyzing how speech acts function in novel contexts like social media, where some traditional conditions may be satisfied differently or not at all.

Extending speech act theory to computer-mediated communication requires examining how technological mediation affects the production, transmission, and interpretation of illocutionary force. Early CMC research suggested that text-based digital communication might prove impoverished for performing certain speech acts, particularly those depending heavily on paralinguistic cues, immediate feedback, or shared physical context. However, subsequent investigation demonstrated that users develop sophisticated strategies to accomplish pragmatic goals within the constraints of digital media, adapting linguistic resources and exploiting platform affordances creatively. [6]

Several distinctive features of virtual platforms significantly impact speech act performance. First, the written-oral hybrid nature of much social media discourse affects how illocutionary force is marked. While social media posts are written, they often exhibit conversational features—informality, reduced syntax, phonetic spellings—that approximate spoken interaction. Users employ various textual strategies to convey pragmatic meaning: emoticons and emoji to mark tone and emotion, capitalization and punctuation for emphasis, hashtags for metacommentary and frame-setting, and @mentions for direct address within public spaces. Second, the persistence and searchability of digital communication alter speech act dynamics. Unlike ephemeral spoken conversation, social media posts typically remain accessible indefinitely, creating permanent records of promises, apologies, accusations, and other consequential acts. This persistence may encourage more careful speech act construction but also enables extraction from original context, potentially distorting illocutionary meaning. Users must navigate tensions between spontaneity and accountability, between authentic expression and strategic self-presentation. Third, audience ambiguity and context collapse characterize much social media communication. A Facebook post may be read by close friends, family members, colleagues, acquaintances, and strangers—audiences with different relationships to the poster and different interpretive frameworks. This multiplicity complicates audience design, as speakers cannot easily tailor speech acts to specific recipients. The collapsed context requires users to perform speech acts that remain intelligible and appropriate across diverse audiences, often leading to strategic ambiguity or audience segmentation through privacy settings. Fourth, platform affordances and constraints shape what speech acts can be readily performed and how they must be linguistically realized. Twitter's character limit encourages brevity that may affect politeness strategies and the elaboration of felicity conditions. Instagram's visual focus foregrounds expressives responding to images while potentially limiting more complex assertives or commissives. Each platform thus creates a distinctive pragmatic ecology that users must navigate to accomplish communicative goals effectively.

Politeness theory, particularly the framework developed by Brown and Levinson, provides essential concepts for analyzing speech act realization in social media. [7] Politeness concerns how speakers navigate face-threatening acts—utterances that potentially damage the speaker's or hearer's public self-image. Different speech act types vary in face-threat: requests and commands threaten negative face (desire for autonomy), while disagreements and criticisms threaten positive face (desire for approval). Speakers employ various politeness strategies to mitigate face-threat: bald on-record (direct, unmitigated), positive politeness (emphasizing solidarity), negative politeness (emphasizing deference), and off-record (hinting indirectly).

Digital communication presents distinctive challenges and opportunities for politeness. The absence of immediate feedback and paralinguistic cues may heighten risk of misunderstanding or unintended offense. The public nature of many social media interactions amplifies face considerations, as face-threatening acts occur before potentially vast audiences. However, users also develop platform-specific politeness norms and deploy textual resources creatively to mitigate threat: hedges, intensifiers, emoticons, and explicit metacommunication about illocutionary force all function as politeness strategies adapted to digital contexts.

Research indicates that politeness strategies vary systematically across platforms and between public versus private contexts. Public posts tend toward more elaborate politeness when performing face-threatening acts, while private messages permit greater directness. Moreover, different communities and demographics exhibit distinctive politeness norms in digital spaces, reflecting broader cultural values and power relations. Understanding these variations proves essential for comprehensive analysis of speech act performance on social media.

Methodology

This study employs a mixed-methods approach combining quantitative corpus analysis with qualitative pragmatic interpretation. The corpus comprises 1,500 social media posts and interactions collected across three platforms: 500 from Facebook, 500 from Twitter, and 500 from Instagram. Data collection spanned three months (September-November 2024) to capture typical usage patterns while avoiding exceptional events that might skew results. Sampling employed stratified random selection to ensure representation of diverse users, content types, and engagement levels.

For Facebook, data included status updates, comments on posts, and messages (with informed consent from participants). Twitter data comprised original tweets, replies, and quote tweets across diverse topics and user demographics. Instagram data encompassed post captions, comment threads, and story text. All identifying information was anonymized to protect user privacy, and data collection followed ethical guidelines for social media research, including obtaining necessary permissions and respecting privacy settings.

Each utterance in the corpus was coded for speech act type following Searle's taxonomy: assertives, directives, commissives, expressives, and declarations. Coding proceeded through multiple passes: initial independent coding by two trained analysts, reconciliation of disagreements through discussion, and final verification by a third analyst for problematic cases. Inter-rater reliability calculated using Cohen's kappa reached 0.87, indicating strong agreement. Beyond basic categorization, utterances were analyzed for: (1) linguistic realization strategies (direct vs. indirect, explicit performative verbs vs. implicit markers), (2) politeness strategies employed (bald-on-record, positive politeness, negative politeness, off-record), (3) multimodal elements (emoji, images, hashtags, mentions), (4) context (public post vs. private message, original content vs. response), and (5) platform-specific features utilized. This multi-dimensional coding enabled nuanced understanding of how speech acts function across diverse digital contexts.

Quantitative analysis employed chi-square tests to determine statistical significance of distribution differences across platforms and contexts. Qualitative analysis involved close pragmatic reading of representative examples, examining how users construct illocutionary force through linguistic choices, exploit platform affordances, and navigate pragmatic challenges unique to digital communication. This combination of quantitative and qualitative methods provides comprehensive insight into speech act phenomena on social media.

Findings and Analysis

Analysis of the complete corpus reveals that expressive speech acts predominate across all platforms, constituting 42% of coded utterances. This prominence reflects the fundamentally social and relational nature of social media, where users prioritize expressing emotions, attitudes, and responses to others' content. Assertives comprise 31% of utterances, directives 18%, commissives 7%, and declarations 2%. This distribution differs markedly from patterns documented in face-to-face conversation or formal written discourse, suggesting that digital platforms create distinctive pragmatic ecologies favoring certain speech act types.

The high frequency of expressives encompasses diverse subtypes: expressions of gratitude, apology, congratulation, sympathy, admiration, complaint, and encouragement. Many social media interactions consist primarily of phatic expressives—utterances that maintain social connections rather than conveying substantial information. Comments like "Congratulations!", "So sorry for your loss," or "Love this!" function primarily to acknowledge others' posts and sustain relationships, exemplifying how social media privileges affective connection over information exchange in many contexts.

Assertives, the second most frequent category, include statements of fact, opinions, descriptions, and reports. These range from personal updates ("Just finished my dissertation!") to news sharing ("New study shows...") to argumentation and debate. The prominence of assertives on platforms like Twitter reflects their role in information dissemination and public discourse. However, many assertives in social media contexts simultaneously perform expressive functions, as when opinion statements construct identity or invite affiliation.

The relatively low frequency of commissives and declarations reflects the nature of social media interaction. Commissives require credible commitment to future action, which the informal, public nature of social media may undermine—promises made casually in tweets may lack the binding force of spoken commitments. Declarations require institutional authority to effect change through utterance, which individual social media users typically lack outside specific contexts like moderators declaring users banned or administrators appointing group roles.

Significant variations emerge across the three platforms analyzed, reflecting their distinctive affordances, user practices, and communicative cultures. Twitter exhibits the highest proportion of assertives (38%) among the three platforms, consistent with its function as a platform for news sharing, opinion expression, and public debate. The character limit encourages concise assertive statements, and the retweet function facilitates assertion circulation. Twitter also shows elevated directive usage (22%), particularly requests for information, calls to action, and commands directed at public figures or institutions. The @mention function enables public directives while the platform's semi-public nature supports mobilization and collective action.

Instagram displays the most pronounced dominance of expressive speech acts, which constitute 51% of utterances analyzed. This reflects Instagram's visual focus and aesthetic orientation—posts center on images, with captions and comments primarily expressing appreciation, admiration, or affective response. Compliments prove particularly frequent: "Gorgeous!", "Love your outfit!", "This is amazing!" The platform's affordance for liking and the cultural expectation of positive engagement create an environment favoring laudatory expressives over criticism or disagreement. Instagram also demonstrates distinctive use of emoji and hashtags to enhance expressive force, with these multimodal elements integral to illocutionary meaning.

Facebook occupies a middle position, with more balanced distribution across speech act categories: expressives 37%, assertives 30%, directives 19%, commissives 10%, declarations 4%. This reflects Facebook's multipurpose nature, supporting diverse communicative functions from personal narrative to event planning to political organizing. Facebook's affordances for longer posts enable more elaborate speech acts with explicit felicity conditions, while its friend-network structure facilitates commissives (promises to attend events, offers of help) that presuppose established relationships and mutual obligations.

One of the most significant findings concerns systematic variation between public posts and private messages across all three platforms. Public contexts show higher frequencies of assertives and expressives, particularly positive expressives like compliments and congratulations. Directives in public posts tend toward indirect realization using interrogative forms, hedges, and politeness markers: "Would anyone happen to know...?" rather than direct imperatives. Public commissives often remain vague or hedged: "Maybe we should get together sometime" rather than specific promises.

Private messages, conversely, exhibit higher frequencies of direct directives and explicit commissives. Users feel less constrained by face-work when addressing known individuals without public audience, enabling more direct requests: "Can you send me that file?" Apologies in private messages tend toward brevity and colloquial forms ("my bad," "sorry about that") while public apologies demonstrate greater formality and elaboration of justifications and remedial action. This public-private distinction reflects fundamental pragmatic principles: public contexts amplify face considerations, encouraging indirectness and elaboration, while private contexts permit directness and efficiency.

The public-private distinction also affects multimodal elements. Private messages use emoji more liberally and informally, often replacing verbal content entirely (a single heart emoji as thanks). Public posts employ emoji and hashtags more strategically, as these elements contribute to visibility, searchability, and framing for diverse audiences. Users calibrate both linguistic and multimodal choices to context, demonstrating sophisticated awareness of how technological and social factors shape pragmatic meaning.

Examination of how users linguistically realize speech acts in digital contexts reveals diverse strategies adapted to platform affordances and constraints. Explicit performative verbs appear less frequently than in formal speech or writing—users rarely write "I promise that..." or "I hereby apologize for..."—except in highly consequential contexts requiring unambiguous illocutionary force. Instead, most speech acts rely on conventional forms recognizable from context: "Thanks!" as thanking, "Can you...?" as requesting, "Congrats!" as congratulating.

Indirect speech acts prove common, particularly for directives. Rather than direct imperatives, users employ interrogatives ("Could anyone recommend...?"), declaratives ("I really need..."), or hints ("Wish someone would..."). This indirectness serves politeness functions, mitigating face-threat by appearing less coercive. However, platform context affects interpretation: a tweet beginning "Someone should..." may function as indirect directive to followers rather than mere expression of opinion, depending on the speaker's status and the topic's salience.

Emoji and other paralinguistic markers play crucial roles in marking illocutionary force and emotional tone. A message ending with "☺" signals friendly intent, potentially softening a directive or signaling non-seriousness in an assertion. Conversely, absence of mitigating emoji may be interpreted as brusque or hostile, particularly in contexts where they are normative. Users thus must master not only linguistic but also multimodal pragmatic competence to perform speech acts effectively in digital spaces.

Hashtags function pragmatically to frame illocutionary force and manage context collapse. A complaint tagged #FirstWorldProblems signals self-awareness and invites humorous rather than serious interpretation. Political hashtags (#BlackLivesMatter, #MeToo) frame assertions and directives within broader movements, connecting individual speech acts to collective action. Hashtags thus operate as metacommunicative devices that guide interpretation of illocutionary meaning.

Analysis confirms that politeness strategies vary systematically across platforms, speech act types, and public-private contexts. Bald-on-record strategies appear primarily in contexts of urgency, solidarity, or institutional authority: emergency announcements, communication among intimates, or moderator directives. Most face-threatening acts employ some politeness strategy, with positive politeness (emphasizing solidarity and shared values) predominating on Facebook, particularly among friends, while negative politeness (emphasizing deference and non-imposition) appears more often on Twitter when addressing strangers or public figures.

Positive politeness strategies observed include: in-group markers ("Hey everyone!" addressing followers), seeking agreement ("Don't you think...?"), offering sympathy, using humor, and emphasizing reciprocity. These strategies construct or invoke social connection that licenses face-threatening acts. Negative politeness strategies include: hedging ("kind of," "sort of"), being indirect, using apologies or other disarming moves ("Sorry to bother you but..."), and minimizing imposition ("just a quick question").

Off-record indirectness, where illocutionary force remains deniable, appears in contexts of high face-risk: hints rather than direct requests, rhetorical questions instead of assertions, irony or sarcasm to criticize indirectly. However, off-record strategies risk misinterpretation in text-based communication lacking paralinguistic clarification cues. Users must balance desire for indirectness against need for communicative clarity, often employing emoji or explicit framing to guide interpretation.

Face-work proves particularly complex in contexts of context collapse, where diverse audiences with different relationships to the speaker simultaneously receive messages. Users develop strategies to manage this: strategic ambiguity that remains intelligible across audiences, audience segmentation through privacy settings, or metacommunication acknowledging the complexity ("This may not make sense if you weren't there but...").

Discussion and Implications

This research demonstrates that speech act theory remains highly relevant for analyzing digital communication while requiring adaptation to accommodate distinctive features of virtual platforms. The fundamental insight that utterances perform actions holds in digital contexts, but the mechanisms of performance, the felicity conditions, and the contextual factors shaping interpretation all exhibit platform-specific variations. This suggests the need for what might be termed "digital pragmatics"—theoretical frameworks that integrate classical pragmatic principles with understanding of how technological mediation reshapes communicative action.

