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Open Science

Open Science Philosophy

Open science encompasses unrestricted access to scientific research articles, access to data from public research, and collaborative research enabled by information and communication technology tools, models, and incentives. Broadening access to scientific research publications and data is at the heart of open science. The objective of open science is to make research outputs and its potential benefits available to the entire world and in the hands of as many as possible:

- Open science promotes a more accurate verification of scientific research results. Scientific inquiry and discovery can be sped up by combining the tools of science and information technologies. Open science will benefit society and researchers by providing faster, easier, and more efficient availability of research outputs.
- Open science reduces duplication in collecting, creating, transferring, and re-using scientific material.
- Open science increases productivity in an era of tight budgets.
- Open science results in great innovation potential and increased consumer choice from public research.
- Open science promotes public trust in science. Greater citizen engagement leads to active participation in scientific experiments and data collection.

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Open Society

An open society allows individuals to change their roles and to benefit from corresponding changes in status. Open science depends to a greater or lesser extent on digital technologies and innovations in structural processes by an open society. When realized, open science research and innovation can create investment opportunities for new and better products and services and therefore increase competitiveness and employment. Open science research and innovation is a key component of thematic open science priorities. Central to the open science digital infrastructure is enabling industry to benefit from digital technology and to underpin scientific advances through the development of an open society. Open science research and innovation can also contribute to society as a global actor because scientific relations can flourish even where global relations are strained. Open science has a critical role across many areas of decision making in providing evidence that helps understand the risks and benefits of different open science choices. Digital technology is making the conduct of open science and innovation more collaborative, more global, and more open to global citizens. Open society must embrace these changes and reinforce its position as the leading power for science, for new ideas, and for investing sustainably in the future.

It is apparent in open society that the way science works is fundamentally changing, and an equally significant transformation is taking place in how organizations and societies innovate. The advent of digital technology is making research and innovation more open, collaborative, and global. These exchanges are leading open society to develop open science and to set goals for research and innovation priority. Open science goals are materializing in the development of scientific research and innovation platforms and greater acceptance of scientific data generated by open science research. Open science research and innovation do not need help from open society to come up with great ideas, but the level of success ideas ultimately reach is undoubtedly influenced by regulation, financing, public support, and market access. Open society is playing a crucial role in improving all these success factors.

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Open science represents a new approach to the scientific process based on cooperative work and new ways of diffusing knowledge by using digital technologies and collaborative tools. These innovations capture a systemic change to the way science and research have been carried out for the last fifty years. Science is shifting from the standard practice of publishing research results in scientific publications after the research and reviews are completed. The shift is towards sharing and using all available knowledge at an earlier stage in the research process. Open science is to science what digital technology is to social and economic transactions: allowing end users to be producers of ideas, relations, and services and in doing so, enabling new working models, new social relationships and leading to a new modus operandi for science. Open science is as important and disruptive as e-commerce has been for the retail industry. Just like e-commerce, the open science research paradigm shift affects the whole business cycle of doing science and research. From the selection of research subjects to the carrying out of research, to its use and re-use, to the role of universities, and that of publishers are all dramatically changed. Just as the internet and globalization have profoundly changed the way we do business, interact socially, consume culture, and buy goods, these changes are now profoundly impacting how one does research and science.

The discussion on broadening the footprint of science and on novel ways to produce and spread knowledge gradually evolved from two global trends: Open Access and Open Source. The former refers to online, peer-reviewed scholarly outputs, which are free to read, with limited or no copyright and licensing restrictions, while open source refers to software created without any proprietary restriction and which can be accessed and freely used. Although open access became primarily associated with a particular publishing

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or scientific dissemination practice, open access already sought to induce a broader practice that includes the general re-use of all kinds of research products, not just publications or data. It is only more recently that open science has coalesced into the concept of a transformed scientific practice, shifting the focus of researchers' activity from publishing as fast as possible to sharing knowledge as early as possible. Open science is defined as the idea that scientific knowledge of all kinds should be openly shared as early as is practical in the discovery process. As a result, the way science is done in the future will look significantly different from the way it is done now. Open science is the ongoing evolution in the modus operandi of doing research and organizing science. This evolution is enabled by digital technology and is driven by both the globalization of the scientific community and increasing public demand to address the societal challenges of our times. Open science entails the ongoing transitions in the way research is performed, researchers collaborate, knowledge is shared, and science is organized.

Open science impacts the entire research cycle, from the inception of research to its publication, and on how this cycle is organized. The outer circle reflects the new interconnected nature of open science, while the inner circle shows the entire scientific process, from the conceptualization of research ideas to publishing. Each step in the scientific process is linked to ongoing changes brought about by open science, including the emergence of alternative systems to establish a scientific reputation; changes in the way quality and impact of research are evaluated; the growing use of scientific blogs; open annotation; and open access to data and publications. All institutions involved in science are affected, including research organizations, research councils, and funding bodies. The trends are irreversible, and they have already grown well beyond individual projects. Theses changes predominantly result from a bottom-up process driven by a growing number of researchers who increasingly employ social media in their research and initiate globally coordinated research projects while sharing results at an early stage in the research process.

Open science is encompassed in five schools of thought:

- o the infrastructure school, concerned with technological architecture
- o the public school, concerned with the accessibility of knowledge creation
- o the measurement school, concerned with alternative impact assessment
- o the democratic school, concerned with access to knowledge
- o the pragmatic school, concerned with collaborative research

According to the measurement school, the reputation and evaluation of individual researchers are still mainly based on citation-based metrics. The h-index is an author-level metric that attempts to measure both the productivity and citation impact of the publications of a scientist or scholar. The impact factor is a measure reflecting the average number of citations to articles published in an academic journal and is used as a proxy for the relative importance of a journal.

Numerous criticisms have been made of citation-based metrics, primarily when used, and often misused, to assess the performance of individual researchers. These metrics:

- o are often not applicable at the individual level
- o do not take into account the broader social and economic function of scientific research
- o are not adapted to the increased scale of research
- o cannot recognize new types of work that researchers are performing

Web-based metrics for measuring research output, popularized as altmetrics, have recently received much attention: some measure the impact at the article level, others make it possible to assess the many outcomes of research in addition to the number of scientific articles and references. The current reputation and evaluation system has to adapt to the new dynamics of open science and acknowledge and incentivize

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engagement in open science. Researchers engaging in open science have growing expectations that their work, including intermediate products such as research data, will be better rewarded or taken into account in their career development. Vice-versa, the use, and reuse of open data will require appropriate codes of conduct requiring, for example, the proper acknowledgment of the original creator of the data.

These ongoing changes are progressively transforming scientific practices with innovative tools to facilitate communication, collaboration, and data analysis. Researchers that increasingly work together to create knowledge can employ online tools and create a shared space where creative conversation and collaboration can occur. As a result, the problem-solving process can be faster, and the range of problems that can be solved can be expanded. The ecosystem underpinning open science is evolving very rapidly. Social network platforms for researchers already attract millions of users and are being used to begin and validate more research projects.

Furthermore, the trends towards open access are redefining the framework conditions for science and thus have an impact on how open innovation is produced by encouraging a more dynamic circulation of knowledge. It can enable more science-based startups to emerge thanks to the exploitation of openly accessible research results. Open science, however, does not mean free science. It is essential to ensure that intellectual property is protected before making knowledge publicly available in order to subsequently attract investments that can help translate research results into innovation. If this is taken into account, fuller and broader access to scientific publications and research data can help to accelerate innovation. Investments that boost research and innovation in open science would benefit society with fewer barriers to knowledge transfer, open access to scientific research, and greater mobility of researchers. In this context, open access can help overcome the barriers that innovative organizations face in accessing the results of research funded by the public.

Open innovation

An open society is the largest producer of knowledge, but the phenomenon of open science is changing every aspect of the scientific method by becoming more open, inclusive, and interdisciplinary. Ensuring open society is at the forefront of open science means promoting open access to scientific data and publications alongside the highest standards of research integrity. There are few forces in this globe as engaging and unifying as science. The universal language of science maintains open channels of communication globally. Open society can maximize its gains through maintaining its presence at the highest level of scientific endeavor, and by promoting a competitive edge in the knowledge society of the information age. The ideas and initiatives described in this publication can stimulate anyone interested in open science research and innovation. It is designed to encourage debate and lead to new ideas on what and open society should do, should not do, or do differently.

An open society can lead to a research powerhouse; however, open society rarely succeeds in turning research into innovation and in getting research results to the global market. Open society must improve at making the most of its innovation talent, and that is where open innovation comes into play. The basic premise of open innovation is to open up the innovation process to all active players so that knowledge can circulate more freely and be transformed into products and services that create new markets while fostering a stronger culture of entrepreneurship. Open innovation is defined as the use of purposive inflows and outflows of knowledge to accelerate internal innovation. This original notion of open innovation was primarily based on transferring knowledge, expertise, and even resources from one company or research institution to another. This notion assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as they seek to improve their performance. The concept of open innovation is continually evolving and is moving from linear, bilateral transactions and collaborations

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towards dynamic, networked, multi-collaborative innovation ecosystems. This means that a specific innovation can no longer be seen as the result of predefined and isolated innovation activities but rather as the outcome of a complex co-creation process involving knowledge flows across the entire economic and social environment. This co-creation takes place in different parts of the innovation ecosystem and requires knowledge exchange and absorptive capacities from all the actors involved, whether businesses, academia, financial institutions, public authorities, or citizens.

Open innovation is a broad term, which encompasses several different nuances and approaches. Two main elements underpin the most recent conceptions of open innovation: the users are in the spotlight and invention becomes an innovation only if users become a part of the value creation process. Notions such as user innovation emphasize the role of citizens and users in the innovation processes as distributed' sources of knowledge. This kind of public engagement is one of the aims of open science research and innovation. The term 'open' in these contexts has also been used as a synonym for 'user-centric'; creating a well-functioning ecosystem that allows co-creation and becomes essential for open innovation. In this ecosystem, relevant stakeholders are collaborating along and across industry and sector-specific value chains to co-create solutions for socio-economic and business challenges. One important element to keep in mind when discussing open innovation is that it cannot be defined in absolutely precise terms. It may be better to think of it as a point on a continuum where there is a range of context-dependent innovation activities at different stages, from research to development through to commercialization, and where some activities are more open than others. Open innovation is gaining momentum thanks to new large-scale trends such as digitalization and the mass participation and collaboration in innovation that it enables. The speed and scale of digitalization are accelerating and transforming the way one designs, develops, and manufactures products, the way one delivers services, and the products and services themselves. It is enabling innovative processes and new ways of doing business, introducing new cross-sector value chains and infrastructures.

Open society must ensure that it capitalizes on the benefits that these developments promise for citizens in terms of tackling societal challenges and boosting business and industry. Drawing on these trends, and with the aim of helping build an open innovation ecosystem in open society, the open society's concept of open innovation is characterized by:

- o combining the power of ideas and knowledge from different actors to co-create new products and find solutions to societal needs
- o creating shared economic and social value, including a citizen and user-centric approach
- o capitalizing on the implications of trends such as digitalization, mass participation, and collaboration

In order to encourage the transition from linear knowledge transfer towards more dynamic knowledge circulation, experts agree that it is essential to create and support an open innovation ecosystem that facilitates the translation of knowledge into socio-economic value. In addition to the formal supply-side elements such as research skills, excellent science, funding and intellectual property management, there is also a need to concentrate on the demand side aspects of knowledge circulation, making sure that scientific work corresponds to the needs of the users and that knowledge is findable, accessible, interpretable and reusable. Open access to research results aims to make science more reliable, efficient, and responsive and is the springboard for increased innovation opportunities, e.g. by enabling more science-based startups to emerge. Prioritizing open science does not, however, automatically ensure that research results and scientific knowledge are commercialized or transformed into socio-economic value. In order for this to happen, open innovation must help to connect and exploit the results of open science and facilitate the faster translation of discoveries into societal use and economic value.

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Collaborations with global partners represent important sources of knowledge circulation. The globalization of research and innovation is not a new phenomenon, but it has intensified in the last decade, particularly in terms of collaborative research, international technology production, and worldwide mobility of researchers and innovative entrepreneurs. Global collaboration plays a significant role both in improving the competitiveness of open innovation ecosystems and in fostering new knowledge production worldwide. It ensures access to a broader set of competencies, resources, and skills wherever they are located, and it yields positive impacts in terms of scientific quality and research results. Collaboration enables global standard-setting, allows global challenges to be tackled more effectively, and facilitates participation in global value chains and new and emerging markets.

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The scholarly research review is a multidimensional evaluation procedure in which standard peer review models can be adapted in line with the ethos of scientific research, including accessible identities between reviewer and author, publishing review reports and enabling greater participation in the peer review process. Scholarly research review methods are employed to maintain standards of quality, improve performance, provide credibility, and determine suitability for publication. *Responsible Peer Review Procedure:* Responsible peer review ensures that scholarly research meets accepted disciplinary standards and ensures the dissemination of only relevant findings, free from bias, unwarranted claims, and unacceptable interpretations. Principles of responsible peer review:

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Fuzzy Approach for the Evaluation of Feasibility Levels of Vehicle Movement on the Disaster-Streaking Zone's Roads

Gia Sirbiladze

Abstract—Route planning problems are among the activities that have the highest impact on logistical planning, transportation, and distribution because of their effects on efficiency in resource management, service levels, and client satisfaction. In extreme conditions, the difficulty of vehicle movement between different customers causes the imprecision of time of movement and the uncertainty of the feasibility of movement. A feasibility level of vehicle movement on the closed route of the disaster-streaking zone is defined for the construction of an objective function. Experts' evaluations on the uncertain parameters in q-rung orthopair fuzzy numbers (q-ROFNs) are presented. A fuzzy bi-objective combinatorial optimization problem of fuzzy vehicle routine problem (FVRP) is constructed based on the technique of possibility theory. The FVRP is reduced to the bi-criteria partitioning problem for the so-called "promising" routes which were selected from the all-admissible closed routes. The convenient selection of the "promising" routes allows us to solve the reduced problem in real-time computing. For the numerical solution of the bi-criteria partitioning problem, the ε-constraint approach is used. Main results' support software is designed. The constructed model is illustrated with a numerical example.

Keywords—q-rung orthopair fuzzy sets, facility location selection problem, multi-objective combinatorial optimization problem, partitioning problem.

G. Sirbiladze is a Professor at the Department of Computer Sciences, Ivane Javakhishvili Tbilisi State University, 13, University street, 0186 Tbilisi, GEORGIA e-mail: gia.sirbiladze@tsu.ge).

Possibility Theory based Multi-Attribute Decision-Making. Application in Facility Location-Selection Problem under Uncertain and Extreme Environment

Bezhan Ghvaberidze

Abstract— A fuzzy multi-objective facility location-selection problem (FLSP) under uncertain and extreme environment based on possibility theory is developed. Model's uncertain parameters in the q-rung orthopair fuzzy values are presented and transformed in the Dempster-Shaper's believe structure environment. An objective function – distribution centers' selection ranking index as an extension of Dempster's extremal expectations under discrimination q-rung orthopair fuzzy information is constructed. Experts evaluate each humanitarian aid from distribution centers (HADC) against each of the uncertain factors. HADCs location problem is reduced to the bicriteria problem of partitioning the set of customers by the set of centers: (1) – Minimization of transportation costs; (2) – Maximization of centers' selection ranking indexes. Partitioning type constraints are also constructed. For illustration of the obtained results a numerical example is created from facility location-selection problem.

Keywords— FLSP, multi-objective combinatorial optimization problem, evidence theory, HADC, q-rung orthopair fuzzy set, possibility theory.

B. Ghvaberidze is an Associate Professor at the Department of Computer Sciences, Ivane Javakhishvili Tbilisi State University, 13, University Street, 0186 Tbilisi, GEORGIA (e-mail: b.ghvaberidze@tsu.ge).

Investment Projects Selection Problem under Hesitant Fuzzy Environment

Irina Khutsishvili

Abstract—In the present research, a decision support methodology for the multi-attribute group decision-making (MAGDM) problem is developed, namely for the selection of investment projects.

The objective of the investment project selection problem is to choose the best project among the set of projects, seeking investment, or to rank all projects in descending order. The project selection is made considering a set of weighted attributes. To evaluate the attributes in our approach, expert assessments are used. In the proposed methodology, lingual expressions (linguistic terms) given by all experts are used as initial attribute evaluations, since they are the most natural and convenient representation of experts' evaluations. Then lingual evaluations are converted into trapezoidal fuzzy numbers, and the aggregate trapezoidal hesitant fuzzy decision matrix will be built. The case is considered when information on the attribute weights is completely unknown. The attribute weights are identified based on the De Luca and Termini information entropy concept, determined in the context of hesitant fuzzy sets. The decisions are made using the extended Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) method under a hesitant fuzzy environment. Hence, a methodology is based on a trapezoidal valued hesitant fuzzy TOPSIS decision-making model with entropy weights. The ranking of alternatives is performed by the proximity of their distances to both the fuzzy positive-ideal solution (FPIS) and the fuzzy negative-ideal solution (FNIS). For this purpose, the weighted hesitant Hamming distance is used. An example of investment decision-making is shown that clearly explains the procedure of the proposed methodology.

Keywords—Investment projects selection problem, multiple attribute group decision-making, lingual assessments, trapezoidal hesitant fuzzy set, information entropy, hesitant fuzzy TOPSIS approach.

I. Khutsishvili is an Associate Professor with the Department of Computer Sciences, Ivane Javakhishvili Tbilisi State University, 13, University Street, 0186 Tbilisi, GEORGIA (e-mail: irina.khutsishvili@tsu.ge).

Recycling Biomass of Constructed Wetlands as Precursors of Electrodes for Removing Heavy Metals and Persistent Pollutants

Álvaro Ramírez Vidal, Martín Muñoz Morales, Francisco Jesús Fernández Morales, Luis Rodríguez Romero, José Villaseñor Camacho, Javier Llanos López

Chemical Engineering Department, Research Institute for Chemical and Environmental Technologies (ITQUIMA), University of Castilla La Mancha UCLM, 13071 Ciudad Real, Spain

Abstract— In last years, biological systems have reached an important role for solving environmental problems. Among them, the utilization of plants (aquatic macrophytes used in constructed wetlands (CW) for wastewater treatment, or terrestrial plant species for the treatment of sludge and polluted soils), are extensively used worldwide, especially in cities with low population. These systems applied in wastewater treatment are probably the most studied and full-scale used bio-based technology with cases for domestic and industrial wastewater treatment, even to remove heavy metals polluted water. Plants used in CW participate in different mechanism for capture and degradation of pollutants that also can retain some pharmaceutical and personal care products (PPCPs) that are very persistent in the environment. Thus, these systems present advantages in line with the guidelines published for the transition towards friendly and ecological procedures as they are environmentally friendly systems, consume low energy or capture atmospheric CO_2. However, the use of CW presents some drawbacks as the slowness of pollutant degradation or the production of important amount of plant biomass which need to be harvested and managed periodically.

If they are not correctly managed, such solid waste will decompose and pollutants as heavy metals or PPCPs will be delivered back to soil, surface and ground water which is not a technological problem but environmental.

Taking this opportunity in mind, it is important to highlight that this residual biomass (of lignocellulosic nature) could be used as the feedstock for the generation of carbonaceous materials using thermochemical transformations such as slow pyrolysis or hydrothermal carbonization to produce high value biomass-derived carbons through sustainable processes as adsorbents, catalysts…, thereby improving the circular carbon economy.

Thus, in this work it was carried out the synthesis of electrodes through hydrothermal carbonization (HTC) at 200 ^{0}C for 2 hours using biomass derived from natural environment in high environmental risk as the **Daimiel Wetlands National Park** in the center of Spain and biomass developed in a CW specifically designed to remove heavy metals. To do this, impact of the nature of the biomass waste and the synthetic parameters applied during HTC on the electrocatalytic activity to produce electro-reactive species of the obtained carbon materials will be investigated and linked to the porosity, surface functionalization, conductivity and mass transfer of the electrodes lytic inks.

Data revealed that carbon materials synthesized have good surfaces properties (good conductivities and high specific surface area) that enhance the electro-oxidants generated and promote the removal of heavy metals and chemical oxygen demand of polluted waters.

Keywords— constructed wetlands, carbon materials, heavy metals, pharmaceutical and personal care products, hydrothermal carbonization.

Decentralized Wastewater Treatment in Coastal Touristic Areas Using Standardized Modular Biological Filtration (SMBF)

Andreas Rüdiger

Abstract— The selection of appropriate wastewater treatment technology for decentralized coastal tourist areas is an important engineering challenge. The local situation in coastal tourist cities and villages is characterized by important daily and seasonal fluctuations in hydraulic flow and pollution, high annual temperature variations, scarcity of building area and high housing density. At the same time, coastal zones have to meet stringent effluent limits all over the year and need simple and easy technologies to operate. This article presents the innovative technology of standardized modular aerated up-flow biofiltration SMBF as an adapted solution for decentralized wastewater treatment in sensitive touristic coastal areas. As modular technology with several biofiltration units, the system is able to treat low and high loads with low energy consumption and low demands for operators. The article focuses on the climatic and tourist situation in Croatia. Full-scale plants in Eastern Europe and Croatia have presented as well as dimensioning parameters and outlet concentrations. Energy consumption as a function of load is demonstrated.

Keywords— wastewater treatment, biofiltration, touristic areas, energy saving.

Andreas Rüdiger is with the Aquabiotec Engineering SARL, France (e-mail: info@aquabiotec.com).

Social Entrepreneurship Transformation: A Practical Case of Expeditionary Learning and Its Value in Business Education

Almaz Sandybayev

Abstract— Transformative changes are happening in Higher Education Institutions worldwide in entrepreneurship education. Entrepreneurship courses are now a feature of the curricula of many business schools globally. While there is a growing body of research on the subject of entrepreneurship education and learning, studies of business education methods and their role in providing value are relatively scarce. Morocco's educational system is evolving and engenders change, and change denotes a departure from traditional class room approach to more tailored and customized curriculum considering significant transformational changes in teaching, testing and refining of content and learning approaches in a university setting.The researchers argue that the process of change implies a fundamental shift in the building block of a nation; change in the social and economic landscape of a nation. The rational explains why social entrepreneurship education impacts on society and how educators can improve the process theory applied to entrepreneurship education. One path to this is to change the cornerstone of entrepreneurship students through engaging them into expeditionary learning with an explicit purpose, guided by learning targets for which students take ownership and responsibility. It is recommended among other things that experts in business education should consider expeditionary learning component embedded into their curriculum review to ensure that the contents to be recommended and taught are in tandem to what is obtainable in the entrepreneurial practices to deliver national transformation assurances.

Keywords— Social entreprenership, transformation, business, education.

Almaz Sandybayev is with the Al Akhawayn University, Morocco (e-mail: a.sandy@aui.ma).

Solid-State Sodium Conductor for Solid-State Battery

Yumei Wang, Xiaoyu Xu, Li Lu

Abstract— Solid-state battery adopts solid-state electrolyte such as oxide- and composite-based solid electrolytes. With the adaption of nonflammable or less flammable solid electrolytes, the safety of solid-state batteries can be largely increased. NASICON ($Na_3Zr_2Si_2PO_{12}$, NZSP) is one of the sodium ion conductors that possess relatively high ionic conductivity, wide electrochemical stable range and good chemical stability. Therefore, it has received increased attention. We report the development of high-density NZSP through liquid phase sintering and its organic-inorganic composite electrolyte. Through reactive liquid phase sintering, the grain boundary conductivity can be largely enhanced while using an organic-inorganic composite electrolyte, interfacial wetting and impedance can be largely reduced hence being possible to fabricate scalable solid-state batteries.

Keywords— solid-state electrolyte, composite electrolyte, electrochemical performance, conductivity.

Li Lu is with the National University of Singapore, Singapore (e-mail: mpeluli@nus.edu.sg).

Evidence Theory based Emergency MAGDM. Application in Facility Location Problem

Bidzina Matsaberidze

Abstract—It is known that, in emergency situations, multi-attribute group decision-making (MAGDM) models are characterized by insufficient objective data and a lack of time to respond to the task. Evidence theory is an effective tool for describing such incomplete information in decision-making models when the expert and his knowledge are involved in the estimations of the MAGDM parameters. We consider an emergency decision-making model, where expert assessments on humanitarian aid from distribution centers (HADC) are represented in q-rung orthopair fuzzy numbers and the data structure is described within the data body theory. Based on focal probability construction and experts' evaluations an objective function – distribution centers' selection ranking index is constructed. Our approach for solving the constructed bicriteria partitioning problem consists of two phases. In the first phase, based on the covering's matrix, we generate a matrix, the columns of which allow us to find all possible partitionings of the HADCs with the service centers. Some constraints are also taken into consideration while generating the matrix. In the second phase, based on the matrix and using our exact algorithm we find the partitionings – allocations of the HADCs to the centers - which correspond to the Pareto-optimal solutions. For illustration of the obtained results, a numerical example is given for facility location-selection problem.

