THE
OPEN UNIVERSITY
OF SRI LANKA

OUSL JOURNAL

ISSN 1800-3621
E-ISSN 2550-2816

Volume 19 | No.02 | December 2024

Published by the Open University of Sri Lanka
Nawala, Nugegoda, Sri Lanka

The OUSL Journal is a peer-reviewed journal, published biannually by The Open University of Sri Lanka (OUSL).

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Subscription Rates

Local: Rs. 1000.00; Foreign: US $ 25.00 (Inclusive of postage)

Local cheque should be crossed and made payable to the "The Open University of Sri Lanka" and should be addressed to the Librarian/OUSL.

Printed at The Open University Press
ISSN 1800-3621
E-ISSN 2550-2816

The Open University of Sri Lanka

OUSL Journal

Volume 19 No. 2
December, 2024

OUSL Journal

Volume 19, No. 2 – December, 2024

Published Biannually by The Open University of Sri Lanka (OUSL)

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OUSL Journal

Volume 19 No. 2 – December, 2024

Published Biannually by The Open University of Sri Lanka (OUSL)

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DOI: https://doi.org/10.4038/ouslj.v19i2.7668

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Editorial

This is the Volume 19, Number 2 issue of the OUSL Journal, the Journal of The Open University of Sri Lanka which is published biannually. The articles published in this volume include research based on the disciplines of Mechanical Engineering, Psychology, Agriculture, Teaching Learning Process and Chemistry.

The study on *The Effect of Silicon Deficiency on Material Properties of Nodular Cast Iron*, describes the following findings. The unexpected failures of automotive components might lead to fatal accidents and injuries to vehicle occupants and pedestrians. Analyses from different perspectives of automotive component failures are important to ensure that a failure does not recur. The crankshaft is considered the heart of a piston engine. The crankshafts are subjected to torsion combined with rotary bending stresses. Possible sources for the failure of crankshafts can be categorized as operating or mechanical sources. The main operating sources are operating in the absence of oil or defective oil lubrication, high operating oil temperature and improper use of the engine, such as over revving or overloading. The main mechanical sources are misalignment, stress concentration, improper heat treatment, improper material composition, incorrect design, excessive vibration, improper clearance and incorrect size bearings. Crankshafts of internal combustion engines are subjected to a complex stress state and are prone to fail prematurely for various reasons. The effect of chemical composition on material parameters of a crankshaft made of nodular cast iron is presented in this paper. The engine is a four-stroke four-cylinder gasoline engine with a displacement of 1498 cc, developing a power of 52 kW at a rate of 4800 rev/min. At the time of failure, the engine undergoes a full load performance test on an engine dynamometer. The analysis revealed that the material properties of the crankshaft were inferior to those encountered in the literature. The yield stress, tensile strength and hardness values were approximately 50% lower than those reported by other researchers. There exists a strong relationship of Si concentration with strength, microstructural defects and formation of shrinkage pores. Chemical analysis revealed a deficiency in Si concentration that deteriorated physical properties. The crankshaft was used as cast without heat treatment. A proper heat treatment could increase the mechanical properties, thus increasing the fatigue strength. The failure could be attributed to the low material quality and deterioration of physical properties.

The article titled *Understanding Women's Horrors in Refugee Camps through "Silence is My Mother Tongue"*, explores the psychological and social challenges faced by women refugees in refugee camps worldwide. Using a semifictional narrative from *Silence is My Mother Tongue* by Sulaiman Addonia, this study examines the mental health impacts of displacement and the compounded marginalization of refugee women in patriarchal societies. It addresses key thematic issues such as identity construction, resilience, gender-based violence, female autonomy and social protection. This article also critically reviews human rights frameworks and the role of humanitarian agencies in addressing the needs of female refugees. The study emphasizes the importance of gender-sensitive policies and aims to contribute to the ongoing discourse on gender justice for displaced women. Using a literary research paradigm, the article discusses how refugee women navigate their experiences in camps offering insight into the broader implications for policy and humanitarian practice.

The study on *Growth and Yield of Salad Cucumber (Cucumis sativus L.) Vine Cuttings Under Protected House Conditions in Low Country Wet Zone of Sri Lanka*, explores the growth and yield of salad cucumber (*Cucumis sativus* L.) vine cuttings to minimize the seedling cost each time for a new crop cycle. A completely randomized design was used with four replicates. There were three treatments as apical end cuttings, lateral branch cuttings and control. Seedlings obtained from seeds were taken as the control. Two-node cuttings of 20 – 25cm in length were prepared from lateral branches and apical ends of salad cucumber mother plants. Growth and yield parameters were measured up to six weeks. Data were statistically analysed and results revealed that vine length, number of leaves per vine, fresh weight of fruits and number of fruits were significantly influenced by different treatments. Significantly higher vine length and number of leaves per vine were recorded by control plants at the end of six weeks. However, fresh weight of fruits and the number of fruits were significantly higher in plants obtained from apical end cuttings over control plants. However, fresh weight of fruits and the number of fruits in apical end cuttings were not significantly different with lateral branch cuttings. Moreover, these parameters in lateral branch cuttings were not significantly different with control plants. This study shows that salad cucumber plants obtained from vine cuttings reported a higher yield and cuttings can be successfully used to obtain new plants for the next crop cycle to reduce the seedling cost.

Depression and anxiety are common psychological problems among Army cadet officers, and they have been extensively researched in the world across varying populations. They are more susceptible to develop these mental health problems due to military training procedures and adjustment issues. Nevertheless, limited research has been conducted to investigate mental health conditions of the Army officer cadets in Sri Lanka. Hence, the purpose of the study on *Anxiety and Depression among Officer Cadets during the Army Basic Training in the Sri Lankan Army*, was to investigate the prevalence of depression and anxiety in Army officer cadets during basic army training as well as associated factors. A cross-sectional study was carried out among 236 officer cadets who had recently completed the training and ranged in age from 18 to 27 years. The prevalence of depression and anxiety was determined using a self-reported questionnaire that included the Depression, Anxiety and Stress Scale-21 and General Health Questionnire-30. Results revealed that the prevalence of anxiety was 43% while depression was reported 22% among the studied cadet officers. The positive correlation between depression and anxiety underscores the importance of implementing comprehensive interventions that address both conductions at the same time. Findings suggest the necessity of focused mental health support for cadet officers during this crucial time. Enhancing the mental health of Army officer cadets can be achieved through the implementation of tailored mental health support programmes that offer accessible resources, counselling services and coping mechanisms.

Ensuring the development of employability skills among business graduates is a significant challenge within the tertiary education system of Bangladesh. In this context, the implementation of the flipped classroom approach, as opposed to the traditional teaching model, could make a substantial contribution. The study on *Assessing Flipped Classroom Techniques for Business Management Education in Bangladesh*, examines the applicability of the flipped classroom strategy in Business Management courses in Bangladesh, aligning it with the country's university curriculum. Primarily based on secondary data, the research explores both the significance and challenges of adopting this approach. Additionally, the study identifies the roles of tutors and learners through a literature review, highlighting key factors for the successful and effective implementation of the flipped classroom technique. A critical evaluation of current practices is also presented to identify their limitations and to underscore the potential of the flipped classroom in fostering higher-order thinking skills. The study concludes with an action plan, including a lesson plan and rubrics, designed around the

flipped classroom model. Furthermore, it identifies potential challenges to implementation, emphasizing how this strategy can promote the development of higher-order skills among students. It is anticipated that this study will benefit tutors, academic institutions, education policymakers and administrators in Bangladesh by highlighting strategies to enhance the employability skills of Business Management graduates.