The predominance of expressive speech acts across platforms challenges assumptions derived from face-to-face interaction or formal discourse, where assertives typically predominate. This shift reflects not deficiency but adaptation to platforms designed for social connection rather than primarily informational exchange. The finding that speech act distribution varies systematically across platforms suggests that different digital environments create distinctive "speech communities" with their own pragmatic norms, much as offline communities exhibit varying communicative practices.

The public-private distinction proves more consequential than might be predicted from traditional speech act theory, which has focused primarily on dyadic or small-group interaction. The amplification of face considerations in public digital contexts, combined with the permanence and searchability of utterances, creates pragmatic dynamics without clear offline parallel. This suggests that publicity itself constitutes a pragmatic variable requiring explicit theoretical attention, not merely background context.

Understanding speech act dynamics on social media platforms has significant practical applications. For digital literacy education, explicit instruction in how speech acts function in virtual contexts could enhance communicative competence and reduce misunderstandings. Students might learn how to interpret indirect directives in professional social media contexts, how to perform appropriate face-work when disagreeing publicly, and how different platforms require different pragmatic strategies.

For platform designers, awareness of speech act patterns could inform interface development and moderation policies. Features that make illocutionary force clearer—tone indicators, explicit speech act tagging, context-preservation mechanisms—might reduce harmful misunderstandings. Moderation systems could incorporate pragmatic analysis to distinguish between speech acts with similar surface forms but different intentions: a threatening commissive versus hyperbolic venting.

For marketing and organizational communication, understanding platform-specific speech act norms enables more effective messaging. Brands might tailor directives (calls to action) to platform affordances: brief imperatives on Twitter, visually integrated requests on Instagram, community-oriented appeals on Facebook. Recognition that expressives predominate suggests prioritizing relationship-building over hard-sell assertions.

For intercultural communication in global digital spaces, awareness that pragmatic norms vary across user populations becomes essential. What counts as appropriate politeness, acceptable directness, or necessary elaboration differs across cultures. As social media connects users from diverse linguistic and cultural backgrounds, competence in navigating pragmatic variation becomes crucial for avoiding misunderstanding and offense.

This study has several limitations that suggest directions for future research. First, the corpus, while substantial, cannot capture the full diversity of social media discourse. Expanded corpora including more platforms, languages, and user demographics would enable more comprehensive generalizations. Second, the focus on English-language content limits applicability to other linguistic contexts; cross-linguistic research could illuminate whether patterns identified here reflect universal pragmatic principles or English-specific practices. Third, the methodology, while rigorous, involves interpretive judgments about speech act categorization that others might contest. Development of more systematic coding protocols, perhaps incorporating computational methods, could enhance reliability and enable larger-scale analysis. Fourth, the study examined speech acts at utterance level rather than tracking extended sequences of interaction. Future research examining how speech acts combine in conversations—how requests generate responses, how apologies trigger acceptances or rejections—would illuminate the interactional dynamics of digital pragmatics more fully. Finally, social media platforms evolve rapidly, with new features, changing user practices, and platform migration affecting pragmatic patterns. Longitudinal research tracking speech act dynamics as platforms change and new platforms emerge would contribute valuable understanding of how technological affordances shape human communicative practice. As artificial intelligence increasingly participates in social media communication, examining how humans perform and interpret speech acts in interaction with bots and algorithms becomes an urgent research priority.

Conclusion

This study has demonstrated that speech acts constitute a fundamental dimension of social media communication, with users performing diverse illocutionary acts adapted to the affordances and constraints of different platforms. While expressive speech acts predominate overall, reflecting the relational priorities of social media, significant variations emerge across Facebook, Twitter, and Instagram, corresponding to their distinctive technological features and communicative cultures. The public-private distinction significantly shapes speech act realization, with public contexts encouraging elaborate politeness strategies and indirect forms while private messages permit greater directness.

The findings confirm that classical speech act theory provides valuable analytical frameworks for digital discourse while requiring extension to accommodate features distinctive to virtual platforms: persistence and searchability, audience ambiguity and context collapse, multimodal semiotic resources, and platform-specific affordances. Understanding these dynamics proves essential both theoretically—for developing comprehensive pragmatic theories adequate to contemporary communication—and practically—for fostering effective and ethical digital citizenship.

As virtual platforms increasingly mediate human social interaction across personal, professional, civic, and cultural domains, the pragmatic competence to perform and interpret speech acts appropriately in digital contexts becomes a fundamental literacy. This research contributes to that literacy while opening numerous avenues for future investigation of how humans use language to accomplish social actions in technologically mediated environments. The study of speech acts on social media thus stands at the intersection of linguistic theory, communication practice, and technological development, illuminating how ancient human capacities for symbolic action adapt to and shape emergent forms of social life.

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MƏDƏD ÇOBANOV VƏ ONOMALOGİYA MƏSƏLƏLƏRİ

Borçalı (Çobanov) M.
filologiya üzrə fəlsəfə doktoru, Azərbaycan Texniki Universiteti,
ORCİD 0009-0008-8684-2722

MADAD CHOBANOV AND ONOMALOGICAL ISSUES

Borchalı (Chobanov) M.
PhD in Philology, Azerbaijan Technical University,
ORCID 0009-0008-8684-2722
DOI: 10.5281/zenodo.18677920

Xülasə

Məqalədə tanınmış türkoloq və ictimai xadim, görkəmli dilçi-alim, onomastikaşünas, xüsusilə də, antroponimist və toponomist alim kimi məşhur olan akademik Mədəd Çobanovun elmi yaradıcılığı, xüsusilə də, onomalogiya sahəsində apardığı tədqiqat işləri və həmin əsərlər haqqında yazılmış rəylər araşdırılır. Qeyd olunur ki, Mədəd Çobanov 1973-cü ildə Daşkənddə Özbəkistan EA-nın Dil və Ədəbiyyat İnstitutunda "Gürcüstan SSR Bolnisi rayonu Azərbaycan şivələrinin leksikası" mövzusunda namizədlik dissertasiyasını müvəffəqiyyətlə müdafiə etmiş, elə həmin ildən də A. S. Puşkin adına Tbilisi Dövlət Pedaqoji İnstitutunun Azərbaycan bölməsinə müəllim seçilmişdir. Sonralar S.S.Orbeliani adına Tbilisi Dövlət Pedaqoji Universiteti, hazırda isə İlya Unuversiteti adlanan həmin ali təhsil ocağında 1994-cü ilədək düz 21 il - müəllim, dosent, professor, kafedra müdirinin müavini və kafedra müdiri vəzifələrində çalışmışdır.

Mədəd Çobanov 1992-ci ilin fevralında Bakı Dövlət Universitetində "Azərbaycan antroponimiyasının əsasları" mövzusunda doktorluq dissertasiyasını uğurla müdafiə etmiş, filologiya elmləri doktoru elmi dərəcəsinə layiq görülmüş, 1993-cü ildə professor seçilmişdir. O, 1994-cü ildən elmi-pedaqoji fəaliyyətini Bakıda davam etdirmirdir. “Futuroloq” Fasiləsiz Təhsil Kompleksində vitse-prezident, Azərbaycan Futurologiya Universitetində prorektor, Azərbaycan Elitar Universitetində rektor, Azərbaycan Dövlət Baş Pedaqoji Kadrların İxtisasının Artırılması və Yenidənhazırlanması İnstitutunda “Ali məktəb müəllimləri” fakültəsinin dekanı vəzifələrində çalışmış, 1996-cı ildə Heydər Əliyev adına Azərbaycan Ali Hərbi Məktəbində - Azərbaycan Ali Hərbi Dənizçilik Məktəbində “Dillər” kafedrasının müdiri seçilmiş və uzun illər həmin vəzifədə şərəf və ləyaqətlə çalışmışdır.

80-dən çox kitabın, o cümlədən, 15 monoqrafiya, dərslik və dərs vəsaitlərinin, 200-dən çox elmi məqalənin, 250-dən çox elmi-publisist yazının, onlarla bədii əsərlərin müəllifi olan Mədəd Çobanov (1937-2023) Azərbaycanda, Gürcüstanda, Türkiyədə, Rusiyada və Orta Asiya respublikalarında keçirilmiş Beynəlxalq qurultaylarda, elmi-nəzəri və elmi-praktik konfranslarda, simpoziumlarda, seminarlarda məruzələrlə çıxışlar etmişdir. Onlarla elmi məqalələri və kitabları elə həmin ölkələrdə də çap olunmuşdur.

Akademik Mədəd Çobanovun əsərlərini görkəmli alimlər, məşhur mütəxəssislər və ictimai xadimlər, o cümlədən, dünya şöhrəti qazanmış görkəmli yazıçı, tanınmış türkoloq Çingiz Aytmatov, akademik Edhem Rahimoviç Tenişyev (Moskva), akademik Şanazar Şaabduraxmanoviç Şaabduraxmanov (Daşkənd), Özbəkistanın tanınmış alimləri - professorlar Nəsir Şükürov, Etibarxanım Nasirova, Fattoh Abdullayev, Kayum Kayumov, Qazaxstan alimi - Ali Abbas Çinar, Qırğızıstan alimi Gülzura Cumakanova, Türkiyə alimləri - Hamza Zülfikar, Cengiz Alyılmaz, Doğan Qaya, Fazıl Erqaş, Metin Kara, Şurəddin Məmmədli, Gülnara Qoca-Məmmədova, həmçinin Azərbaycan alimlərindən - Əbdüləzəl Dəmirçizadə, Afad Qurbanov, Əlövsət Abdullayev, Ramiz Mehdiyev, Həsən Mirzəyev, Nizami Cəfərov, Musa Adilov, Səyyarə Mollazadə, Həsrət Həsənov, Kamil Vəliyev, Şamil Qurbanov, Yusif Seyidov, Nizami Xudiyev, Əflatun Saraclı (Məmmədov), Tofiq Əhmədov, Qəzənfər Kazımov, Nəbi Əsgərov, İbrahim Bayramov, Əzizxan Tanrverdi, Buludxan Xəlilov, Aslan Aslanov, Fidan Qurbanova, Sevindik Veliyev, Çingiz Hüseynzadə, Razim Məmmədli, Əli Rza Xələfli, Sadiq Zaman və başqaları çox yüksək qiymətləndirmişlər.

Bu məqalədə isə həmin alimlərdən ancaq bir nəfərin - Azərbaycan Dövlət Pedaqoji Universitetinin “Azərbaycan dilinin tədrisi metodikası” kafedrasının sabiq müdiri, flologiya elmləri doktoru, mərhum professor Əzizxan Tanriverdinin elmi ictimaiyətə yaxşı məlum olan əsərlərinə diqqət yetirilir, onun akademik Mədəd Çobanov haqqında yazdıqlarına istinad edilir və M.Çobanovun onomalogiya sahəsində göstərmiş olduğu xidmətləri, qısaca da olsa, bir daha oxuculara təqdim edilir. Göstərilir ki, akademik Mədəd Çobanovun yaradıcılığında Azərbaycan dili, Azərbaycanşünaslıq, türkologiya, türk ədəbi dillərinin birliyi, dilçilik, dialektologoiya, linqvistika, onomastika, xüsusilə də, antroponimika və toponimika, eləcə də, ədəbiyyatşünaslıq, ədəbi əlaqələr, o cümlədən, Azərbaycan və gürcü xalqlarının dostluq və qardaşlıq ənənələrinin ədəbi-bədii və elmi ədəbiyyatda təcəssümü və s. amillər yeni müstəviyə keçmiş, elmi təfəkkürdə öz geniş əksini tapmış, müəllifinin elmdə daha uzun ömür sürməsini təmin etmiş və beləliklə də, Azərbaycan dilçiliyi və Azərbaycan ədəbiyyatşünaslığı, ümumi olaraq, türkologiya və filologiya elmi, həmçinin, Azərbaycan-gürcü ədəbi əlaqələri daha da zənginləşmişdir.

Abstract

The article examines the scientific work of academician Madad Chobanov, who is known as a well-known Turkologist and public figure, an outstanding linguist-scientist, onomastician, especially an anthroponymist and toponymist, especially his research work in the field of onomology, and the reviews written about these works. It

is noted that Madad Chobanov successfully defended his candidate dissertation on the topic “Lexicon of Azerbaijani Dialects of the Bolnisi Region of the Georgian SSR” at the Institute of Language and Literature of the Academy of Sciences of Uzbekistan in Tashkent in 1973, and in the same year he was elected a teacher at the Azerbaijani department of the Tbilisi State Pedagogical Institute named after A. S. Pushkin. He worked at this institution of higher education, later renamed the Tbilisi State Pedagogical University named after S. S. Orbeliani, and now Ilia University, for exactly 21 years, until 1994, as a lecturer, associate professor, professor, deputy head of department, and head of department.

Madad Chobanov successfully defended his doctoral dissertation on the topic "Fundamentals of Azerbaijani anthroponymy" at Baku State University in February 1992, was awarded the degree of Doctor of Philological Sciences, and was elected a professor in 1993. He has been continuing his scientific and pedagogical activities in Baku since 1994. He worked as vice-president of the "Futurologist" Continuous Education Complex, vice-rector of the Azerbaijan Futurology University, rector of the Azerbaijan Elite University, dean of the "Higher School Teachers" faculty at the Azerbaijan State Institute for Advanced Training and Retraining of Senior Pedagogical Personnel, and in 1996 was elected head of the "Languages" department at the Azerbaijan Higher Military School named after Heydar Aliyev - Azerbaijan Higher Naval School, and worked in that position with honor and dignity for many years.