Keywords—Emergency MAGDM, Q-rung Orthopair Fuzzy Sets, Evidence Theory, HADC, Facility location problem, multi-objective combinatorial optimization problem, Pareto-optimal solutions.

B. Matsaberidze is an Assistant Professor at the Department of Computer Sciences, Ivane Javakhishvili Tbilisi State University, 13, University Street, 0186 Tbilisi, GEORGIA (e-mail: b.matsaberidze@gmail.com).

The Restriction Theory and the Christopher-Adeogun's Theorem

Christopher Oluwatobi Adeogun

Abstract— ChristopherAdeogun's restrictionproblem for Fourier transforms is a deep and only partially solved conjecture in harmonic analysis. Below we state the problem and the Christopher-Adeogun's theorem, which solves a particularly useful case of the conjecture. We then introduce the Fourier transform of complex-valued measures and the stationary phase method as tools used in the proof of the Christopher-Adeogun's theorem. We givea proof of the theorem, andthen turn to applications in deriving the Strichartz estimate for the Schroedinger equation.

Keywords— Christopher-Adeogun's Theorem, Restriction Theory, Fourier Transforms, smooth complex valued functions.

Christopher Adeogun is with the Tai Solarin University of Education, Ijebu-Ode, Nigeria (e-mail: oluwatobichris88@gmail.com).

The Effect of Awareness-Raising on Household Water Consumption

R. Morbidelli, C. Saltalippi, A. Flammini, J. Dari

***Abstract*—**This work analyses what effect systematic awareness-raising of the population on domestic water consumption produces. In a period where the availability of water is continually decreasing due to reduced rainfall, it is of paramount importance to raise awareness among the population.

We conducted an experiment on a large sample of homes in urban areas of Central Italy. In a first phase, lasting three weeks, normal per capita water consumption was quantified. Subsequently, instructions were given on how to save water during various uses in the household (showers, cleaning hands, use of water in toilets, watering small green areas, use of water in the kitchen, ...), and small visual messages were posted at water dispensers to remind users to behave properly. Finally, household consumption was assessed again during a further 3 weeks.

This experiment made it possible to quantify the effect of the awareness-raising action on the reduction of water consumption, without the use of any structural action (replacement of dispensers, improvement of the water system, ...).

***Keywords*—**Water saving, Urban areas, Awareness-raising, Climate change.

R. Morbidelli is with the Department of Civil and Environmental Engineering, Perugia University, Perugia, Italy (phone: +39 0755853620; e-mail: renato.morbidelli@unipg.it).

C. Saltalippi is with the Department of Civil and Environmental Engineering, Perugia University, Perugia, Italy (phone: +39 0755853891; e-mail: carla.saltalippi@unipg.it).

A. Flammini is with the Department of Civil and Environmental Engineering, Perugia University, Perugia, Italy (phone: +39 0755853894; e-mail: alessia.flammini@unipg.it).

J. Dari is with the Department of Civil and Environmental Engineering, Perugia University, Perugia, Italy (phone: +39 0755853894; e-mail: jacopo.dari@unipg.it).

Geomatic Techniques to Filter Vegetation from Point Clouds

M. Amparo Núñez-Andrés, Felipe Buill, Albert Prades

Abstract— More and more frequently, geomatics techniques such as terrestrial laser scanning or digital photogrammetry, either terrestrial or from drones, are being used to obtain digital terrain models (DTM) used for the monitoring of geological phenomena that cause natural disasters, such as landslides, rockfalls, debris-flow. One of the main multitemporal analyses developed from these models is the quantification of volume changes in the slopes and hillsides, either caused by erosion, fall, or land movement in the source area or sedimentation in the deposition zone. To carry out this task, it is necessary to filter the point clouds of all those elements that do not belong to the slopes. Among these elements, vegetation stands out as it is the one we find with the greatest presence and its constant change, both seasonal and daily, as it is affected by factors such as wind. One of the best-known indexes to detect vegetation on the image is the NVDI (Normalized Difference Vegetation Index), which is obtained from the combination of the infrared and red channels. Therefore it is necessary to have a multispectral camera. These cameras are generally of lower resolution than conventional RGB cameras, while their cost is much higher. Therefore we have to look for alternative indices based on RGB. In this communication, we present the results obtained in Georisk project (PID2019-103974RB-I00/MCIN/AEI/10.13039/501100011033) by using the GLI (Green Leaf Index) and ExG (Excessive Greenness), as well as the change to the Hue-Saturation-Value (HSV) color space being the H coordinate the one that gives us the most information for vegetation filtering. These filters are applied both to the images, creating binary masks to be used when applying the SfM algorithms, and to the point cloud obtained directly by the photogrammetric process without any previous filter or the one obtained by TLS (Terrestrial Laser Scanning). In this last case, we have also tried to work with a Riegl VZ400i sensor that allows the reception, as in the aerial LiDAR, of several returns of the signal. Information to be used for the classification on the point cloud. After applying all the techniques in different locations, the results show that the color-based filters allow correct filtering in those areas where the presence of shadows is not excessive and there is a contrast between the color of the slope lithology and the vegetation. As we have advanced in the case of using the HSV color space, it is the H coordinate that responds best for this filtering. Finally, the use of the various returns of the TLS signal allows filtering with some limitations.

Keywords— RGB index, TLS, photogrammetry, multispectral camera, point cloud.

María Amparo Núñez-Andrés is with the Universitat Politècnica de Catalunya, Spain (e-mail: m.amparo.nunez@upc.edu).

Evaluation of Coupled CFD-FEA Simulation for Fire Determination

D. M. Fellows, S. P. Walton, J. Thompson, O. Hassan, K. Tinkham, E. Quigley

Abstract— Fire performance is a crucial aspect to consider when designing cladding products, and testing this performance is extremely expensive. Appropriate use of numerical simulation of fire performance has the potential to reduce the total number of fire tests required when designing a product by eliminating poor performing design ideas early in the design phase. Due to the complexity of fire and the large spectrum of failures it can cause, multi-disciplinary models are needed to capture the complex fire behaviour and its structural effects on its surroundings. Working alongside Tata Steel U.K., the authors have focused on completing a coupled CFD-FEA simulation model suited to test Polyisocyanurate (PIR) based sandwich panel products to gain confidence before costly experimental standards testing. The sandwich panels are part of a thermally insulating façade system primarily for large non-domestic buildings.

The work presented in this paper compares two coupling methodologies of a replicated physical experimental standards test LPS 1181-1, carried out by Tata Steel U.K. The two coupling methodologies that are considered within this research are; one-way and two-way. A one-way coupled analysis consists of importing thermal data from the CFD solver into the FEA solver. A two-way coupling analysis consists of continuously importing the updated changes in thermal data, due to the fire's behaviour, to the FEA solver throughout the simulation. Likewise, the mechanical changes will also be updated back to the CFD solver to include geometric changes within the solution.

For CFD calculations, a solver called Fire Dynamic Simulator (FDS) has been chosen due to its adapted numerical scheme to focus solely on fire problems. Validation of FDS applicability has been achieved in past benchmark cases. In addition, an FEA solver called ABAQUS has been chosen to model the structural response to the fire due to its crushable foam plasticity model, which can accurately model the compressibility of PIR foam. An open-source code called FDS-2-ABAQUS is used to couple the two solvers together, using several python modules to complete the process, including failure checks.

The coupling methodologies and experimental data acquired from Tata Steel U.K are compared using several variables. The comparison data includes; gas temperatures, surface temperatures, and mechanical deformation of the panels. Conclusions are drawn, noting improvements to be made on the current coupling open-source code FDS-2-ABAQUS to make it more applicable to Tata Steel U.K sandwich panel products. Future directions for reducing the computational cost of the simulation are also considered.

Keywords— Fire engineering, Numerical coupling, Sandwich panels, Thermo fluids.

D. M. Fellows is with Department of engineering, Swansea University, Swansea ,UK (e-mail: 2130101@swansea.ac.uk).

S. P. Walton is with Department of Computer Science, Swansea University, Swansea, UK (e-mail:s.p.walton@swansea.ac.uk).

J. Thompson is with the Department of Engineering, Swansea university, Swansea, UK (e-mail: jennifer.thompson@swansea.ac.uk).

O. Hassan is with the Department of Engineering, Swansea university, Swansea, UK (e-mail: o.hassan@swansea.ac.uk).

K. Tinkham is with the Research and development, Tata Steel U.K, Swansea, UK (e-mail: kevin.tinkham@tatasteeleurope.com).

E. Quigley is with the Research and development, Tata Steel U.K, Swansea, UK (e-mail: Ella.Quigley@tatasteeleurope.com).

A Mixed 3D Finite Element for Highly Deformable Thermoviscoplastic Materials Under Ductile Damage

João P. Pascon

Abstract— In this work, a mixed 3D finite element formulation is proposed in order to analyze thermoviscoplastic materials under large strain levels and ductile damage. To this end, a tetrahedral element of linear order is employed, considering a thermoviscoplastic constitutive law together with the neo-Hookean hyperelastic relationship and a nonlocal Gurson`s porous plasticity theory The material model is capable of reproducing finite deformations, elastoplastic behavior, void growth, nucleation and coalescence, thermal effects such as plastic work heating and conductivity, strain hardening and strain-rate dependence. The nonlocal character is introduced by means of a nonlocal parameter applied to the Laplacian of the porosity field. The element degrees of freedom are the nodal values of the deformed position, the temperature and the nonlocal porosity field. The internal variables are updated at the Gauss points according to the yield criterion and the evolution laws, including the yield stress of matrix, the equivalent plastic strain, the local porosity and the plastic components of the Cauchy-Green stretch tensor. Three problems involving 3D specimens and ductile damage are numerically analyzed with the developed computational code: two notched samples and the necking problem. The effect of the nonlocal parameter and the mesh refinement is investigated. Results indicate the need of a proper nonlocal parameter. In addition, the numerical formulation can predict ductile fracture, based on the evolution of the fully damaged zone.

Keywords— Mixed finite element, large strains, ductile damage, thermoviscoplasticity.

I. INTRODUCTION

MODELING ductile damage is crucial in many areas of engineering and industry. The failure of a ductile material takes place with significant levels of plastic deformation, as well as the development and evolution of internal cavities (or voids) along the microstructure. In the context of mechanical or structural components, the ductile damage process leads to the material degradation, which reduces the component strength and, in severe cases, causes the complete loss of load-bearing capacity. In addition, the localization of plastic deformation and damage along the so-called shear banding is usually accompanied by thermal effects and strain-rate dependence [1-3].

One of the most used ductile damage models is the Gurson-Tvergaard-Needleman (GTN) formulation, which is an extension of the Gurson´s porous plasticity, presented in [4], based on the modifications proposed in [5-7]. The GTN model is based on void volume fraction (or porosity) as a measure of damage and accounts for the effect of the mean stress and damage on the yield surface, as well as void growth, nucleation and coalescence. To include rate-dependent plasticity and thermal effects, thermoviscoplastic GTN models have been proposed along the last decades, including thermal softening, plastic work heating and thermal diffusion (see, for instance,

the works of [7-15]). Further enrichments regarding the GTN approach can be considered, such as void shearing mechanism [16,17], void shape influence [18,19], anisotropic orientation [20,21] and size-scale effects [22,23].

Numerical methods are often employed in order to analyze engineering problems involving a high level of complexity. In the context of finite element analysis of ductile fracture, three main categories can be cited: discrete (or discontinuous) approaches; continuum damage descriptions; and continuous-discontinuous transition methods. In the first case, a discontinuity is incorporated into the displacement field to allow the explicit crack modeling, which includes the element erosion (or deletion) method [24], the extended finite element method or XFEM [25] and the cohesive zone models [26]. The continuous damage models, in turn, are based on the modeling of the homogenized effect of microstructural changes on the macroscopic behavior of the material. For ductile damage prediction, the most used continuous formulations are probably the phenomenological model of Lemaitre [27] and the micromechanics-based approaches of Gurson [4] and Rousselier [28]. In such cases, the damage is introduced as an internal variable and is coupled with plastic strains. In addition, multiscale methods for ductile fracture analysis [29,30] can also be considered in the continuum damage category. The third group corresponds to the intermediate situation between the first two categories, combining the crack discontinuity with the continuous damage approach. In this context, one of the most employed techniques is the phase-field method or PFM [31], in which the crack initiation and propagation are treated as an optimization problem and the damage is described continuously through weakly described sharp interfaces. The PFM is combined with the GTN formulation, for instance, in the works of [32] and [33], among many others. An interesting detailed review on computational methods for ductile fracture analysis can be found in [34].

In general, the main disadvantages of discontinuous approaches, when compared to continuous damage models, are the prohibitive computational cost for the microscale, the need of complex remeshing techniques and the difficulties arising from the crack discontinuity tracking, particularly in 3D problems. Nevertheless, the standard continuum damage formulations suffer from severe mesh dependence due to damage localization. As pointed out by [35], the absence of a physical length scale that is needed to regularize the governing equations leads to a material failure at zero energy dissipation. Numerically, the tangent stiffness matrix stops being positive definite when damage softening localizes and, thus, the boundary value problems become ill-posed.

João Pascon is with the University of São Paulo, Brazil (e-mail: jppascon@usp.br).

In order to avoid the above-mentioned problems, nonlocal formulations have been proposed to enhance the performance of continuum damage models. These formulations can be classified into two broad groups: the integral-type approach; and the gradient-enhancement formulation. In the first case, an average-type integral is introduced into the damage evolution rate equation. The method has been proposed in [36] and extended to GTN model in [37] and [38], for instance. In the second category, a nonlocal Laplacian operator is included together with a material length scale. The nonlocal formulation can be explicit [39,40] or explicit [41,42]. In the nonlocal GTN thermoviscoplastic formulation of [35], the void diffusion-type model of [43] is employed and it is shown that the adopted gradient-enhanced technique, when applied explicitly to the rate of porosity, alleviates mesh dependence and results in a smoother damaged zone. However, the strain rate may affect the choice of the nonlocal parameter.

The purpose of the present work is to develop a mixed 3D finite element formulation to predict ductile damage in thermoviscoplastic materials under finite strain levels. The constitutive model accounts for GTN yield surface, including void growth, nucleation and coalescence, a hyperelastic 3D stress-strain relationship, plastic work heating, strain hardening, thermal softening, rate-dependent plasticity and thermal diffusion. The finite strain framework is fully Lagrangian and based on the multiplicative split of the deformation gradient into the elastic, plastic and thermal components. The formulation is enriched by means of a nonlocal gradient-enhanced model applied to the rate of porosity. In the numerical model proposed, a linear-order tetrahedral solid element is adopted together with the following degrees of freedom defined at the deformed configuration: the current three nodal positions; the absolute temperature at the node; and the nonlocal value defined at the node. The three unknown fields (positions, temperature and nonlocal porosity) are discretized as usually done in isoparametric finite elements, via a three-field variational principle. The remaining variables are defined locally, at each element, and includes the yield stress, the equivalent plastic strain, the local porosity and the corresponding plastic components of the right Cauchy-Green stretch tensor. A similar work has been presented in [44], but using 8-node plane strain elements and rate-independent plasticity.

II. Constitutive Modeling

The adopted constitutive models are described in the present section, including the deformation decomposition, the hyperelastic stress-strain law, the yield criterion and the evolution equations for plastic strains, damage and temperature. The thermodynamic consistency is addressed in the small-strain thermoviscoplastic GTN formulation of [15].

A. Kinematics and thermodynamic laws

In order to describe finite deformations, the Kröner-Lee decomposition is applied to the deformation gradient, using the elastic, plastic and thermal parts:

$$\boldsymbol{F} = \boldsymbol{F}_e \boldsymbol{F}_t \boldsymbol{F}_p \tag{1}$$

In the present framework, fully-Lagrangian description is used and strains are described in terms of the right Cauchy-Green stretch tensor:

$$\boldsymbol{C} = \boldsymbol{F}^T \boldsymbol{F} = \boldsymbol{F}_p{}^T \boldsymbol{F}_t{}^T \boldsymbol{C}_e \boldsymbol{F}_t \boldsymbol{F}_p = \boldsymbol{F}_{tp}{}^T \boldsymbol{C}_e \boldsymbol{F}_{tp} \tag{2}$$

where $\boldsymbol{F}_{tp}$ is the thermoplastic gradient; and $\boldsymbol{C}_e$ is the elastic Cauchy-Green stretch tensor.

The rate of tensor $\boldsymbol{C}$ can be obtained from (2):

$$\dot{\boldsymbol{C}} = \frac{1}{2}\boldsymbol{F}^T \boldsymbol{D} \boldsymbol{F} = \boldsymbol{F}_{tp}{}^T \dot{\boldsymbol{C}}_e \boldsymbol{F}_{tp} + \boldsymbol{F}_{tp}{}^T \boldsymbol{C}_e \boldsymbol{L}_{tp} \boldsymbol{F}_{tp} \tag{3}$$

where $\boldsymbol{D}$ is the rate of deformation tensor, which is the symmetric part of the velocity gradient $\boldsymbol{L} = \dot{\boldsymbol{F}} \boldsymbol{F}^{-1}$.

B. Hyperelastic stress-strain law

The constitutive equations are derived from thermodynamic principles, ensuring consistency of the model. The stress power resultant from (3) is given by:

$$\frac{1}{2}\boldsymbol{S}:\dot{\boldsymbol{C}} = \frac{1}{2}S_e:\dot{\boldsymbol{C}}_e + (\boldsymbol{C}_e\boldsymbol{S}_e):\boldsymbol{L}_{tp} \tag{4}$$

$$\boldsymbol{S}_e = \boldsymbol{F}_{tp}\boldsymbol{S}\boldsymbol{F}_{tp}{}^T \tag{5}$$

where $\boldsymbol{S}$ is the second Piola-Kirchhoff stress tensor, defined at the reference (undeformed) configuration; and $\boldsymbol{S}_e$ is the elastic counterpart, defined at the stress-free intermediate configuration $\boldsymbol{F} = \boldsymbol{F}_{tp}$ (or $\boldsymbol{F}_e = \boldsymbol{I} \rightarrow \boldsymbol{C}_e = \boldsymbol{0}$) by means of a push-forward operation regarding the thermoplastic gradient.

The material response is described via the Helmholtz free-energy, which is a scalar-valued function defined as follows:

$$\psi = \psi(\boldsymbol{C}_e, \boldsymbol{C}_p, \varsigma) \tag{6}$$

where ς is a set of internal variables, to be specified later. The stress-strain relationship is obtained assuming that the elastic energy dissipation is null:

$$\left(\frac{1}{2}S_e - \frac{\partial\psi}{\partial C_e}\right):\dot{\boldsymbol{C}}_e = 0 \rightarrow \boldsymbol{S}_e = 2\frac{\partial\psi}{\partial C_e} \rightarrow \boldsymbol{S} = \boldsymbol{F}_{tp}{}^{-1}\frac{\partial\psi}{\partial C_e}\boldsymbol{F}_{tp}{}^{-T} \tag{7}$$

Considering finite elastic strains, the isotropic hyperelastic neo-Hookean model has been adopted in the present work:

$$\psi_e = \frac{K}{2}(lnJ_e)^2 + \frac{\mu}{2}(i_{e1} - 3 - 2lnJ_e) \tag{8}$$

where K and μ are, respectively, the bulk and shear moduli; $J_e = \sqrt{det\boldsymbol{C}_e}$ is the elastic Jacobian; and $i_{e1} = tr\boldsymbol{C}_e$ is the first elastic strain invariant. Combining (7) and (8), one obtains the neo-Hookean stress-strain relationship:

$$\boldsymbol{S} = (KlnJ_e - \mu)\boldsymbol{C}^{-1} + \mu\boldsymbol{C}_{tp}{}^{-1} \tag{9}$$

As demonstrated in the work of [45], the linear thermal expansion model results in a thermal Cauchy-Green stretch tensor defined as a diagonal matrix:

$$\dot{C}_t = 2C_t D_t = 2\alpha\dot{T}C_t \rightarrow C_t = exp(2\alpha\Delta T)I \qquad (10)$$

where α is the thermal expansion coefficient; and $\dot{T}$ is the temperature change. Thus, the thermoplastic Cauchy-Green stretch tensor results in:

$$C_{tp} = exp(2\alpha\Delta T)C_p \qquad (11)$$

Therefore, all the stress components in (9) can be determined from tensors C and C_p, together with the current temperature T, avoiding the calculation of all the components of the deformation gradients.

C. Yield criterion

The yield criterion is written in terms of the elastic Mandel stress tensor $M_e = C_e S_e$, which is present in the plastic dissipation term of (4):

$$\phi = M_{eq} - \varphi\sigma_Y \leq 0 \qquad (12)$$

where M_{eq} is the equivalent Mandel stress; σ_Y is the matrix yield stress; and φ is the GTN pressure-dependent function, defined in terms of the mean stress $p = trM_e/3$, the yield stress and the effective porosity f^*:

$$\varphi^2 = 1 + (q_1 f^*)^2 - 2q_1 f^* cosh\left(\frac{3q_2 p}{2\sigma_Y}\right) \qquad (13)$$

$$f^* = f \text{ if } f < f_C \qquad (14)$$

$$f^* = f_C + \frac{f_U - f_C}{f_F - f_C}(f - f_C) \text{ otherwise} \qquad (15)$$

where q_1 and q_2 are adjusting parameters; f is the void volume fraction, also called porosity; f_C is the void coalescence limit; f_U is the ultimate value for the effective porosity; and f_F is the failure limit. One can observe the accelerating effect of void coalescence on damage evolution once the porosity level achieves f_C. In addition, the complete material failure occurs when the level of damage $q_1 f^*$ achieves 100%, reducing the yield surface to a single point.

D. Plastic strain evolution

The flow rule could be defined for the thermoplastic velocity gradient tensor L_{tp}, present in (4). Nevertheless, it can be shown that, for isotropic models, the elastic Mandel stress tensor is symmetric and, thus, the plastic dissipation term in (4) can be replaced by: D_{tp}. Moreover, considering the linear expansion model (10), the thermoplastic rate of deformation tensor results in:

$$D_{tp} = D_t + D_p = \alpha\dot{T}I + D_p \qquad (16)$$

According to the finite elastoplastic model of [46], one possible way to satisfy the non-negativeness of plastic dissipation is the following associative flow rule applied to yield criterion (13):

$$D_p = \dot{\lambda}\frac{\partial\phi}{\partial M_e} = \dot{\lambda}\sqrt{\frac{3}{2}}\left[\frac{devM_e}{|devM_e|} - \frac{\partial\varphi}{\partial p}\frac{\sigma_Y}{3}I\right] \qquad (17)$$

where $\dot{\lambda}$ is the plastic multiplier. Using the rate transformation defined in (3), one can write the flow rule in Lagrangian description:

$$\dot{C}_p = 2\dot{\lambda}\sqrt{\frac{3}{2}}\left[\frac{devY}{|devY|} - \frac{\partial\varphi}{\partial p}\frac{\sigma_Y}{3}I\right]C_p \qquad (18)$$

where $Y = CS$ is an auxiliary stress tensor, defined at the reference configuration. The plastic multiplier is eliminated via the plastic work equivalence:

$$W_p = M_e : D_p = (1-f)\sigma_Y\dot{\kappa} \rightarrow \dot{\lambda} = \sqrt{\frac{3}{2}}\dot{\kappa}\frac{1-f}{\varphi - \frac{\partial\varphi}{\partial p}p} \qquad (19)$$

where W_p is the plastic power; and $\dot{\kappa}$ is the equivalent plastic strain.

To avoid the determination of the plastic multiplier, the equivalent plastic strain rate should be defined. In the present work, the modified Litonski model [47] is employed:

$$\dot{\kappa} = g_0\left[\frac{\sigma_Y}{h(\kappa)s(T)}\right]^m \qquad (20)$$

$$h(\kappa) = K(\varepsilon_0 + \kappa)^n \qquad (21)$$

$$s(T) = 1 - \delta\left[exp\left(\frac{T-T_0}{k}\right) - 1\right] \qquad (22)$$

where g_0 and m are the viscoplastic parameters; K, ε_0 and n are the Swift parameters from the isotropic hardening evolution; and δ, T_0 and k are the coefficients of the thermal softening law. As one can see, the evolution equation (20) accounts for strain and strain-rate hardening, as well as thermal softening.