The article titled *Synthesis and Characterization of Iridium(III) Complexes Containing (ppy)$_2$Ir-unit and Nitrogen Based Donor Ligands*, describes that Octahedral cyclometallated Ir(III) complexes of the type $[Ir(C^N)_2(N^N)]X$ have shown applications in the fields of photovoltaic cells, chemo-sensors, light-emitting devices (LEDs) and phosphorescent dopants in organic light-emitting diodes (OLEDs). $[Ir(C^N)_2(N^N)]X$ can easily be prepared by reacting the $[Ir(ppy)_2(\mu\text{-}Cl)]_2$ dimer with a bidentate ligand (N^N) in the presence of a suitable anion X. These Iridium(III) complexes possess important properties such as rigid configurational stability, high emissive quantum yields, long phosphorescence lifetime (in μs) and high electrochemical stability. Luminescent Ir(III) polypyridine complexes are also candidates for biomolecular and cellular probes. Parameters such as water solubility, lipophilicity, cytotoxicity, cellular uptake and intracellular localization could all be tuned by using various cyclometallated (C^N) and polypyridine (N^N) ligands. Some of the ligands used to explore the chemistry of Iridium(III) complexes are monodentate pyridine ligand, L^1 = 4-dimethylamino pyridine (DMAP), bridging ligand, L^2 = di(4-pyridyl) acetylene (DPA), and bidentate N^N ligands = 6,6′-dimethyl-2,2′-bipyridine (L^3), 6,7-di(4-*tert*-butylphenyl)-5,8-diphenyl-1,12-diazatriphenylene (L^4), tetraphenyl-2,2′-bipyridine (L^5), and 7,10-di(4-*tert*-butylphenyl)-9-(2-pyridyl)-8-azafluoranthene (L^6). Synthetic routes to the complexes of the type $[Ir(ppy)_2(L)Cl]$, $[Ir(ppy)_2(L)_2]PF_6$, $[Ir(ppy)_2(N^N)]PF_6$ and $[(ppy)_2ClIr]_2(\mu\text{-}L)$ have been devised where ppy = 2-pyridylphenyl.

We welcome your suggestions for further improvement of this Journal. We are looking forward to publishing your current research findings in our next issue.

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DOI: https://doi.org/10.4038/ouslj.v19i2.7616

RESEARCH ARTICLE

OUSL Journal, 2024
Vol. 19, No. 2, (pp 5-16)

The Effect of Silicon Deficiency on Material Properties of Nodular Cast Iron

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Abstract

The brittle failure of a crankshaft was investigated. The chemical composition and material properties of the crankshaft were analyzed. The hardness profile indicated that the manufacturer used the crankshaft as cast without heat treatment. The chemical composition and material parameters were compared with those found in the literature for similar applications. The yield strength, tensile strength, and hardness values observed for the crankshaft were lower than those observed in other crankshafts in the literature. The chemical analysis revealed that the Si composition deviated from the composition in the literature for a typical crankshaft material. Furthermore, low modularity and irregular nodule distribution were observed. The main reason for this failure was the poor mechanical properties arising from the chemical composition, processing, and inoculation characteristics.

Keywords: *crankshaft, nodular cast iron, fracture, forging, metallographic structure, mechanical properties, case hardening*

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(Received 6th March 2024; Revised 26th November 2024; Accepted 15th December 2024, © OUSL)

Introduction

Modern automobiles and their components are manufactured to meet high standards that ensure continuous operation without failure. In most cases, components of automobiles may fail with a warning that allows the operators to replace them without much trouble. However, unexpected failures are still being reported in vital automotive components, hindering the entire operation of a vehicle and potentially leading to fatal accidents and injuries to vehicle occupants and pedestrians.

Analyses from different perspectives of automotive component failures are important. One important reason for these analyses is to ensure that a failure is not recurring, which can lead to many other vehicles failing during service. If it is only an isolated event, the reason for such failures is of interest to ensure the safety of passengers and pedestrians. Heyes (1998) reported that most of such failures occur in parts related to engines, and the main reason is abuse (29%, while the second reason is related to manufacturing or design).

The crankshaft is considered the heart of a piston engine. The crankshaft converts the reciprocating motion of the piston to rotary motion. The crankshafts are subjected to torsion combined with rotary bending stresses. In this paper, a case of crankshaft failure is presented.

Possible sources for the failure of crankshafts can be categorized as operating or mechanical sources. The main operating sources are operating in the absence of oil or defective oil lubrication, high operating oil temperature, and improper use of the engine, such as over revving or overloading. The main mechanical sources are misalignment, stress concentration, improper heat treatment, improper material composition, incorrect design, excessive vibration, improper clearance, and incorrect size bearings (Silva, 2003). Crankshafts of internal combustion engines are subjected to a complex stress state and are prone to fail prematurely for various reasons. The effect of Chemical Composition on material parameters of a crankshaft made of nodular cast iron is presented in this paper. The engine is a four-stroke four-cylinder gasoline engine with a displacement of 1498 cc, developing a power of 52 kW at a rate of

4800 rev/min. At the time of failure, the engine undergoes a full load performance test on an engine dynamometer.

Review of Literature

A literature review was carried out specifically on the failures of crankshafts made of nodular cast iron. The main mechanisms, material compositions, and physical properties of previously reported failures were studied. Keskin & Aydin (2010) analyzed the physical and chemical properties of a crankshaft against the manufacturer-specified properties. There were no metallurgical defects apart from a slightly increased carbon content. The reason identified for the failure was thermal fatigue. The micro hardness values changed from 502 to 930 HV. As per the manufacturer's specifications, the yield strength and tensile strength should be greater than 440 MPa and 800 MPa, respectively. The investigators observed the yield strength to be 485 MPa and the tensile strength to be 860 MPa, which was following the manufacturer's specifications. Furthermore, the elongation was 4%, which was following the manufacturer's specification of a minimum value of 2%. Referring to the literature, Keskin & Aydin (2010) identified the material investigated as EN-GJS-800-2. Osman (2006) analyzed the failure of a crankshaft made of ductile cast iron. The test results showed that the material was EN-GJS-700-2 ductile cast iron. The scholars identified that the absence of a hardened case in the fillet region initiated a crack leading to failure.

As per the specifications for E`N-GJS-700-2, the proof strength and tensile strength should be greater than 420 MPa and 700 MPa, respectively. The investigators observed the yield strength to be 450 MPa and the tensile strength to be 765 MPa, which was following the specification for the material. Furthermore, the elongation was 3%, which was following the manufacturer's specification of a minimum value of 2%. Furthermore, the specified hardness for EN-GJS-700-2 was in the range of 225 HB–350 HB. The hardness observed during the investigation was 295 HB, which was well accepted.