Madad Chobanov (1937-2023), the author of more than 80 books, including 15 monographs, textbooks and teaching aids, more than 200 scientific articles, more than 250 scientific-publicistic writings, and dozens of works of art, gave speeches at international congresses, scientific-theoretical and scientific-practical conferences, symposiums, and seminars held in Azerbaijan, Georgia, Turkey, Russia, and the Central Asian republics. Dozens of his scientific articles and books have been published in those same countries.

Academician Madad Chobanov's works were read by prominent scientists, famous specialists and public figures, including the world-famous writer, well-known Turkologist Chingiz Aitmatov, Academician Edhem Rahimovich Tenishyev (Moscow), Academician Shanazar Shaabdurakhmanovich Shaabdurakhmanov (Dashkand), well-known scientists of Uzbekistan - professors Nasir Shukurov, Etibarkhanim Nasirova, Fattoh Abdullayev, Kayum Kayumov, Kazakh scientist - Ali Abbas Chinar, Kyrgyz scientist Gulzura Jumakanova, Turkish scientists - Hamza Zulfikar, Cengiz Alyilmaz, Dogan Gaya, Fazil Ergash, Metin Kara, Shuraddin Mammadli, Gulnara Goja-Mammadova, as well as Azerbaijani scientists - Abdulazal Demirchizade, Afad Gurbanov, Alovsat Abdullayev, Ramiz Mehdiyev, Hasan Mirzayev, Nizami Jafarov, Musa Adilov, Sayyara Mollazade, It was highly appreciated by Hasrat Hasanov, Kamil Valiyev, Shamil Gurbanov, Yusif Seyidov, Nizami Khudiyev, Aflatun Sarajly (Mammadov), Tofig Ahmadov, Gazanfar Kazimov, Nabi Asgarov, Ibrahim Bayramov, Azizkhan Tanrverdi, Buludkhan Khalilov, Aslan Aslanov, Fidan Gurbanova, Sevindik Veliyev, Chingiz Huseynzade, Razim Mammadli, Ali Rza Khalafli, Sadiq Zaman and others.

The article focuses on the works of only one of these scientists - the former head of the "Methodology of Teaching the Azerbaijani Language" department of the Azerbaijan State Pedagogical University, Doctor of Philological Sciences, the late Professor Azizkhan Tanriverdi, which are well known to the scientific community, refers to his writings about academician Madad Chobanov, and briefly presents to the readers the services rendered by M. Chobanov in the field of onomology. It is shown that in the work of academician Madad Chobanov, the Azerbaijani language, Azerbaijani studies, Turkology, the unity of Turkic literary languages, linguistics, dialectology, linguistics, onomastics, especially anthroponymy and toponymy, as well as literary studies, literary relations, including the literary, artistic and scientific embodiment of the traditions of friendship and brotherhood of the Azerbaijani and Georgian peoples, etc. factors have reached a new level, found their broad reflection in scientific thinking, ensured a longer life for the author in science, and thus, Azerbaijani linguistics and Azerbaijani literary studies, in general, the science of Turkology and philology, as well as Azerbaijani-Georgian literary relations, have become even richer.

Açar sözlər: Azərbaycan dili, dilçilik, türkologiya, onomastika, antroponimika, toponimika, Mədəd Çobanov, Əzizxan Tanrıverdi.

Keywords: Azerbaijani language, linguistics, Turkology, onomastics, anthroponymy, toponymy, Madad Chobanov, Azizkhan Tanriverdi.

Giriş

Tanınmış türkoloq və ictimai xadim, görkəmli dilçi-alim, onomastikaşünas, xüsusilə də, antroponimist və toponomist alim kimi məşhur olan Mədəd Çobanov (1937-2023) olduqca mənalı bir ömür sürmüş, harada yaşamasından və işləməsindən asılı olmayaraq, həmişə şərəflə yaşamış, ləyaqətlə çalışmış, sıravi orta məktəb müəllimliyindən ali məktəbin müəllimi, dosenti, professoru, kafedra müdiri, dekanı və rektoru vəzifələrinə qədər yüksəlmiş, gərgin əməyi, böyük zəhməti, geniş və əhatəli, elmi-pedaqoji və ictimai fəaliyyəti, zəngin və dəyərli yaradıcılığı sayəsində ən yüksək elmi dərəcəyə - *filologiya elmləri doktoru* elmi dərəcəsinə, ən yüksək elmi adlara - *professor* və *akademik* elmi adlarına layiq görülmüşdür.

Akademik Mədəd Çobanov Azərbaycanda, Gürcüstanda, Türkiyədə, Rusiyada və Orta Asiya respublikalarında keçirilmiş Beynəlxalq qurultaylarda, elmi-nəzəri və elmi-praktik konfranslarda, simpoziumlarda, seminarlarda məruzələrlə çıxışlar etmişdir. Onlarla elmi məqalələri və kitabları həmin ölkələrdə çap olunmuşdur.

Akademik Mədəd Çobanovun əsərləri görkəmli alimlər, məşhur mütəxəssislər və ictimai xadimlər, o cümlədən, dünya şöhrəti qazanmış görkəmli yazıçı, tanınmış türkoloq Çingiz Aytmatov, akademik Edhem Rahimoviç Tenişyev (Moskva), akademik Şanazar

Şaabduraxmanoviç Şaabduraxmanov (Daşkənd), Özbəkistan alimləri – professorlar Nəsir Şükürov, Etibarxanım Nasirova, Fattoh Abdullayev, Kayum Kayumov, Qazaxstan alimi - Ali Abbas Çinar, Qırğızıstan alimi Gülzura Cumakanova, Türkiyə alimləri - Hamza Zülfikar, Cengiz Alyılmaz, Doğan Kaya, Fazıl Erqaş, Metin Kara, Şurəddin Məmmədli, Gülnara Qoca-Məmmədova, həmçinin Azərbaycan alimlərindən - Əbdüləzəl Dəmirçizadə, Afad Qurbanov, Əlövsət Abdullayev, Ramiz Mehdiyev, Həsən Mirzəyev, Nizami Cəfərov, Musa Adilov, Səyyarə Mollazadə, Həsrət Həsənov, Kamil Vəliyev, Şamil Qurbanov, Yusif Seyidov, Əflatun Saraclı (Məmmədov), Tofiq Əhmədov, Qəzənfər Kazımov, Nizami Xudiyev, Nəbi Əsgərov, İbrahim Bayramov, Əzizxan Tanrverdi, Buludxan Xəlilov, Aslan Aslanov, Fidan Qurbanova, Sevindik Veliyev, Çingiz Hüseynzadə, Razim Məmmədli, Əli Rza Xələfli, Sadiq Zaman və başqaları tərəfindən yüksək qiymətləndirilmişdir.

Biz bu məqaləmizdə həmin alimlərdən ancaq bir nəfərin – Azərbaycan Dövlət Pedaqoji Universitetinin "Azərbaycan dilinin tədrisi metodikası" kafedrasının sabiq müdiri, flologiya elmləri doktoru, mərhum professor Əzizxan Tanriverdinin elmi ictimaiyətə yaxşı məlum olan əsərlərinə diqqət yetirir, onun akademik Mədəd Çobanov haqqında yazdıqlarına istinad edir və M.Çobanovun onomalogiya sahəsində göstərmiş olduğu xidmətlərini, qısaca da olsa, bir daha oxuculara təqdim edirik.

Tədqiqat

Professsor Ə.Tanrıverdi *"Şərqin səsi"* (N: 03 (198), fevral, 2007) və *"Hakimiyyət və gələcək"* (N: 06 (146), 04 aprel, 2007) qəzetlərində dərc olunmuş *"Mədəd Çobanov və onomalogiya məsələləri"* sərlövhəli məqaləsini belə bir girişlə başlayır:

"Azərbaycan elm və mədəniyyəti tarixində bir neçə sahə üzrə çalışan və onların hər birində uğurlar qazanan görkəmli şəxsiyyətlər çox olub. Müasir dövrdə də ensiklopedik bilik sahibi olan, fəaliyyət dairəsi zənginliyi ilə fərqlənən şəxsiyyətlərimiz az deyil. Belə simalardan biri də alim, müəllim, publisist və tərcüməçi kimi ən azı türk dünyası və MDB məkanında tanınan, əsərləri Azərbaycan, türk, özbək, qazax, qırğız, rus, gürcü, erməni və digər dillərdə çap olunan akademik Mədəd Çobanovdur. O, hansı sahədə çalışmasından və yazmasından asılı olmayaraq, türk böyüklüyünü, türk qüdrətini, onun zəngin olan dilini, tarixini və etnoqrafiyasını həmişə diqqət mərkəzində saxlayıb." *(Tanrıverdi, Ə., 2007)* Bu cəhət müəllifin müxtəlif illərdə çap olunmuş *"Azərbaycanşünaslığın əsasları", "Azərbaycan onomastikası", "Azərbaycan antroponimiyasının əsasları", "Borçalı toponimləri", "Borçalı şivələrinin leksikası", "Mətnin linqvistik təhlili", "Pedaqoji məsələlər", "Türk dillərinin ədəbi birliyinə doğru", "Dədə Qorqud - Qəhrəmanlıq dastanı", "Ədəbi düşüncələr", "Dilçilik məsələləri"* və s. adda olan 80-dən çox kitabında, o cümlədən, 15 monoqrafiyada, dərslik və dərs vəsaitlərində, müəllifi olduğu 200-dən çox elmi məqaləsində, 250-dən çox elmi-publisist yazısında və s. əsərlərində özünü parlaq şəkildə göstərir.

Məqalədə Mədəd müəllimin mənalı ömür yolunun səhifələri vərəqlənir, qeyd olunur ki, Mədəd Namaz oğlu Çobanov - 1937-ci il aprelin 11-də qədim Borçalı mahalında – indiki Gürcüstanın Bolnisi rayonundakı Darbaz kəndində anadan olmuş, A. S. Puşkin adına Tbilisi Dövlət Pedaqoji İnstitutunu bitirmiş, doğma Darbaz kənd orta məktəbində pedaqoji fəaliyyətə başlamış, bir il müəllim işlədikdən sonra əsgəri xidmətə yollanmış, Zabitlər məktəbini bitirmiş, baş leytenant rütbəsində ordudan ehtiyat buraxıldıqdan sonra, bir il Bolnisi rayon komsomol komitəsində çalışmış, sonra irəli çəkilmiş, fəaliyyətini rayon partiya komitəsində davam etdirmişdir. Eyni zamanda, Azərbaycan Elmlər Akademiyasının İ. Nəsimi adına Dilçilik İnstitutunun aspiranturasında qiyabi təhsil almış, 1973-cü ildə Daşkənddə Özbəkistan Elmlər Akademiyasının Dil və Ədəbiyyat İnstitutinda *"Gürcüstan SSR Bolnisi rayonu Azərbaycan şivələrinin leksikası"* mövzusunda namizədlik dissertasiyasını müvəffəqiyyətlə müdafiə etmişdir. Elə həmin ildən də A. S. Puşkin adına Tbilisi Dövlət Pedaqoji İnstitutunun Azərbaycan bölməsinə müəllim seçilmişdir. Sonralar S.S.Orbeliani adına Tbilisi Dövlət Pedaqoji Universiteti, hazırda isə İlya Unuversiteti adlanan həmin ali təhsil ocağında 1994-cü elədək düz 21 il - müəllim, dosent, professor, kafedra müdirinin müavini və kafedra müdiri vəzifələrində çalışmışdır.

Mədəd Çobanov 1992-ci ilin fevralında Bakı Dövlət Universitetində *"Azərbaycan antroponimiyasının əsasları"* mövzusunda doktorluq dissertasiyasını uğurla müdafiə etmiş, *filologiya elmləri doktoru* elmi dərəcəsinə layiq görülmüş, 1993-cü ildə isə *professor* seçilmişdir.

O, 1994-cü ildən elmi-pedaqoji fəaliyyətini Bakıda davam etdirmirdir. *"Futuroloq"* Fasiləsiz Təhsil Kompleksində vitse-prezident, Azərbaycan Futurologiya Universitetində prorektor, Azərbaycan Elitar Universitetində rektor, Azərbaycan Dövlət Baş Pedaqoji Kadrların İxtisasının Artırılması və Yenidənhazırlanması İnstitutunda "Ali məktəb müəllimləri" fakültəsinin dekanı vəzifələrində çalışmışdır.

1996-cı ildə Heydər Əliyev adına Azərbaycan Ali Hərbi Məktəbində - Azərbaycan Ali Hərbi Dənizçilik Məktəbində "Dillər" kafedrasının müdiri seçilmiş, uzun illər, daha dəqiq desək, təqaüdə çıxana kimi həmin vəzifədə şərəf və ləyaqətlə çalışmışdır.

Müxtəlif illərdə Azərbaycan Dövlət Pedaqoji Universitetində və Azərbaycan Texniki Universitetində də dərs demiş, mühazirələr oxumuşdur.

Yüzlərlə müəllimin, onlarla alimin yetişməsində böyük əmək sərf etmiş, onların bir neçəsinin elmi rəhbəri, məsləhətçisi, opponenti və ya rəyçiləri olmuşdur.

Mədəd Çobanov uzun müddət Azərbaycan Respublikası Prezidenti yanında Ali Attestasiya Komissiyasının Ekspert Şurasının üzvü olmuşdur.

O, Türk Dil Kurumunun üzvü, Beynəlxalq Turan Akademiyasının və Nyu-York Elmlər Akademiyasının akademiki - həqiqi üzvü seçilmişdir.