E. Damage evolution

The damage evolves according to the rate of porosity, including the growth and nucleation contributions:

$$\dot{f} = (f-1)trD_p + D_\kappa\dot{\kappa} \qquad (23)$$

$$D_\kappa = \frac{f_N}{s_N\sqrt{2\pi}}exp\left[-\frac{1}{2}\left(\frac{\kappa - \varepsilon_N}{s_N}\right)^2\right] \qquad (24)$$

where f_N, s_N and ε_N are the void nucleation coefficients. The first part corresponds to the plastic incompressibility of the matrix, which results in the growth of existence voids. The nucleation contribution, in turn, corresponds to the strain-controlled model proposed in [48]. The damage evolution expression (23) is also employed in the work of [49], in the context of large strains and ductile crack extension.

F. Heat equation

Following the thermodynamic GTN formulation presented in [15], the rate of temperature can be defined applying the Fourier's law of conductivity to the energy equation:

$$\rho\hat{c}\dot{T} = \chi W_p + K_T\nabla^2 T \qquad (25)$$

where ρ is the mass density; $\hat{c}$ is the specific heat; χ is the Taylor-Quinney coefficient, assumed to be constant; K_T is the thermal conductivity parameter; and $\nabla^2 T$ denotes the Laplacian operator applied to the temperature. Whereas the plastic work heating has the effect of concentrating (or localizing) the temperature gradients along the damaged zone, the thermal diffusion term $\nabla^2 T$ has the role of smoothing such gradients, regularizing the shear banding instability.

III. NUMERICAL STRATEGY

The present section describes the nonlocal gradient-enhanced model, the variational form of field equations, the resultant mixed finite element formulation and the linearization procedure.

A. Nonlocal gradient enhancement

Following the gradient enhancement proposed in [44], the nonlocal porosity is considered:

$$\bar{f} - n_L \nabla^2 \bar{f} = f \qquad (26)$$

where $\bar{f}$ is the nonlocal porosity field; and n_L is the nonlocal parameter. The idea of the above enrichment is to include a resistance to porosity gradients, which tend to localize along the damaged zone. In addition, the local porosity f is replaced by the corresponding nonlocal variable $\bar{f}$ in equations (14) and (15). Thus, the neighborhood conditions around a point affect the onset of void coalescence, which is relevant when large gradients occur [44].

B. Three-field variational principle

In the numerical approximation, there are three main variables (or three field equations) together with four internal variables. The variational principle is applied to the following field variables: current position Y; current nonlocal porosity $\bar{f}$; and current temperature T. Using the weighted residual method, the balance equation becomes:

$$\int_\Omega (div\boldsymbol{\sigma} \cdot \delta Y) d\Omega = 0 \qquad (27)$$

where Ω denotes a volume element; $\boldsymbol{\sigma}$ is the true Cauchy stress tensor; δ represents a virtual variation; and F_{ext} is the vector of applied external forces. In a similar way, the nonlocal porosity field defined in (26) results in:

$$\int_\Omega \left(\bar{f} - n_L \nabla^2 \bar{f} - f\right) d\Omega \cdot \delta\bar{f} = 0 \qquad (28)$$

where $\delta\bar{f}$ is a virtual variation of the nonlocal porosity field.

For the thermal field, the backward Euler integration method is employed in (25) considering a time increment of Δt:

$$T^{N+1} = T^N + \Delta t \frac{1}{\rho\hat{c}} \left(\chi W_p + K_T \nabla^2 T\right) \qquad (29)$$

where N and $N+1$ denote, respectively, the value at the beginning and at the end of the time step. The corresponding residual term is:

$$\int_\Omega \left[T^{N+1} - T^N - \Delta t \frac{1}{\rho\hat{c}} \left(\chi W_p + K_T \nabla^2 T\right)\right] d\Omega \cdot \delta T = 0 \qquad (30)$$

where δT is the virtual variation of the thermal field. Then, the thermomechanical problem consists of determining the three main variables: positions, temperature and nonlocal porosity.

The numerical approximation is completed by the local system composed of equations (12), (18), (20) and (23), whose unknowns are the local values of the yield stress σ_Y, the equivalent plastic strain κ, the local porosity f and the plastic Cauchy-Green stretch tensor C_p. Since the integrals are evaluated numerically, such local values are defined at the Gauss points. Moreover, the backward Euler method presented in (29) is used in the rates defined in (18), (20) and (23).

C. Finite element

The finite element adopted is the solid tetrahedron of linear order (with four nodes). Since the global system of equations is composed of three fields, a mixed finite element formulation is used. The main variables are interpolated by means of standard shape functions:

$$Y_i = Y_i^{(k)} \phi_k \qquad (31)$$
$$T = T^{(k)} \phi_k \qquad (32)$$
$$\bar{f} = \bar{f}^{(k)} \phi_k \qquad (33)$$

where ϕ_k is the linear-order shape function associated with node k. Due to the linear approximation degree, there is only one Gauss point per each element.

Using (31-33), the residual expressions (27), (28) and (30) can be expressed in index notation as follows (see, for instance, the works of [44] and [45]):

$$(R_Y)_i = \int_{\Omega_0} \frac{1}{2} \boldsymbol{S}:\frac{\partial \boldsymbol{C}}{\partial Y_i} d\Omega_0 - (F_{ext})_i \qquad (34)$$

$$\left(R_{\bar{f}}\right)_i = M_f \cdot \bar{f} + g_{fi} - g_{fe} \qquad (35)$$

$$M_f = \int_\Omega \boldsymbol{\phi} \cdot \boldsymbol{\phi} d\Omega \qquad (36)$$

$$g_{fi} = n_L \int_\Omega \nabla\boldsymbol{\phi} \cdot \nabla\boldsymbol{\phi} d\Omega \cdot \bar{f} \qquad (37)$$

$$g_{fe} = \int_\Omega f\boldsymbol{\phi} d\Omega \qquad (38)$$

$$(R_T)_i = M_T \cdot (T - T^N) + g_{Ti} - g_{Te} \qquad (39)$$

$$M_T = \rho\hat{c} \int_\Omega \boldsymbol{\phi} \cdot \boldsymbol{\phi} d\Omega \qquad (40)$$

$$g_{Ti} = \Delta t \int_\Omega K_T \nabla\boldsymbol{\phi} \cdot \nabla\boldsymbol{\phi} d\Omega \cdot T \qquad (41)$$

$$g_{Te} = \Delta t \int_\Omega \chi(1-f)\sigma_Y \dot{\kappa}\boldsymbol{\phi} d\Omega \qquad (42)$$

D. Linearization procedure

The global system of equations defined in (34-42) are highly nonlinear regarding both main and internal variables. The strategy adopted in this work to solve the thermomechanical problem is the elastic trial followed by plastic update. At the beginning of each load step, it is assumed that the material response is purely elastic, that is, the internal variables do not evolve. If the yield criterion (12) is satisfied at all the Gauss points, the simulation advances to next step once the main

variables are determined from the following iterative procedure:

$$\begin{Bmatrix} R_Y \\ R_{\bar{f}} \\ R_T \end{Bmatrix} + \begin{bmatrix} J_{YY} & 0 & J_{YT} \\ 0 & J_{\bar{f}\bar{f}} & 0 \\ 0 & 0 & J_{TT} \end{bmatrix} \begin{Bmatrix} \Delta Y \\ \Delta \bar{f} \\ \Delta T \end{Bmatrix} = \begin{Bmatrix} 0 \\ 0 \\ 0 \end{Bmatrix} \qquad (43)$$

where J denotes the Jacobian matrices.

Otherwise, if the yield criterion is violated, a local system of equations is solved for the points at which the criterion is not satisfied:

$$r_{\sigma Y} = M_{eq} - \varphi \sigma_Y = 0 \qquad (44)$$
$$r_\kappa = \kappa - \kappa^N - \Delta t g_\kappa = 0 \qquad (45)$$
$$r_f = f - f^N - \Delta t g_f = 0 \qquad (46)$$
$$\boldsymbol{R_{Cp}} = \boldsymbol{C_p} - \boldsymbol{C_p}^N - \Delta t \boldsymbol{G_{Cp}} = \boldsymbol{0} \qquad (47)$$

where g_κ, g_f and $\boldsymbol{G_{Cp}}$ are, respectively, the functions that define the rate of equivalent plastic strain ($\dot{\kappa}$), local porosity ($\dot{f}$) and plastic Cauchy-Green stretch tensor ($\dot{\boldsymbol{C}}_p$); and variables with superscript N denote fixed values at the beginning of the step. One should note that the system above has dimensions 9x9, whose unknowns are the following values at the end of the step: σ_Y, κ, f, C_{p11}, C_{p12}, C_{p13}, C_{p22}, C_{p23} and C_{p33}.

IV. RESULTS

The performance of the proposed formulation is validated by means of three numerical problems: two notched samples and the necking of a prismatic specimen. The material parameters are provided in Table I. Most of them have been extracted from the structural steel employed in [15]. The effect of the nonlocal parameter together with mesh refinement on the mechanical behavior is investigated. In this work, only displacement-control is employed. As usually done, convergence problems are avoided near the complete failure of the material by keeping the porosity level constant once it achieves 90% of the failure limit f_F, that is, $f = 0.225$. Moreover, due to the resultant high nonlinearity of the model proposed, the loading is divided into 10000 steps. It should be highlighted that the porosity fields provided in the results correspond to the nonlocal porosity defined at the nodes.

A. V-notched specimen

The first problem is a V-shaped notched sample, depicted in Fig. 1. The specimen dimensions have been extracted from [50], in which the GTN parameters are experimentally obtained for an aluminum alloy. Due to the symmetry regarding the planes $y = 10mm$ and $z = 5mm$, only one quarter of the specimen is discretized. The imposed horizontal displacement is uniformly applied to the right edge, reaching a maximum value of 8 mm in 1 second, which corresponds to a 10% of nominal strain and a strain rate of 0.1 /s.

Four meshes have been used for the present example. Moreover, two cases are compared: the local formulation ($n_L = 0$) and the nonlocal formulation with $n_L = 0.1$. According to Fig. 2, the selected nonlocal parameter provides more stability than the local formulation, together with more smooth curves.

In both cases, the coarsest mesh presents an extremely stiff behavior. In addition, for the nonlocal formulation, the two most refined discretizations provide almost the same final response. A similar specimen has been analyzed in the finite strain formulation of [51] under plane strain conditions, considering two length scales: one for the phase-field approach and one for gradient plasticity. It is shown that the nonlocal gradient plasticity parameter alleviates mesh sensitivity.

TABLE I
MATERIAL COEFFICIENTS

| Symbol	Parameter	Value
K	Bulk modulus	50 GPa
μ	Shear modulus	10 GPa
ρ	Mass density	7860 kg/m³
$\hat{c}$	Specific heat	473 J/kg·K
χ	Taylor-Quinney	0.9
K_T	Thermal conductivity	50 W/m·K
α	Thermal expansion	0.000017 1/K
f_0	Initial porosity	0.02
f_C	Coalescence limit	0.12
f_F	Failure limit	0.25
q_1	GTN parameters	1.25
q_2		0.95
f_N	Nucleation rate	0.04
s_N	Nucleation distribution	0.1
ε_N	Nucleation strain	0.3
g_0	Reference strain rate	0.001 1/s
m	Rate sensitivity	70
σ_0	Initial yield stress	312 MPa
K		423.63 MPa
ε_0	Swift parameters	0.003806
n		0.0549
T_0	Reference temperature	295 K
δ	Thermal softening	0.8
k		500 K
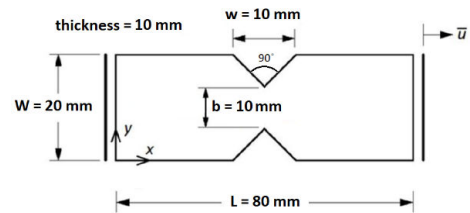
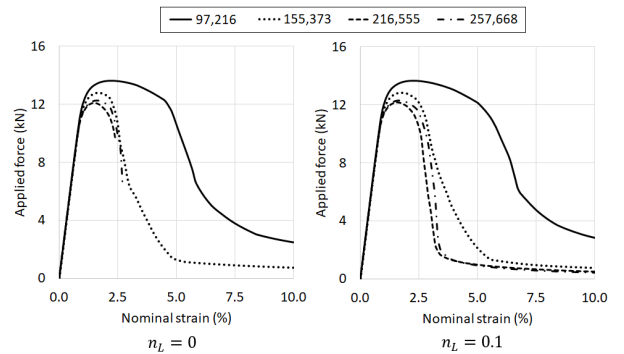Fig. 1 V-notched sample: geometry and boundary conditions

Fig. 2 Force-displacement curve for the V-notched sample. The numbers in the subtitle denote, respectively, the number of nodes and the quantity of finite elements

For the most refined mesh, the final field of nonlocal porosity $\bar{f}$ is shown in Fig.3 considering the nonlocal formulation. One can observe the evolution of the fully damaged zone in three dimensions, starting at the notch tip in the symmetry plane $z = 5mm$, that is, the porosity field is not uniformly distributed along the z-direction. At the end, all the central cross-section is damaged, indicating the complete failure of the specimen and explaining the final high flexibility shown in Fig. 2. As in [51], the damaged zone is more pronounced in the cross-section with minimum area.

0.06 0.115 0.17 0.225
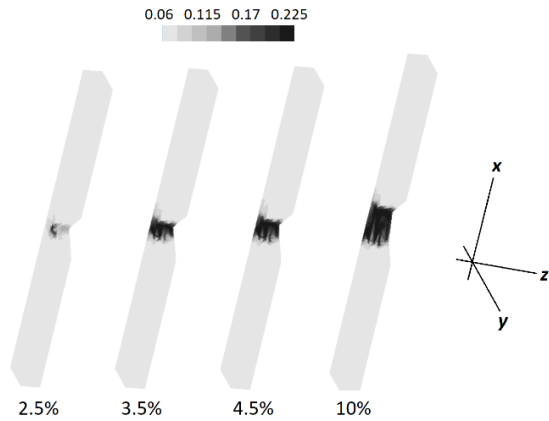

2.5%   3.5%   4.5%   10%

Fig. 3 Final porosity field provided by the most refined mesh used for the V-notched sample with the nonlocal formulation. The values at the bottom denote the nominal strain

B. A-notched specimen

The second example is the A-notched specimen illustrated in Fig.4. The geometric data are the same as those adopted in the work of [52], in which a new ductile damage model is proposed and experimentally validated. In that work, plane stress conditions are assumed. As in the first example, only one quarter of the specimen has been discretized due to symmetry conditions. In this case, the imposed vertical displacement increases linearly over time up to 9 mm, corresponding to a maximum nominal strain of 5%. Two values for the final time are selected in the second problem: $t_f = 0.1s$ and $t_f = 0.001s$, which correspond to a strain rate of 0.5 /s and 50 /s, respectively. For the second example, only one mesh is employed: 196 nodes and 487 tetrahedra.
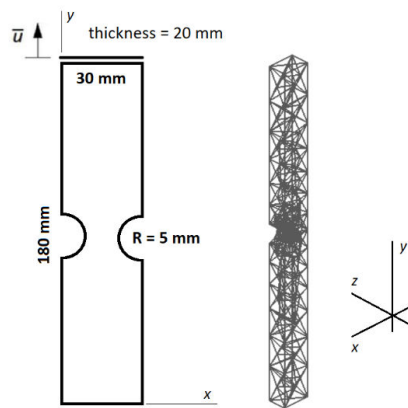

Fig. 4 A-notched specimen: geometry, boundary conditions and mesh

For both strain rates, the effect of the nonlocal parameter is studied using three values: 0 (local), 0.01 and 1.0. According to Fig. 5, increasing the nonlocal parameter delays the damage initiation and evolution for both strain rates adopted. Ductility (or the strain at fracture) is not significantly affected by the strain rate, whereas the peak stresses become higher by increasing the strain rate.
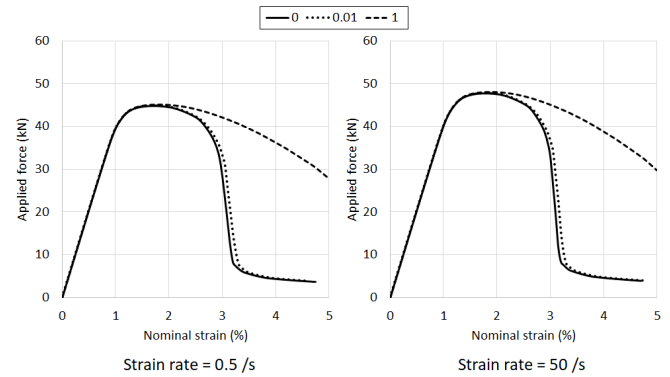
Fig. 5 Effect of the nonlocal parameter (values in the subtitle) in the force-displacement curve of the A-notched sample

The porosity field is provided in Fig. 6 at the end of some steps for each nonlocal parameter selected, considering the fastest case (strain rate of 50 /s). It can be observed that the nonlocal parameter delays both damage initiation and fracture, although the difference between the local and the nonlocal case $n_L = 0.01$ is not so evident. In such cases, fracture initiates at the notch in the symmetric plane $z = 0$ and propagates initially along the z-direction followed by a propagation across the x-direction. A similar propagation trend has been experimentally observed in [52] considering plane stresses. For the highest value of n_L, the numerical failure limit of $f = 0.225$ is not reached, indicating that a sufficiently large value chosen for the nonlocal parameter is not reliable.

0.06 0.1425 0.225

2.5%   3.0%   4.7%   2.5%   3.0%   4.8%   2.5%   5.0%
        (a)   (b)   (c)
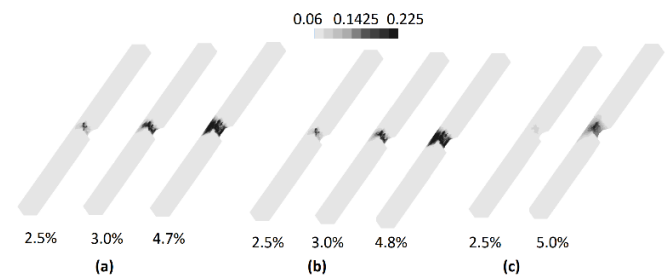
Fig. 6 Final porosity fields for the A-notched sample, considering the strain rate of 50 /s: (a) local formulation; (b) $n_L = 0.01$; (c) $n_L = 1.0$. The percentage numbers denote the nominal strain

C. Necking problem

The last problem is the necking of a prismatic specimen, as depicted in Fig. 7. Only one quarter of the sample is discretized and, in order to trigger the necking instability, a linear variation of cross-section dimensions along the y-direction is adopted. A mesh with 183 nodes and 430 tetrahedral solid elements has been employed in this case. The imposed vertical displacement increases linearly over time up to 50 mm in 0.1 s, which

corresponds to a maximum nominal strain of 25% and a strain rate of 2.5 /s.
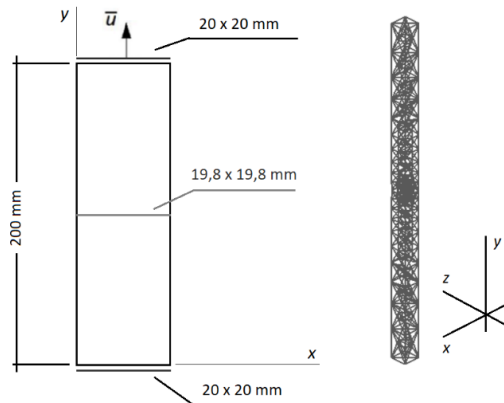
Fig. 7 Necking problem: geometry, boundary conditions and mesh

The effect of the nonlocal parameter on the specimen response is investigated. According to Fig. 8, increasing the value of n_L provides a higher ductility. In this example, the nonlocal case $n_L = 0.1$ has led to a loss of convergence before the end of fracture, represented by the complete drop in the force level. Besides, as in the other examples, one can observe the initial linear-elastic response, followed by hardening and softening behaviors for all the values of the nonlocal parameter.
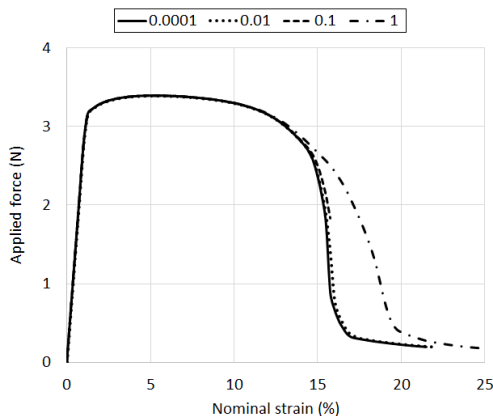
Fig. 8 Effect of the nonlocal parameter (values in the subtitle) on the force-displacement curve of the necking problem

The influence of the nonlocal parameter on the porosity field is investigated. As shown in Fig. 9, increasing the nonlocal parameter delays the evolution of the damaged zone. Moreover, one can see the large transverse displacements in the central cross-section due to necking instability, even for the largest nonlocal parameter. As in the second example, the damaged zone starts in the symmetry plane $z = 0$ around the center of the specimen and propagates horizontally towards the plane xz.

V. CONCLUSIONS

In this work, a mixed 3D finite element formulation is proposed to predict ductile damage in thermoviscoplastic materials under finite strain levels. The thermodynamically consistent constitutive model encompasses a hyperelastic stress-strain relationship, the GTN yield criterion together with void growth, nucleation and coalescence, thermal effects such as diffusion and plastic work heating, as well as strain and strain-rate hardening. The damage field is enriched by a gradient nonlocal formulation. The numerical approximation involves a tetrahedral finite element of linear order whose degrees of freedom are positions, nonlocal porosity and temperature at the nodes. The formulation is implemented in a computer code in order to assess the element performance in the analysis of large strain problems under ductile damage and quasi-static conditions.
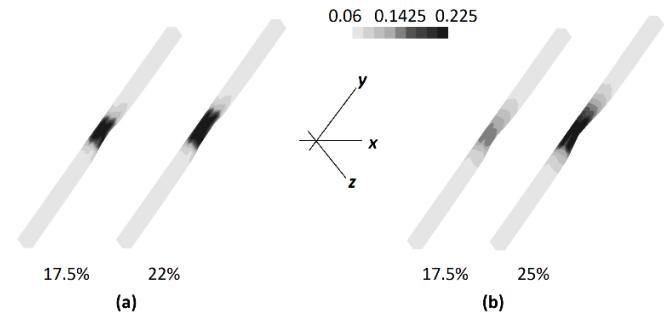
Fig. 9 Final porosity fields for the necking problem: (a) $n_L = 0.01$; (b) $n_L = 1.0$. The percentage numbers denote the nominal strain

Three mechanical problems are numerically analyzed: two notched samples and the necking of a prismatic bar. It is demonstrated that the present formulation can be used to predict ductile damage in the finite strain setting, as well as the effect of the nonlocal parameter on the behavior of the specimens analyzed. As expected, the nonlocal parameter delays the damage evolution and plays a major role in the force-displacement curves, as well as porosity fields, providing a more stable response. Since the model is new, comparisons with other related studies are performed only qualitatively.

Next objectives are to employ more refined meshes and a higher order of approximation to investigate if the present formulation can avoid or - at least - alleviate the mesh sensitivity, which is a challenge due to the high processing time involved in analyzing mechanical problems with a full 3D large strain ductile damage model.

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Introduction of Microbial Symbiosis in Genus of Tridacna and Kiwardae with Insights in Aquaculture

Jincao Guo
23rd March 2023 University of Manchester

Abstract:

Aquaculture plays a significant role in the diet of people in many regions. However, problems such as bioaccumulation have risen with the rapidly growing industry due to lack of control in the feeding process which brings uncertainty to the quality of the products. The paper tackles the problem by introducing the symbiosis of the Giant Clam (Tridacna) with photosynthetic algae and Yeti Crab (Kiwaidae) with chemosynthetic bacteria in molecular and developmental details. By combing the knowledge gained from the two models and past studies, innovative ideas such as using mass selection methods to domesticate and farm those symbiotic species, as well as improvements for the current farming methods such as introducing algae feeding are discussed. Further studies are needed but experiments are worth conducting since it increases the variety of choices for consumers and can potentially improve the quality and efficiency of aquaculture.