An investigation on the failure of a crankshaft from a four-cylinder engine made of nodular cast iron grade EN-GJS-800-2. The analysis of the chemical composition revealed that the composition complied with the requirement for that of EN-GJS-800-2 nodular ductile cast

iron. Upon testing of mechanical properties, it was revealed that even though the tensile strength and yield strength complied with the requirement, the hardness was less than that specified for EN-GJS-800-2. The elongation was 5.89%, whereas the specification dictated that it should be greater than 2%. The reason for failure was identified as inadequate lubrication and overload on the engine causing crack initiation. The low nodularity and low hardness of the material were identified as causes for the propagation of fatigue cracks.

Farrahi et al. (2011) investigated the failure of a four-cylinder diesel engine crankshaft made of EN-GJS-700-2 ductile cast iron and concluded that the failure was a brittle fracture. The scholars did not find any mismatch between the material compositions and physical parameters with the specified material. However, the researchers proposed evaluating the design and manufacturing processes to optimize the fillet rolling process by changing the parameters. This recommendation was adopted by the manufacturer, and no further fracture has been reported since.

Xu & Shi (2020) analyzed the failure of a nodular cast iron crankshaft made of EN-GJS-800-2. The researchers found that the material properties and chemical composition matched the specifications of the material. However, the failure was attributed to shrinkage and surface cracks in the casting process.

Materials and Methods

The initial estimate was that the crankshaft failed due to excessive loading. The material composition, failure morphology, and physical parameters of the crankshaft material were investigated.

The chemical composition of the crankshaft was analyzed using spark emission spectrometric analysis. The composition is given in Table 1.

Table 1. *Chemical composition of the crankshaft material (%)*

C	Si	Mn	S	P	Cr	Ni	Cu	Mg	Ce
3.7	1.77	0.36	0.004	0.099	0.01	0.02	0.01	00	0.01

Table 2 presents a summary of the physical properties of the investigated crankshaft. The magnitudes were much lower than those observed for typical nodular cast iron crankshaft material encountered during the literature review.

Table 2. *Material properties comparison with literature*

Parameter	**value**
Yield strength (MPa)	210
Tensile strength (MPa)	387
Elongation (%)	3

The hardness values for EN-GJS-700-2 and EN-GJS-800-2 were in the range of 225–350 HB, whereas a hardness in the range of 197–210 was observed for the investigated crankshaft. The variation in hardness for the crankshaft is shown in Figure 1. The nominal diameter of the crank pin journal was 40 mm.

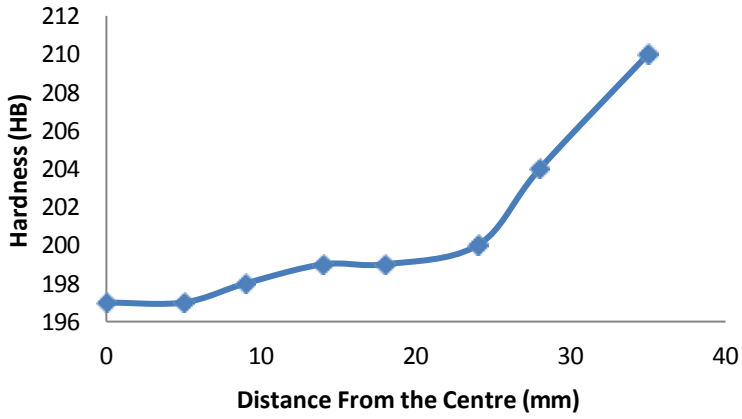

Figure 1. Hardness profile

The hardness profile indicated that the manufacturer used the crankshaft as cast without heat treatment. A specimen obtained in the vicinity of the failure was observed using optical microscopy after etching with a 2% Naital solution. A typical structure that could be observed is shown in Figure 2.

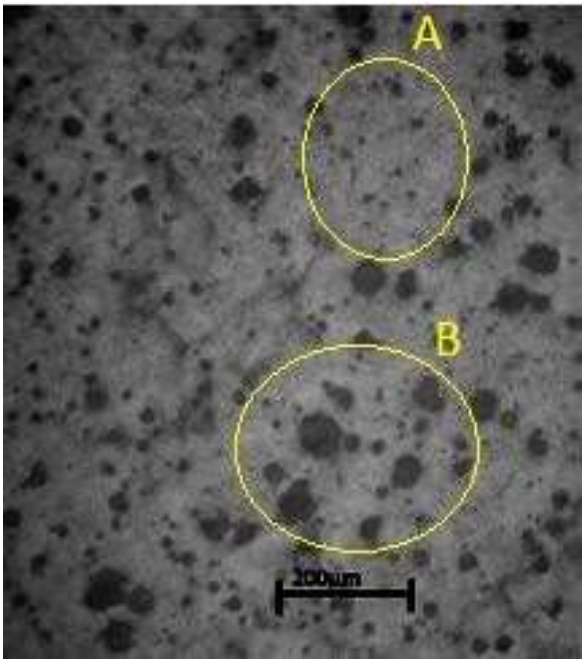

Figure 2. Microstructure of the material (2% Naital)

Optical microscopy revealed the material was nodular cast iron with a ferrite matrix. The failed section of the crankshaft was analyzed using optical imaging. The failed section is shown in Figure 3.

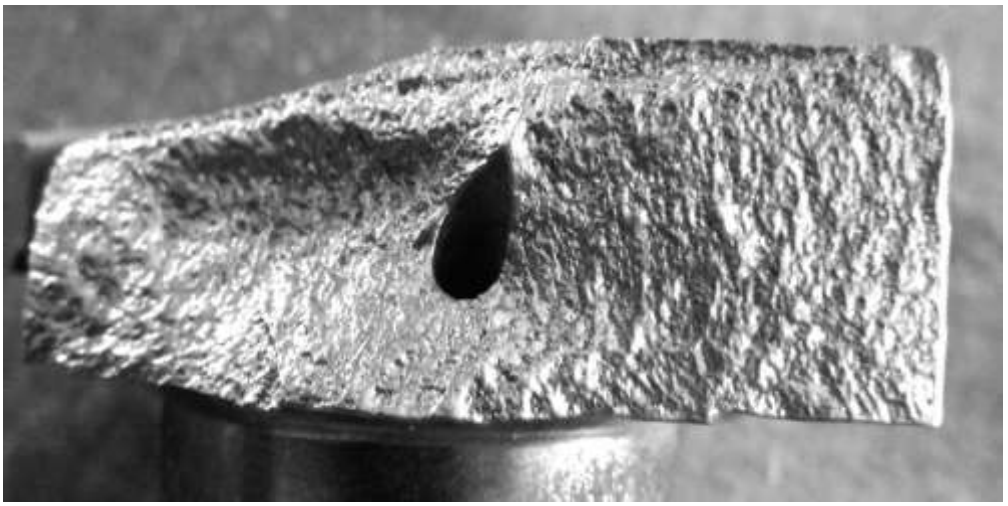

Figure 3. Damage profile

Discussion

From the literature review, it is evident that high-strength nodular cast iron grades EN-GJS-700-2 and EN-GJS-800-2, where the tensile strengths are in the region of 700–800 MPa and the yield strengths are in the range of 430–450 MPa, have been predominantly used to manufacture crankshafts for automobile engines. However, the crankshaft investigated has very low tensile strength and yield strength values of 210 MPa and 387 MPa, respectively. The microscopic analysis revealed large variations in nodule size and nodule distribution. A comparison of the chemical compositions of the investigated crankshaft and the crankshaft from the literature is shown in Table 3.