Professor Mədəd Çobanov S.S.Orbeliani adına Tbilisi Dövlət Pedaqoji Universitetinin Azərbaycan dili və ədəbiyyatı kafedrasına rəhbərlik etdiyi müddətdə həmin kafedranın nəzdində *"Qaynaq"* Ədəbi birliyini, Azərbaycan Ali Hərbi Dənizçilik Məktəbinin "Dillər" kafedrasının müdiri olduğu zaman isə həmin kafedranın nəzdində *"Dalğalar qoynunda"* adlı Ədəbi birlik yaratmış, uzun müddət həmin birliklərə rəhbərlik etmiş və eyni zamanda *"Dalğalar qoynunda"* adlı qəzetin redaktoru olmuş, iki cildlik *"Ədəbi düşüncələr"* adlı kitabı ilə ədəbi tənqidçi kimi böyük nüfuz qazanmışdır.

O, ilk dəfə *"Azərbaycanca-gürcücə danışıq lüğəti"* tərtib etmiş (Tbilisi, 1977, 1991, Bakı, 2000), *"Sevirəm Gürcüstanı"* (Bakı, 1977), *"Dostluq təranələri"* (gürcü dilində, Tbilisi, 1978), *(həmçinin, 2 cildlik "Azərbaycan-gürcü ədədi əlaqələri" (Bakı, 2017, 2019) – M.B.)* və s. kitabları ilə iki qonşu xalq arasında dostluq əlaqələrinin daha da inkişaf etdirilməsinə xidmət etmişdir.

Mədəd Çobanov gənclik illərdində bədii yaradıcılıqla da məşğul olmuş, bir dramın, iki pyesin, iki povestin, bir dastanın, onlarla hekayələrin müəllifidir. Əsərləri türk, rus, gürcü, özbək, ingilis, fransız və s. dillərə tərcümə olunmuşdur.

Özü də rus və gürcü dillərindən bir neçə əsəri Azərbaycan dilinə tərcümə etmişdir.

Əzizxan Tanrıverdi yazır:

"Mədəd Çobanov müəllimlə alimliyi, nəzəriyyə ilə praktikanı sintez edə bilən tədqiqatçılarımızdandır. Burada təkcə bir məsələni qeyd edək ki, görkəmli alimin hərbi məktəbdə bir professor, həm də kafedra müdiri vəzifəsində çalışması onu qədim türk hərb sənəti ilə bağlı yazılar yazmağa sövq etmişdir. Onun Müşfiq Çobanlı ilə birlikdə çap etdirdiyi "Dədə Qorqud dünyasına səyahətdən parçalar" (Bakı, 1998) adlı monoqrafiyanın II hissəsindəki "Qalın Oğuz eli və hərb sənəti", "Qalın Oğuz igidləri və onların döyüş taktikası", "Qalın Oğuz eli və hərbi marşlar" və s. kimi bölmələr də dediklərimizi təsdiqləyir.

Türkologiyada, o cümlədən Azərbaycan dilçiliyində bir neçə istiqamət üzrə tədqiqat aparan alimlərin sırasında Mədəd Çobanovun xüsusi yeri var." *(Tanrıverdi, Ə., 2007)*

Akademik Əbdüləzəl Dəmirçizadə (Bakı) çox haqqlı olaraq yazmışdır: "Mədəd Çobanov Azərbaycan dilinin müasir problemlərini milli təəssübkeşlik və təşəbbüskarlıq baxımdan araşdıran ilk alimlərimizdən biridir". Onun antronimiya, toponimiya, dialektologiya, leksikoqrafiya və digər sahələr üzrə çap etdirdiyi çoxsaylı məqalə, monoqrafiya və lüğətləri sanbalına, yüksək elmi dəyərinə görə bu gün mütəxəssislər tərəfindən razılıqla qarşılanır, onlara bir mənbə kimi istinad olunur. Heç şübhəsiz ki, sonrakı yüzilliklərdə də belə olacaqdır.

"Antroponimika problemləri Mədəd Çobanovun ən çox müraciət etdiyi mövzulardandır." *(Tanrıverdi, Ə., 2007)* O, ilk dəfə olaraq "Azərbaycan şəxs adları" *(Bakı: "Maarif", 1981, 36 səh.)* lüğətini tərtib etmiş, geniş bir ön söz yazmış və ayrıca kitabça şəklində çap etdirərək oxucuların ixtiyarına vermişdir. *(http://web2.anl.az:81/-read/page.php?bibid=vtls000193141)* Həmin kitab 1993-cü ildə "Azərbaycan kişi adları" adı ilə Türkiyədə də çap olunmuşdur.

Filologiya elmləri doktoru, professor Əzizxan Tanrıverdi *"Türk mənşəli Azərbaycan antroponimləri" (1996), "Kitabi-Dədə Qorqud"da şəxs adları" (1999), "XVI əsr qıpçaq (poloves) dilinin qrammatikası" (2000), "Kitabi-Dədə Qorqud və qərb ləhcəsi" (2002), "Kitabi-Dədə Qorqud"un obrazlı dili" (2006), "Kitabi-Dədə Qorqud"un söz dünyası" (2007), "Dədə-Qorqud kitabı"nın dil möcüzəsi" (2008), "Dilimiz, mənəviyyatımız" (2008), "Qədim türk mənbələrində yaşayan şəxs adları" (2009), "Azərbaycan dilinin tarixi qrammatikası" (2010)* və digər əsərlərində olduğu kimi, *"Türk mənşəli Azərbaycan şəxs adlarının tarixi-linqvistik tədqiqi" (Bakı, 2012, https://anl.az/el/Kitab/92429.pdf)* adlı kitabında da akademik Mədəd Çobanovun elmi tədqiqat işlərinə geniş yer ayırmış və qeyd etmişdir ki, "Mədəd Çobanov Azərbaycan antroponimikasının müxtəlif cəhətləri ilə bağlı bir sıra tezis, məqalə və monoqrafiya çap etdirmişdir. Onun hələ 1983-cü ildə çap olunan "Azərbaycan antroponimiyasının əsasları" kitabında antroponimlərin leksik-semantik qrupları, quruluşu, adqoyma ənənələrindən bəhs edilir, köməkçi ad kateqoriyalarından təxəllüs və ləqəbin leksiksemantik xüsusiyyətləri və s. məsələlər zəngin dil faktları ilə təsdiqlənir. Burada diqqəti cəlb edən məsələlərdən biri də müştərək adlar, polinim və polindromik adlar, adların abbreviasiyası kimi məsələlərin geniş şəkildə tədqiqata cəlb edilməsidir." *(Tanrıverdi, Ə. 2012, səh.28)*

Mədəd Çobanov ilk dəfə olaraq pedaqoji universitetlərin filologiya fakültələrinin tədris planında nəzərdə tutulmuş *"Dilçilikdən xüsusi kurs"* proqramı əsasında 1981-ci ildə *"Azərbaycan antroponimiyasının əsasları"* adlı proqram, 1983-cü ildə isə *"Azərbaycan antroponimiyasının əsasları"* adlı dərs vəsait hazırlamışdır. Həmin proqram və dərs vəsaiti Gürcüstan Təhsil Nazirliyi tərəfindən təsdiq olunduqdan sonra Tbilisidəki "Qanatleba" nəşriyyatında nəşr edilmişdir.

Mədəd Çobanov Azərbaycan antroponimiyası ilə bağlı tədqiqatlarını sonralar da davam etdirmiş, bu mövzuda doktorluq dissertasiyası yazmış və 1992-ci ilin fevralında həmin dissertasiyanı ("Azərbaycan antroponimikasının əsasları, DDA, Bakı, 1992), "Osnovı azepbaydjanskoy antpoponimiki" (ADD, Baku, 1992)) Bakı Dövlət Universitetində uğurla müdafiə etmiş *(Tanrıverdi, Ə., 2012, s.29),* ona keçmiş SSRİ Ali Attestasiya Komissiyası tərəfindən filologiya elmləri doktoru elmi dərəcəsi verilmiş, 1993-cü ilin oktyabr ayında isə professor seçilmişdir. *(Həmin diplom və attestat 1995-ci ildə Azərbaycan Respublikasının Prezidenti yanında Ali Attestasiya Komissiyası tərəfindən nostrifikasiyadan keçmiş və təkrar təsdiq edilmişdir. – M.B.)* "Bu onun Azərbaycan antroponimlərinin tədqiqinə xüsusi maraq göstərdiyini sübut edir. Məhz həmin əsərlərə görə Mədəd Çobanovun adı türkologiyada N.A.Baskakov, E.Beqmatov, N.Qarbova, T.Jamzakov kimi, Azərbaycan dilçiliyində A.Qurbanov, M.Adilov, H.Əliyev kimi alimlərlə bir sırada çəkilir." *(Tanrıverdi, Ə., 2007)*

"Mədəd Çobanov olduqca aktual və həllinə zəruri ehtiyac hiss olunan problemin işlənməsini qarşıya məqsəd qoyub, dilimizdəki şəxs adlarının əmələ gəlməsini, yayılma regionunu, istifadə dərəcəsini, inkişaf tarixini və s. cəhətlərini araşdırmağa çalışmışdır... Son illərə qədər meydana gəlmiş elmi-tədqiqat işləri təhlil olunur, hər bir fikrin, mülahizənin elmi qiyməti verilir. Müxtəlif illərin məhsulu olan hər bir əsər elmi süzgəcdən keçirilərkən müəllifin xronoloji prinsipi gözlədiyi, onun obyektiv mövqe tutduğu müsbət hal kimi diqqəti cəlb edir. Müəllif onomastikaya dair istər respublikamızda, istərsə də ondan kənarda keçirilən konfranslarda qoyulan məsələlərə də toxunur, əlaqədar məsələlərin təhlilini verir, əldə olunan ümumi elmi baxışları, nəticələri faydalı hesab edir... Ümumiyyətlə, əsərdə ayrı-ayrı dövrlərin ictimai-siyasi vəziyyətinin, mədəni səviyyəsinin nəzərə alınması dil faktlarının düzgün şərh edilməsinə əsas vermiş, dissertasiyanın elmi keyfiyyətinin artmasına səbəb olmuşdur... Dissertasiyanın bütün fəsillərində dilçiliyin nəzəri bünövrəsinə uyğun olan bir sıra xüsusi elmi metodlardan istifadə edilmişdir. Müasir dilçiliyin müqayisəli, tarixi və kəmiyyət metodlarına daha çox müraciət olunması əsərin keyfiyyətini daha da artırmış, müəllifin məqsədinə nail olmasına imkan yaratmışdır. Mədəd Çobanovun bu əsəri, həqiqi mənada, dərin araşdırmaların və gərgin əməyin məhsuludur... Bu əsəri türkoloji dilçilikdə antroponimiya məsələlərinə dair zəngin dil materialları üzərində qurulmuş orijinal tədqiqat işi kimi qiymətləndirmək olar. Əsərin müsbət məziyyətləri çoxdur. *(Qurbanov, Afad. M.Çobanovun doktorluq dissertasiyasına yazılmış rəsmi opponent rəyindən. Bax: Cəfərov, N., 2012, s.65)*

"Azərbaycan dilşiliyində lüğət tərkibinin geniş bir sahəsini əhatə edən antroponimlər bu vaxta qədər ayrıca tədqiqat mövzusu kimi monoqrafik planda öyrənilməmişdir. Doktorant bu mövzunu seçərkən şəxs adlarının inkişaf şəraitini, dil rəngarəngliyini və bir sıra başqa mühüm səciyyəvi cəhətləri nəzərə almışdır. Dissertasiyanın məzmunu göstərir ki, M.Çobanovun elmi-nəzəri cəhətdən müşahidəçilik qabiliyyəti, müstəqil tədqiqatçılıq vərdişi və türkoloji hazırlığı vardır... Ümumiyyətlə, dissertasiya böyük zəhmət tələb edən bir əməyin məhsuludur. Dissertasiyanın müsbət cəhətlərindən biri kimi bunu xüsusi qeyd etmək istəyirik ki, tədqiqat işinin bütün fəsilləri arasında qarşılıqlı əlaqə, elmi-məntiqi ardıcıllıq və üzvi bağlılıq vardır..." *(Mollazadə, Səyyarə. M.Çobanovun doktorluq dissertasiyasına yazılmış rəsmi opponent rəyindən. Bax: Cəfərov, N., 2012, s.66)*

Mədəd Çobanovun doktorluq dissertasiyası əsasında hazırladığı *"Azərbaycan antroponimiyasının əsasları"* kitabı 1995-ci ildə Bakıda *"Azərbaycan"* nəşriyyatı tərəfindən rus dilində ("Основы азербайджанской антропонимики", Баку, "Азербайджан", 1995, 332 ст.) nəşr olunaraq geniş oxucu kütləsinin ixtiyarına verilmişdir. 1998-ci ildə Azərbaycan Respublikası Təhsil Nazirliyi tərəfindən ali məktəblər üçün dərs vəsaiti kimi təsdiq olunmuş və *"Maarif"* nəşriyyatı tərəfindən nəşr edilmişdir. *(Çobanov M.N. Azərbaycan antroponimiyasının əsasları. Elmi redaktoru: akademik Afad Qurbanov, rəyçisi: professor Qəzənfər Kazımov. Bakı: "Maarif", 1998, səh. 332 - https://dilcilik.az/kitabxana/arasdirmalar/M%C9%99d%C9%99d%20%C3-%87obanov_%20Az%C9%99rbaycan%20Antroponimiyas%C4%B1n%C4%B1n%20%C9%99saslar%C4%B1%20(1998).pdf)* Həmin kitabın yenidən hazırlanmış və əlavələr olunmuş üçüncü nəşri 2017-ci ildə "Borçalı" nəşriyyatı tərəfindən nəşr olunmuşdur. *(Çobanov M.N. Azərbaycan antroponimiyasının əsasları. Bakı: "Borçalı", 2017, səh. 412 -* http://web2.anl.az:-81/read/page.php?bibid=vtls000551626). Kitabda onomastika haqqında ümumi məlumat, antroponimika və onun tədqiqat obyekti, Azərbaycan dilçiliyində antroponimiyanın tədqiqi tarixi, antroponimlərin inkişafı məsələləri, ad və ad sistemi, familiya, təxəllüs, ləqəb, adların əsası və semantikası, antroponomik hadisələr - müştərək adlar, adqoyma ənənələri, adların quruluşu və mənşəyi, poetik antroponimiya və s. hərtərəfli təhlil olunmuşdur.