Introduction: As human population keeps increasing, essential nutrient such as protein is becoming more and more important. Although meat, egg, and milk is the main protein source for the majority of the population, 15.3% of all protein consumed is still from aquatic animals. (Boyd, McNevin and Davis, 2022) In areas where farming is difficult, people can be more dependent on seafood as a protein source. Aquaculture as a more stable way of harvesting aquatic animals was the fastest-growing farming industry in the past 3 decades (Martínez-Córdova et al., 2016). Aquaculture on many species is highly dependent on environmental factors. Such example is the farming of bivalves which usually depends on the nutrient of the water it inhabits (Quayle, 1989) and the farming of crabs and fish which fed on chum that can contain accumulable toxins such as farmed salmons were shown to contain mercury. (Khristoforova et al., 2018) (Ju et al., 2020).

Microbial symbionts have helped the host to nutrients in many marine organisms. Such example is the Giant clam which obtains nutrients from photosynthetic dinoflagellates symbiosis and the yeti crab which farms chemosynthetic bacteria growing on its carapace. The naturally occurring symbiotic relationship provides insights into innovative ways of aquaculture. This paper introduces the underlying mechanism of those symbiotic relationships while exploring potential innovative methods in aquaculture such as introducing the microbial-based nutrient to already commercialized species or the potential farming of those symbiotic species.

Photosynthetic symbiosis in giant clams

Animals are usually heterotrophs which they gain energy by ingesting other organisms. However, the giant clam from the genus *Tridacna* are able to gain energy through autotrophy using sunlight. The clam inhabits the warm shallow ocean of Southern Pacific and Indian ocean. The nutrient of the warm shallow ocean is low compared to cold ocean

since the temperature difference prevents the mixing of nutrient rich water from the deep with the warm surface water (de Goeij et al., 2013). This specialized mechanism allows those clams to obtain essential carbon hydrates under nutrient poor conditions. The microbe associated with the clam are known as zooxanthella from the family *Symbopdinium*, which can also be found in many cnidaria. An example is *Symbopdinium microadriaticum* which is potentially the dominant species of zooxanthella associated with *Tridacna* (FITT and TRENCH, 1981) The host which "farm" those dinoflagellates benefit from the carbohydrates fixed through photosynthesis while the dinoflagellates are sheltered by the host from predation and in some cases being provided with essential nutrients. The clam, especially when young and small, obtain at least 65% of all carbon required for growth and respiration from the photosynthates generated by the microbes. (Klumpp, Bayne and Hawkins, 1992) The efficiency of photosynthesis is sufficient for this due to a special phenomenon called "host factor" which describe the situation where the same species of zooxanthella produces photosynthate with better efficiency when associated with host tissue or when host tissue is presence around it compared to both free living flagellated form. (Sutton and Hoegh-Guldberg, 1990) The dinoflagellates although can be found all over the surface and most interior of the clam, tend to cluster in the mantel membrane which the clam exposes towards the sunlight as shown on figure 1. The mantel is vascularized to transport the carbohydrates typically in the form of glucose produced by the microbes into blood stream. The species *T. squamosa* pushes this symbiosis to another level which study shows that the clam develops vacuolar proton ATPase in the mantel to provide protons for the dinoflagellates to establish proton gradient. (Ip et al., 2018).

Figure 1 demonstrates an overview of the symbiotic relationship between the dinoflagellate and the clam, to achieve this, both sides need to make compromises (Gates et al., 1995). The figure shows that the clam has blue outer mantel which expands to the edge of the shell and is able to open to a larger degree compared to the majority of clam species to increase the surface area exposed to sunlight. This compensation made by the clam causes it to be more vulnerable to predation. (Todd, Lee and Chou, 2009) The blue and green color of the mantel is caused by the chlorophyll a and c in the dinoflagellates. The dinoflagellates, just like the clam also make compensations for the symbiotic relationship. Comparative study shows that *symbopdinium* typically fixes the carbon in the form of glycerol in lab conditions when in free-living form. However, the microbes tend to fix the carbohydrates in the form of glucose as evidence from carbon isotopes suggests. The major photosynthates also change from neutral lipids to mainly glucose to better feed the clam. More direct evidence is that the hemolymph glucose level exhibits a diurnal pattern which is high in the day when photosynthesis is feasible but low at night where potentially no photosynthesis can occur. (Trench 1971) The carbon fixation in the form of glucose is a compromise made by the microbe since it as a monosaccharide with a smaller molecular size and simpler structure and is more easily absorbed and utilized compared to glycerol. (Ishikura, Adachi and Maruyama, 1999) There is a daily pattern of the movement of the mantel as it expands during the day and retracts in night. The dinoflagellates living in it reproduce when sunlight is sufficient. The clam digests a proportion of the microbes intracellularly by the amoebocytes in the mantel. The unabsorbable remaining of dinoflagellates is moved to the digestive diverticula to be thoroughly digested. (Morton, 1978) The clam is not obligated "autotrophs" by only consuming the photosynthate generated by the microbes, the proportion of dinoflagellates digested varies depending on environmental factors such as the available nutrient in water and the efficiency of filter feeding. (YONGE, 1981)

The symbiotic relationship between the clam and the dinoflagellates is a complex process and it is initiated with filter feeding. The symbiotic relationship was initially thought to be adopted from sexual reproduction just like in cnidaria species (M, 1930). However, no zooxanthella was found in lab raised veliger although the egg was collected from parents in the wild. This symbioted veliger is shown to have better survival rate even in lab conditions where nutrient is sufficient and no predation which reveals that the symbiotic relationship could be promoted by natural selection. (Fitt, Chang and Trench, 1981) The free-living dinoflagellate enters the host cell through filter feeding during the veliger form and through special mechanisms it enters the circulation system through digestive system. (FITT and TRENCH, 1981) The process of the symbiosis in clam has not been confidently confirmed, but it is suspected to be similar to that of coral which the symbiodinum glycan on the microbes signals the pattern recognition receptors of the host to trigger endocytosis and alternation to the transforming growth factor β pathway which inhibits immune response of the host triggered by the zooxanthella in a genetic level. (Detournay et al., 2012) The zooxanthella provides the host with UV resistant molecules mycosporine-like amino acids to prevent the host animal cell from UV damage when exposing the symbiotic tissue to sunlight for photosynthesis. (Shick et al., 1999)

Farming of chemosynthetic epibiotic bacteria by curstceans
The cradle of life back in the day is a harsh environment for the majority of animals in the present. Crustaceans from the genus *kiwaidae*, also known as the yeti crabs, are found clustered around hydrothermal vents in the South pacific ocean. Certain strains of bacteria and archaea thrive in this environment where they conduct chemosynthesis such as sulfur respiration to fix carbon, this potentially provides a solution for food for those animals. (Grassle, 1985)

Animals living around the vents all exploit the bacteria to some extent, but the yeti crab is able to farm the microbes. The yeti crab gets its name from its white furry looking resembling the unidentified animal yeti. The white fur is composed of setae of crabs and a dense population of epibiotic filamentous microbes. Initially, the white fur was thought to be composed solely of microbes, but the dissection of the fur showed it has a chitin-based stiff interior, indicating its crustacean origin (Thurber, Jones and Schnabel, 2011). The specific strains of microbes found on the setae are not thoroughly studied yet but they all are able to use sulfur in their metabolism (Goffredi et al., 2008) Through the analysis of 16s RNA in the stomach content, the microbes the crab primarily feeds on species of *Campylobacteria* and 53% of all carbon in the crab derived from a bacterial source. (Niemann et al., 2013) Based on the isotopic study, the crab can solely on the nutrient generated by the microbes using inorganic materials from the hydrothermal vent. (McCutchan et al., 2003)

Figure 2 demonstrates the basal mechanism for yeti crab to obtain nutrients through microbial symbiosis. Those filamentous bacteria use nitrates to oxidize the sulfide provided by the vent and make the sulfur-containing compound more available as electron acceptors in anaerobic respiration known as sulfur respiration. (Fonseca et al., 2017) Bacteria from the family *Thiotrichaceae*, a filamentous chemosynthesis bacterium that belongs to the same phylum *pseudomonadot*a as *Campylobacterota* store large volumes of nitrate in vacuoles, allowing it to have sufficient nitrate for sulfide oxidizing. (Schulz and Jørgensen, 2001) The specific mechanism of each epibiotic bacteria on the crab is not thoroughly studied but it is believed to be in a similar manner as the filamentous bacteria *Candidatus Venteria ishoey* (C.A. ishoey) from the *thiothrichacea* family(Fonseca et al., 2017). The enzymes and key pathways involved in sulfur oxidation identified in *C.A.ishoey* are the dissimilatory sulfite reductase (Dsr) and Sulfur oxidation (SOX) systems and they are relatively conserved among different strains. The Dsr proteins are involved in both the oxidation

of sulfur to sulfite and the reduction of sulfite back to sulfur when receiving electrons passed down from the electron transport chain as demonstrated by fig2 (Stockdreher et al., 2012). The SOX includes Sox AX, Sox YZ, and Sox B as the core of the system for sulfite oxidation which the overview of the oxidation can be found in fig2. (Kojima et al., 2014)(Simon et al, 2013). The adenosine -5` phosphosulfate (APS) plays an important role in all sulfur respiring prokaryotes (Friedrich, 2002). The enzymes and pathways involving the production and reduction of APS is essential for receiving electrons from the electron transport chain and the overview of its function is shown in fig2 (Friedrich, 1997). The gene of the key enzymes involved in the APS related pathway includes ATP sulfurylase and adenosine phosphosulfate reductase (apr) which gone through lateral gene transfer across different bacterial lineages and is conserved showing their effectiveness and importance for sulfur-respiring prokaryotes. (Klein et al., 2001)

To improve the efficiency of the farming and nutritious, the crab develops specialized behaviors. The crab occasionally waves its limbs in a dance like manner and stand in an upright posture towards the hydrothermal vent. Researchers initially associate it with territorial defense but later confirm the purpose of the behavior is for nurturing the epibiotic microbes' growth which allow more water to pass through the colony (Thurber, Jones and Schnabel, 2011). The crab forages the microbes by stroking the setae with its maxilliped which traps the microbial colony in its comb-like mouth part which it can ingest. The microbes are not obligated to be grown on the setae of crabs which the crab sometimes also conducts foraging behaviors by collecting the bacterial culture grown on other surface with its cheliped (Yong, 2011)

inducing symbiosis in commercialized bivalves or use microbes as animal food

Symbiotic microbes help provide nutrients for the host in the wild, based on the symbiotic mechanism, it is theoretically possible to induce a similar relationship between those microbes and aquacultural species. In the *Tridacna* case, the symbiosis is induced by filter feeding during the veliger plankton form. For many commercialized species of bivalves for example in the family *of Meretrix*, the whole life cycle including the planktonic phase is farmed in an artificial environment (Wang et al., 2013). Since the zooxanthella itself possess certain mechanisms to induce the symbiosis and maintain it at a molecular level (Detournay et al., 2012) (Shick et al., 1999), the only obstacle to the building of this relationship is to induce the development of certain structures and behaviors for the symbiosis. A less bald approach compared to inducing symbiosis is using microbes to improve the feeding of aquacultural species has already been shown successful for example in decapod *Penaeus aztecus* (Wilkenfeld, Lawrence and Kuban, 2009). The insight gained from the yeti crab case demonstrates that decapods can survive on a mainly microbial-based diet. However, the gut microbial of the yeti crab is not thoroughly studied yet, and certain sulfide detoxicating mechanism is already found in the gill of the crab (Chou et al., 2022). It is reasonable to hypothesize that the gut also possesses certain traits, if not for detoxicating sulfur, there must be certain adaptation compared to related species with different diets. For both cases, the specialized traits can be theoretically induced through methods such as genetic modification, hybridization, and mass selection. Among them, mass selection can be the best method in terms of public acceptance compared to genetic modification which exploits the fast rate and the large number of spawning by aquacultural species (Bennett et al., 2005) (Hadley, et al, 1991).

Domestication of the symbiotic species

Since microbial symbiosis helps the host to obtain food in a nutrient low environment, another insight is to domesticate the symbiotic species. This promotes low-cost farming in which the microbes aid the host with autotrophic products and offer more choices for customers. Species of the giant clam family *Tridacna* have already been farmed by the locals of the Solomon Islands. Although primarily farmed as pets, the study reveals the potential of the giant clam being a commercialized seafood species for its abductor muscle (Tisdell, 1922) The clam reaches 16mm in average shell length after 24 months of growing which is nowhere near the growth rate of commercialized hard-shell clams *Meretrix*. (Hart, Bell, and Foyle, 1998) However, the species has not been through any levels of selective breeding at least not on purpose. Mass selection method has been successfully implemented on bivalve species for example the *meretrix* which improves the growth rate by 5.5mm annually compared to the wild type (Wang et al., 2013). Mass selection also functions well on crustaceans which reduces the genetic bottleneck effect on the size of *Eriocheir sinensis* (Wang et al., 2018). Applying mass selection on symbiotic species like the giant clam or yeti crab for fast growing larger sized variants is worth experimenting.

conclusion:

Supplementing aquacultural species using microbes helps improve food safety and potentially reduce costs. As demonstrated by the two cases, both bivalves and decapods are capable of gaining nutrients using symbiotic microbes through digestion or transportation of autotrophic products. For many commercialized seafood farms such as mud crab farms, the animal food is made from unwanted fish parts (Sathiadhas, 2004) known as chum which has little to non-quality control and can lead to bioaccumulation of toxins (Rahman et al 2017). Using microbes as food has much higher quality control and easily screened for toxins such as the paralytic shellfish toxin (Moore et al 2011). For raising symbiotic species, essential inorganic nutrients, and an easily controllable carbon source such as bicarbonate are potentially the only or at least the majority of resources required which can be easily screened for toxins (Trench 1971) (Niemann et al., 2013). Experiences can be derived from the successful domestication of related species of symbiotic ones. There is more research to be done to successfully induce symbiosis in commercialized species as shown in the two cases.

Reflection: The investment for both the induction of microbial symbiosis in commercialized species or domestication of the symbiotic species is high in terms of time and money. For example, the yeti crab lives 3000m under the ocean, and studying them can be costly (Grassle, 1985). The traits and behaviors associated with the symbiotic relationship may not be as straightforward as the modification of one gene. Identifying and modification of the gene for those traits and behaviors require time. If using mass selection, for adopting the symbiosis or ingesting microbes as the main food source, potential new traits derived from mutations are required such as the enlargement of the mantel for bivalves. Although with a large number of offspring, the chance of the discovery of non-deleterious traits fitting such requirements is low. If breakthroughs are made rapidly, there is still a time lag for the commercialization of the species. For example, different countries have different sets of tests for genetically modified food, and people also take time mentally to accept newly emerged food. (Kuiper et al., 2002)

Figures page
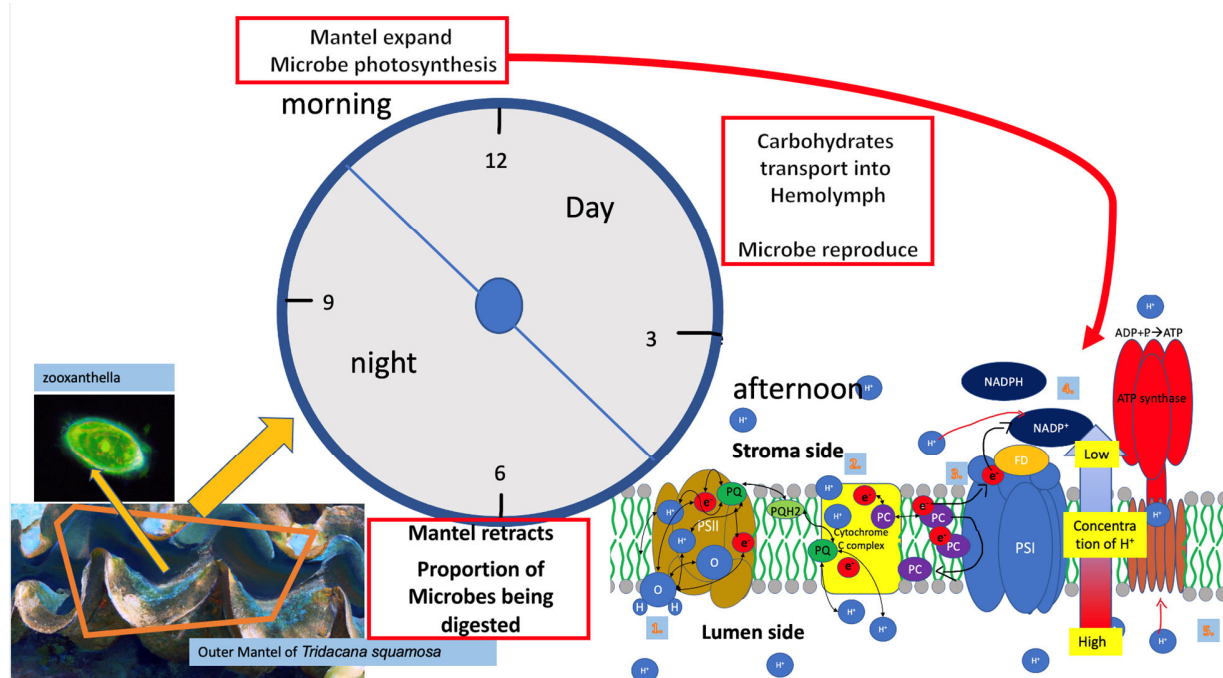
Figure 1: The overview of the symbiosis of the giant clam with the zooxanthellae and details of photosynthetic pathway in the zooxanthella (Image generated using https://labs.openai.com/)
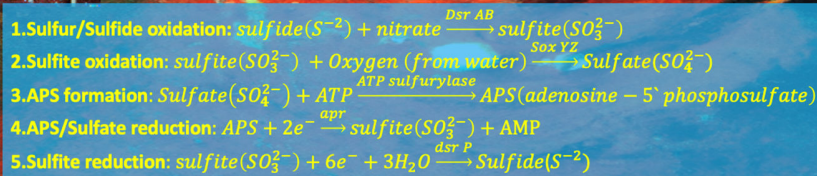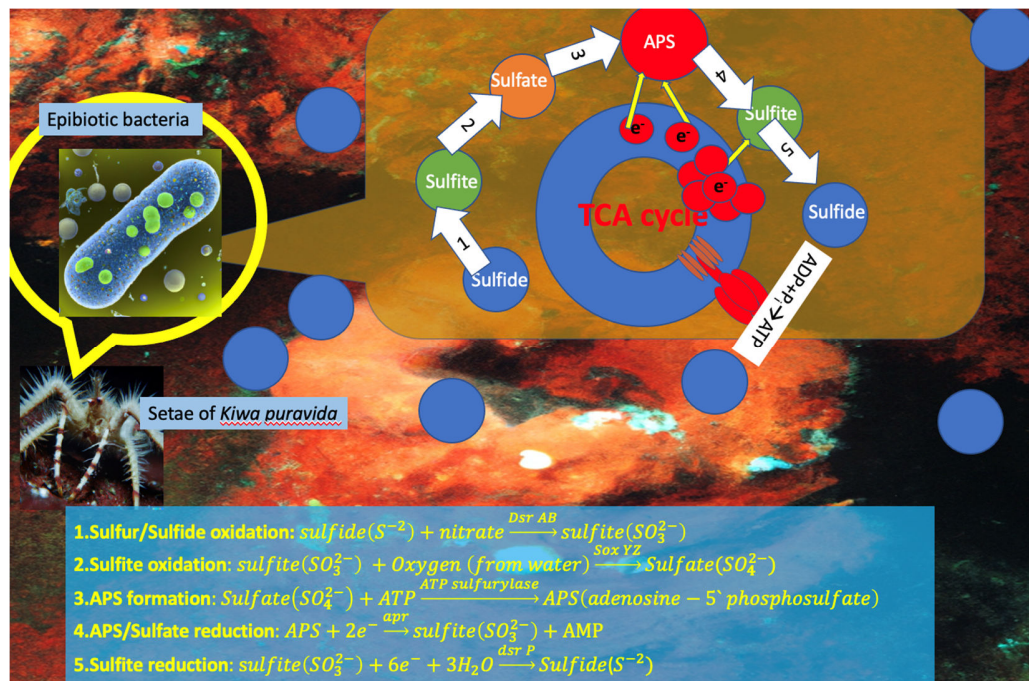
Figure 2: The simplified process of sulfur respiration by epibiotic bacteria living on the setae of K.puravida. The chemical reaction for each steps of the sulfur redox is shown on the figure (STETTER et al, 1985) (Barton & Fauque, 2009) (Dannenberg et al., 1992) (image generated by https://labs.openai.com).

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The Principle of Methodological Rationality and Security of Organisations

Jan Franciszek Jacko

***Abstract*—** This investigation presents the principle of methodological rationality of decision making and discusses the impact of an organisation's members' methodologically rational or irrational decisions on its security. This study formulates and partially justifies some research hypotheses regarding the impact. The thinking experiment is used according to Max Weber's ideal types method. Two idealised situations("models") are compared: Model A, whereall decision-makers follow methodologically rational decision-making procedures. Model B, in which these agents follow methodologically irrational decision-making practices. Analysing and comparing the two models will allow the formulation of some research hypotheses regarding the impact of methodologically rational and irrational attitudes of members of an organisation on its security. In addition to the method, phenomenological analyses of rationality and irrationality are applied.

***Keywords*—** methodological rationality, rational decisions, security of organisations, philosophy of economics.

Jan F. Jacko is with the Jagiellonian University in Krakow, Poland (e-mail: 379@wp.eu).

Student Perceptions of Defense Acquisition University Courses: An Explanatory Data Collection Approach

Melissa C. LaDuke

Abstract—The overarching purpose of this study was to determine the relationship between the current format of online delivery for Defense Acquisition University (DAU) courses and Air Force Acquisition (AFA) personnel participation. AFA personnel (hereafter named "student") were particularly of interest, as they have been mandated to take anywhere from 3 to 30 online courses to earn various DAU specialization certifications. Participants in this qualitative case study were AFA personnel who pursued DAU certifications in science and technology management, program/contract management, and other related fields. Air Force personnel were interviewed about their experiences with online courses. The data gathered were analyzed and grouped into 12 major themes. The themes tied into the theoretical framework and addressed either teacher-centered or student-centered educational practices within DAU. Based on the results of the data analysis, various factors contributed to student perceptions of DAU courses to include the online course construct and relevance to their job. The analysis also found students want to learn the information presented but would like to be able to apply the information learned in meaningful ways.

Keywords—Educational theory, computer-based training, interview, student perceptions, online course design, teacher positionality.

I. INTRODUCTION

THE purpose of this correlational explanatory qualitative study was to provide a foundation of student perceptions toward DAU courses. Student perceptions were explored in order to address the question "How do students' perceptions toward the current format (i.e., teacher-centered) of online DAU courses affect AFA personnel (i.e., student) participation?" Supporting questions that guided the data collection on the specific phenomena included:

1. How does choice of online DAU courses improve student motivation and participation in online DAU courses?
2. How does the number of online DAU courses taken affect student motivation and participation in online DAU courses?
3. How do students' job experience(s) affect their motivation and participation in online DAU courses?
4. How do students' career fields affect their motivation and participation in online DAU courses?

Finding the answers to the research questions is significant to the field of course design, specifically DAU online courses

designed for adults, as the data gathered could lead to course modifications (if necessary) to improve participation. Improved participation may lead to greater achievement in terms of greater retention of knowledge learned. This increase in knowledge retention could ultimately save the Air Force time and money and may improve the understanding of participation in other online courses. Also, the findings from this study could have broader application beyond DAU. Much more needs to be understood about the quality of online instruction. After its creation, online instruction may not consider instructional design, teacher positionality, or meaningful application of content. The findings of this study may give online course designers ideas on instructional design techniques that prove beneficial to adult learners.

II. THEORETICAL FRAMEWORK

The theoretical framework for this study is comprised of eight different educational theories: motivation, instructional design, behaviorism, cognitive learning, constructivism, situated learning theory, connectivism, and adult learning. Each of the eight theories is tied to how students learn through feedback from more capable peers (student−teacher relationship), social interaction (student−student relationship), and student-mediated learning.