Table 3. *Comparison of the chemical compositions of the investigated crank shaft and the crankshaft found in the literature (%)*

Element	EN-GIS-800-2 [Ali Keskin and Kadir Aydin (2010)]	EN-GIS-700-2 [Osman A (2006)]	Crankshaft analyzed
C	3.2–4.7	3.2–4.1	3.7
Si	1.8–2.8	1.8–2.80	1.77
Mn	0.10–1.0	0.10–1.00	0.36
S	0.035 (max)	0.040 (max)	0.004
P	0.040 (max)	0.035 (max)	0.099
Cr	0.080–1.20	-	-
Ni	-	0.05–0.20	-
Cu	0.80–1.20	0.80–1.20	0.01

When the composition of each element is compared with the composition of the standard material, the analyzed crankshaft complies with the requirements, except for the silicon content. The silicon content is less than the recommended value for that observed in the literature for crankshafts made of nodular cast iron (Keskin & Aydin, 2010) All cases analyzed have silicon contents above 2%. The case presented by Keskin & Aydin (2010) has a silicon content of 2.58%. A decrease in the graphite content can be seen with a decrease in the Si content (Riposan & Skaland, 2017). Silicon is considered an important factor influencing carbon equivalent levels. Silicon decreases the solubility of carbon in molten iron and supports graphite formation during the cooling process to the end of solidification.

Aliakbari (2021) analyzed the von Mises stresses of six crankshaft failures where the stress ranges from 186 to 236 MPa. The literature review reveals that the nodular cast iron used to manufacture crankshafts should have a yield strength of at least 400 MPa. The yield strength of the material investigated is only 210 MPa.

Increased fractions and increased mean diameters of graphite nodules tend to increase the fracture toughness (Benedetti et al., 2018). High strength can be achieved by promoting a ferritic microstructure. Silicon acts as a ferritic stabilizer which promote the ferritic microstructure thus increasing the strength (Arshad et al., 2018; Soivio, 2018).

Gumienny, (2013) has studied five different samples of ductile cast iron that is being used in the industry. The silicone composition of all samples varied within the range of 2.37% to 2.61%. González-Martínez et al., (2018) have shown that at silicon concentrations between 5.0-5.2 wt% ductile cast irons achieve the highest UTS which is in the range of 628 MPa to 719 MPa. Further, they have shown that beyond 5.2 wt%, silicone decline the ductility of cast iron. The above facts substantiate the fact that the low concentration of Silicone affected the strength of the sample investigated.

For the case presented, the microstructure reveals a low fraction and small diameter nodules with low nodularity. These characteristics are evident from the lower fracture toughness experienced by the material

of the crankshaft under investigation. Furthermore, defects that can be suspected to be shrinkage porosities are visible. Shrinkage pores are responsible for crack initiation (Borsato et.al, 2018). Khalil-Allafi, & Amin-Ahmadi (2011). have investigated the effect of Silicone concentration on the microstructure, shrinkage volume and porosity defects. They have revealed that higher silicon levels from 2.1% to 3.3% enhance graphite nodule formation and reduce the porosity defects and shrinkage volume.

Wang et al., 2013 have studied the effect of shrinkage porosities on tensile strength of ductile cast iron. They have revealed that with the increase of shrinkage porosities the tensile strength decreases linearly. Further, shrinkage porosities affect the elongation thus reducing the ductility. Microstructure analysis reveals many small diameter nodules in the range of 5–10 μm. Nodules that are smaller than approximately 5 μm in diameter are mainly classified as inclusions or micro porosities (Pedersen & Tiedje, 2008). Furthermore, the reduced degree of nodularity significantly reduces the strength and ductility. Figure 2 shows two distinct regions identified as A and B, where region A has very small nodules and region B has comparatively large nodules.

In the process of making ductile cast iron, specially formulated alloys are added to molten metal. This process is called liquid treatment. During processing, inoculation is carried out to increase the nodule count. In ductile iron processing, increasing the nodule count is an important goal because a high nodule count is associated with a high as-cast ferrite/pearlite ratio (Riposan & Skaland, 2017).

Typical alloys used for inoculation are based on ferrosilicon, which contains several other elements, such as calcium, aluminum, barium, strontium, and cerium. Inoculation is affected by the quality of the charge material, such as pig iron, steel scrap ratio, and recarburizers (Riposan & Skaland, 2017).

Conclusions

Analyses of automotive component failures were important to ensure that the failure was not a recurring failure that could lead to many

other vehicles failing under service and to ensure the safety of passengers and pedestrians.

The analysis revealed that the material properties of the crankshaft were inferior to those encountered in the literature. The yield stress, tensile strength, and hardness values were approximately 50% lower than those reported by other researchers.

There exist a strong relationship of Si concentration with strength, microstructural defects and formation of shrinkage pores.

Chemical analysis revealed a deficiency in Si concentration that deteriorated physical properties.

The crankshaft was used as cast without heat treatment. A proper heat treatment could increase the mechanical properties, thus increasing the fatigue strength.

The failure could be attributed to the low material quality and deterioration of physical properties.

Acknowledgements

The Author wishes to acknowledge the technical support of Ms Anusha Waijayanthi and Mr KCK Deraniyagala in conducting this investigation.

References

Aliakbari, K. (2021). Failure Analysis of Ductile Iron Crankshaft in Four-Cylinder Diesel Engine. *International Journal of Metalcasting*.
doi: https://doi.org/10.1007/s40962-020-00550-y

Arshad, W., Mehmood, A., Hashmi, M.F., & Rauf, O. ur (2018). The Effect of Increasing Silicon on Mechanical Properties of Ductile Iron. *Journal of Physics*: Conference Series, 1082, p.012059. doi: https://doi.org/10.1088/1742-6596/1082/1/012059

Benedetti, M., Fontanari, V., & Lusuardi, D. (2018). Effect of graphite morphology on the fatigue and fracture resistance of ferritic ductile cast iron. *Engineering Fracture Mechanics*, *206*, 427–441. doi: https://doi.org/10.1016/j.engfracmech.2018.12.019

Borsato, T., Ferro, P., & Berto, F. (2018). Novel method for the fatigue strength assessment of heavy sections made by ductile cast iron in presence of solidification defects. *Fatigue & Fracture of Engineering Materials & Structures*, *41*(8), 1746–1757. doi: https://doi.org/10.1111/ffe.12815

Edwards, K. L. (2004). ASM handbook, volume 11: failure analysis and prevention. *Materials & Design*, *25*(8), 735–736. doi: https://doi.org/10.1016/j.matdes.2004.03.005

Farrahi, G. H., Hemmati, F., Abolhassani, S., & Sakhaei, M. (2011) Failure Analysis of a Four Cylinder Diesel Engine Crankshaft Made from Nodular Cast Iron. *The Journal of Engine Research, 22*. https://www.magiran.com/p985502

González-Martínez, R., de la Torre, U., Ebel, A., Lacaze, J. & Sertucha, J. (2018). Effects of high silicon contents on graphite morphology and room temperature mechanical properties of as-cast ferritic ductile cast irons. *Part II – Mechanical properties. Materials Science and Engineering: A, 712*, 803–811. doi: https://doi.org/10.1016/j.msea.2017.11.051