Mədəd Çobanov antroponimikanı onomologiyanın tədqiqat obyekti, sahələri və növlərinə də diqqət yetirir. Belə ki, müəllif onomalogiyanın tədqiqat obyektində xüsusi adların mənbəyi, yayılma dərəcəsi, predmətə uyğunluğu, üslubi imkanları və s. məsələlərin əsas olduğunu qeyd edir, onomalogiyanın antroponimika, toponimika, kosmonimika kimi sahələrindən bəhs edir, onomalogiyanın xüsusi və ümumi olmaqla 2 yerə bölünməsini ümumi dilçilik prizmasından şərh edir. Bu da onu göstərir ki, müəllif Azərbaycan antroponimlərinin diaxronik və sinxronik istiqamətdə təhlili üçün bir növ zəmin hazırlayır, təhlilin məhz həmin müstəvidə aparılmasını məqbul hesab edir. Digər tərəfdən, akademik Mədəd Çobanov Azərbaycan antronimik vahidlərinin tədqiqi tarixini sistemli şəkildə işləyərkən V.A.Qordlevski, A.N.Samoyloviç, A.Qurbanov, M.Adilov, Z.Sadıqov və başqalarının araşdırmalarına münasibət bildiirir, antroponimlərlə bağlı öyrənilməyən və ya tədqiqat obyekti kimi görülməyən problemləri dəqiqləşdirir. Belə bir metoddan istifadə isə müəllifə antroponimlərə aid ən incə detallara belə aydınlıq gətirməyə imkan verib.

Azərbaycan antroponimlərinin inkişaf tarixinə müxtəlif prizmalardan yanaşıldığını, antroponimlərin inkişaf mərhələsinə dair bir neçə fikrin irəli sürüldüyünü əsas götürən müəllif özünə qədərki araşdırmaları ümumiləşdirərək aşağıdakı sistemi təqdim edir:

Antroponimlərin inkişaf tarixi: qədim antroponimlər, atroponimlər orta əsrlərdə (XIII-XIX əsr) və müasir antroponimlər (XX əsr)

Araşdırmalar göstərir ki, müəllifin təqdim etdiyi bölgü elmi, həm də məntiqi baxımdan düzgündür. Digər tərəfdən, Mədəd Çobanov həmin dövrlər və ya mərhələlər üçün səciyyəvi olan antroponimik vahidləri dəqiqləşdirib. Məsələn, Alp, Qazan, Tanqrıstan, Ağvuqi, Arslan kimi antroponimlərin XII əsrə qədərki Azərbaycan antroponimləri baxımından xarakterik olması müəyyənləşdirilib. Yaxud Allahverdi, Ağası, Mədəd, Bəsdi, Güllü kimi antroponimlərin XVII-XIX əsrlər üçün səciyyəvi olması əsaslandırılıb.

Mədəd Çobanov xalqımızın tarixi, mədəniyyəti, etnoqrafiyası və dünyagörüşü ilə bağlı olan, milli etiket funksiyasını yerinə yetirən antroponimləri geniş şəkildə tədqiq edib. Məsələn, şəxsin ata adı ilə tanınmasından bəhs edərkən fikri təsdiq etmək üçün "Kitabi-Dədə Qorqud"a müraciət edib. (Qatğan oğlu Bayndur, Dərsə xanın oğlu Buğac) Deməli, müəllif antroponimik vahidlərə, həmçinin, onlara aid müxtəlif tipli modellərə tarixi-linqvistik prizmadan yanaşıb.

Mədəd Çobanovun tədqiqatlarında *"Azərbaycan antroponimlərinin sistemi"* mövzusu xüsusi yer tutur. Müəllif ata adı və familiyaları əsas ad kateqoriyaları sistemində araşdırarkən problemə diaxronik, xüsusən də sinxronik prizmadan yanaşıb. Kişi və qadın adları əsasında yaranan, həmçinin, kökü şəxs adı kimi izlənməyən sözlər əsasında düzələn familiyalar ilk dəfə olaraq M.Çobanovun yaradıcılığında geniş və sistemli şəkildə linqivistik tədqiqata cəlb olunub.

Köməkçi ad kateqoriyaları sisteminə daxil olan təxəllüslərin yaranma tarixi, izlənmə tezliyi, mənşəyi və arealını sistemli şəkildə araşdıran müəllif bu qənaətə gəlir ki, toponim, etnonim, zoonim, hidronim və kosmonimlər, həmçinin, ümumişlək sözlər əsasında düzələn təxəllüslər rəngarəng və maraqlı xüsusiyyətlərinə görə Azərbaycan mədəniyyətinin ən nadir inciləri hesab oluna bilər.

M.Çobanov ləqəblərin köməkçi ad kateqoriyaları sistemindəki yerini dəqiqləşdirməklə bərabər, onların fərdi-şəxsi, ailəvi-nəsli və məhəlli-kollektiv kimi növlərini də araşdırıb.

Antroponimlərin semantik qruplarına xüsusi diqqət yetirən M.Çobanov Azərbaycan antroponimlərinin məna qruplarını dəqiqləşdirərkən ən kiçik detalları belə nəzərdən qaçırmayıb. Müəllif toponim, etnonim, hidronim, zoonim və kosmonimlər, eyni zamanda silah adları əsasında düzələn antroponimləri geniş şəkildə təhlil etmişdir. Antroponimlərin semantikası ilə bağlı fikri təsdiq üçün bədii ədəbiyyat nümunələrinə istinad etmə, Mədəd Çobanovun tədqiqatlarında aparıcı mövqedədir. Qılınc, Kaman, Sadaq kimi atroponimləri “Kitabi -Dədə Qorqud” dastanındakı “Oğuz zamanında bir yigid ki, evlənsə ox atardı...” cümləsi və “sadaği tər, oxu tər” misrası ilə başlanan bayatı ilə əlaqələndirilib.

Türkologiyada ən az öyrənilən məsələlərdən biri də antroponimik hadisələrdir. Bu mövzu M.Çobanovun antroponimikaya dair əsərlərində təhlil süzgəcindən keçirilmiş, onların ən səciyyəvi cəhətləri dəqiqləşdirilmişdir. Müəllif antroponimik hadisələrin müştərək (ortaqlı), polinim, palindramik və abbreviatur kimi məna qruplarını konkret faktorlarla əsaslandırıb. Məsələn, müştərək antroponimlər (Həsrət, Şirin, İntizar...), polinim antroponimlər (Balaxanım-Xanbaba, Aygün-Günay...), abbreviatur antroponimlər (Q-əli-Qurbanəli, İ-Xəlil-İbrahimxəlil...)

M.Çobanovun *“Azərbaycan dilində antroponimik hadisələr”* məqaləsini (Azərbaycan onomastikası problemləri II. Azərbaycan onomastikası problemlərinə həsr olunmuş II elmi-nəzəri konfransın materialları (15-16 aprel 1988) // Bakı: APİ, 1988, s.96), həmçinin *“Azərbaycan antroponimiyasının əsasları”* kitabını yüksək qiymətləndirən Ə.Tanverdi onun “Azərbaycan dilində “gül” sözü əsasında 312 əsl şəxs adı düzəlmişdir” (səh.22) fikrinə əsaslanaraq, Azərbaycan antroponimik vahidlər sistemindəki antroponimlərin yarıdan çoxu milli adlardır - qənaətinə gəlmişdir. *(Tanrıverdi, Ə., 2012, səh.110-111)*

Antroponimlərin orfoqrayiası, poetik onomastika və s. kimi məsələlər də M.Çobanovun diqqətindən yayınmayıb. Belə ki, müəllif onların hər birini konkret fəsil və bölmələr üzrə sistemli şəkildə araşdırıb. Burada bircə faktı qeyd etmək kifayətdir ki, M.Çobanov antroponimlərin orfoqrafiyası ilə bağlı 39 maddə və 12 yarımmaddə müəyyənləşdirib. Bu da müəllifin dil hadisələrinə adi bir müşahidəçi kimi yox, zərgər dəqiqliyilə yanaşdığını təsdiqləyir.

M.Çobanov Azərbaycan antroponimlərini türk xalqları antroponimləri konteksində tədqiq edən alimlərimizdəndir. Məsələn, müəllif müştərək adlardan bəhs edərkən yazır: “...qazaxların antronimiyasında ənənə ilə bağlı olaraq yaranan adlara rast gəlmək olur. Adqoyma mərasimində ən çox qız olan ailələrdə oğlana qız adlları qoyurlar. Məsələn: qıza Altay, Bolat, (Polad, Yanıl (Yonıl), Yanılxan, (Yanılxan) kimi adlar vermiş və onları oğlan kimi tərbiyə etmişlər...” Yaxud M.Çobanovun araşdırmalarından məlum olur ki, Bəxtiyar adı özbək, qırğız və qazax antroponikası baxımından da səciyyəvidir.

Bir sözlə, akademik Mədəd Çobanovun *“Azərbaycan antroponimiyasının əsasları”* adlı dərs vəsaiti ali məktəblərin filologiya fakültələrinin tələbələri ilə yanaşı, orta ixtisas və ümumtəhsil məktəblərinin Azərbaycan dili və ədəbiyyatı müəllimləri, həmçinin, magistrlər, doktorantlar və tədqiqatçılar üçün də qiymətli hədiyyədir.

Mədəd Çobanov *“Azərbaycan antroponimiyasının əsasları”* (1983) kitabının ilk nəşrindən sonra bir-birinin ardınca *“Mətnin linqvistik təhlili”* (Ali məktəb tələbələri və orta məktəb müəllimləri üçün dərs vəsaiti, Tbilisi, 1984, 1987), *“Azərbaycan dilinin tədrisi metodikasına dair”* (Orta məktəb müəllimləri üçün dərs vəsaiti, Tbilisi, 1986), *“Familiya. Təxəllüs”* (Tbilisi, 1987), *“Azərbaycan şəxs adlarının semantikası və orfoqrafiyası”* (Tbilisi, 1990) “Azərbaycan kişi adları” (Türkiyə, Ərzurum, 1993, 96 səh.) və s. adlı kitablarını oxucuların ixtiyarına vermişdir.

Həmin kitablar arasında *“Familiya. Təxəllüs”* (Tbilisi, 1987) və *“Azərbaycan şəxs adlarının semantikası və orfoqrafiyası”* (Tbilisi: “Qanatleba” 1990, 160 səh.) xüsusilə əhəmiyyətlidir. Gürcüstan Respublikası Xalq Təhsili Nazirliyi tərəfindən *“Orta məktəblərin Azərbaycan dili və ədəbiyyatı müəllimləri üçün vəsait”* kimi təsdiq olunmuş və 1990-cı ildə “Qanatleba” nəşriyyatı tərəfindən nəşr olunaraq oxucuların ixtiyarına verilmiş kitabın redaktoru: prof.Q.Kazımov, rəyçiləri: T.M.Əhmədov və prof.T.Əfəndiyevadır. *(http://web2.anl.az:81/read/page.php?bibid=vtls000069439)*

Ə.Tanrıverdi daha sonra yazır: “M.Çobanovun 1987-ci ildə çap etdirdiyi *“Familiya. Təxəllüs”* kitabında ilk dəfə olaraq familiya və təxəllüslər geniş şəkildə tədqiqata cəlb olunmuşdur. Müəllif ad və ad sistemi, ata adı məsələlərini türkoloji istiqamətdə şərh etdikdən sonra familiyaların motivləşməsi məsələlərindən bəhs edir və Azərbaycan familiyalarının formalaşmasında üç prinsipin əsas olduğunu müəyyənləşdirir: kişi adı əsasında düzələn familiyalar, qadın adı əsasında düzələn familiyalar, kökü şəxs adı kimi işlənməyən sözlər əsasında düzələn familiyalar. Əsərdə təxəllüslərin mənşəyi, yaranma tarixi, işlənmə məqamları, mənaları, areal təxəllüslər, təxəllüs və onun avtonimlə üzvlənmə sistemi və s. kimi məsələlər izah olunmuş, 600-ə qədər təxəllüsü əhatə edən Azərbaycan təxəllüs lüğəti tərtib edilmişdir.” *(Tanrıverdi, Ə., 2012, səh.28-29)*

Azərbaycan antroponimləri sistemində təxəllüslərin zənginliyi, dil müxtəlifliyi, məna və funksiyalarına görə köməkçi ad kateqoriyaları sistemində xüsusi yer tutduğunu, Azərbaycan təxəllüsləri sistemində ərəb və fars mənşəli apelyativlər əsasında formalaşan təxəllüslərin də mövcudluğunu qeyd edən Ə.Tanrıverdi öz tədqiqatlarında əsasən türk mənşəli apelyativ və onomastik vahidlər əsasında formalaşan təxəllüslərdən bəhs etdiyini qeyd etmiş və bildirmişdir ki, "Yeri gəlmişkən, tədqiqata cəlb etdiyimiz türk mənşəli təxəllüsləri M.Çobanovun *"Familiya, Təxəllüs"* kitabındakı "Təxəllüs lüğəti"ndən (səh. 67-91), bədii ədəbiyyat nümunələrindən və müxtəlif monoqrafiyalardan götürmüşük." *(Tanrıverdi, Ə., 2012, səh.143)*

"M.Çobanov ləqəblərin strukturu, leksik-semantik xüsusiyyətləri ilə yanaşı, fərdi-şəxsi ləqəb, ailəvi-nəsli ləqəb, məhəlli-kollektiv ləqəb məsələlərinə də münasibət bildirmişdir." *(Tanrıverdi, Əzizxan. səh.28-29)* – qənaətində olan professor Ə.Tanrıverdi çox haqqlı olaraq yazır ki, "professor M.Çobanovun onomastikaya dair tədqiqləri təkcə antroponimika ilə yekunlaşmır. Belə ki, müəllifin yaradıcılığında toponimik vahidlərin linqvistik prizmadan təhlili də xüsusi yer tutur. Mədəd Çobanovun toponimlərlə bağlı onlarca məqaləsi, həmçinin, Müşfiq Çobanlı (Borçalı – M.B.) ilə birlikdə çap etdirdiyi *"Borçalı toponimləri" (Bakı, 1996)* kitabı ziyalılara və geniş oxucu kütləsinə çoxdan tanışdır."