Additionally, the application of new literacies is an underlying theme within the theoretical framework. Using a compilation of theories from other new literacies researchers, Lankshear and Knobel [1] claimed, "New literacies hav[e] new 'technical stuff' and new 'ethos stuff' that are dynamically interrelated". The technical aspects are comprised of the hardware and software needed to take part in new literacies work [1]. The ethos stuff is related to the social practices of learning as well as the evolution in technology development [2]. Using these definitions, the ethos part of new literacies directly ties into connectivism, constructivism, and situated learning theory. The technical parts may be related to behaviorism and cognitivism. adult learning theory, motivation, and instructional design incorporate both ethos and technical considerations. A summary of theories is found in Fig. 1.

Melissa LaDuke is with National Intelligence University, United States (e-mail: mci1783@yahoo.com).

Educational Theory	Highlights	Ties to New Literacies	Application to DAU Courses
Motivation	Includes three different types - intrinsic, extrinsic, and amotivation; intrinsic motivation causes students to want to learn because they find the material interesting or can apply it to specific goals; students with external motivation only take part in learning activities due to the influence of outside parties; students influenced by amotivation are affected by forces outside of their control [3]	*"Technology stuff"* - Internal motivation, or presence may be influenced by the personal learning environment [4] *"Ethos stuff"* - The online environment chosen could lead to externally-motivated learners; the learner could be punished or constrained for not supporting the environment [3].	Students take online DAU courses because of a combination of the three types of motivation; overlaps is motivation such as extrinsic and intrinsic can lead students to take online DAU courses to earn a certification; amotivation may be present if a student does not have a choice in what courses to take [5], [6]
Instructional Design	Originated from instructional needs of World War II military; offers guidance on how to help learners develop cognitive, emotional, social, physical, and spiritual skills [7], [8]	*"Technology stuff"* - The method of instruction includes the online environment constructed to support educational goals [7] *"Ethos stuff"* - Instructional situation allows the construct of the content-delivery tools to tie back to other educational theories [7]	Instructional designers of online DAU courses could gear courses to help DAU professionals at various stages in their career; entry-level personnel could take courses that reinforce basic concepts while more experienced personnel could take courses that assess application of concepts learned
Behaviorism	Students do not have prior knowledge of the given subject; educators determine what students have learned through using assessment of student actions [9], [10]	*"Technical Stuff"* - Students need to show their ability to navigate the technology used to gain ownership of the knowledge needed to better perform knowledge analysis and synthesis [11].	Student learning is determined through the overemployment of rote types of assessment (drill and practice; factual questions) in formative and summative multiple choice assessments [12]
Cognitive Learning	Students do not have prior knowledge of the given subject; learners work to move information stored in short-term memory to into schemes already present in their long term memory [13]	*"Technical Stuff"* - Students gain foundational knowledge through online literature reviews that may or may not be moved to long-term storage	Learners may/should seek to move knowledge into from short-term memory to long-term memory using potential applications to their job but may be unable due to being passive learners within the online courses
Constructivist	Students' learning experiences allow them to pair their own experiences with presented facts; students use social and community interaction to build a stronger knowledge base [14], [15]	*"Ethos stuff"* - Online courses can allow students to belong and communicate within a community of fellow learners while giving them the ability to practice their skills through guided, individual activities [11]	Learners may use knowledge gained in future DAU courses
Situated Learning Theory	Students cannot transfer skills learned if they are gained in one specific context; learners gain more if they are allowed to be active members of the learning process [16], [17]	*"Ethos stuff"* - Learners are required to be active in their own learning while adapting to new situations [4]	Currently online DAU courses are dependent on passive learning techniques such as slide presentations; because of the level and finite context in which the information is presented, students may not be able to apply knowledge to authentic (real-life) situations
Connectivism	Focuses on considerations on how information changes due to Digital Age; students ingest information then determine its relevance; seeks to amplify learning by tying students' prior knowledge with socially-learned facts [13]	*"Ethos stuff"* - Individual's personal learning environment (PLE) requires high levels of motivation to be involved in the communication and/or collaboration conducted using the new literacy [4]	Online DAU courses teach federal and Air Force regulations which change based on emerging needs; personnel may be able to better apply facts to real-life situations if the knowledge is transferred to the people who need it [18], [13]
Adult Learning in the 21st Century	Adult learners need to move towards self-directedness and be able to apply their knowledge to real-world tasks; adult learners are more driven by internal motivators [19]	*"Technology stuff"* - Adult learners need to tap into their prior knowledge, to include use of technology, to increase their own competence [20] *"Ethos stuff"* - Social aspect of learning may be fueled by a learner's responsibility to help others [20]	Students who can apply knowledge learned in online DAU courses may be more motivated to internalize the material presented [21]

Fig. 1 Highlights of Educational Theories

III. BACKGROUND AND METHODOLOGY

A qualitative case study was the approach used for this study. The design of the case study fell in line with Yin's [22] beliefs and procedures. Yin [22] subscribed to a positivist epistemology in seeking to answer "how" and "why" questions in contexts where he had little control. The combination of Yin's [22] emphasis on ensuring validity and reliability (or credibility, transferability, and dependability for a qualitative study) and the influence scientific methodologies had on his practices were especially important as AFA leaders and policy makers tend to have scientific backgrounds. A correlational explanatory lens was employed for this qualitative study. In a correlational study, none of the variables are manipulated by the researcher; all data for this study were collected without the influence of the researcher [23].

Data were collected through interviews, course documents and screenshots provided by participants, and the researcher's reflexive journal. Data collected were analyzed using constant comparison analysis [24], [25]. Grounded theorists specifically use constant comparison analysis to analyze data collected and turn it into theory [26]. After each interview and document submission, the data were inductively coded and compared to other events that fed into the coding [27]. Through the data analysis, recurring codes/words were classified into separate

themes [27]. Applying an inductive process to the data analysis enabled broader generalizations to be made from the specific data collected [28]. The themes and codes constructed using participant data were tied to the eight educational theories forming the foundation of this research.

The target participant population was AFA personnel located at various bases across the United States. The study data were comprised of responses from 18 personnel, ranging from 26 to 46 years of age. This group was particularly targeted, as there is a wide range of individuals who take DAU courses. The wide age range aided in gathering data from participants with different experiences; personnel who had taken a few courses (younger personnel) may view the courses differently than personnel who had completed numerous courses over the years (older personnel). All participants were native English speakers and active duty Air Force members. All participants have at least a Master's degree in their respective science or engineering discipline. Participants were chosen due to their availability and willingness to participate. The majority of participants work currently within the field of higher education, so they were familiar with both Acquisitions and adult learning.

IV. RESULTS AND DISCUSSION

The resulting themes and codes and related educational theories can be found in Figs. 2 and 3.

The data collected showed a tendency for online DAU courses to lean toward teacher-centered educational practices within its instructional design. This was evidenced through the participants' comments on an overreliance on text-filled slides and the memorization of redundant facts as evidenced in Theme 2, "The amount and presentation of information is a hindrance to student learning." Because of the instructional design techniques used, participants found themselves not reading the course material but downloading the slides, illustrated by the codes found within Theme 1, "Students are passing the test but not internalizing the material." Within Theme 1, several students mentioned using a guess-and-check test taking technique or searched through the downloaded slides for the correct answers. The memorization of facts and redundant information fell into cognitive learning theory and Theme 2. Both test-taking techniques are tied to behaviorism and Theme 1.

Participants could not recall most of the information when the course ended as they were not given opportunities to employ the information in a real-world setting. Participants also found the information presented in online DAU courses to be broad and not easily matched to their current job experiences as reported within the codes comprising Theme 3, "The types of information presented as well as the format may influence student learning." Some participants were able to use the material later in their career but only in a general sense, such as remembering terminology or where information can be found within Federal Acquisitions Regulations. The purpose of the courses was not clear to many of the participants as evidenced in Theme 5, "Students who are driven by external motivators approach the courses and learning differently." The participants were informed on the courses needed for their jobs unofficially through supervisors, training managers, and/or peers but did not receive formal mentorship on the path to job certification using online DAU courses. Relying on broad information and unclear certification standards forces participants to construct their own knowledge, which follows constructivist educational techniques which is embodied in Theme 2.

Motivation		Instructional Design		Behaviorism
Students who are driven by external motivators approach courses and <u>learning differently.</u>	**Students are internally motivated to learn the material and apply it but <u>run into roadblocks.</u>**	**Students are passing the tests but not internalizing the <u>material.</u>**	**Students' background may affect their desire to take online DAU courses in their <u>current form.</u>**	**Students are passing the tests but not internalizing <u>the material.</u>**
Working toward mandatory certifications	In-residence courses are helpful	Guess and check test technique	Not knowing audience	Guess and check test technique
Supervisor/job provides requirements/guidance	Motivation to learn info outside assigned billet/career field due to perceived value	Not reading course material	Academics/Educational Experience	Not reading course material
Training Manager	Hindrances to taking voluntary courses	Using reference materials for testing		Using reference materials for testing
Requirements list for certification	Certification billet as a hindrance	Downloading/ reference		Downloading/ reference
Courses/certification requirement issues		Information is easy to understand		Information is easy to understand
Course approach - just get it done		Course design		
Check the box		Course feedback		
Future career goals		Teaching Method		
Taking courses and continuous learning points		Instructor help		
		In-residence training not helpful		
		Course graphics		
		Ineffective group work		

Fig. 2 Overarching Themes with Support Codes and Ties to Theoretical Framework – Motivation to Behaviorism

Cognitive Learning	Constructivist	Situated Learning Theory	Connectivism			Adult Learning Theory
The amount and presentation of information is a hindrance to student <u>learning.</u>	The types of information presented as well as the format may influence <u>student learning.</u>	Students want to take an active role in <u>their learning.</u>	Students' work environment affects their active <u>participation.</u>	Students' ability to receive accurate and valuable information affects their active <u>participation.</u>	Students want to help DAU address issues within training <u>and processes.</u>	The ability for a student to apply the knowledge gained from an online DAU course is dependent on his/her <u>position and rank.</u>
Redundancy	Confusion	In-residence courses are helpful	Work as a distraction	Google/ Researching	DAU Instructor	Rank/job versus training requirements incongruence
Memorization of topics/facts; rote knowledge	Scaffolding	On-the-job training is helpful	Road shows	Accuracy of Information	DAU Growth/Improvement	*Students who could not apply the material*
Too much information	Broad/higher-level information	Hindrances to active engagement	Training Time	Information value	Acquisitions issues	Online courses not useful for job
Right amount of information	Courses did not build on each other	Critical thinking		Updating information	Other organizations providing same type of training	Hindrances to training
Note taking	Courses work together					*Students who could apply the material*
Reading course material	Group/peer work					Online courses useful for job
Obscure information	No formal guidance/mentorship on courses					Real/Actual/Applied learning
						Authentic Learning
						Timeliness

Fig. 3 Overarching Themes with Support Codes and Ties to Theoretical Framework – Cognitive Learning to Adult Learning

Educational practices desired by the participants fell in line with student-centered learning practices. Participants desired to take a more active role in their learning as evidenced through recommendations made by participants within the various themes. Participants benefited greatly from on-the-job training and group work within in-residence courses as illustrated in codes within Theme 9, "Students are internally motivated to learn the material and apply it but run into roadblocks," and Theme 10, "The ability for a student to apply the knowledge gained from an online DAU course is dependent on his/her position and rank." The ability to discuss experiences with others assisted in being able to learn how to apply the information presented in individual job settings. The group work included in online and hybrid DAU courses proved to be ineffective in helping participants remember the data presented as evidenced in participants' comments within Theme 11, "Student perceptions concerning the construct and interactiveness of the DAU website and online courses may affect student learning." Wanting to learn and apply the information presented in online DAU courses ties back to motivation, Themes 8 and 9, and adult learning theory, Theme 10.

Participants also wanted to better develop their critical thinking skills using up-to-date authentic activities to think through problems within their work environments, which is evidenced in Theme 9. Using outdated information within the online DAU courses led participants to question to utility of DAU courses in general; this is seen in Theme 6, "Students'

ability to receive accurate and valuable information affects their active participation." Participants also were motivated to learn material presented in online DAU courses if they could apply it to their current jobs, as exhibited in Theme 10. Participants who were able to apply the course material took part in applied/ authentic learning activities, which was also seen in Theme 10. The accuracy of information aligns with the connectivist learning theory and Themes 5 ("Students' work environment affects their active participation"), 6, and 7 ("Students want to help DAU address issues within training and processes").

Lastly, participants valued instructor interaction as they could learn from instructors in an unofficial mentor-mentee capacity. Instructor help was a code under Theme 11. Participants valuing group engagement and critical thinking skills falls within situated learning theory or Theme 4. The desire to have instructor interaction and mentorship can be grouped within instructional design theory, specifically Themes 11 and 12 ("Students' background may affect their desire to take online DAU courses in their current form").

Overall, there are three educational theories that emerged as highly influential in the course of this study. Behaviorism seems to be the learning theory that most dominates the current construct of online DAU courses. This is exhibited through the overuse of assessments as the only method to determine if student learning occurred. Behaviorism is also present as the majority of participants reported online DAU courses presented foundational knowledge even within more advanced courses. The learning theory that most drove participants was

motivation. Participants were motivated to use the material in their current and/or future jobs and wanted to help DAU improve the learning experience. Not being able to use material from online DAU courses greatly discouraged students from being active learners in the online DAU environment. Instructional design is the third major educational theory present within the findings. Instructional design is the means to address the concerns discussed by the participants to craft a more beneficial online learning experience. The other five educational theories can influence instructional redesign efforts.

V. IMPLICATIONS

There are three major implications to this study. The main implications are lack of up-to-date information, waste of time, and not using the training for their jobs. These implications have far-reaching effects to include wasting government resources, improperly executing contracts and/or contracted work, and taking Acquisition professionals away from more beneficial tasks such as hands-on innovation efforts.

The lack of up-to-date training can lead participants to not trust any information presented by DAU. As multiple participants indirectly stated, DAU courses that lack current information can cause participants to lose faith in DAU to train personnel appropriately. If participants do not trust DAU training as a whole, even courses with valuable information will not be seen as value-added by Acquisitions professionals.

Another implication is continuing to take ineffective online DAU courses wastes time. Participants reported online DAU courses can take anywhere from an hour to days and weeks to complete. Participants found this time could be better spent learning daily tasks through on-the-job training, taking courses that directly apply to participants' current jobs, or completing current job requirements.

A third implication is the current DAU course and certification construct may leave Acquisition professionals feeling like they do not have the tools to do their jobs. As all participants believed the online DAU courses were not beneficial to their jobs, they relied on on-the-job training and/or attempting to find needed information themselves. If needed information cannot be found, Acquisition professionals may be left guessing what would be the best course of action may be for major programs. Participants discussed failures within major Acquisitions programs such as the development of the F-35 aircraft. These failures caused participants to wonder why they should bother with certification if the courses taken did not seem to help better develop needed technology.

VI. TIES TO THEORETICAL FRAMEWORK

The main educational theories impacting this study were connectivism and instructional design. Connectivism is highly influential because it helps identify to the learner which pieces of information is important to retain while addressing changes in the technological and Acquisitions environments. Instructional design is key as it provides DAU professionals guidance on how to best help DAU participants grow as Acquisitions professionals by incorporating other educational theories. The other six theories can be applied within connectivism and instructional design to define specific issues within the current online DAU course construct.

A. Behaviorism

While participants pushed for more student-centered learning experiences, there is still a need for behaviorist theory within DAU courses. Students' behaviors still need to be seen to determine if learning has occurred. As behaviorism assumes learners have no prior knowledge, incorporating behaviorist principles may be most beneficial in Level One (basic) certification courses [9]. Students taking these courses rely heavily on the instructor to present foundational knowledge needed for more advanced courses. Summative and formative assessments that use instantaneous feedback then need to be designed to gauge if students understand the knowledge presented in the course [12]. Students need to have shown they have understood enough of the basic principles presented to move on to learn more advanced topics in the Level Two (intermediate) and Level Three (advanced) certification courses. For behaviorist theory to work effectively, topics assessed should be more than Federal Acquisition Regulation numbers. Suggested assessments might include matching needed acquisition documents to their correct spot in a project timeline, identifying roles and responsibilities of offices within an acquisitions program, and determining legal and illegal activities that could be presented within a project manager's scope of responsibilities.

B. Cognitive Learning Theory

Cognitive learning theory can help instructional designers bridge the gap between old and new knowledge specifically within online DAU course assessment [29]. First, instructional designers could craft pre-tests given at the beginning of each module to determine how much information a student has previously acquired or retained. Any questions that cover key information that were answered incorrectly would lead the student to a review lesson before bringing them back to the assessment. The assessment questions at the end of the module could ask students to reflect on how they used or could use the information presented within their own practices. Having students tie the information presented in the online DAU courses to personal experiences helps move concepts from short-term to long-term knowledge [13]. The questions should be constructed to have more than one right answer which may mean using short essay questions to determine if learning occurred [29].

C. Constructivism

For online courses to follow constructivist beliefs, instructional designers need to account for the digital learning environment. The learning environment must be interactive and socially driven which motivates students to take an active role in their learning [31]. Instructors can aid those who are not active participants through synchronous means such as online discussions as well as asynchronous methods such as emails or threaded discussions [31]. Online learning environments should

also create opportunities for collaboration with peers and more-experienced mentors [31. Participants in this study desired more interactions with others as these experiences helped them construct their own applied knowledge. The digital learning environment can use what students say, do, and feel to access and incorporate their experiences in course experiences to better aid others in constructing knowledge [30].

D. Situated Learning Theory

Online environments can easily be established to support communities of practice. Through archived chat rooms, bulletin board systems, or other asynchronous or synchronous methods, instructional designers can establish online networking environments that allow teams to grow, pursue common understandings in a given topic, and reflect on the knowledge gained [31]. Additionally, establishing communities of practice may help DAU professionals learn skills that are transferrable to various situations which can help them execute daily tasks more effectively [16]. Effective communities of practice can also help Acquisitions professionals keep abreast of changes within the Acquisition environment. Members of the community who work with evolving regulations can help inform others of the changes and aid them in applying the revised regulations appropriately [13]. DAU already attempts to grow communities of learners through newly-implemented forums but they are not widely-publicized nor used [32].

E. Connectivism

Connectivism as an educational theory could majorly influence how future online DAU courses are constructed. Participants in this study acknowledged their desire to connect their knowledge to other people's experiences for more meaningful learning environments [33]. DAU instructional designers could build communities of practice that serve many different purposes. One type of community of practice could mimic an integrated product team. Students can learn about each part of the Acquisitions process from someone who specializes in the Contracting career field or interfacing with contractors. This diversity of opinions connects "specialized nodes or information sources" to gain a breadth of knowledge [13]. This type of community of practice could also help students see between ideas and fields they cannot experience on their own [13].

Another type of community of practice could combine less-experienced Acquisitions personnel with senior mentors of the same field. For instance, senior Developmental Engineers could be paired with engineers just earning Level Two certification. This pairing would allow new personnel to see senior-level decision making processes while senior personnel learn about the evolving Acquisitions environment from those who experience the changes at a tactical level [13]. As study participants also discussed learning information using Googling, constructivist theory could help DAU course designers build a searchable database or website Acquisitions professionals can use to find targeted training, case studies, and other useful artifacts [13].

F. Motivation

Motivation is critical to DAU students taking part in meaningful learning activities. As participants stated their motivation was affected by taking courses not applicable to their jobs, DAU course designers can use this information to make more meaningful learning experiences. First, online DAU courses could mimic real-world scenarios and activities. Based on participants' comments, active learning would increase if the courses would help them better accomplish their duties. Featuring real world scenarios in an online setting would grow intrinsic motivation as students may be more driven to learn the information [34].

Internal motivation may also increase if students were allowed to pick the certifications they accomplished [34]. Numerous participants discussed choosing to take online DAU courses for certifications that were of interest rather than required. These participants were internally motivated to learn from DAU courses outside of their certification requirements because they found the information helpful for current jobs and future goals.

Unfortunately, external motivation, and amotivation may need to factor in student learning as DAU still needs personnel with specific certifications and learned knowledge [3]. However, DAU personnel can still attempt to grow internal motivation by making certification mandatory when an Acquisitions professional is about to transition into a job in which the information is needed [5].

G. Adult Learning Theory

Instructional designers who create courses for adult learners should follow the principles and goals established by Knowles [19] and Merriam [35]. Online courses should have direct ties to real-world applications, which create a need to learn [19]. Courses should provide opportunities for adult learners to reflect on their own progress and their learning processes [36]. For online DAU courses, instructional designers could frame topics around a simulated contract management scenario and ask open-ended questions based on the scenario. The scenario could progress based on the student's response(s), have opportunities for the learner to see and reflect on the ramifications of their decisions. This student reflection is a key point in Merriam's [35] adult learning goals.

H. Instructional Design Theory

DAU course designers who employ instructional design theory can scaffold concepts throughout the progression of courses needed to earn certifications. For instance, multiple participants discussed the Acquisition process as a whole. An instructional designer building a course within Level One certification could ask students to identify different parts of the Acquisition process using situational cues such as listening to/participating in avatar-led meetings within the online DAU course. This identification falls in line with constructivist and cognitive learning practices.

Students taking Level Two courses could then apply their Level One knowledge to determine the actions that occur at each Acquisition milestone using an online model. Students

would need to continue the activity until all activities associated with the milestone have been addressed. This activity would incorporate pillars of behaviorism.

In Level Three, students could take part in a group project that analyzes case studies to assess the actions taken and what, if anything, they would have done differently which is part of adult learning theory and situated learning theory. Asking students to include new technological and procedural considerations would bring in aspects of connectivism. Motivation is carried throughout the levels of courses as passing the course serves as an extrinsic motivator and being able to apply the knowledge they learned to their jobs (intrinsic motivation).

VII. RECOMMENDATIONS

Initial suggested changes incorporate student-centered learning practices that would aid Acquisitions professionals in learning and applying the material to their jobs. The first recommendation is to ensure information presented is up to date. As students rely on the information presented in the online DAU courses when they are performing program management tasks, the information needs to reflect current regulations and best practices. One way to do this is to break the online courses into smaller, objective-based sections that could be replaced if or when information changes. These segmented modules could then be used as refresher training for personnel re-entering the Acquisitions field or as easy online reference. These smaller modules could also be linked together and used as targeted reference material.

A second recommendation is to present information using multiple methods. As many participants commented on the daunting amount of text included in each course or learning better from video, DAU course designers should explore presenting the same information using video and/or animations, transcripts of video and/or audio files, and graphs or pictures when possible. DAU may also choose to use virtual reality to better mimic authentic activities such as discussions in staff meetings, working with contractors, and other actions that may not be fully experienced through online environments. Appealing to a wide variety of learning styles may help more of the Acquisitions population learn the desired objectives.

A third recommendation is to include more meaningful group work in the online courses. Participants wanted more opportunities to work with other Acquisitions professionals to learn from their experiences. Group work in terms of incorporating synchronous sessions with asynchronous work, including discussion boards, blog work, and other cooperative practices could help DAU students better relate the material presented to real-world tasks.

The final recommendation for design changes would be to scaffold learning to improve mastery and application of material. Level One students focus on learning Acquisitions basics such as learning names of important milestones, when necessary paperwork is due, and other such items. This would match typical roles and responsibilities of lower-ranking individuals who would be managing small contracts or serving as a project lead in a large program. Level Two becomes more

applications-based but in a sterile environment. This would match the ranks and experience levels of students taking the courses. Students seeking Level Two certifications tend to be managing or seek to manage larger contracts with bigger impact on the Air Force. Level Three could then become completely applications-based authentic learning activities that use real Acquisitions projects to guide students through the knowledge they need to know to be successful in their executive positions. This scaffolded construct may help DAU better meet their intent of designing courses based on the intent of growing Acquisitions professionals capable of serving in increased levels of responsibility.

VIII. FUTURE WORK

As this study served as foundational research in an under-studied field, more work is needed to ensure DAU students have a more beneficial experience. First, more research on student perceptions is needed. This study should be conducted at different Air Force bases that employ Acquisition personnel. The study should then be conducted at Army, Navy, and Marine Corps bases that have the equivalent of AFA personnel. The findings of these studies should then be compared to studies using AFA personnel to identify any trends in student perceptions, issues, and/or recommendations. Any trends found among the Armed Services should then be presented to DAU for consideration.

The next step would be to work to address issues discussed in previous studies of DAU course participants and course administrators. Addressing participant concerns would hopefully lessen any negative perceptions experienced by DAU course participants while ensuring DAU course administrators are delivering beneficial content in a more meaningful yet sustainable way.