Gumienny, G. (2013). Effect of the Carbides and Matrix on the Wear Resistance of Nodular Cast Iron. *Archives of Foundry Engineering, 13*(3), 25–29. doi: https://doi.org/10.2478/afe-2013-0053

Heyes, A. (1998). Automotive component failures. *Engineering Failure Analysis, 2,* 129-41. doi: https://doi.org/10.3390/risks8020056

Keskin, A., & Aydin, K. (2010). Crack Analysis of a Gasoline Engine Crankshaft, *Gazi University Journal of Science*, *23* (4), 487-492. https://www.researchgate.net/publication/289188661_Crack_analysis_of_a_gasoline_engine_crankshaft

Khalil-Allafi, J., & Amin-Ahmadi, B. (2011). Influence of Mold Preheating and Silicon Content on Microstructure and Casting Properties of Ductile Iron in Permanent Mold. *Journal of Iron and Steel Research International, 18*(3), 34–39. doi: https://doi.org/10.1016/s1006-706x (11)60034-4

Osman, A. (2006). Failure Analysis of a Crankshaft from Ductile cast iron, Elsevier, *Engineering Failure Analysis, 13*, 1260-1267. doi: https://doi.org/10.1016/j.engfailanal.2005.11.005

Pedersen, K. M., & Tiedje, N. S. (2008). Graphite nodule count and size distribution in thin-walled ductile cast iron, *Materials characterization 59*, 1111– 1121. doi: https://doi.org/10.1016/j.matchar.2007.09.001

Riposan, I., & Skaland, T. (2017). Modification and inoculation of cast iron. In: D.M. Stefanescu (Ed.), *ASM Handbook on the Cast Iron Science and Technology,* vol *1A*, (pp. 160-176). American Society of Materials. doi: https://doi.org/doi:10.31399/asm.hb.v01a.a0006315

Silva, F. S. (2003). Analysis of a vehicle crankshaft failure. *Engineering Failure Analysis*, *10*(5), 605–616. doi: https://doi.org/10.1016/s1350-6307 (03)00024-4

Soivio, K. (2018). Austempering Experiments of Production Grade Silicon Solution Strengthened Ductile Iron. *Materials Science Forum, 925,* 239–245. doi: https://doi.org/10.4028/www.scientific.net/msf.925.239

Wang, Z., Zhao, W., Zhou, Z., Jiang, S., Yu, X., & Wang, Q. (2013). Effect of shrinkage porosity on mechanical properties of ferritic ductile iron. *China Foundry*, *10*, 141-147. doi: https://doi.org/10.1007/s41230-017-6117-z

Xu, M.S., & Shi, J.L. (2020). 'Fracture analysis of nodular cast iron crankshaft', *Metalurgija*, *59*(4), 517-520. https://api.semanticscholar.org/CorpusID:229522648

DOI: https://doi.org/10.4038/ouslj.v19i2.7649

RESEARCH ARTICLE

OUSL Journal, 2024
Vol. 19, No. 2, (pp 17-32)

Understanding Women's Horrors in Refugee Camps through *Silence is My Mother Tongue*

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Abstract

The study on "Understanding Women's Horrors in Refugee Camps through *Silence is My Mother Tongue*" explores the psychological and social challenges faced by women refugees in refugee camps worldwide. Using a semi fictional narrative from *Silence is My Mother Tongue* by Sulaiman Addonia, this study examines the mental health impacts of displacement and the compounded marginalization of refugee women in patriarchal societies. It addresses key thematic issues such as identity construction, resilience, gender-based violence, female autonomy and social protection. This paper also critically reviews human rights frameworks and the role of humanitarian agencies in addressing the needs of female refugees. The study emphasizes the importance of gender-sensitive policies and aims to contribute to the ongoing discourse on gender justice for displaced women. Using a literary research paradigm, the paper discusses how refugee women navigate their experiences in the camps offering insight into the broader implications for policy and humanitarian practice.

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(Received 22nd August 2024; Revised 19th December 2024; Accepted 24th December 2024, © OUSL)

Keywords: *refugee crisis, women refugees, gender-based violence, Sulaiman Addonia*

Introduction

The global refugee crisis has reached an alarming scale with over 100 million displaced individuals worldwide, as reported by the United Nations High Commissioner for Refugees (UNHCR) in 2022. Military tensions, political instability and ongoing conflicts continue to force people from their homes in search of safety and shelter creating urgent humanitarian challenges. Refugee camps, often overcrowded and under-resourced, are not only spaces of physical displacement but also emotional and psychological trauma, particularly for women. These individuals face compounded vulnerabilities due to gender-based violence, lack of autonomy and the erosion of personal identity in an environment where basic rights are often violated.

This research aims to explore the psychological and social challenges faced by women refugees in camps, with a focus on how gender-based violence, social protection and the limitations on autonomy impact their well-being. Using Addonia's semi fictional account, *Silence is My Mother Tongue*, as a data pool, this paper critically examines the intersection of gender, identity and the refugee experience. The novel's portrayal of refugee women's suffering serves as an entry point for understanding the broader humanitarian issues at play and is used as a means of interpreting the lived realities of displaced women in refugee camps.

By investigating issues like gender and violence in the context of refugee camps, the paper seeks to contribute to the growing body of knowledge on gender justice, human rights and refugee studies with the goal of advancing policy reforms and creating more effective interventions that support the rights and agency of women refugees. Ultimately, this research emphasizes the importance of amplifying women's voices in refugee camps to foster social justice and equity.

Research objectives

The primary aim of this study is to explore and foreground the lived experiences of women refugees in refugee camps with a focus on the psychological, social and gendered challenges they face. By using

Sulaiman Addonia's *Silence is My Mother Tongue* as a data source, the study seeks to examine the complex factors that influence women refugees' identity, agency, resilience and overall well-being in the context of displacement. The study will analyze the portrayal of women refugees in the novel, particularly focusing on themes of agency, resilience and survival in the face of displacement and violence. It will also explore the role of societal elements such as gender, religion and cultural norms in shaping and constraining the identities of women refugees within the camps. Additionally, this research will investigate the impact of gender dynamics and power structures on the mental health and well-being of women refugees, examining how these dynamics affect their experiences of violence, autonomy and survival. Finally, this study will aim to assess the effectiveness of current humanitarian interventions and policies in addressing the unique needs of women refugees, identifying gaps in these responses from a gender-sensitive perspective.

Hypothesis

In *Silence is My Mother Tongue*, women characters in refugee camps are depicted as very fragile as they are more prone to exploitation. They often have been more abused and marginalized in comparison to their male counterparts. Despite these challenges, these women have demonstrated incredible agency and resilience. Governmental and non-governmental agencies that are working in this area should not overlook this issue and develop a better mechanism to deal with this humanitarian crisis.