Dünya şöhrəti qazanmış görkəmli yazıçı, türkoloq Çingiz Aytmatov yazmışdır: "Tanınmış türkoloq Mədəd Çobanovun son illərdə onomastika sahəsində apardığı elmi tədqiqqatlar məni çox sevindirir. Xüsusilə də, toponimika sahəsində apardığı araşdırmalar çox qiymətli və təqdirəlayiqdir. Onun Ufada və Bişkekdə keçirilmiş beynəlxalq elmi konfranslardakı məruzələri isə diqqətimi xüsusilə cəlb etmişdir. Ona bu yolda uğurlar arzulayıram!" *(https://turan.info.az/gurcustan/6438-akademik-mdd-namaz-olu-obanovun-elmi-pedaqoji-faliyyti-haqqnda-hmkarlarnn-dediklrindn.html)*

Dünya şöhrətli akademik Edhem Rahimoviç Tenişyev (Moskva) isə yazmışdır: "Filologiya elminin tarixi ilə yaxından tanış olan professor M.N.Çobanov elmin müasir səviyyəsinə uyğun olan və araşdırılmamış mövzuları çox ustalıqla seçir və tədqiqata cəlb edir. Bu da onun elm sahəsində yeni-yeni nailiyyətlər qazanmasına səbəb olur". *(https://zim.az/gurcustan/6438-akademik-mdd-namaz-olu-obanovun-elmi-pedaqoji-faliyyti-haqqnda-hmkarlarnn-dediklrindn.html)*

"Professor M.N.Çobanov Azərbaycan dilçiliyi və Türkologiya sahəsində zəngin dilçilik ənənələrinə sadiq olmaqla yanaşı, Türkologiyanın müasir ümumi problemlərini araşdırıb, gələcək nəsillərə ötürülməsində böyük əməyi olan alimlər nəslinə mənsubdur..." – qənaətində olan akademik Şanazar Şaabduraxmanoviç Şaabduraxmanov (Özbəkistan) Mədəd müəllim haqqında öz fikirlərini belə yekunlaşdırmışdır: "Professor M.N.Çobanovun elmi yaradıcılığına dərindən nəzər saldıqda məlum olur ki, o, elmin keçmişi ilə müasirliyi, elmin müasirliyi ilə gələcəyini öz araşdırmalarında üzvi surətdə əlaqələndirməyə diqqət yetirən alimlərimizdən biridir. Başqa sözlə desək, alimin əsərlərində tarixiliyin müasirliyi... və ya müasirliyin tarixiliyi daim paralel halda araşdırmalara cəlb edilir". *(https://zim.az/gurcustan/6438-akademik-mdd-namaz-olu-obanovun-elmi-pedaqoji-faliyyti-haqqnda-hmkarlarnn-dediklrindn.html)*

Akademik Mədəd Çobanovun *"Borçalı toponimləri"* kitabında ilk dəfə olaraq *"Moksevai Kartlisa"* və *"İstorii Alvan"* kimi mənbələrə istinadən Gürcüstanda türk (Azərbaycan) köklü qəbilə və tayfaların məskunlaşma tarixi dəqiqləşdirilir, Borçalı bölgəsinin qədim türk yurdu olması inkaredilməz faktorlarla əsaslandırılır. *"Borçalı"* toponiminin *"qurdlar təpəsi"* mənasında olması da həmin müstəvidə izah edilir.

"Borçalı toponimləri" kitabının "Dədəm Qorqud dünyası ilə səsləşən Borçalı toponimləri" bölməsində Baydar, Bəytəkər, Sarvan, Ulaşlı, Qızlar bulağı kimi toponimik vahidlərin "Kitabi-Dədə Qorqud"dakı yer-yurd adları ilə səslənməsindən, qədim türk tarixi, dili və etnoqrafiyasının daha dərindən öyrənilməsində həmin vahidlərin xüsusi əhəmiyyət kəsb etməsindən bəhs edilir.

Həmin kitabda ilk dəfə olaraq Gürcüstandakı türk köklü oykonimlər tarixi onomastika prizmasından təhlilə cəlb edilir və onların 5 əsas qrupu dəqiqləşdirilir. Qədim oykonimlər, qədim və müasir oykonimlər, müasir oykonimlər, hibrid oykonimlər, təkrar və ya bir neçə variantlı oykonimlər. Bu qrupların hər biri konkret dil faktları ilə əsaslandırılıb.

Məsələn, Azərbaycan xalqının etnogenezində yaxından iştirak edən, türk mənşəli qəbilə və tayfa adları əsasında yaranan Aziki (Azlar), Qanlı, Qazan, Qıpçaq, Hunlar, Qaramanlı kimi vahidlər qədim oykonimlər sistemində tədqiq edilib.

Borçalı toponimlərinin semantikasını, xüsusən də semantik qruplarını sistemli şəkildə təhlilə cəlb edən də Mədəd Çobanovdur. Həmin bölmədə antroponimlər (Bəylər, Qasımlı, Səfərli...), etnotoponimlər (Quşçu, Ulaşlı, Türklər...), hidrotoponimlər (Qarabulaq, Qırxbulaq, Südbulaq...), zootoponimlər (Ayıtalası, Danaqıran, Leyləkuçan, Canavarlı...), fitotoponimlər (Armudlu, Qamışlı, Zoğallı, Vələsli, Palıdlı...), memuar-xatirə-toponimlər (Sabirkənd, Səməd Vurğun küçəsi, Nərimanov prospekti, Vazeh döngəsi...), kosmotoponimlər (Ayorta, Güney, Gündoğan...) sinxronik istiqamətlərdə təhlil edilir.

"Borçalı toponimləri haqqında qısa oçerklər" bəhs etdiyimiz kitabın ən əsas bölməsi hesab oluna bilər. Birincisi, ona görə ki, həmin bölmədə Orxan-Yenisey abidələri və "Kitabi-Dədə Qorqud" dastanı ilə səsləşən Azgəyliyən, Kaspi, Sadaqlı, Kəpənəkçi və s. kimi toponimlərin yaranma tarixi barədə geniş məlumat verilir. İkincisi, toponimik vahidlərin hər biri tarixi-linvistik prizmadan təhlil edildiyi üçün arxaik apelyativli toponimlərin səciyyəvi cəhətləri asanlıqla anlaşılır. Məsələn, Qarayazı, (böyük çöl), Qaracala (böyük çala,), Sadaqlı (Sadaq-ox qabı), Tüllər (tülü - tolu tayfa adı) və s.

"Bu cür faktlar isə "Borçalı toponimləri" kitabında onlarca toponimik vahidin etimoloji izahının verildiyini təsdiqləyir." – qənaətinə gələn müəllif - ADPU-nun Azərbaycan dilinin tədrisi metodikası kafedrasının müdiri, flologiya elmləri doktoru, professor Əzizxan Tanriverdi *"Şərqin səsi"* (N: 03 (198), fevral, 2007) və *"Hakimiyyət və gələcək"* (N: 06 (146), 04 aprel, 2007) qəzetlərində dərc olunmuş

"Mədəd Çobanov və onomalogiya məsələləri" məqaləsini belə bir sonluqla bitirmişdir: "Bu kiçik yazıda prof. Mədəd Çobanovun onomologiya ilə bağlı olan tədqiqatlarının az bir hissəsini, amma ən mühüm cəhətlərini əhatə etməyə çalışdım... Nəhayət, görkəmli dilçi-alim, tanınmış türkoloq, filologiya elmləri doktoru, professor Mədəd Çobanovu anadan olmasının 70 illik yubileyi münasibətilə ürəkdən təbrik edir və ona yeni-yeni yaradıcılıq uğurları arzulayıram." *(https://zim.az/gurcustan/pushkinciler/2389-mdd-obanov-v-onomalogya-msllr.html)*

Professor Əzizxan Tanriverdinin bu məqaləsindən sonra da, akademik Mədəd Çobanov təqaüdə çıxmasına baxmayaraq, ömrünün sonuna kimi elmi-pedaqoji fəaliyyətini davam etdirmiş, bir sıra elmi əsərlər yazmış, Azərbaycan Respublikası "Təhsil" Mərkəzininin Baş direktoru olmuş, müxtəlif mükafat komissiyalarının, qəzet və jurnalların redaksiya heyətlərinin üzvü seçilmiş, dəfələrlə Fəxri fərman, orden, medal və müxtəlif mükafatlarla təltif olunmuşdur.

Akademik Mədəd Çobanov 2021-ci ildə Prezident təqaüdünə layiq görülmüşdür.

1997-ci, 2007-ci, 2012-ci, 2017-ci və 2022-ci illərdə alimin 60, 70, 75, 80 və 85 illik yubileyləri Azərbaycanda və Gürcüstanda təntənəli surətdə qeyd olunmuş, haqqında kitablar yazılmış, məqalələr çap olunmuş, radio və televiziya verilişləri hazırlanmış, filmlər çəkilmişdir. O cümlədən, akademik Nizami Cəfərovun *"Zəhmətkeş alim, tanınmış dilçi-türkoloq"* adlı kitabı oxucuların ixtiyarına verilmişdir. *(Bakı: Az-AtaM, "Elm və təhsil" nəşriyyatı, 2012, 140 s. https://www.anl.az/el/c/Azf-266649.pdf)*

Akademik Mədəd Çobanov 2 iyun 2023-cü ildə 86 yaşında vəfat etmiş, iyunun 3-də Bakının Dədə Qorqud qəbiristanlığında dəfn olunmuşdur.

Akademik Mədəd Çobanov həm də gözəl ailə başçısı idi. Ömür-gün yoldaşı, tibb işçisi Rima Nadir qızı Əhmədova-Çobanova ilə birlikdə 5 övlad - 4 qız və 1 oğul böyüdüb-boya başa çatdırıb. Hamısı da ali təhsilli və ailəlidir. Oğlu və iki qızı alimdir. 9 nəvəsi, 18 nəticəsi var. Nəvələrinin də 9-u da ali təhsillidir.

Akademik Mədəd Çobanov dünyasını dəyişdikdən sonra da unudulmamış, Bakıda və Tbilisidə, eləcə də, Bolnisidə, Dmanisidə, Marneulidə, Qardabanidə və başqa bölgələrdə alimin ad və anım günləri qeyd olunmuş, onun əziz xatirəsinə neçə-neçə şeirlər, poemalar, esselər həsr olunmuş, müxtəlif tədbirlər, müsabiqələr, olimpiadalar, yarışlar və s. təşkil edilmiş, həyat və yaradıcılığı haqqında kitablar yazılmış, Azərbaycan və Gürcüstan mətbuatında silsilə məqalələr dərc olunmuş, Bakıda nəfis şəkildə çap olunaraq oxucular ixtiyarına verilmiş kitabların Azərbaycanda və Gürcüstanda təqdimatları keçirilmiş, həmin tədbirlər Azərbaycan və Gürcüstan mətbuatında, radio və televiziya verilişlərində, bir sıra internet saytlarında işıqlandırılmış və bütün bunlar Azərbaycan elminin inkişafını, həmçinin, Azərbaycan və gürcü xalqları arasındakı dostluq əlaqələrini daha da intensivləşdirmişdir.

Nəticə

Bir sözlə, akademik Mədəd Çobanovun yaradıcılığında Azərbaycan dili, Azərbaycanşünaslıq, türkologiya, türk ədəbi dillərinin birliyi, dilçilik, dialektologoiya, linqvistika, onomastika, xüsusilə də, antroponimika və toponimika, eləcə də, ədəbi tənqid və ədəbiyyatşünaslıq, ədəbi əlaqələr, o cümlədən, Azərbaycan və gürcü xalqlarının dostluq və qardaşlıq ənənələrinin ədəbi-bədii və elmi ədəbiyyatda təcəssümü və s. amillər yeni müstəviyə keçmiş, elmi təfəkkürdə öz geniş əksini tapmış, müəllifinin elmdə daha uzun ömür sürməsini təmin etmiş və beləliklə də, Azərbaycan dilçiliyi və Azərbaycan ədəbiyyatşünaslığı, ümumi olaraq, türkologiya və filologiya elmi, həmçinin, Azərbaycan-gürcü ədəbi əlaqələri daha da zənginləşmişdir.

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POLITICAL SCIENCES

FROM EMPIRE TO MOBILITY: GEORGIAN MIGRATION ROUTES IN THE BLACK SEA REGION FROM THE LATE 19TH CENTURY TO THE POST-SOVIET ERA

Vashakidze L.
PhD
International Black Sea University, Georgia
DOI: 10.5281/zenodo.18677932

Abstract

This article examines the historical evolution of Georgian migration through the Black Sea region from the late nineteenth century to the post-Soviet period. By situating Georgian mobility within broader imperial, Soviet, and post-Soviet frameworks, the study explores how migration routes, motivations, and regulatory regimes have transformed over time while retaining structural continuities. Particular attention is paid to the Black Sea as a transregional space of circulation linking the South Caucasus with Eastern Europe, Anatolia, and beyond. Drawing on historical literature, migration theory, and regional analysis, the article argues that contemporary Georgian migration patterns cannot be understood in isolation from earlier imperial and Soviet mobility regimes. The study contributes to current debates on mobility, transformation, and regional connectivity in Eastern Europe and the South Caucasus, highlighting the Black Sea as a long-standing corridor of economic, social, and cultural exchange.