The last step would be to conduct this study again once changes in online DAU courses are made. Conducting this study again with the same or similar populations would assist in determining if any Acquisition personnel perceptions have changed. Conducting a cyclical review of DAU courses could also determine if DAU courses were seen as being more applicable to participants' jobs. Changes in participant perceptions and/or job applicability could then lead to further changes in online DAU courses or DAU maintaining any changes made.

IX. CONCLUSION

This study examined the research question "How do students' perceptions toward the current format (i.e., teacher-centered) of online DAU courses affect AFA personnel (i.e., student) participation?" The theoretical framework was comprised of eight different learning theories, motivation, instructional design, behaviorism, cognitive learning theory, constructivism, situated learning theory, connectivism, and adult learning theory. Data were divided into similar categories then grouped into themes. Each of the eight learning theories was used to create themes stemming from data collected from the participants.

The findings of this study were reported according to the themes constructed. Participants reported an overuse of teacher-centered practices such as reading copious amounts of text and learning rote knowledge. Participants believed they would learn more from student-centered educational practices such as group work, applying learned knowledge to scenarios, and learning from instructors in a mentorship relationship. The findings were then used to make recommendations such as incorporating more group work, reinstating DAU course road shows, and including targeted training for various DAU personnel groups. Other recommendations include conducting the same study at different AFAs bases, within other Armed Services, and working with DAU to examine their internal practices and constraints. Ideally, DAU will use the information presented in this study to better train current and future Acquisition personnel as not changing the current DAU course and certification construct will result in a continued lack of benefit for the Acquisitions community.

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Melissa C. LaDuke earned her PhD in curriculum and instruction from Texas Tech University in Lubbock, Texas, USA. Prior to that, Dr. LaDuke completed her bachelor's degree in chemistry from Hawaii Pacific University, Honolulu, HI, USA and Master's degree in chemistry from University of Dayton, Dayton, OH, USA.

She currently serves as a faculty member at National Intelligence University in Bethesda, MD, USA. She has been in the U.S. Air Force since 2005 and held instructor and faculty positions within the U.S. Air Force Academy, U.S. Air Force Reserve Officer Training Corps, Global School for Professional Military Education, and Squadron Officer School. In addition, she has spoken at numerous national and international conferences. Her research interests include adult education, teacher education, and online education.

Dr. LaDuke is a member of the Literary Research Association and International Society for the Scholarship of Teaching and Learning. Dr. LaDuke also chairs the Inclusion and Equity Committee for the Association of American University Women.

Sexual Minority Victims of DV/ IPV from a Police Perspective

Jennifer L. Hartman, Breanna Haney, Angela Gover, Michael Turner, Janne Gaub

Abstract— Intimate partner violence (IPV) targeting sexual minority individuals is receiving more academic attention, which is revealing insights concerning prevalence and disclosure patterns. In Obergefell v. Hodges (2015), the U.S. Supreme Court recognized marriage rights for same sex couples. This ruling allowed those individuals that identify as members of a sexual minority (LGBTQIA+) to now celebrate marriage legally in any state. While this seminal case redefined marriage, this ruling also created new policy implications within the criminal justice system. Specifically, whether law enforcement agencies have taken steps to ensure that sexual minority populations receive legal protections granted in the 2015 ruling. Some studies suggest that specialized domestic violence training is necessary for law enforcement officers to understand the nuance of domestic violence/ intimate partner violence. Other research suggests that having a domestic violence unit is not necessarily needed and on par with generalized policing. In comparison to heterosexual victims, sexual minority victims may face unique conditions from responding law enforcement officers regarding frequency and reporting of abuse, and discrimination from police not believing they are truly victims. Using a nation-wide survey of police agencies (municipal, sheriff, tribal), perceptual issues on how to address sexual minority domestic violence/ intimate personal violence cases will be presented. Specifically, whether sworn officers currently perceive training status to be effective, adequate, and ultimately prepared for sexual minority calls for service? Findings will discuss whether diversity training for sexual minorities is a necessity. Challenges and barriers within law enforcement agencies will be discussed as will future policy implications.

Keywords— sexual minority, domestic violence, case law, police training

In 2015, the U.S. Supreme Court ruled in *Obergefell v. Hodges* that bans on same-sex marriage are unconstitutional and required states to recognize marriage rights. This ruling allowed those individuals that identify as members of a sexual minority to now celebrate marriage legally in any state. A sexual minority as defined by the National Academies of Sciences, Engineering, and Medicine (2022) includes individuals who identify as lesbian, gay, bisexual, asexual, queer, intersex and transgender. While this seminal case redefined marriage, this ruling also created new policy implications within the criminal justice system.

This study aims to uncover if municipal, county sheriffs and tribal law enforcement agencies in the United States provide training related to sexual minority domestic violence/intimate partner violence to their officers since the *Obergefell v. Hodges* case. Further, a look into the possible challenges of current training and what barriers hinder an agency's absence of training. It is the goal of this paper to emphasize and inform the role that law enforcement agencies have in ensuring that there is established training to confirm that sexual minority populations receive the legal protections granted by *Obergefell v. Hodges* (2015).

I. THE ROAD TO SEXUAL MINORITY MARRIAGE LEGISLATION

The road to sexual minority marriage legislation is not necessarily something new nor has it taken a linear path. For example, the legal rights and protections of same-sex couples has been on the docket for over three decades, when the Supreme Court of Hawaii ruled in *Baehr v. Miike* (1993) that prohibition of same-sex marriage violated the constitution (Isaacson, 2015). While Hawaii was not successful in granting same-sex-sex unions as it required a classification of sex which was susceptible to scrutiny under the Hawaii constitution (Hermann, 2015) this set precedent for discussions and future action on the issue. Although not in favor of same-sex marriage, the federal government and President Bill Clinton enacted the Defense of Marriage Act (DOMA) in 1996 to define marriage as one man and women and asserted that states were not able recognize same-sex unions that were discerned under another state's legislature and that these couples would be afforded the same the federal law benefits as opposite-sex couples (Clarkson-Freeman, 2005). The General Accounting Office noted that 1,049 federal laws were impacted by DOMA including denied access to a spouse's employment benefits, joint tax returns and exemptions, or the denial to reside together in collegiate or military housing (Clarkson-Freeman, 2005; Cornell Law School, n.d.). However, *Goodridge v. Department of Public Health* (2003) changed the dialogue when Massachusetts became the first state to legalize same-sex marriage (Gates & Brown, 2015, Hermann 2015). Following Massachusetts, several states followed suit in legalizing same-sex marriage such as Connecticut in 2008; Iowa, New Hampshire, Vermont, and District of Columbia in 2009; New York in 2011; Maine, Maryland, and Washington in 2012 (Pew Research Center, 2015).

In fact, the landmark decision in *Windsor v. United States* (2013) 570 U.S. 744 set forth that the federal government was required to recognize same-sex marriages and granted some federal benefits to those couples that resided in states that did not honor their marriage, ultimately ruling that aspect of DOMA unconstitutional (Gates & Brown, 2015; Hermann, 2015; Isaacson, 2015). Specifically, the Court held that Section 2 of the DOMA which denied federal recognition of same-sex

Jennifer Hartman is with the University of North Carolina at Charlotte, United States (e-mail: jhartman@uncc.edu).

marriages, was a violation of the Due Process Clause of the Fifth Amendment. In response to *Windsor v. United States,* in 2013, Delaware, Hawaii, Illinois, Minnesota, and Rhode Island, New Mexico and New Jersey issued rules that permitted same-sex couple unions (Pew Research Center, 2015). By 2014, 34 states had legalized same-sex marriages leaving 16 states with constitutional bans on such marriages (Pew Research Center, 2015).

In 2015, *Obergefell v. Hodges* ruled that the constitutional Fourteenth Amendment required all states to grant a marriage license between two same-sex partners and to recognize such when performed in another state (Isaacson, 2015). The opposing dissent included Chief Justice John G. Roberts, Jr. argument that although same-sex unions could be a fair practice, it is not the constitution's duty to address it and should rather be up to state voters and electoral will to decide whether same-sex marriage licenses are recognized (Hermann, 2015; Oyez, n.d.). Justice Clarence Thomas and Justice Samuel A. Alito, Jr. also argued against the minority, that the right of marriage among same-sex couples is not conveyed in the constitution and the decision to deviate from the traditional form of marriage should be reserved for state legislature (Hermann, 2015; Oyez, n.d.). Justice Clarence Thomas further claimed that the opinion of due process rights via the Fourteenth Amendment altered democratic process by violating religious freedoms by taking the decision away from individual states (Oyez, n.d.).

The Court concluded in a 5-4 decision in favor of the minority that there is no difference in a same-sex union and an opposite-sex union therefore the exclusion of same-sex partners was a breach of the Due Process Clause of the Fourteenth Amendment (Oyez, n.d.). An analysis of the fundamental liberties protected by the Fourteenth Amendment is applicable to same-sex partners in the same fashion as the traditional opposite-sex couples. Responding to Justice Thomas' comment, the Court declared that the First Amendment does provide protections to religious institutions to honor their principles but does not grant states to deny same-sex couples a marriage license (Oyez, n.d.).

Although, from a legal standpoint, this landmark case addressed the national controversy that captured discussion and debate for decades, the Court's decision does not identify any form of equality beyond a marriage license. Little attention was given to provide further claims of rights and protections to these individuals. Further, Hermann (2015) highlights that the decision does not include any additional claims for protections relating to discrimination in employment or accommodations, and argued in this paper, potentially by law enforcement.

Prevalence of Sexual Minority DV/IPV

Much like heteronormative relationships, research has shown any relationship between two people presents a unique risk of domestic violence/ intimate partner violence (Kimmes et al., 2019). Undoubtedly intimate partner violence was occurring prior to the *Obergefell v. Hodges (2015)* decision, however, now couples are granted the right to expect legal protections therein. Research has highlighted the prevalence of domestic violence/intimate partner violence among sexual minorities even suggesting that it is as common or *more*

rampant than heterosexual couples (Brown & Herman, 2015; Edwards et al., 2015; Greenwood et al., 2002; McKenry et al. 2006; Messinger, 2011; Walters et al., 2013). The 2010 National Intimate Partner and Sexual Violence Survey (NISVS) disclosed that the prevalence of lifetime intimate partner violence was 43.8% for lesbian women, 61.1% for bisexual women, 35% for heterosexual women, 26% for gay men, 37% for bisexual men, and 29% for heterosexual women (Walters et al., 2013).

Additional research echoed this sentiment in a meta analysis of 42 existing studies ranging from 1989 to 2015 that analyzed the prevalence of intimate partner violence among the LGBT population (Brown & Herman, 2015). Findings revealed that lesbian and bisexual women, gay and bisexual men, and transgender individuals report a lifetime prevalence of intimate partner violence just as high or higher as heterosexual individuals (Brown & Herman, 2015). Specifically, of the studies examined between 25% - 40% of lesbians and between 25% - 33% of gay men reported experiencing lifetime intimate partner violence in comparison to approximately 33% of women and 28% of men in the general population lifetime (Brown & Herman, 2015).

Contemporary research using the National Crime Victimization Survey (NCVS) began asking about respondents' sexual orientation in 2016 (Martin et al., 2023). Since documentation of such, Flores et al., (2020) verified that rates of violent victimization perpetrated by intimate partners reported in the 2017 NCVS, the first national examination of victimization of sexual minorities, was substantially higher among sexual minorities. Violent victimization that was perpetrated by a well-known offender, specifically by an intimate partner, was 16.2 per 1000 persons among sexual minorities vs. 2.4 per 1000 persons for non-sexual minorities (Flores et al., 2020).

Peculiarity of Sexual Minority DV/IPV

Although research provides persuasive evidence that sexual minorities are indeed at a high risk of experiencing domestic violence/intimate partner violence, it is estimated that less than half of these incidents are even reported to police, therefore it can be assumed that these rates are actually considerably higher than what is officially reported (Kuehnle & Sullivan, 2003). Granted, the underreporting of domestic violence/ intimate partner violence is often a concern for all, sexual minorities may face additional risks that their heterosexual counterparts do not (Kimmes et al., 2019). Specifically, sexual minorities report experiencing discrimination by law enforcement via profiling, homophobic and transphobic attitudes (Mallory et al., 2015; Martin et al., 2023 Ritchie & Jones-Brown, 2017). Likewise, research has established that sexual minorities perceive the police to not be helpful when reporting their victimization (Brown & Herman, 2015; Mallory et al., 2015). A study of gay and bisexual intimate partner violence victim's opinions on the effectiveness of police response in their case found that 59% viewed police as less helpful towards them rather than heterosexual women victims (Stephenson et al., 2013).

In contrast, some research has suggested that the response to domestic violence/intimate partner violence is uniform thus, invalidating the need for specialized training for sexual minorities. In fact, Gover et al. (2011) reported that the majority

of officers (77%) in their sample of 307 officers from a large urban police department reported that same-sex and opposite-sex domestic violence happened for the same reasons and 79% agreed that law enforcement policy and laws should ensure protection for homosexual partners.

Some scholars have indeed identified similarities in the nature of same-sex and opposite sex domestic violence/intimate partner violence (Pattavina et al., 2007; Renzetti,1992), however there are a number of reasons why domestic violence/intimate partner violence differentially impacts same-sex couples (Brown, 2008, Rollè, et al., 2018). Legally same-sex couples are granted the same marriage protection, although socially it is seemingly not as accepting. Reporting their dispute and victimization would be an "outness" stressor. That is, contacting law enforcement would force them to "out" their sexuality to law enforcement officials but also to their family and friends (Kimmes et al., 2019). The fear of discrimination associated with being a sexual minority may be a driving force and challenge for victims of same-sex intimate partner violence to seek assistance from any service provider and arguably to report incidents to law enforcement (Brown, 2008). Sexual minority victims have reported that they do not report their victimization to police in fear that it will not be treated and responded to as serious as heterosexual intimate partner violence and instead as mutual violence (Martin et al., 2023). Society often stigmatizes lesbian relationships so uniquely that some reports outline that shelters were not accepting and stated that their abuse did not constitute domestic violence (Renzetti, 1989).

Especially in a society accepting of male aggression the expectation for men to defend themselves, intimate partner violence among gay or bisexual men may be dismissed as simply an expression of Connell and Messerschmidt's (2005) ideology of hegemonic masculinity that men assert power to achieve status, making a victim less likely to seek assistance (Duke & Davidson, 2009; Rollè, et al., 2018). Men are socially taught to defend themselves in violent situations and being observed as a victim could be construed as a sign of weakness and that they are unable to uphold their masculinity (Tesch et al., 2010). Further, an abuser may challenge their victim's status as a "real" man in society and manipulate their partner so that no one will believe that they were abused by a man (Duke & Davidson, 2009). In the same sense, women are socially viewed as perpetrators of violence and rather are seen as passive in romantic relationships. Law enforcement may adopt this belief, making it challenging to identify violence in lesbian relationships (Tesch el al., 2019). It is known that officer's struggle to discern the victim's actions (Gover et al., 2011), and arguably in a same-sex dispute, the struggle is even more difficult. This can result in an inaccurate response to domestic violence incidents (Gover et al., 2011; Toon & Hart, 2005).

A victim of same-sex intimate partner violence may also experience what scholars refer to as internalized oppression, distress and low self-esteem as a result of societal oppression, as leverage to assert control (Duke & Davidson, 2009). That is, the victim begins to assume the harmful societal image of them and believe that they are deserving of the abuse (Duke & Davidson, 2009). Additionally, sexual minority individuals are also at greater risk due to minority stress from homophobic discrimination to such extent that their perpetrator can coax them to not report or seek assistance because it would reveal their sexuality; exacerbating the struggle of being a victim (Kimmes et al., 2019; Messinger, 2011).

Failed Role of Specialized DV/IPV Units and Training

Domestic violence/intimate partner violence has been acknowledged as a serious area of concern and discussion for law enforcement agencies and victim services (Pattavina et al., 2007). Many agencies have responded with a widespread change in policy and enhanced training standards and resources in the study of the nature of violence (Pattavina et al., 2007; Russell & Sturgeon, 2018; Saunders et al., 2016). The emergence of specialized police domestic violence units has also been introduced as a strategy to combat the issue. These units can provide an array of specialized professionals ranging from trained officers and investigators to respond to the case and emphasis on a coordinated community response assuring victim legal assistance and counseling (Exum et al., 2014; Regoeczi & Hubbard, 2018). Specialized domestic violence policing units began as early as the 1990's when the Violence Against Women Act (VAWA) in 1994 communicated to law enforcement agencies that domestic and intimate partner violence was a crisis in need of attentiveness and thus provided grant funding to be used in the response to such violence (Exum et al., 2014; Jennings et al., 2021). VAWA funding largely contributed to the enactment of specialized domestic and intimate partner violence units and specialized training for officers (Jennings et al., 2021). In 2005, a national survey of 14,000 law enforcement agencies revealed that 11% of departments had a specialized domestic violence unit with 56% of those agencies with 100 or more officers reported having a unit (Townsend et al., 2005). In terms of general domestic violence training, 74% of agencies required all patrol officers to receive domestic violence training, with 24% only a part of recruit training, 11% a part of in-service training and 63% to both recruit and in-service training (Townsend et al., 2005). Of those agencies with an officer requirement of domestic violence training, 65% included topics of primary aggressor determination, 68% including state domestic violence laws, and 51% covering social cultural differences (Townsend et al., 2005).

The development of specialized domestic violence courts has also been a judiciary response to increased domestic violence related cases (Gover et al., 2007). Domestic violence courts have assumed the responsibility of responding to all domestic violence cases in one court and emphasized collaboration among all parties to ideally address both the needs of the victims and defendants alike. Theoretically, this approach would result in a better grasp and consensus on the motivations of such cases (Gover et al., 2007). Interviews with 50 victims and 50 defendants who were attending a specialized criminal domestic violence court in Lexington County, South Carolina reported that the existence of this specialized court indeed positively impacted all parties involved (Gover et al., 2007).

A more recent examination in 2013 by the U.S Department of Justice concluded that 92% of sheriff's offices and 89% of local police departments had a domestic violence specialized unit, dedicated personnel, policies or training (Reaves, 2017). Specifically, 11% local police departments reported having a specialized unit with full time personnel, 14% reported having dedicated personnel and 58% addressed the issue with policies and training (Reaves, 2017). Seventeen percent (17%) of sheriff's offices reported having a specialized unit with full time personnel 18% reported having dedicated personnel and 52% addressed the issue with policies and training (Reaves, 2017). In spite of the federal funding granted to assist in appropriate response and the growing concern of domestic violence/intimate partner violence, the goal of such specialized units and training has often failed to assume the role of ensuring the legal protections of sexual minority victims.

Narrow-Bodied Research

Despite the policy changes over the last three decades and strides taken by federal legislation more recently seeking to advance attention to sexual minority domestic and intimate partner violence, empirical research investigating law enforcement training and police perceptions involving same-sex domestic violence/intimate partner violence disputes is scarce (Franklin et al., 2019; Russell & Sturgeon, 2019). Much research and training standards dedicated to law enforcement response to domestic violence and intimate partner violence has consisted of heterosexual couples and lack guidance on sexual minority incidents (Hamel & Russell, 2013; Pattavina et al., 2007). This gap in research is particularly concerning given that the sexual minority population experience higher rates of domestic violence and risk factors compared to heterosexual individuals (Martin et al., 2023). Of those that have briefed the topic, they have largely consisted of examining officer homophobic beliefs (Bernstein & Kostelac, 2002; Franklin et al., 2019; Lyons et al., 2005; Younglove et al., 2002), the heteronormative lens of intimate partner violence (Baker et al., 2013; Franklin et al., 2019; Peterman & Dixon, 2002), and mandatory arrests outcomes between same sex and opposite sex couples (Durfee & Goodmark, 2020, Pattavina et al., 2007).

Limited studies addressed the topic on the analysis of training protocols pertaining to sexual minority domestic violence/intimate partner violence disputes and nonetheless, all have shortcomings in examining the issue. In 2010, Tesch et al., accessed the knowledge, experience and training of police officers relating to same-sex domestic violence by surveying 91 active police officers in 5 different police departments in the suburban Chicago areas. Respondents were asked about their experience with encounters of same-sex domestic violence, departmental training on same-sex domestic violence, and respondent's opinions on their department's handling of same-sex domestic violence cases. Findings revealed that 90% of officers reported that they had responded to a sexual minority domestic violence case during their career in law enforcement, 81% of officers reported that their agency did not have an established procedure specifically dedicated to sexual minority domestic violence while 17% reported that they were unsure if their department had training available. Further, 25% reported

that they did receive training that would be applicable to the sexual minority population and 29% reported that they were provided with training specific to sexual minority domestic violence (Tesch et al., 2010). Attitudinal measures asking about officers' opinions on their agency's handling of sexual minority domestic violence revealed that 82% believed their agency was doing an adequate job, 17% shared they believed their agency's approach was inadequate, and 32% stated that their agency could be doing more (Tesch et al., 2010). Authors emphasized how future studies should draw from a more diverse socio demographic area (broader range of locations, urban and rural) and how demographic characteristics impact response to better understand how police departments respond to same-sex domestic violence (Tesch et al., 2010). As Tesch et al., (2010) was groundbreaking in the study of law enforcement approach to same-sex domestic violence, the study lacked generalizability and was limited methodologically.

Additional research used other metrics to determine police training effectiveness on domestic violence cases. Hamel and Russell (2013) analyzed the content of 16 training manuals from police departments representing 23 states with dominant aggressor laws to determine if law enforcement training and response was acting on empirical research. Eight states included a power and control wheel representative of heterosexual domestic violence, only 1 state included a gender neutral power and control wheel, there was no discovery of a power and control wheel for heterosexual female abusers, lesbians, gays, or transsexuals. It was discovered that only one of the manuals had guidance specific to sexual minorities and concluded that law enforcement practices lack information relative to domestic violence by female abusers, male victims, or same sex couples (Hamel & Russell, 2013).

Trujillo and Ross (2008) advised that there are three distinguishing factors that influence an officer's response to a domestic violence dispute. Of importance in this study, one of the three include officer beliefs and assumptions about domestic violence/intimate partner violence episodes. Gover et al., (2011) echoed this sentiment in that attitudes and beliefs toward such are going to impact their decisions and response. Although, despite their influence, examinations of law enforcement officer's perceptions and attitudes of domestic violence in general are lacking in research (Gover et. al., 2011). A study of 309 police officers from a large urban police department found that officers in their sample were highly frustrated about the lengthy time commitment that domestic violence calls require. When asked about training, the majority of officers did not view training to be beneficial and disagreed that additional training would be any more helpful. However, officers were confused and had misconceptions about the complexities of domestic violence incidents (Gover et al., 2011). Only twenty eight percent (28%) disagreed that many domestic violence victims could leave the situation with ease but choose not to. Even though there was an overall agreement that training was not necessary, authors put forth recommendations that more training on domestic violence would be indeed beneficial for law enforcement officers given the misunderstandings that officers had about domestic violence cases (Gover et al., 2011). Although it is known that officers have biased and incorrect assumptions toward domestic violence cases, researchers have affirmed police attitudes are

susceptible to change and that specialized training can dispel these biases and misunderstandings (Garner, 2005; Toon & Hart, 2005).

More recent research assessed how officers perceive same-sex and opposite-sex intimate partner violence incidents and how their experience as well as frequency and recency of required intimate partner violence training influences their evaluation (Russell and Sturgeon, 2019). The authors surveyed 309 police officers representing 27 states using a hypothetical scenario of IPV and fairness first developed by Finn and Stalans (1997). Demographic variables including officer age, race, education, rank, years of experience responding to domestic violence, and if their department had required training on domestic violence (as well as how frequent said training was). In terms of officer characteristics, years of experience had a correlation with only a few variables: providing informal advice, mediation, and asking one partner to leave the premises (Russell and Sturgeon, 2019). This contributes to the dissensus on how officer demographic characteristics influence their response to domestic violence calls for service. Earlier studies stated that an officers' age, race, rank, years of service served as no indicator of the likelihood of arrest (Saunders, 1995). Logan et al., (2006) determined that less experienced officers were more likely to respond more positively than more experienced officers.

Although Russell and Sturgeon (2019) addresses the topic of agency training protocols, their findings reveal that recency and frequency of training had no effect on an officer's evaluation of incidents and it was not specific to domestic violence training for sexual minority populations. In fact, research affirmed that additional examination *is* needed on the type of training that the officers receive, distinctively stating that LGBT-inclusive training possibly varies from traditional training standards (Russell & Sturgeon 2019). In sum, research focusing on domestic violence/intimate partner violence training protocols specific to sexual minority populations is lacking, and with the exception of (Russell and Sturgeon, 2019), all studies examining training and perceptual attitudes of officers toward domestic violence/intimate partner violence officers occurred before Oberfefell v Hodges (2015).