Research gap

Refugee crisis is not a new topic; it has been explored by multiple authors across various disciplines in numerous ways. However, there remains a significant gap in the literature regarding the specific experiences of women refugees, particularly concerning gendered trauma, identity formation and psychological resilience in refugee camps. Few researchers have focused on the intersection of gender and displacement, specifically addressing the unique challenges faced by women refugees in these settings. This study aims to fill this gap by conducting a comprehensive investigation into the intersectional dynamics of gender, trauma, and displacement, with a particular

focus on women's agency, resilience, and identity through a semi-fictional narrative titled *Silence Is My Mother Tongue*. In doing so, this paper seeks to provide a more nuanced understanding of the challenges faced by women refugees and contribute to the development of gender-sensitive policies and interventions.

Methodology

This study adopts a qualitative literary research methodology to explore the unique challenges faced by women refugees in camps using Sulaiman Addonia's *Silence is My Mother Tongue* as the primary text. The methodology is interdisciplinary, drawing upon feminist theory, migration studies and humanitarian frameworks to examine gendered experiences of displacement. To be specific, the study adopts theoretical insights from gender and feminist theory, particularly focusing on the intersection of gender-based violence, power dynamics and patriarchal ideology in refugee contexts. Through close reading techniques, the study critically analyzes the novel's portrayal of gendered trauma, identity formation, resilience and survival. Insights from secondary sources are integrated to construct a cohesive and persuasive argument, providing a multifaceted understanding of the complexities surrounding women's experiences in refugee camps.

Delimitation

This study concentrates on the experiences of female refugees living in camps as portrayed in Sulaiman Addonia's *Silence is My Mother Tongue*. It deals with the obstacles, resilience, and quiet narratives of women living in these camp settings while noting the larger difficulties encountered by all refugees. By focusing just on women refugees, the research hopes to offer a thorough grasp of the unique struggles they face, such as gender-based violence, limitations on their freedom and the challenges of navigating identity and belonging when displaced. Besides the chosen primary text, the study will bring in references from other sources that are pertinent to the study's findings.

Organization of the study

This literary research paper is organized to provide a thorough analysis of the refugee crisis, focusing on the challenges faced by

women refugees using a semifictional work titled *Silence is My Mother Tongue* by Sulaiman Addonia. It begins with an introduction that outlines the scope, objectives and key research questions setting the contextual background for the study. Quickly identifying gaps in the literature and establishing a theoretical foundation, this study enters into a critical textual analysis of the related data from the chosen primary and secondary texts. The Assessment of Humanitarian Interventions and Policies evaluates the effectiveness of current policies highlighting strengths and areas for improvement. Finally, the conclusion summarizes the findings, offers policy recommendations and suggests directions for future research on gender and refugee experiences.

Findings and Discussion

Living in a camp for refugees is characterized by a great deal of struggle and suffering when people and families are forced from their homes and communities because of hostilities, persecution or natural disasters. A common problem in many refugee camps is overcrowding. Families are forced to live in small tents or crude shelters due to lack of money and space, frequently, without the luxury of privacy or personal space. There are frequent shortages of clean water, sanitary facilities, food, healthcare and education for children, which force camp residents to wait in line for meagre rations and frequently receive rudimentary medical care. The lack of resources might exacerbate the difficult circumstances that camp residents currently experience by increasing their risk of various health issues and malnourishment. The traumas and injustices that women endure in these camps can sometimes be unimaginable. A woman refugee does her best to forge her new life in this packed and frequently hostile place, always looking out for her family. International Rescue Committee reports, "With regard to women, there are reiterated observations that domestic violence is one of the dominating forms of violence against women in refugee camps, and challenges have been identified for administration due to the presence of a variety of justice mechanisms" (Rescue. Org., 1). There is an urgent need for increased attention to domestic violence against women within refugee camp settings. Addonia in her texts, raises these issues seriously.

Addonia's *Silence is My Mother Tongue* is a moving and evocative examination of the difficult lives that women refugees lead in a world of conflict and relocation. The reader is drawn into a profoundly intimate and moving story via the novel's lens, one that illuminates the fortitude, bravery and little-known tales of women who have been forced to escape their homes and face the harsh reality of life as refugees. The book explores the various atrocities and difficulties that women refugees confront. It draws attention to the psychological and physical traumas people experience, frequently brought on by bereavement, violence and persecution. The book illustrates the long-lasting effects of displacement on women's lives via the stories of its characters, highlighting the resilient spirit that enables them to face hardship head-on. *Silence is My Mother Tongue* also explores the difficulties associated with maintaining a sense of self amid upheaval and identification as well as identity and belonging. It discusses the significant ways that living as a refugee modifies the roles, agency and voices of women.

Silence is My Mother Tongue presents a sympathetic and relatable picture of women migrants and refugees, struggling in refugee camps. It is an important monument to their stories which are too frequently ignored or pushed to the outer limits of world history. To make sure that the experiences of displaced women are heard and understood, *Silence is My Mother Tongue* serves as a reminder of the importance of seeing, understanding and supporting these women's voices. In addition to gender stereotypes in typical contexts, *Silence is My Mother Tongue* describes gender-based and sexual abuse against women and girls in refugee camps. Wallace (1996) writes that among the many horrors frequently performed against women include rape, honour killing, bride-burning, genital mutilation, forced sterilization, forced abortion and domestic abuse. The risk arises from membership in the female sex. In international forums, women have received little attention, and this is especially true when it comes to refugee women's horrors and plights (p. 702).

Men have been at the centre of social justice most of the time in human recorded history. When it comes to numbers, it is often women and children who form the majority of the human population and the same is true with refugees, but mostly, men have controlled the policy making, controlled the justice system and determined the fate of

women and children. For example, in an instance from the novel, readers are informed in a flashback section of the book about Saba and Hagos' early sexual abuse in bed by their uncle. The siblings' virginity and self-worth were violated as these lines from Larson suggest— "The siblings have formed a close and intricate bond through early sexual experiences, following their repeated rape by an uncle while they were lying side by side in bed as children" (Larson, 2020, p.7). Such a heinous act of human defilement is an atrocity. This is an act of criminalization. Amnesty International, in its global campaign, has been making an effort to address the criminalization and regulation of sexuality and reproduction. However, this issue persists notably within refugee camps. One report that outlines the experiences of refugee women in Sudan and Syria highlights the challenges they face: Many women felt abandoned and neglected by the professionals responsible for their asylum cases, even though they were entitled to integration measures. The lack of institutional support led to constant uncertainty about their situation. Women expressed distress, unfair treatment, and anger towards the professionals responsible for their asylum applications. Ama (Togo) recalled a particularly harmful incident: "I spent two nights outside the center taking care of a sick friend. When I returned, I was told I could no longer stay. The manager yelled at me, threatened to call security, and denied me a bed." Jassim (Syria) and her family left Portugal for Germany after six months due to the lack of assistance they received, "We felt unwelcome and faced prejudice from the very people who were supposed to help us." (Borges, 2023, p. 15)

It shows that women refugees and children are in a hopeless situation in the refugee camps. Despite the promises and support policies, these refugees often encounter deliberate or indeliberate neglect from the authorities responsible for their asylum cases. There is an absence of institutional backing and that perpetuates a state of limbo, incrementing feelings of distress, unfairness and frustrations among refugee women and children.