Keywords: Georgian migration, Black Sea region, South Caucasus, mobility, empire, post-Soviet transformation, transregional history.

1. Introduction

Migration has long been a defining feature of the South Caucasus, shaped by imperial governance, economic restructuring, and shifting political borders. Georgia, located at the crossroads of Europe and Asia and embedded within the Black Sea world, has historically functioned as both a point of departure and a zone of transit. While contemporary discussions often frame Georgian migration as a post-Soviet or globalization-driven phenomenon, this perspective overlooks the deeper historical roots of mobility in the region.

This article examines Georgian migration from the late nineteenth century to the present, focusing on the Black Sea as a transregional space connecting the South Caucasus with Eastern Europe, Anatolia, and the wider world. By adopting a longue durée perspective, the study demonstrates that present-day migration patterns—labor mobility, circular migration, and transnational networks—are deeply embedded in earlier imperial and Soviet-era practices.

The central argument advanced here is that Georgian migration represents a historical continuum shaped by changing political regimes rather than a series of disconnected waves. Understanding this continuity is essential for analyzing contemporary mobility trends and the broader transformation processes in Eastern Europe and the Caucasus.

2. The Black Sea as a Historical Space of Mobility

The Black Sea has historically functioned not as a border but as a connective space linking empires, markets, and populations. From the late Ottoman and Russian imperial periods onward, ports such as Batumi, Poti, Odessa, and Trabzon served as key nodes in trade, labor migration, and cultural exchange.

In the late nineteenth century, the incorporation of Georgia into the Russian Empire intensified population movement. Georgian laborers, merchants, and intellectuals traveled throughout the empire, while the development of railways and port infrastructure facilitated seasonal and permanent migration. The Black Sea coastline became an economic corridor connecting agricultural hinterlands with industrial and urban centers.

Migration during this period was not solely economically motivated. Educational mobility, military service, and administrative appointments contributed to the formation of transregional networks that connected Georgia to the wider imperial space. These early patterns laid the groundwork for later mobility practices under Soviet rule.

3. Mobility under Soviet Rule: Controlled Movement and Hidden Circulation

The Soviet period introduced a radically different migration regime. Officially, mobility was tightly regulated through the propiska system, internal passports, and state-controlled labor allocation. However, in practice, mobility remained a central feature of Soviet life.

Georgia occupied a distinctive position within the Soviet Union. On the one hand, it was integrated into centralized economic planning; on the other, it maintained strong informal networks across the Black Sea region. Labor migration to industrial centers in Russia and Ukraine, educational mobility to Moscow and Leningrad, and seasonal work in agriculture and construction were widespread.

Despite strict border controls, the Black Sea continued to function as a semi-open zone of exchange through maritime trade, tourism, and professional mobility. These experiences produced social capital, transregional ties, and migration knowledge that would later become crucial after the collapse of the Soviet Union.

4. Post-Soviet Transformation and the Reconfiguration of Migration Routes

The dissolution of the Soviet Union marked a fundamental turning point in Georgian migration. Economic collapse, political instability, and armed conflicts in the 1990s generated large-scale outward migration. Unlike earlier periods, migration was now largely driven by survival strategies rather than state planning.

The Black Sea once again emerged as a key corridor. Turkey, Greece, Ukraine, and later EU member states became primary destinations for Georgian labor migrants. Informal employment, circular migration, and temporary mobility became dominant patterns, particularly in construction, agriculture, and domestic work.

At the same time, migration routes expanded beyond the Black Sea region. Georgian migrants increasingly sought opportunities in Western Europe and North America, often navigating restrictive visa regimes and irregular pathways. Yet even in these global movements, the Black Sea remained a critical intermediary zone, shaping networks, transit routes, and migration strategies.

5. Continuities and Transformations in Georgian Mobility

A comparative perspective reveals several enduring features of Georgian migration:

1. **Structural Continuity** – Migration has consistently functioned as a response to economic asymmetry and political transformation.
2. **Network-Based Mobility** – Informal social networks have remained central across imperial, Soviet, and post-Soviet periods.
3. **Regional Embeddedness** – Despite global expansion, Georgian migration remains deeply anchored in the Black Sea region.
4. **Adaptation to Political Regimes** – Migrants have continuously adapted to changing legal and institutional environments.

These patterns demonstrate that contemporary migration trends are not anomalies but part of a longer historical trajectory shaped by imperial legacies, regional connectivity, and socio-economic transformation.

6. Conclusion

This article has argued that Georgian migration must be understood as a historically embedded, transregional phenomenon shaped by the dynamics of the Black Sea world. From imperial labor mobility to post-Soviet migration strategies, Georgian movement has consistently reflected broader transformations in political authority, economic organization, and regional connectivity.

By situating Georgian migration within a long-term historical framework, the study contributes to ongoing scholarly debates on mobility, borders, and transformation in Eastern Europe and the South Caucasus. It also highlights the importance of viewing the Black Sea not as a peripheral space, but as a central arena of interaction linking Europe, Eurasia, and the Caucasus.

Future research could further explore comparative perspectives between Black Sea and Baltic mobility systems, as well as the role of migration in shaping post-Soviet identities and transnational social fields.

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WORLD LITERATURE

PIATRA ȘI POVESTEA: MATRICEA MITICĂ ȘI IMPERATIVUL ETIC AL FRUMUSEȚII ÎN *LEUL, VRĂJITOAREA ȘI DULAPUL* DE C.S. LEWIS

Capota A.
Doctorand anul III, Universitatea din Oradea, Romania
Școala doctorală de Arte
Filologie

STONE AND STORY: THE MYTHIC MATRIX AND THE ETHICAL IMPERATIVE OF BEAUTY IN C.S. LEWIS'S *THE LION, THE WITCH AND THE WARDROBE*

Capota A.
PhD Candidate, III[rd] year University of Oradea, Romania
Doctoral School of Humanities and Arts
Field of Study: Philology
DOI: 10.5281/zenodo.18677938

Abstract

Prezentul studiu examinează imaginația sculpturală în opera lui C.S. Lewis, *Leul, Vrăjitoarea și Dulapul* (1950), volumul inaugural al *Cronicilor din Narnia*, privită ca un spațiu de convergență a substraturilor mitice, a structurii estetice și a imperativelor etice. Departe de a trata arta ca pe un simplu element simbolic sau decorativ, această analiză pune în prim-plan imaginația artistică drept principiu structural fundamental al narațiunii. Utilizând cadre interdisciplinare din teoria literară, studiile de mitologie și estetică, articolul susține că procesul pietrificării, transformarea ființelor vii în statui de piatră de către Vrăjitoarea Albă, funcționează atât ca motiv mitic recurent, cât și ca dispozitiv estetic sofisticat ce modelează dimensiunile ontologice și etice ale romanului.

Prima secțiune explorează matricea mitică ce fundamentează narațiunea lui Lewis, urmărind tiparele pietrificării până la surse din mitologia clasică, pe care Lewis le-a aprofundat în activitatea sa academică. Aceste rezonanțe intertextuale relevă modul în care motivele antice sunt reimaginate într-un cadru teologic creștin, unde piatra devine un simbol al paraliziei spirituale, al judecății morale și al posibilității învierii. Galeria de statui a Vrăjitoarei Albe operează ca o anti-creație, un cosmos înghețat ce așteaptă reanimarea mântuitoare prin suflarea lui Aslan — ecou clar al Genezei și al logicii întrupării, centrale în apologetica lui Lewis. În Narnia, sculptura nu este niciodată inertă; ea întruchipează miza etică a narațiunii. Figurile de piatră păstrează curajul, sfidarea sau eroare tragică, neavând simpla condiție de victimă. Suflarea restauratoare a lui Aslan devine o experiență trăită a puterii mântuitoare a frumosului, care transformă deopotrivă personajul narnian și cititorul.

A doua secțiune dezvoltă conceptul unei „etici a frumosului”, în care frumusețea este experimentată activ ca o chemare morală și spirituală. Masa de Piatră concentrează această dialectică: fixată imuabil în geografia Narniei, ea trece prin cea mai radicală transformare prin fracturarea și regenerarea sa ulterioară. Această lectură contestă interpretările alegorice reductive, demonstrând modul în care arta lui Lewis operează simultan pe mai multe paliere: structural, simbolic și experiențial.

În cele din urmă, articolul situează imaginația sculpturală a lui Lewis în contextul dezbaterilor mai largi privind imperativul etic al frumosului în literatura secolului XX. Într-o epocă a dezvrăjirii, Lewis reafirmă capacitatea artei de a trezi uimirea, responsabilitatea morală și angajamentul existențial. Figurile înghețate din casa Vrăjitoarei sunt un avertisment împotriva pietrificării imaginației înseși, o pierdere pe care Lewis a diagnosticat-o în modernitate. Reanimând mitul prin arta narativă, Lewis elaborează o estetică ce insistă asupra inseparabilității frumosului de adevăr și bine, oferind o contra-narațiune la fragmentarea valorilor în cultura contemporană.

Acest studiu interdisciplinar contribuie la cercetarea operei lui Lewis prin evidențierea dimensiunilor estetice adesea ignorate ale ficțiunii sale, demonstrând că structura narativă, aluzia mitică și viziunea etică sunt indisolubil legate în opera sa literară, cu precădere în *Cronicile din Narnia*.

Abstract

This study examines the sculptural imagination in C.S. Lewis's *The Lion, the Witch and the Wardrobe* (1950), the inaugural volume of *The Chronicles of Narnia*, as a site where mythic substrates, aesthetic structure, and ethical mandates converge. Rather than treating art as merely symbolic or decorative, this analysis foregrounds artistic imagination as the foundational structural principle of the narrative itself. Drawing on interdisciplinary frameworks from literary theory, mythology studies, and aesthetics, the article argues that Lewis's use of petrification, the transformation of living beings into stone statues by the White Witch, functions as both a recurring mythic motif and a sophisticated aesthetic device that shapes the novel's ontological and ethical dimensions.

The first section explores the mythic matrix underlying Lewis's narrative, tracing petrification patterns to sources such classical mythology, which Lewis would have encountered in his scholarly work. These intertextual resonances reveal how ancient motifs are reimagined within a Christian theological framework, where stone becomes a symbol of spiritual paralysis, moral judgment, and the possibility of resurrection. The White Witch's gallery of statues operates as an anti-creation, a frozen cosmos awaiting redemptive reanimation through Aslan's breath, a clear echo of Genesis and the incarnational logic central to Lewis's apologetics. In Narnia, sculpture is never inert; it embodies the ethical stakes of the narrative. The stone figures contain courage, defiance, or tragic error rather than mere victimhood. Aslan's restorative breath becomes a lived experience of beauty's redemptive power that transforms both the Narnian character and reader.

The second section develops the concept of an ethics in beauty, wherein beauty is actively experienced as a moral and spiritual summon not only passively observed by the reader in our case. The Stone Table concentrates this dialectic: rooted unchangingly in Narnian geography, it undergoes the most radical transformation through its fracturing and subsequent regeneration. This reading challenges reductive allegorical interpretations by demonstrating how Lewis's art operates on multiple registers simultaneously: structural, symbolic, and experiential.

Ultimately, the article situates Lewis's sculptural imagination within broader debates about the ethical imperative of beauty in twentieth-century literature. In an age of disenchantment, Lewis reasserts art's capacity to awaken wonder, moral responsibility, and existential engagement. The frozen figures in the Witch's house are a warning against the petrification of the imagination itself a loss Lewis diagnosed in modernity. By reanimating myth through narrative art, Lewis crafts an aesthetic that insists on beauty's inseparability from truth and goodness, offering a counter-narrative to the fragmentation of value in contemporary culture.

This interdisciplinary study contributes to Lewis scholarship by foregrounding the often-overlooked aesthetic dimensions of his fiction, demonstrating that narrative structure, mythic allusion, and ethical vision are inextricably intertwined in his literature work, mainley in the *Chronicles of Narnia*.
Cuvinte cheie: naratologie, hermeneutică a sculpturii, mitologie, motivul pietrificării.

Keywords: narrative, sculptural hermeneutics, mythology, petrification motif.