Other Strides in LEA Policy

The National Conference of State Legislatures provides a public database of law enforcement legislation in all 50 states and the District of Columbia (last updated December 2022). The legislation in this database include policing bills and executive orders on topics of data, training, technology, executive and legislative orders, certifications, etc., (National Conference of State Legislatures, n.d.). A keyword search of sexual minority, LGBT, transgender, same sex, domestic violence and intimate partner violence was conducted for years 2020-2022 (only these years are provided by NCSL) and returned 0 results. Although several results were returned for searches for domestic violence related to training and curriculum – 2021 AR H 1721, NY A 10577, UT H 301, these results did not pertain to, or were inclusive of, sexual minorities (National Conference of State Legislatures, n.d.).

Ritchie and Jones-Brown (2017) examined policies at 36 police departments across the United States to determine if (and which) departments had adopted policies pertaining to 6 topics including interactions with LBGTQ individuals. It was revealed that 30% of departments had a policy outlining sexual orientation discrimination. Only 5% had training detailing how to accurately engage with LGBTQ suspects in custody such as, 14% prohibited searches to assign gender based on anatomy, 9% ensured safe placement in detainment, and only 2 spoke to access hormonal treatment while in custody (Ritchie & Jones-Brown, 2017).

Research has established that changes in domestic violence/ intimate partner violence policy have taken place only after sustained effort over a significant period of time. It could be argued that not enough time has passed to adapt to the *Obergefell v. Hodges* ruling, however, law enforcement agencies have implemented other policy changes addressing other legislative issues. For example, legislation has taken strides in addressing the mental health crisis. In 2015, California State Bill 29 and Pennsylvania HB 221 as well as Oklahoma SB 1202 in 2016 required its officers to be trained to ensure that they are able to successfully respond to calls of service and de-escalate situations individuals with a mental or intellectual illness/disability (National Conference of State Legislatures, n.d.). Likewise in 2015, Illinois HB 4112 required the Illinois Law Enforcement Training and Standards Board to design a curriculum on police response to mental health crises (National Conference of State Legislatures, n.d.).

Furthermore, use-of-force standards and legislation have been implemented in response to the death of Michael Brown in 2014, President Obama's Task Force on 21st Century Policing, and succeeding the murder of George Floyd in 2020, the National Conference of State Legislatures (n.d.) reported that at least 22 states enacted more than 40 laws addressing use of force by law enforcement officers between 2014 and April of 2020. These laws included a combination of data collection requirements, new training and standards, and creation of investigation systems (National Conference of State Legislatures, n.d.). Specifically, Connecticut HB 7103 (2015) demands that their police training programs include instruction on use-of-force, cultural sensitivities and bias-free tactics (National Conference of State Legislatures, n.d.). Similarly, Utah HB 355 (2016) granted authorization for a training center and available resources for their officers regarding legal use-of force (National Conference of State Legislatures, n.d.).

Admittedly, use of force issues were far more mortal than training on sexual minority domestic violence/intimate partner violence in that law enforcement had to respond accordingly to unjustful deaths. However, their return of heightened training protocols sets an optimistic outlook that agencies do acknowledge the pressing issues making their communities vulnerable.

Current Study

The overwhelming prevalence and uniqueness of same-sex domestic violence/ intimate partner violence signals that responding to such would require training that differs and is beyond the traditional and generalized forms of training and thus an examination of same-sex domestic violence/intimate partner voice cannot be achieved from a heterosexual sample (Pattavina et al., 2007). The failure of law enforcement to

historically address incidents as such has resulted in barriers in identifying and responding to sexual minorities (Pattavina et al., 2007). Research into the adoption of training protocols is understudied, outdated and given how much has changed since research speaking to the topic has been conducted, it is not considerate of the change in legal landscape for same-sex unions. For these reasons, a study seeking to address this potential gap in law enforcement training protocols in their response to domestic violence/intimate partner violence involving same-sex disputants. Further, an audit of law enforcement officer's perception of identifying and responding to same-sex domestic disputes as well as their report of the benefits and potential challenges to the status of training is warranted. It is the goal that this study's evaluation of law enforcement agency training on sexual minority domestic violence/intimate partner violence can improve office response and future help-seeking efforts from victims.

METHODS

This thesis aims to better understand response and training efforts dedicated to sexual minority domestic violence/intimate partner violence within law enforcement agencies and how the status of such is perceived within the agency. To be explored is whether law enforcement agencies have put into place training and/or standards of practice (either new implementation or changes to existing protocols) in responding to sexual minority domestic violence/intimate partner violence. Specifically, to be determined is whether law enforcement agencies provide training related to sexual minority domestic violence/intimate partner violence to their officers. It will be further investigated how individuals within agencies report the training or lack of training and how this might contribute and hinder their ability to respond and identify incidents of such nature. Attitudinal measures among chiefs will be compared of those agencies where training does occur and where it does not. Challenges and barriers associated with both the existence and non-existence of training will be assessed.

The study will examine the following questions:

1. To what extent have law enforcement agencies implemented new training exclusive to sexual minority domestic violence /intimate partner violence in the recent past (since *Obergefell v. Hodges* 2015)?
2. To what extent have law enforcement agencies revised an existing training to be applicable to sexual minority domestic violence /intimate partner violence in the recent past (since *Obergefell v. Hodges* 2015)?
3. To what extent do individuals within law enforcement agencies perceive the status (training or no training) in terms of aspects of the occupation that relate to effectiveness, beneficence, adequacy, and preparedness?
4. To what extent are challenges associated within law enforcement agencies that do provide training
5. What barriers limit those agencies that do not provide training?

While examining these research questions, the study will also identify spatial (a particular region, urbanity, etc.,) as well as agency and respondent demographic (rank, years of service, sexual orientation, type of agency, etc.,) differences as noted as limitations in Tesch et al., (2010), and if a specialized DV/IPV unit also existed. An inquiry of the existence of training in tandem with a specialized domestic violence/intimate partner violence will be included.

Data

The data was collected by disseminating an online survey via Qualtrics to chief executive (or designee) roles, older than the age of 18, and employed within municipal, county sheriffs, or tribal police agencies in the United States. Using the 2020 National Directory of Law Enforcement Administrators (NDLEA), email addresses of chief executives and locations from the above agencies were obtained. Although mixed methods research often carries the burden of the commonly large sample sizes known to quantitative research and small sample sizes associated with qualitative research (Onwuegbuzie & Collins, 2007), this study ensured that the sample size is appropriate for both methods and types of data collected. The NDLEA consists of 10,728 municipal police departments, 3,028 county sheriffs and 117 tribal police agencies, totaling 13,873 agencies. Similar to Nix et al., (2020) who also used NDLEA data, all departments will be placed into a stratum based on the region of the agency (Southwest, West, Southeast and Midwest). A stratified random sample was taken to ensure a greater sample heterogeneity, recruitment of chiefs from different agencies (of different sizes and locations) and to increase the generalizability of results (Nix et al., 2019).

Methodological research surveying police officers presents distinctive challenges such as gaining access to the population; understanding the close-knit nature and the confidential aspect of law enforcement work; and legal policy and procedures presents challenges (Nix el al., 2019). This study may further present strain on the response rate due to the seemingly sensitive topic at hand, their fear of a breach of confidentiality considering their responses to attitudinal questions, and no incentive benefit. In an analysis of 497 surveys on policing related topics reported in 390 articles published in 15 journals from 2008- 2017, the response rate ranged from 5.2% to 100% with those conducted online receiving lower response rates than other modes (Nix et al., 2019) Additionally, over the nine year period, response rates are declining for surveys administered via mail, phone, and online (Nix et al., 2019). Therefore, it is reasonable to assume that the response rate of online surveys of police officers, including this one, could potentially be low (Nix el al., 2019). Although this can be a concern in terms of low statistical power and potential nonresponse bias, it is not a plausible reason to dismiss the study's merit outright (Nix et al., 2019). Despite the possibility of a lower response rate than other methods of research, this study does incorporate recommendations put forth as limitations by Gover et al., (2011), by using a larger sample of officers resulting in more representative and generalizable findings. A twenty percent (20%) response rate is expected, however, to minimize the concern of a considerably low response rate, considerations put forth by Dillman et al., (2014) on internet survey design and use

will be utilized. Specifically, a printable copy of the survey questions will be provided in the recruitment email as an attachment to ensure that respondents are able to obtain and prepare information (if needed); an option to designate another employee within the agency that is best suited to complete the survey will also be offered. Additionally, survey definitions and instructions for each section will be provided with the response path rather than at the beginning of the questionnaire. The creation of the survey is mindful of the demands of the policing profession and it is anticipated that the survey will be completed within 15 to 20 minutes. In addition, a gauge of their progress during the survey to limit premature termination will be offered.

Survey Instrument

An original survey was created to access the research questions for this project. Consultations were had with applied experts in the law enforcement field who have first-hand knowledge of the issues as well as a member of the sexual minority population, in an effort the survey items were considerate and not overly burdensome to the participants in your study. Study participants will be initially contacted via email, briefed on the objectives of the study, informed of their rights as a participant in the study, provided with a copy of the survey items, and invited to participate in the survey (link to Qualtrics survey provided). The survey instrument is designed so that participants will receive different follow-up questions based on their answers to initial questions. A participant's response to questions such as if a specialized unit exists and if additional training related to sexual minority domestic violence/intimate partner violence has been implemented determines what additional questions will be asked.

Demographic information about the agency and respondent will be presented, also whether a specialized DV/IPV unit existed. Further data will explore the comfort level and struggles of officers identifying and responding to calls for service of same-sex disputants, if changes in training protocols on LGBTQIA+ domestic violence/intimate partner violence have occurred in the recent past and the officer's perception of the status of training either in aid or hindrance of performing their job.

Data was analyzed using a mixed methods approach to combine both quantitative and qualitative data within one research effort to expand the understanding of law enforcement agency training standards and attitudes toward sexual minority domestic violence/intimate partner violence (Timans et al., 2019). Use of a mixed methods approach supports the view that triangulation of different research methods strengthens the findings and inferences made for understanding of the phenomena at hand and in more depth, compared to using a single method.

To assess the quantitative contributors of the outcomes of interest, multivariate analyses were employed. Further, a thematic analysis will be conducted on qualitative responses such as struggles to respond and identifying sexual minority domestic violence/intimate partner violence, motivations that encouraged the implementation of training, challenges and barriers in both the existence and nonexistence of training, as well as formal and informal conversations about concerns relevant to sexual minority populations. This method will be used to reveal emergent themes and patterns within the data set to address the research question(s).

The challenge for policy-makers, researchers and law enforcement officials centers on interpreting mixed methods results and executing appropriately. This research project will help all to better understand and guide the best path forward in responding to an ongoing domestic violence/intimate partner violence for sexual minorities. Data discussion and policy implications will be discussed.

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Integrated Approach of Knowledge Economy and Society in the Perspective of Higher Education Institutions

DR. S K Ashiquer Rahman
Associate Professor (Adjunct), The Rajshahi Science and Technology University (RSTU), Bangladesh
Financial Operator, Tradelink, Paris. France
Email: ashiq_firoza@gmail.com
Contact No: +33762224182

Abstract— the innovation, sustainability, and higher education are the vital issues of the knowledge economy and society. In-fact the concentration of these issues, educators and researchers convinced the learners to prepare productive citizens for the knowledge economy and society, and many initiatives have been launched worldwide. The concept of knowledge economy requires simultaneous and balanced progress in three dimensions (Innovation, Education and Sustainability) those are totally interdependent and correlated. The paper discusses the importance of integrated approach of knowledge economy and society in the perspective of higher education institutions. It remarks the advent of knowledge based economy and society, and need for combination of innovation, sustainability, and education. The paper introduces nine (9) important issues or challenges of higher education institutions that have emphasized, Cross-linked each other, and combined in a new education system that can form a new generation for the completive world as well as able to manage the knowledge based economy and societal system. Moreover, the education system must be the foundation for building to the necessary knowledge based economy and society, which must manage the innovation process through a more sustainable world. In this view point, Innovation, sustainability and higher education are becoming more and more central in our economy and society, and it is directly associated to the possibility of global wealth distribution to the economy and social. The objective of this research is to demonstrate the knowledge based economy and social paradigm in order to create the opportunity of the higher education institutions development. The paper uses the collective action methodologies to examine "the mechanisms and strategies" uses by higher education institution's authority to accommodate an integrated pattern as per connecting behaviours of knowledge economy and society. The paper accomplishes that the combination of innovation, sustainability and education is a very helpful approach to build knowledge based economy and society for practicing the higher education institution's challenges.

Keywords— Education, Innovation, Knowledge Economy, Sustainability.

Preventive Interventions for Central Venous Catheter Infections in Intensive Care Units: A Systematic Literature Review

Jakob Renko, Deja Praprotnik, Kristina Martinovič, PhD Igor Karnjuš

Abstract— **Introduction:** Catheter-related bloodstream infections are a major burden for healthcare and patients. Although infections of this type cannot be completely avoided, they can be reduced by taking preventive measures. The aim of this study is to review and analyze the existing literature on preventive interventions to prevent central venous catheters (CVC) infections. **Methods:** A systematic literature review was carried out. The international databases CINAHL, Medline, PubMed, and Web of Science were searched using the search strategy: "catheter-related infections" AND "intensive care units" AND "prevention" AND "central venous catheter." Articles that met the inclusion and exclusion criteria were included in the study. The literature search flow is illustrated by the PRISMA diagram. The descriptive research method was used to analyze the data. **Results:** Out of 554 search results, 22 surveys were included in the final analysis. We identified seven relevant preventive measures to prevent CVC infections: washing the whole body with chlorhexidine gluconate (CHG) solution, disinfecting the CVC entry site with CHG solution, use of CHG or silver dressings, alcohol protective caps, CVC care education, selecting appropriate catheter and multicomponent care bundles. **Discussion and conclusions:** Both single interventions and multicomponent care bundles have been shown to be currently effective measures to prevent CVC infections in adult patients in the ICU. None of the measures identified stood out in terms of their effectiveness. Prevention work to reduce CVC infections in the ICU is a complex process that requires the simultaneous consideration of several factors.

Keywords— central venous access, critically ill patients, hospital-acquired complications, prevention.

INTRODUCTION

Critically ill patients are admitted to intensive care units (ICU), where they receive advanced and complex care. The insertion and management of peripheral and central venous catheters (CVC) is a mandatory part of the complex process of treating these patients [1]–[3]. Venous catheters are used to administer intravenous fluids, drugs, blood and blood products, parenteral nutrition, central venous pressure monitoring, blood draws for tests, hemodialysis, etc. [3]–[5].

In addition to all the advantages of venous catheters, there is also a risk of developing complications. There is a potential for occlusion, deep vein thrombosis and infection [6]. These complications are strongly associated with higher morbidity, mortality, longer hospitalization times and higher treatment costs [2]–[4]. The development of infections is considered one of the more common and challenging complications, as it accounts for the vast majority of all bloodstream infections in intensive care units [6], [7]. Two terms are used to describe CVC-related bloodstream infections: catheter-related bloodstream infection (CRBSI) and central line-associated bloodstream infection (CLABSI) [1]. In both cases, the bloodstream infection appears with a patient who has had a CVC inserted, or has had one inserted in the last 48 hours, and has no other obvious cause of infection. In addition to the previous characteristics, the use of the term CRBSI requires a pathological diagnosis through positive blood cultures [1], [8].

Nursing plays an important role in preventing CVC-related bloodstream infections [8]. Nurses have complete autonomy when inserting peripheral venous catheters, choosing both the size of the cannula and the insertion site. They are involved in the insertion of the CVC, where their role is the psycho-physical preparation of the patient, the material and the room. Through systematic nursing care and careful handling of the vascular access, they contribute to preventing complications and the spread of infections [9].

Bloodstream infections associated with CVC are a major burden for healthcare systems and patients worldwide [4], [8], [10]–[12]. Although infections of this type cannot be completely avoided, the incidence can be significantly reduced through the correct implementation of preventive measures, internal controls and regular staff training [9]. Staff knowledge of the insertion and care of vascular catheters was found to be insufficient, suggesting a need for further education and research in the prevention of CVC-related bloodstream infections [4], [7], [12].

The amount of new interventions, studies and tools is large, thanks to the focused efforts to tackle this issue. A literature review is needed to assess the effectiveness of improvements and compare them with each other. This would give the nursing profession insight into current evidence-based

Jakob Renko is with the Faculty of Health Sciences, University of Primorska, Polje 42, 6310 Izola, Slovenia (corresponding author, phone: 303-555-5555; e-mail: jakob.renko@fvz.upr.si).

Deja Praprotnik is with the Faculty of Health Sciences, University of Primorska, Polje 42, 6310 Izola, Slovenia (e-mail: 97210463@student.upr.si).

Kristina Martinovič is with the Faculty of Health Sciences, University of Primorska, Polje 42, 6310 Izola, Slovenia (e-mail: kristina.martinovic@fvz.upr.si).

PhD Igor Krnjuš is with the Faculty of Health Sciences, University of Primorska, Polje 42, 6310 Izola, Slovenia (e-mail: igor.karnjus@fvz.upr.si).

activities in the field of CVC infection prevention, which could be used to adapt and improve daily practices.

Aim and Objective

The aim of this study is to review and analyze the existing literature on preventive measures to avert CVC infections.

The objective of the study:

• To identify the most effective preventive measures for CVC care.

In line with our aims and objectives, we formulated the following research question: Which preventive measures are best to prevent central venous catheter infections in adult patients in intensive care units?

I. METHODS

A systematic review of the scientific and professional literature on interventions for the prevention of CVC infections in the ICU was conducted.

Review Method

A descriptive research method was used, with a systematic review of domestic and foreign professional and scientific literature. The method chosen was used to demonstrate the most effective measures to prevent infections of central venous accesses in the ICU. Literature searches were performed in CINAHL, Medline, PubMed and Web of Science databases. The literature search was performed using a unique search string in October 2022, which was created using MeSH terms, free English terms, and Boolean AND (IN) operator. We used the following final unique search strategy: ("catheter related infections" AND "intensive care units" AND "prevention" AND "central venous catheter"). We included literature published from 2017 to 2022, as the last systematic review of the literature in this area was published in 2017 [3]. The literature search and review was further constrained by the inclusion and exclusion criteria shown in Table I.

TABLE I
INCLUSION AND EXCLUSION CRITERIA

Criteria	Inclusion criteria	Exclusion criteria
Theme	Prevention of central venous catheter infections in the intensive care unit.	Preventing infections of other types of catheters (peripheral venous catheter, arterial line, urinary catheter) in or out of the ICU.
Population	Patients in intensive care.	Patients outside the intensive care unit.
Age of population	Adults.	Children aged 0 to 18 years.

Type of study	Original scientific articles, randomized clinical trials, meta-analyses.	Protocols, case studies.
Language	English.	
Publication date	2017 – 2022.	
Availability	No limitations.	

Review Results

Figure 1 shows the literature search process according to the PRISMA methodology [1]. We identified 97 hits in CINAHL, 176 hits in Medline, 180 hits in PubMed and 101 hits in Web of Science. All hits were imported into Zotero [14] for easy organization, citation and referencing. After removing 113 duplicates, we screened 441 hits based on title and abstract, of which 394 were removed for thematic inappropriateness. In the next step, we screened 47 articles in full-text and retained 26 of them, after which we additionally excluded 4 articles on the basis of inadequate quality. Finally, 22 articles were included in the detailed literature analysis, as shown in Figure 1.
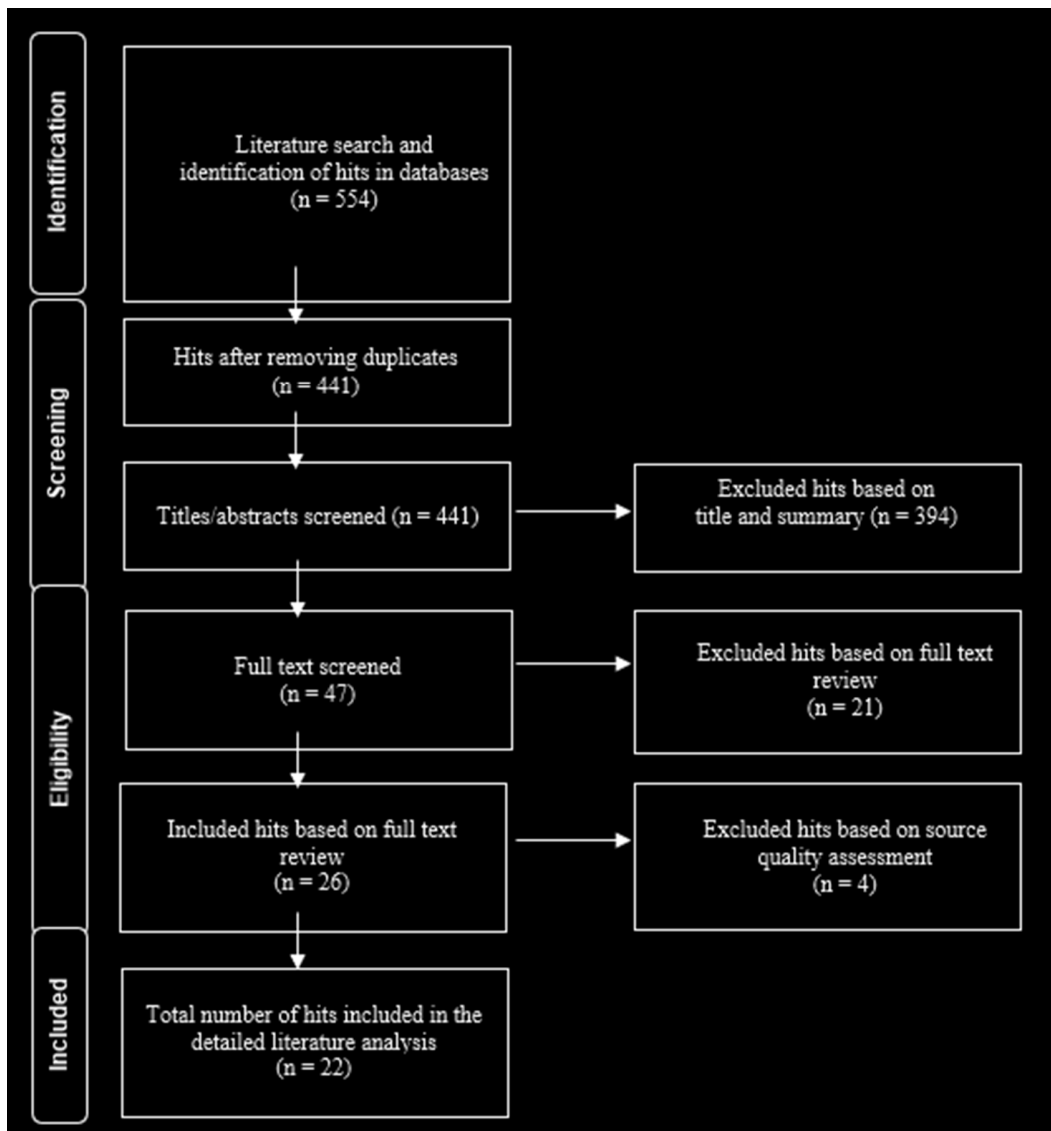
Fig. 1 PRISMA diagram of literature review process [13]

Assessment of the Quality of the Overview and Description of Data Processing

The selection of the literature was based on the relevance and quality of the articles selected. The quality of the articles was assessed using the Critical Appraisal Skills Programme (CASP) tools: the CASP Systematic Reviews Checklist, the CASP Randomized Controlled Trial Checklist, the CASP Cohort Study Checklist [15]. This allows for a critical assessment of the quality of a source based on the evaluation and interpretation of the evidence, systematically checking the reliability of the research, the results and the relevance of the content to the chosen topic. The articles were primarily separately evaluated by two researchers, with a third author involved in case of differences in the ratings for each study. Each article could be graded on one of four levels: inadequate, sufficient - C, good - B, excellent - A. If an article was graded as inadequate, it was excluded from further analysis. Table II shows the ranking of the included articles according to their quality in the last section.

II. RESULTS

In the final analysis, we included 22 studies investigating preventive measures to prevent CVC infections in adult patients in the ICU. Table II shows the main characteristics of the individual studies included in the final analysis. We have systematically focused on the type and purpose of the research, the intervention considered and the main findings. In addition, we have placed compliance with the PICO research question and the CASP research quality assessment in the last section.