Awareness of the support system is also very crucial in this case. Many refugee women do not even know what they are entitled to and which authorities they are supposed to talk to in case they find oppression inside the camps. In the novel, how Saba's body is constantly on the verge of being attacked and becomes a target serves

as a testimony to women refugees' plight. For example, Saba's mother pushes her to go through painful medical procedures and humiliating virginity tests, all under the advice of a local midwife (Larson, 2020, p. 8). How can a mother force her daughter to be humiliated this way? It shows that she herself has become a victim of the larger patriarchal mind game. Arguably, a woman in a camp endures suffering not only from men but also from other women.

In refugee camps, one of the main causes of conflict is restrictions on freedom of movement. The four main reasons why most refugees want to live outside of camps are—Freedom, social networking, career development and security. Refugee camps limit refugee rights and freedom since the refugees are often under the constant watch of the entitled authorities. The character Hajj Ali in the novel recommends planning a journey to a nearby village to pick up some supplies for their enterprise. He says, they "have been told they are not authorized to leave the camp without a permit, Eyob laments, nonetheless" (Addonia, 2020, p. 171).

Once a refugee arrives at the camp, s/he perceives a feeling of being imprisoned. With this heaviness in their heart, they start navigating their surroundings in the camp– "Refugees are easy to police," the Khwaja remarks in the novel (Addonia, 2020, p. 69). He goes on to say, "The authorities are aware that it is less expensive and simpler to keep [them] there due to fear and ignorance of their surroundings" (Addonia, 2020, p. 69). To have complete control over the natural and political lives of refugees living in camps, host governments try to determine who survives and who dies.

Life in refugee camps is mostly bland and frustrating for women. Saba tells Zahra in the book she is "a refugee living in a refugee camp. Nothing significant occurs here" (Addonia, 2020, p. 177). Samhiya does not anticipate better circumstances like a lot of other refugees: "Aid workers promise anything to get rid of people," she tells Saba (Addonia, 2020, p.58). Among other things, the aid workers promise them travel permits, wholesome food, schools and clinics— "The aid workers have said this since day one," yells Zahra . . . The clinic, the school, the hygienic improvements, the travel permits—none of these materialized. Here, is imprisoned" (Addonia, 2020, p. 177). With a

hope in their heart that sooner or later their dreams may one day come true, refugees must continue to live and struggle.

According to the UNHCR Policy on Refugee Women (2002), "military, police, and segments of the local population frequently treat the refugees with hostility" in addition to outside the camps. It is heart-wrenching to see women and children undergoing violence and sexual aggression. Gender-based and sexual assaults are so rampant in many of our societies. As they travel in the street or the park, they may encounter predators. For example, streets and parks in Delhi are considered so unsafe for girls. Moreover, refugee camps might be more intimidating for them. In the novel, the author also highlights similar situations. Addonia mentions that when refugee women leave their camps to get firewood, fodder or drinking water, they can become victims of sexual assault. For instance, once Saba went to a river that was outside the camp one bright morning after getting her pail, a group of men separated to allow Saba to pass, standing on either side of the narrow path. She was not used to the swing in which her hips bounced against their bodies. She found herself in a traumatic situation, not knowing what to do or how to defend herself. This is a stark reminder of the fact that women in refugee camps may be harassed at any time. Similarly, when Saba changed into a dancing beauty, one of the men teased her, "another grabbed her hair, halting her march. . . He bemoaned the amount of time he had passed since he had smelled the scent of a woman's skin as he pressed his nose against her neck" (Addonia, 2020, p. 87). What could she have done in that situation as a refugee woman in somebody's surveillance? The majority of young females are forced to choose between risking their self-esteem and traveling to fetch drinking water and other food supplies for their families. Boys may be playing at the camp, but daughters are expected to do all the household chores. Gender stereotypes are so common that daughters and daughters-in-law feel obligated to venture out for daily essentials.

Out of the shelter, it is one thing but even when these refugee women are inside the campground, women are still seen as little more than sex toys for men to satiate their sexual fantasies. Addonia in the text refers that Saba is amazed because the midwife constantly smells like fresh incense. Afterward, Saba finds out that the midwife covers herself with a thick sheet and ties her scarf around a stick of

frankincense gum so she may inhale the fumes of sandalwood from an incense burner— "making her skin glow, sweat, and increase her appetite. Her husband adores her sensual appearance" (Addonia, 2020, p. 55). Saba and Hagos are defiled by their blood relative. The reader is informed, in a flashback, how the siblings were sexually assaulted in bed during their childhood, robbing them of their innocence— "Whenever they visited her uncle, who was a politician turned bandit, he would call her and Hagos to his room, and ask them to take off their tops" (Addonia, 2020, p. 75). He would also "rub Hagos's breasts – as if he could flatten them by pushing them inward– and pull Saba's nipples harder and longer to increase her breast size" (Addonia, 2020, p. 75). Saba recalls one of such painful moment as her landlord took her to his studio and showed her how the negatives of pictures were developed. At that time, "he came behind her in the darkroom and squeezed her waist" (Addonia, 2020, p. 96). Men take advantage of dark and deserted places for sexual abuse or any other unethical conduct. Men often fail to realize that the cost of such molestation in young girl children would be devasting.

In Refugee camps, women must be very vigilant, not only of young and middle-aged men but also of elderly men always in camps. Even in the presence of old men, refugee women cannot feel safe and secure. For instance, in the novel, an old man confides to Saba that he has been closely observing her since the first day they arrived at the camp. Saba has so many natural talents that don't get the old man's attention but he does not fail to compliment her on her external beauty, moving "his hand to her face. He caressed away a strand of her hair" (Addonia, 2020, p. 97). Such old naughty men are no less than vultures and they may be found everywhere in our societies, and even more in refugee camps, since in camps, there is an intense family disintegration and erosion of human values and sentiments. Many survey results show that the most prevalent issue among women refugees living in camps is the atrocities against them. Women are often tormented and exploited instead of concentrating on how the lives of refugee men, women and children can be improved. These men often fail to recognize that both young and old men are in the same boat, including women.

Poor girls are often pushed to the limit of selling their bodies just to meet the necessities, and at times, to make sure that their safety and

shelter are secured. They are forced into prostitution and subjected to male degradation. Some of the men are found so of double standard that at first, they seek such girls, defile them and later criticize the girls for being so lowly and characterless. Thus, girls are blamed for the very behaviour boys themselves encouraged or engaged in. For instance, in the novel, Nasnet asks Saba if she does not "know what they are all saying about her. She is a prostitute. She . . . diseased" (Addonia, 2020, p. 114). The mortification of girls is quite common in camps. An athlete tells Tedros and other gentlemen that since Mariam got divorced, "she's been giving it away for free" (Addonia, 2020, p. 157). The so-called poet continues to make fun of her calling "her the aid center. . . Now she no longer has her virginity to guard, she can live as she always wanted" (Addonia, 2020, p. 157). Besides, when the men hear the voice of Hajj Ali's daughter, selling milk, Tedros calls her and the athlete asks whether she is going to drink milk and beer. Azyeb asks the men why men are so obsessed with a woman's blood. She adds that "girls' livelihoods are being destroyed because of (the men's) failure to understand" (Addonia, 2020, p. 157). When Jamal says women are so difficult to understand, he is stereotyping women. Such stereotyping is common in the camps as depicted by Addonia. Jamal says that "a woman is too complex for a man. Offering a strong counterargument to Jamal's point, Azyeb claims that such a stereotypical belief reveals, "how much violence there is against women, if even love has to be equated to withdrawing blood from a woman" (Addonia, 2020, p. 157). These acts of overgeneralization and commodification of women hint at the existence of sexual and gender-based violence against women in refugee camps.