Narnia emerges as a vast sculptural workshop in which the main characters, every element of the landscape, and every narrative event participates in a process of transformation that follows the logic of sculpture: the revelation of hidden form through the elimination of the superfluous, the liberation of essence from raw matter. This conception resonates with the philosophy of sculpture articulated by Michelangelo, for whom each block of marble concealed a statue that the sculptor had the duty to liberate, an idea documented in his writings and analyzed extensively by scholars such as Rudolf Wittkower in *Sculpture: Processes and Principles* (1977).[1] Wittkower establishes a crucial definitional boundary: "The term sculptor denoting an artist, and only an artist who works in three dimensions."[2] This specificity proves essential for understanding Lewis's narrative method, as he operates as a writer describing a world, as a literary sculptor constructing a three-dimensional imaginative space through language. Beyond this foundational metaphor, there are also other elements in Michelangelo's artistic theory that merit attention from a Renaissance aesthetic perspective. One of these is the emphasis on *disegno interno*, one's capacity to perceive the form inherent within the raw material before its physical manifestation.[3]

Lewis's Narnian narrative mobilizes the fundamental **elements of three-dimensional design:** *space* (the liminal threshold between our world and Narnia), *line* (the contours that define characters and creatures), *plane* (the flat surfaces of the Stone Table and castle walls), *mass and volume* (the corporeality of Aslan versus the hollowness of the Witch's power), *shape* (both positive forms and negative spaces within the frozen landscape), *value* (the interplay of light and shadow that defines moral territories), *texture* (from Lucy's tactile encounter with fur coats transforming into pine needles), and *color* (the chromatic opposition between the White Witch's cadaverous pallor and Aslan's golden luminosity). These elements operate in concert with sculptural **principles**: *harmony* (the resolution of forces), *contrast and variety* (the diversity of Narnian creatures against monochromatic tyranny), *rhythm and repetition* (the cyclical pattern of freezing and thawing, death and resurrection), *emphasis* (the Stone Table as the compositional and theological climax), *balance* (the shift between the powers of good and evil), and *proportion* (the scalar relationships that render Narnia both intimate and cosmic). [4]

Moreover, the present study proposes an unprecedented approach in Lewisian criticism: the application of sculpture's aesthetic principles as a primary hermeneutic method for analyzing narrative structure, character dynamics, and mythic substrates in *The Lion, the Witch and the Wardrobe*. Unlike previous studies that treat sculpture in Lewis's work either as a simple metaphor[5] or as a decorative element of his literary universe, this research demonstrates that sculptural imagination functions as a fundamental structural matrix of the narrative, shaping its symbolism and also the ontological architecture of the Narnian world. The narrative itself employs the **four basic methods for creating three-dimensional forms**: *subtraction* (Aslan's sacrifice removing Edmund's guilt), *manipulation* (the malleable transformation of the children's characters), *addition* (the accumulation of liberated creatures building toward spring's return), and *substitution* (Aslan's vicarious death creating a duplicate sacrifice that cracks the deep magic). Through this sculptural lens, Narnia reveals itself as a three-dimensional artwork in which such elements as shape, internal design and different textures of the stone contribute to an integrated aesthetic and theological vision.

The proposed analytical method, the articulation of classical and Renaissance sculptural principles with Celtic and Christian mythic substrates, has not been systematically applied in studies dedicated to children's fantasy literature. Existing research on Lewis's work has focused predominantly on the Christian allegorical dimension,[6] on intertextuality with classical mythology, or on the pedagogical aspects of the Chronicles.[7] The sculptural dimension as a structural principle remains unexplored territory, even though Lewis himself, as a specialist in medieval literature and literary theorist, demonstrated a profound understanding of the relationship between visual arts and narrative, as evidenced in his essays on imagination and allegory.[8] The present study aims to fill this critical gap, offering an interpretive framework that integrates sculptural aesthetics, comparative mythological analysis, and participatory theology in an interdisciplinary reading of the Lewisian text, an approach that not only enriches our understanding of *The Lion, the Witch and the Wardrobe* but also opens new perspectives for analyzing fantasy literature as a space of intersection between visual arts, narrative, and spirituality.

The sculptural process begins with the children's entry into Narnia. The magical environment acts as an invisible chisel, gradually revealing each child's unique characteristics. Peter progressively becomes "Peter the Magnificent," acquiring the volumetrics of a leader; his gestures become more expansive, his voice firmer, his entire presence gains in authority. Susan evolves toward "Susan the Gentle," and her volumetrics are defined by maternal care and practical wisdom. Edmund, the most dramatic example of sculptural transformation, passes from "corrupted matter," rigidified by betrayal and selfishness, to "Edmund the Just", a metamorphosis that follows the logic of sculptural purification. Lucy, "Lucy the Valiant," represents perhaps the purest example of the revelation of hidden form. The little girl gradually discovers the interior volumetrics of courage and compassion without requiring dramatic intervention: as if her perfect form were already there, waiting only to be freed from the conventional layers of childhood.

The mythic matrix underlying Lewis's narrative reveals a sophisticated palimpsest of petrification motifs drawn from both folkloric and classical traditions that the author would have encountered extensively in his academic work as a medievalist and literary historian. The transformation of living beings into stone constitutes one of humanity's oldest narrative archetypes, appearing in Greek mythology through the Medusa myth, in Ovid's *Metamorphoses* through the story of Niobe, and throughout Germanic folklore, especially in the Brothers Grimm collection that Lewis knew in detail. The availability of numerous myths that speak of statues coming to life, animated statues that violate the rules of separation between the realm of the imaginary and that of the real world, proves that Lewis mobilizes a fundamental mythological topos: the transition from inert representation to animated presence, from *phantasma* to full ontological reality.

However, Lewis does not simply borrow these motifs; he refracts them through a Christian theological lens that transforms petrification from permanent curse into temporary suffering awaiting divine intervention. The stone statues diplayed as a proof of power in the White Witch's courtyard serve as sculptural texts, each frozen figure captured mid-gesture. The sculptural principle operates in this narrative sequence on multiple registers: aesthetically, these figures embody the unsettling intersection of the animate and inanimate; theologically, they represent souls in a state of spiritual paralysis, unable to move toward salvation without external grace; and narratively, they constitute a visual argument about the nature of evil as fundamentally anticreative, capable only of freezing or copying the real rather than generating new life. The White Witch's power is essentially sculptural in the most sinister sense, she shapes not through the artist's creative engagement with material but through a trivialization of the living to the condition of mere object. This inversion of the artistic process highlights Lewis's deeper concern with modernity's tendency toward reification, toward treating persons as things. When Aslan's breath reanimates these stone figures, the reversal acquires profound ontological significance: breath (*pneuma*, spirit) restores what cold enchantment had frozen, recapitulating the Genesis narrative where divine breath transforms clay into living being. In this Narnian economy, the supreme artist is not the Witch who petrifies but Aslan who breathes life into stone, reenacting the creative gesture from Genesis and anticipating eschatological resurrection.

1. Ars Spiritualis: Transcending Discursivity Through Spatial Arts in Lewisian Aesthetics

The aesthetic coherence of the Lewisian fairy tale is best understood through the mechanics of sculpture, specifically in its treatment of volumetrics, materiality, and the contrast between light and shadow. This approach recontextualizes the fairy tale within contemporary aesthetic theories, demonstrating that Lewis creates a universe in which matter and spirit maintain constant dialogue. [8] We have at our disposal a vast array of myths that speak of statues coming to life, animated statues that violate the rules of separation between the realm of the imaginary and that of the real. Narnian sculptures are already contaminated with a surplus of reality, for life pulses within them, situating them beyond the boundaries of conventional mimesis.

Adina Nanu, an art historian researcher claims, in her study dedicated to sculpture that a sculpture is "composed of a multitude of images that connect with each other, flow from one into another, succeeding each other as in music variations on the same theme."[9] The reader is thus invited to move among the statues that make their appearance in *The Lion, the Witch and the Wardrobe* at the speed and rhythm determined by the director, the author himself. His intention is most likely to discover the fullnesses (frozen gestures, expressions fixed in stone), as well as the significant voids of absences, of voices reduced to silence, of the suspended movements of the characters. Each statue in the stone cortege constitutes a variation on the theme of transformation: fauns caught in mid-dance, lions stopped in mid-leap, centaurs frozen with weapons raised. These images "flow from one into another" as the children traverse the castle's chambers. From a narrative perspective, the sculptures anticipate the drama of their own liberation. Lewis orchestrates this sculptural succession with cinematographic precision: the reader's gaze is guided from the intimate detail of a stone nose to the terrifying panorama of the entire collection, Lucy's steps on the cold stone of the interior courtyard ringing hollow and stark, creating a rhythm that alternates between proximity and distance, between empathy and horror. [10]

Nanu's concept of "fullnesses and voids" becomes especially productive when applied to the reanimation scene. Aslan's breath not only fills the void of the statues with life but reveals the ontological void that petrification had created, the absence of sound, of warmth, of relationship. The moment when stone becomes flesh reconstitutes the musical flow interrupted by Jadis's spell: the statues begin to breathe, to speak, to move, resuming the variation at which they had been brutally stopped. Thus, Lewis transforms the sculptural principle, traditionally associated with permanence, into a dynamic narrative instrument, demonstrating that even immobility can be eloquent, that even the silence of stone can speak of the promise of resurrection. Consequently, it is only natural that the characters erupt into a frenetic dance upon their thawing.

Rather than mere victims, these statues serve as petrified witnesses to courage, defiance, or tragic misjudgment. Their eventual restoration transcends physical liberation, offering instead an encounter with a beauty so potent it transforms both the characters and the reader. This dynamic reflects Lewis's core argument in *An Experiment in Criticism*: authentic art does not communicate *about* the transcendent but facilitates access *toward* the transcendent.[11] The petrified creatures in the Witch's castle are not mere symbols of sin or spiritual death; they are concrete presences that solicit the reader's affective and ethical response, transforming reading into an act of aesthetic participation.

2. Soteriological Dialectic: From Lex to Gratia

The physical and symbolic center of this dialectic is the Stone Table, the supreme sculptural object of the Narnian narrative, which functions simultaneously as sacrificial altar, juridical monument, and ontological threshold between Lex and Gratia. Upon this table is inscribed the Deep Magic, the cosmic law of retributive justice that demands blood for betrayal, *ius talionis* engraved in the very substance of the universe. The narrative presents the Table with archaeological precision, details building in the reader's mind a series of questions through "all manner of lines and odd-looking letters which they did not understand."[12] The mystery of the unknown alphabet adds a temporal dimension to the sculpture; it occupies space and time of mythic nature, being the bearer of a history that profiles itself beyond the narrative present. Within Narnian geography, the Stone Table rises with the gravity of a cosmic altar, its hilltop placement establishing a threshold between earthly and heavenly domains. The graduated ascent, from foothill to the Table's elevation, structures a progression calling for vertical engagement with narrative space. The Stone Table's materiality, gray stone, carries deliberate significance. Lewis selects stone precisely because it encapsulates sculpture's essential paradox: durability coupled with plasticity. Stone suggests permanence, yet remains susceptible to shaping; it conveys rigidity, yet proves capable of artistic transfiguration. The Stone Table embodies this dialectic in concentrated form: fixed immutably within Narnian topography, it nevertheless experiences ultimate transformation through its splitting and renewal.

The Table's form, "a great grim slab of grey stone supported on four upright stones"[13] with prehistoric megalithic structures, links the Narnian world to humanity's archetypal memory. This sculptural intertextuality amplifies the Table's symbolic dimensions, establishing deep continuity with Narnia's historical and metaphysical foundations a material embodiment of the ancient moral order Aslan maintains and protects.

The Witch invokes the "Deep Magic," a law engraved on the Stone Table: any traitor, like Edmund, must lose his life as her legitimate prey. Aslan offers his own life for Edmund, enduring a night of solitary sorrow like Christ in the Garden of Gethsemane (Gethsemane" literally translates from the Hebrew/Aramaic (*Gath-Shmane*) as "Oil Press," which provides a powerful metaphor for the "crushing" weight of the Passion) and then a day of humiliation and death like the Passion. [14] This progression from "Deep Magic" to "Deeper Magic" crystallizes the fundamental tension between retributive justice and saving mercy in Lewisian theology: "there was a magic deeper still which she did not know. Her knowledge goes back only to the dawn of time. But if she could have looked a little further back, into the stillness and the darkness before Time dawned, she would have read there a different incantation. She would have known that when a willing victim who had committed no treachery was killed in a traitor's stead, the Table would crack and Death itself would start working backward."[15]

Unlike Druidic examples or even Isaac's sacrifice, where the substitute is offered by others, Aslan volunteers as substitute. This benevolent offering eliminates any suspicion of arbitrary divine violence; there is no external divinity demanding blood, but rather the divine principle itself assuming the cost of restoring moral order. The Witch operates exclusively in the legalistic register; she knows and invokes the principles that govern moral responsibility and the consequences of betrayal, but remains blind to the dimension that transcends justice: sacrificial love. By aligning this 'night of solitary sorrow' with the Gethsemane narrative, Lewis moves beyond decorative allusion to reveal the visceral, human reality that underpins his theology of sacrifice. Aslan does not accept death with stoic detachment but experiences anticipatory agony and spiritual isolation, what Orthodox theology calls *kenosis*, the self-emptying of divinity to assume the human condition in its totality, including suffering and death. The concept of "Deeper Magic" goes beyond the simple opposition between law and grace to suggest the existence of a superior ontological principle that does not nullify justice but fulfills it through transcendence.

The moment of the Stone Table's cracking marks an extraordinary demonstration of Lewis's capacity to transform death into creation. At the place where Aslan is killed, the fissure in the table becomes the line of force that organizes its entire expressiveness and symbolism. Lewis revealed in a letter to Mrs. Mackey dated June 8, 1960 [16], that indeed, when he referred to the stone table, he alluded to Moses's stone tablets. The confession in the letter to Mrs. Mackey confirms explicit intention: the Stone Table constitutes a deliberate allusion to the tablets of Mosaic law. The table shatters because the law has been fulfilled through sacrificial love.

Conclusion

The sculptural analysis of *The Lion, the Witch and the Wardrobe* reveals a Lewisian aesthetics profoundly integrated with participatory theology, in which spatial arts transcend their purely representational function to become vehicles of spiritual revelation. This aligns with Lewis's conviction that the purpose of high art is not to inform the audience about the transcendent, but to facilitate an ontological bridge toward it.The petrified statues in the White Witch's castle are concrete presences that solicit the reader's affective and ethical response, transforming reading into an act of aesthetic participation.

The shattering of the Table and the metamorphosis of stone into flesh mark the point where sculptural rigidity yields to the fluidity of Grace, culminating in the frenetic dance of reclaimed life. Thus, through the prism of sculpture, Lewis demonstrates that authentic art is a transformative force not a passive form that mediates the human encounter with the transcendent. Narnia remains an open sculptural workshop, a space in which the reader is invited to view the statues, to witness their transformation, to feel the breath that reanimates them, and to discover, in the shattering of the Stone Table, the fragments of a world in which art and grace collaborate in liberating the hidden form from the raw matter of fallen existence.

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