We have also ranked the research according to the hierarchy of evidence [16], with three studies placed to tier 1 [17]–[19], five to tier 2 [20]–[24], one survey to tier 4 [25], the remaining

research is classified as tier 3 [26]–[37].

The analysis identified seven effective preventive measures for CVC infections. Five studies [25], [26], [29], [30], [37], identified CVC care bundles that differed from one another as an effective intervention. All care bundles included hand hygiene, use of protective measures and use of chlorhexidine gluconate (CHG) solutions for insertion or entry site care. Individual additional specific actions of the care bundles are listed in Table II under the intervention section.

Research has identified the use of CHG solutions as an effective preventive measure for daily washing of the whole body [27], [35], [38] or for disinfection of the point of entry of the CVC [19], [24], [31].

Entry site dressings with CVC have also been shown to be effective in preventing CVC infection [17], [18] or silver [28]. The use of alcohol-soaked protective caps for needle-free use is also effective in reducing the incidence of CVC infections [23], [33]. Reference [20] found alcohol-soaked protective caps to be effective in combination with the use of additional educational content. On their own, various educational contents (hand hygiene, standard precautions, video content, lectures, posters, etc.) have been identified as an effective preventive measure in two other studies [34], [36].

The incidence of CLABSI and CRBSI can also be influenced by the correct choice of the location or type of CVC and the properties of the CVC itself. CVC infections have been shown to occur more with CVCs than with PICC catheters [32], and less with closed systems [21] and antibacterial-coated CVCs [22].

TABLE II

A REVIEW OF THE KEY FINDINGS OF THE ARTICLES INCLUDED IN ANALYSIS

Author, country, year	Study design	Study aim	Intervention	Main findings	PICO/CASP 0-3 / A-B+-
[26]	Retrospective, observational, quasi-experimental study	To assess the effect of multimodal measures on CLABSI rates and to analyze the effect of automatic notification of catheter days.	Use of protective measures - use of sterile headgear, mask, cap, sterile gloves and sterile gown; automatic notification of catheter days; daily assessment of the need for CVC; wash all body surfaces once daily with a non-woven cloth soaked in 2% CHG.	The number of days in the ICU, catheter days and CLABSI rate were reduced by multimodal measures including maximal precautions, automatic notification of catheter days and 2% CHG washout.	3/3 B
[27]	Observational quasi-experimental prospective study	To evaluate the effects of whole-body decolonization with 2% CHG on the incidence and type of CVC infections.	Disinfecting and skin cleansing wipes impregnated with 2% CHG.	Decolonization with 2% CHG reduced the overall incidence of healthcare-associated infections, especially CVC-related infections.	3/3 B
[17]	Meta-analysis of clinical trials	To assess whether the gradual introduction of CHG liners into the current CVC care bundle can further reduce the CLABSI rate.	Phasing in CHG dressings in addition to the existing CVC care bundle.	The gradual introduction of different CHG dressings over nine years, in addition to the continuous use of the CVC care bundle, gradually and significantly reduces the number of CLABSIs.	3/3 A
[20]	Prospective randomized study	To evaluate the effectiveness of educational interventions alone and in combination with the use of protective caps for needle-free fittings at CLABSI rates.	GAVECELT training kit; protective cap for needle-free nozzle, impregnated with 70% isopropyl alcohol.	Educational measures combined with the use of an impregnated protective cap resulted in a CLABSI rate of zero.	3/3 B+

Ref	Study design	Aim	Intervention	Results	Score	Level
[28]	Observational cohort study	To describe the results of the use of a new silver dressing for CVC protection, compared to CHG-impregnated dressings, in the prevention of CLABSI.	Silver dressing to protect CVK.	The use of a silver dressing to protect the CVC is associated with a significant reduction in CLABSI in adult patients in the ICU compared to patients receiving care with a CHG dressing.	3/3	B+
[21]	Randomized, prospective, double-blind study	Assess the impact of open and closed CVC systems on infection prevention.	Open and closed CVC systems.	Closed CVC systems, combined with adequate training of nurses, reduce CRBSIs.	3/3	A
[29]	Prospective quasi-experimental observational study	To determine the incidence of CLABSI and to identify the profile of micro-organisms causing the infection and the impact of the preventive measures implemented to reduce the CLABSI rate.	CVC insertion care bundle: hand hygiene before catheter insertion, optimal choice of catheter site, use of protective measures at insertion and skin preparation with CHG. CVC maintenance care bundle: daily assessment of CVC need, hand hygiene before and after all access maintenance procedures, alcohol disinfection of the catheter before each access, observation of the insertion entry site, dressing change using aseptic technique.	A significant reduction in CLABSI rates was observed after the introduction of a CVC care bundle comprising a number of prevention measures.	3/3	B+
[22]	Prospective, randomized, double-blind study	To investigate the safety and efficacy of the antibacterial catheter in terms of catheter colonization rates and bloodstream infections.	CVC antibacterial catheter; CVC without antibacterial coating.	Antibacterial CVC effectively reduced the incidence of CLABSI but not the rate of catheter colonization.	3/3	A
[30]	Quasi-experimental, non-randomized, clinical study	Assess the impact of the CVC care bundle in the 27 ICUs.	The care bundle for insertion included hand hygiene, use of protective measures at insertion, use of CHG for skin preparation and avoidance of the femoral veins as an access site. The maintenance care bundle included hand hygiene,	The introduction of the multidimensional care bundle for CVC has led to a significant reduction of 12. 2% in the CLABSI rate in almost all participating ICUs, except surgical units.	3/3	B

Ref	Study design	Aim	Intervention	Findings	Rating
			correct dressing changes, aseptic technique for accessing and changing needleless catheters, and daily assessment of catheter need.		
[31]	Prospective, quasi-experimental, cross-sectional study	To compare the incidence of CRBSI and the growth of flora at the CVC insertion site between the use of 2% CHG and 10% povidone-iodo-alcohol (PVI) in the context of CVC care.	Use 2% CHG or 10% PVI to disinfect the entry point when setting up CVC.	When 2% CHG is used instead of 10% PVI, skin flora colonization at CVC insertion sites can be greatly reduced, and it may even lower the incidence of CRBSI in patients in the ICU.	3/3, B
[32]	Retrospective cohort study	To investigate the epidemiological characteristics of CLABSI and to assess whether peripherally inserted central venous catheters (PICCs) are associated with a protective effect for CLABSI.	Position of the insertion site; type of catheter (CVC and PICC).	CVCs are associated with a higher risk of CLABSI compared to PICC.	3/3, B+
[33]	Quasi-experimental, non-randomized, clinical study	To evaluate the effect of alcohol-impregnated CVK protective caps on the reduction of CLABSI incidence in the burn ICU.	Alcohol-impregnated caps to protect the CVC.	The use of alcohol-impregnated protective caps can potentially reduce the incidence of CLABSI.	3/3, B-
[34]	Quasi-experimental, non-randomized, clinical study	To investigate whether an education programme aimed at health workers has led to a significant change in infection rates and trends.	An educational programme covering hand hygiene and standard precautions to prevent infections.	An educational programme that focused on general good practice in infection control rather than CVC care bundles reduced the CRBSI rate, although the improvement was not sustained.	3/3, B
[18]	Systematic literature review and meta-	To evaluate the effectiveness of CHG coatings for the	CHG CVC dressings.	CHG wraps prevent CRBSI in adults with short-lived CVCs, including patients with	3/3, A

	analysis			prevention of CRBSI.	
[35]	Quasi-experimental observational study	To analyze the effect of daily CHG washing in patients in the ICU on the incidence of CLABSI.	Daily washing with CHG.	The introduction of daily CHG washing resulted in a reduction in the incidence of CLABSI in the ICU.	3/3, B+
[36]	Quasi-experimental observational study	Determine whether the training programme can reduce the level of CRBSI in the ICU.	CLABSI Incidence Reduction Training Programme: 30-minute video introduction, 120-minute lecture with numerous practical training sessions, test, posters, safety checklists and feedback from the Infection Control Committee.	A programme aimed at educating healthcare workers about CRBSI prevention has led to a dramatic reduction in the rate of primary bloodstream infections.	3/3, B
[19]	Meta-analysis	To evaluate the efficacy of chlorhexidine and povidone solutions as skin disinfectants in CVC care.	Chlorhexidine solutions; povidone solution.	Chlorhexidine CVC care solution can significantly reduce the rate of CRBSI and catheter colonization compared to povidone solution. The disinfecting effect of chlorhexidine-alcohol is better than that of other solutions.	3/3, A
[23]	Randomized control study	Comparison of standard CVC protective caps with alcohol-containing caps in terms of CLABSI prevention	Alcohol-impregnated protective caps for the needle-free CVC nozzle	The findings suggest that protective alcohol caps for needle-free fittings are effective in preventing CLABSI.	3/3, A
[38]	Quasi-experimental observational study	To test whether the introduction of CHG washing throughout the ICU instead of triclosan would have an impact on the CLABSI rate.	Washing with CHG.	Routine washing with CHG versus triclosan did not affect the CLABSI rate or the positive blood cultures obtained in the ICU. However, it has significantly reduced the incidence of MRSA.	3/3, B+
[25]	Cohort study	To assess the CLABSI rate following the	CVC insertion and care bundle: hand hygiene before insertion and	After the introduction of the CVC insertion and maintenance care	3/3,

	introduction of a care bundle for CVC deployment and maintenance.	during handling of CVCs, aseptic insertion technique, use of protective measures, avoidance of femoral veins, use of CVCs with antimicrobial coating, use of CVCs with a lower lumen count, use of sterile devices, change of dirty, soaked and peeled liners, standardized weekly changing of liners, daily CHG wash for all CVC patients, protective alcohol caps for needle-free adapter, daily assessment of CVC need, education of medical staff on correct insertion and maintenance of CVC, root cause analysis and re-education for each CLABSI case, avoidance of blood cultures from CVC.	bundle, the results showed a reduction in the CLABSI rate.	B
[37]	Cohort, quasi-experimental study	Determine whether the introduction of a checklist reduces the CLABSI rate.	Checklist of hygiene standards: hand hygiene, use of protective measures, sterile disinfection of the entry site, avoidance of femoral veins, clear indications for CVC.	The introduction of a checklist to improve adherence to hygiene standards in CVC insertion has significantly reduced the incidence of infections.	3/3, B
[24]	Multicenter randomized control study	To compare the efficacy of three antiseptic solutions: 0. 5% and 1. 0% CHG and 10% PVI to prevent CVC colonization.	0. 5% alcoholic CHG; 1. 0% alcoholic CHG; 10% water PVI.	Both 0. 5% and 1. 0% alcoholic CHG are better than 10% aqueous PVI at preventing CVC colonization.	3/3, A

III. DISCUSSION

The answer to the research question is complex, as it is not possible to single out one sole most important intervention for the prevention of CVC infections. Individual interventions (washing the whole body with CHG solution, disinfecting the CVC entry site with CHG solution, use of CHG or silver liners, alcohol protective caps, CVC care education, selection of appropriate catheter), as well as multicomponent care bundles have been shown to be effective measures to prevent CVC infections in adult patients in the ICU at the moment.

Regarding efficacy, none of the listed measures stood out. None of the studies analyzed compared all measures with each other. Other research [1], [3], which looked at the effectiveness of several preventive measures together, came to similar conclusions. In line with our findings, different CVC care bundles, educational programmes, catheter characteristics, protective stoppers, and the use of CHG solutions for washing or in dressings were identified as effective.

Trends in research and healthcare settings indicate the popularity of implementing care bundles for CVC. They differ in their component precautions, but all have in common hand hygiene, the use of protective measures and the use of CHG solutions for insertion or entry site care [25], [26], [29], [30], [37]. Consistent with our findings, other studies [39], [40] identified multicomponent CVC care bundles as effective in preventing infections. Individual studies [10], [12], [41], [42], [43] identify certain limitations in their implementation and adherence, despite the effectiveness of the bundles. To achieve good outcomes with the care bundles, all measures in each bundle need to be introduced and implemented [10], [41], [43]. Before implementing a specific CVC care bundle, its selection or design should be checked for compatibility and appropriateness with the specific health facility or department and the way it works [42]. Before implementing a new care pathway, healthcare staff need to be prepared and trained to implement the individual interventions involved [12], [41].

Education programmes found in other research [1], [43], [44], [45] have shown to be effective in preventing CVC infections. To be effective, training programmes need to include a variety of components ranging from content (hand washing, use of protective measures, use of CHG solutions, choice of entry point, etc.) to teaching strategies (classical lecture, video content, posters, training in a simulated environment, etc.) [1], [45]. Literature [43] notes that training needs to be delivered and planned according to the needs and characteristics of the individual department and learners. To achieve lasting effects, education must be continuous [44], [45]. Even in one of the studies included in the analysis, one-off education only achieved results that were not sustainable [34].

CHG washing has also been recommended for the prevention of CVK infections based on the research work of other authors [46] – [48]. It should be noted, however, that CHG solutions should only be used on skin that is not damaged, as even when the integrity of the skin is preserved, irritation or even allergies may occur and are discouraged [47]. In relation to the use of CHG solutions, a randomized clinical study [49] found that CHG dressings are an effective measure to reduce CVK infections. In contrast, a study [50] found that CHG coatings do not reduce the incidence of CLABSI. However, they do make nurses' jobs easier, as they need to be changed less often.

Open CVC systems are also a risk factor for CLABSI. Alcohol caps are used to prevent this factor. The research carried out [1], [51] – [54] also notes the benefits of using protective alcohol caps. In addition, a study [53] found that the use of these reduces the cost of treatment. Although there is a large body of literature supporting the prevention of CLABSI through the use of protective alcohol caps, some conclude that these are not effective without other protective measures [55], [56].

As mentioned in the results, the choice of a catheter with the right properties is also very important for the prevention of CVC infections. With advances in medical devices, different types of catheters, antibacterial-coated CVCs and open or closed CVC systems are now available. Of all the CVC variants, there is the most research [1], [57], [58] which supports the use of antibacterial-coated CVCs to prevent CLABSI. Two studies [2], [59] conclude that the use of antibacterial-coated CVCs as a stand-alone intervention does not reduce the incidence of CVC infections.

The findings of the survey should be interpreted with caution due to implementation limitations. Only certain databases were reviewed, only English-language surveys were included, and the surveys measured different outcomes in different sample sizes. In our research, we took a broad approach, looking for the single most effective preventive measure among many. Given that several simultaneous measures are needed to reduce CVC infections, it would be worthwhile to investigate each one separately to see if it is effective.

Through a literature review, we demonstrated that preventative efforts to lower CVC infections in the ICU are a complicated process that demands the joint evaluation of a number of parameters. We have shown that different CVC care bundles, addressing the topic from different perspectives and with multiple interventions in parallel, are best suited to achieve a reduction in the incidence of CLABSI.

In future research, it would be worthwhile to focus on empirical research on each of these measures. A systematic literature review with meta-analysis of CVC care bundles would also be advisable. This would allow us to qualitatively evaluate the best CVC care bundles and design the most appropriate one that would represent universal guidelines for the clinical setting and would require minimal adaptations to cover specifics.

IV. CONCLUSION

The ICU is a challenging environment where various complications often arise. CVC infection is one of them, and is a major burden on the health system. In our study, we

identified several different measures for effective prevention, such as: washing the whole body with CHG solution, disinfecting the CVC entry site with CHG solution, use of CHG or silver liners, alcohol protective caps, CVC care education, selection of an appropriate catheter, and CVC care bundles consisting of different preventive measures. Given that the different care bundles include several individual interventions, it would be reasonable to first investigate the effectiveness of individual preventive interventions and then combine the proven effective ones into a new care bundle. The research could be used to update current practice and help improve patient care, the working environment and cost-effectiveness. Through a systematic literature review, we have provided the nursing profession with insights into current evidence-based practices in the prevention of CVC infections. The findings can potentially improve their daily practice and make their work easier. This would also ensure better quality of care and higher patient satisfaction.

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The Influence of Attachment Style on Sexual Health Beliefs and Risk of Hypoactive Sexual Desire Disorder (HSDD) In Chinese Women

Luo Lan, Huang Jingjing, Li Huafang

Abstract— Hypoactive sexual desire disorder (HSDD) was common in China, and Chinese women's sexual health-seeking behaviors were found to be mainly impeded by their psychological barriers. However, underlying mechanisms for such unhealthy sexual health attitudes and symptoms of HSDD were unknown. Many studies suggested the correlation between women's psychological barriers, HSDD and attachment style but had limitations, so this study further explored their relationship. Chinese women of childbearing age were recruited from May 2020 to December 2022 in Shanghai, China. The Revised Adult Attachment Scale (RAAS), the Female Sexual Function Index (FSFI), the Female Sexual Distress Scale-Desire/Arousal/Orgasm (FSDS-DAO), a sexual health attitude questionnaire, and a psychiatric interview were administered. The analytic sample contained 279 women, of which 107 women were HSDD patients. Women with a fearful attachment style were found to be more likely to be unwilling to communicate sexual health (aOR 2.55, 95%CI 1.05-6.28) and feel ashamed of sexual health-related disorders (aOR 2.66, 95%CI 1.14-6.13). They are also linked with a higher risk of HSDD (aOR 3.25, 95%CI 1.35-8.12). Therefore, fearful attachment style should be given enough attention in the whole process of the diagnosis and treatment of HSDD and should be one of the focuses that guide sexual education.

Keywords— attachment style, hypoactive sexual desire disorder, attitude to health, sexual desire, sexual distress.

Lan Luo is with the Shanghai Jiao Tong University, China (e-mail: lan-luo@foxmail.com).

Nutrition and Physical Activity in Obese Women

Shubeska Stratrova S., Muca A., Panovska S.

Abstract—

Rationale: Obese subjects have a high energy density diet, low physical activity levels, a sedentary lifestyle, as well as eating disorders, which are considered important risk factors for the development of obesity.

Methods: In order to discover the imbalance of energy intake and energy expenditure in obese women (W), two groups of examinees answered questionnaires regarding nutrition and physical activity: 1st group of women with normal body mass index (BMI <25 kg/m²) and 2nd group of obese women with BMI >30 kg/m².

Results: 61.11% of obese W from the 2nd group reported good appetite, which was higher than the 1st group (45%). In 55.56% W, frustrations were a provocation for over nutrition. In the 2nd group, 38.89% W ate too much compared to 9.09% W from the 1st group. In the 2nd group, 35.29% W reported consuming food rarely and too much, while 29.41% W reported consuming food often and too much. All examinees from the 2nd group had consumed food in less than 5 hours, compared to only 8.33% W from the 1nd group and had consumed hyper-caloric food. Consumption of fruits and vegetables was lower in the 2nd group compared to the 1st group. Half of the subjects in the 2nd group were physically inactive, compared to only 8% in the 1st group. All of the examinees in the 2nd group walked for less than 3 hours a day, compared to 54% in the 1st group. In the 2nd group, 67% W reported watching TV very often, 39% reported watching TV longer than 3 hours, which is significantly higher than 8.33% W in the 1st group. Overall, 81.25% of examinees from the 2nd group reported sitting for more than 3 hours a day, which is significantly more compared to the 1st group (45.45%).

Conclusions: Obese women are less physically active, have a sedentary lifestyle, good appetite, and consume too much hyper-caloric food very often.

Keywords— (W) obese women, BMI(Body mass Index), nutrition, hyper-caloric food.

Sonja Panovska Panovska is with the University Clinic of Endicrinology Skopje North Macedonia, Macedonia (e-mail: sonjica_2000@yahoo.com).

Characterizing Nasal Microbiota in COVID-19 Patients: Insights from Nanopore Technology and Comparative Analysis

D. Pinzauti, S. De Jaegher, M. D'Aguanno, M.Biazzo

***Abstract*—** The COVID-19 pandemic has left an indelible mark on global health, leading to a pressing need for understanding the intricate interactions between the virus and the human microbiome. This study focuses on characterizing the nasal microbiota of patients affected by COVID-19, with a specific emphasis on the comparison with unaffected individuals, to shed light on the crucial role of the microbiome in the development of this viral disease.

To achieve this objective, Nanopore technology was employed to analyze the bacterial 16s rRNA full-length gene present in nasal swabs collected in Malta between January 2021 and August 2022. A comprehensive dataset consisting of 268 samples (126 SARS-negative samples and 142 SARS-positive samples) was subjected to a comparative analysis using an in-house, custom pipeline.

The findings from this study revealed that individuals affected by COVID-19 possess a nasal microbiota that is significantly less diverse, as evidenced by lower α diversity, and is characterized by distinct microbial communities compared to unaffected individuals.

The beta diversity analyses were carried out at different taxonomic resolutions.

At the phylum level, *Bacteroidota* was found to be more prevalent in SARS-negative samples, suggesting a potential decrease during the course of viral infection. At the species level, the identification of several specific biomarkers further underscores the critical role of the nasal microbiota in COVID-19 pathogenesis. Notably, species such as *Finegoldia magna*, *Moraxella catarrhalis*, and others exhibited relative abundance in SARS-positive samples, potentially serving as significant indicators of the disease. This study presents valuable insights into the relationship between COVID-19 and the nasal microbiota. The identification of distinct microbial communities and potential biomarkers associated with the disease offers promising avenues for further research and therapeutic interventions aimed at enhancing public health outcomes in the context of COVID-19.

***Keywords*—** 16s rRNA gene, biomarkers, Covid-19, Nanopore Technology, Nasal microbiota.

D. Pinzauti, S. De Jaegher, M. D'Aguanno, M. Biazzo are with the Institute of Microbiome and Applied Sciences, Life Sciences Park, San Gwann, SGN3000, Malta (phone: +35677052255, e-mail: m.daguanno@thebioarte,com).

River Habitat Modeling for the Entire Macroinvertebrate Community

Pinna Beatrice., Laini Alex, Negro Giovanni, Burgazzi Gemma, Viaroli Pierluigi, Vezza Paolo

Abstract— Habitat models rarely considers macroinvertebrates as ecological targets in rivers. Available approaches mainly focus to single macroinvertebrate species, not addressing the ecological needs and functionality of the entire community.

This research aimed at providing an approach to model the habitat of the macroinvertebrate community. The approach is based on the recently developed Flow-T index, together with a Random Forest (RF) regression, which is employed to apply the Flow-T index at the meso-habitat scale. Using different datasets gathered from both field data collection and 2D hydrodynamic simulations, the model has been calibrated in the Trebbia river (2019 campaign), and then validated in the Trebbia, Taro and Enza rivers (2020 campaign). The three rivers are characterized by a braiding morphology, gravel riverbeds and summer low flows.

The RF model selected 12 mesohabitat descriptors as important for the macroinvertebrate community. These descriptors belong to different frequency classes of water depth, flow velocity, substrate grain size and connectivity to the main river channel. The cross-validation R^2 coefficient (R^2_{cv}) of the training dataset is 0.71 for the Trebbia River (2019), whereas the R^2 coefficient for the validation datasets (Trebbia, Taro and Enza Rivers 2020) is 0.63. The agreement between the simulated results and the experimental data show sufficient accuracy and reliability. The outcomes of the study reveal that the model can identify the ecological response of the macroinvertebrate community to possible flow regime alterations and to possible river morphological modifications.

Lastly, the proposed approach allows to extend the MesoHABSIM methodology, widely used for the fish habitat assessment, to a different ecological target community. Further applications of the approach can be related to eflows design in both perennial and non-perennial rivers, including river reaches in which fish fauna is absent.

P.B. Author is with the Department of Environment, Land and Infrastructure Engineering, Polytechnic University of Turin, Turin, Italy (e-mail: beatrice.pinna@polito.it).

L.A. Author is with the Department of Life Sciences and Systems Biology, University of Turin, Turin, Italy (e-mail: alex.laini@unito.it).

N.G. Author is with the Department of Environment, Land and Infrastructure Engineering, Polytechnic University of Turin, Turin, Italy (e-mail: giovanni.negro@polito.it).

B.G. Author is with the Institute for Environmental Sciences, Quantitative Landscape Ecology, University of Koblenz-Landau, Landau, Germany (e-mail: burgazzi@uni-landau.de).

V.P. Author is with the Department of Chemistry, Life Sciences and Environmental Sustainability, University of Parma, , Parma, Italy (e-mail: pierluigi.viaroli@unipr.it).

V.P. Author is with the Department of Environment, Land and Infrastructure Engineering, Polytechnic University of Turin, Turin, Italy (e-mail: paolo.vezza@polito.it).