Some men exhibit such behaviours that they do not respect women at all; forget about their stepmothers or sisters, some of them don't even show respect to their mothers. They appear to be misogynistic. The camp that Addonia describes in the novel is full of such men. Saba's would-be stepson Tedros intimidates her to defile before their nuptial night. He conveys his annoyance and dissatisfaction saying he "always knew Saba was a slut. Just like his mother" (Addonia, 2020, p. 164). With an assumption that Saba has already lost her virginity, Tedros believes she won't bleed on their first night of marriage. In the text, Tedros and a few of his friends surged through the gate while Saba and Zahra were asleep, laughing and yelling. Tedros clicks his

fingers at his pretend stepmother, telling her to make tea for them. He tries to dominate that woman in an attempt to proclaim his manhood. As a man full of manliness, he thinks, he is above all women and can take hold and conquer any woman, regardless of her identity and age. Zahra declines to go back to Saba's hut and sleep in the kitchen, despite Saba's begging to keep her safe from these boisterous males. She was afraid of these men over there. In the same chapter, as Tedros enters his room with a bottle of beer, Zahra makes her way into the kitchen. Suddenly, a scream thunders from the room and Saba wakes up— "High-pitched cries come out of Tedros's hut. Saba rushes inside and finds Zahra on the floor" (Addonia, 2020, p. 180). Zahra is heard pleading, "Please help me" (Addonia, 2020, p. 180). This atrocious incident in the novel cannot be linked with alcohol alone. Concerning alcohol and violence, UNHCR (2002) writes, "While alcohol does in many cases exacerbate violence, alcohol does not itself cause violence against women. The focus is on alcohol or drugs, rather than on male patriarchal ideology". Male patriarchal ideology has significantly acted here as a fuel that drives men at the refugee camp crazy and they often dare to insult and violate women. It is further exacerbated by the lack of proper policies to safeguard women's rights and dignity.

Silence is My Mother Tongue depicts men in the camp as viewing women as public property that may be exploited anytime. In one incident in the novel, Saba and Hajj Ali are shown standing in an area with bushes, grass, and other vegetation all around. Saba informs Hajj Ali that the particular area was the place where the relief workers had pledged the authorities to construct a school. While she was busy in the conversation, without seeking Saba's consensus, Hajj Ali "reaches his hand and massages her chest, between her breasts, as if to unclog her airways, as he tries to open his zipper" (Addonia, 2020, p. 181). This is a shocking behavior on the part of the man. Moreover, he commands her to "take off her clothes." This is indeed an indecent and insulting act that invades a refugee woman's freedom and dignity. Her autonomy and personal boundaries are thus violated and she is not the only character in the novel who goes through such atrocities. Similarly, as the story proceeds, Eyob gives Saba shelter, a generous act. Naturally, Saba feels grateful to Eyob, and Hagos, who always stand by her at all times. However, to our shock as a reader, to pay them for what they did, later, she has to go through the horror—

"Undresses and squeezes herself between the two men" (Addonia, 2020, p. 183). This outrageous act suggests several things, i.e., how women refugees are being mistreated worldwide in refugee camps.

Compared to life in places where violence or war takes place, refugee camps are much better. However, can't we make it a more livable place? Is it something undoable? Who knows, one day we may end up there by some misfortune! Yes, refugees at least receive food, medicine, and clothes in a camp. Yet, are these minimum enough? Pittaway states that "unregistered refugees are often forced to take on the worst jobs unwanted by others to live. Because of their 'illegal' status they are open to all forms of exploitation . . . Access to shelter is critical for unregistered women and children" (Addonia, 2020, p. 8). though they feel safer in an encampment when compared to that in war-stricken places, "However, camps may not always offer better protection to refugees and the internally displaced. The closed environment of camps is particularly conducive to exploitative and manipulative activities by people who seek to gain from the vulnerable nature of the residents" (UNHCR, 2002, p. 76). Therefore, it is very important to recognize the challenges faced by millions of refugees worldwide and we need to be more conscious about what women refugees might be going through in these camps as they are the subalterns, if to use Spivak's terminology, can't often speak (Spivak, 1988, p. 301).

The oppressive patriarchal system often views women's bodies as a chattel. Women like Saba are imprisoned in the refugee camp that has its dictum from this sort of patriarchal idea box. Women refugees' fate lies at the whim of those in positions of authority. Saba meets Hajj Ali amidst this insecure environment, exposing the widespread abuse culture that usurps women's physical and mental resources. The irony is that they have been targeted, mutilated and defiled just because they are the female gender. There are many other refugee-related problems that women share with men but women find themselves doubly or even triply marginalized. Vulnerability here in this context becomes synonymous with exploitation. The constant fear that women refugees often encounter in most of the refugee camps as depicted in *Silence is My Mother Tongue* serves as a clarion call, echoing the urgency for immediate corrections.

Conclusions

Silence is My Mother Tongue succeeds in making it very clear that there is an urgency to manage women refugees living worldwide in refugee camps. The novel provides a moving tale of horrific situations faced by women in refugee camps. Using the facade of fiction, the author unearths deeply real truths about the conditions in some of these camps, drawing attention to the often-ignored plight of displaced women. The novel daringly challenges the patriarchal norms that often target women and make them a scapegoat. It is also frankly acknowledged in the text that not all camps are the same. The novel presses our minds hard for structural reform to defend the rights and honour of refugee women.

Women refugees who flee from their homeland and are displaced find it difficult to adjust to the new and often hostile refugee camps. Many of their experiences are heart-rending. There is overcrowding, a shortage of necessary goods and services and often a lack of safety. They find poverty, lawlessness and violence rampant everywhere in the surroundings and they often lack autonomy and human agency. These complex and depressing realities of living there often result in a serious risk to women's visibility and recognition as rights holders in these refugee camps. The consequences of not getting the dignity that they deserve in the refugee camps may be very disturbing. For instance, Oliveira writes, “In women, it can lead to mental disorders, obstetric complications, sexual dysfunctions, unwanted pregnancies, unsafe abortions, and sexually transmitted infections” (Araujo et al., 2019). These challenges are often so very debilitating for not just for women but also for those who rely on these victimized women such as her children and even husbands. These disheartening circumstances of life within these camps pose a significant threat to human rights.

To entitle refugee women to the rights that they are entitled to, we need to develop a more sophisticated support system, which includes general concerns for economic empowerment, education and health. Gender-sensitive policies are to be incorporated with humanitarian interventions. The message has been loud and clear that policymakers, practitioners and international human rights organizations need to work together to ensure that bureaucratic

hurdles and geopolitical interests don't confiscate the rights of women refugees. We must take immediate action to ensure that everyone understands the universality of human dignity. A more equitable and just world is possible only when women are not just empowered but also given due dignity, be it refugee women or any other.

References

Addonia, S. (2020). *Silence is my mother tongue*. Graywolf Press.

Araujo, J. de O., et al. (2019). Prevalence of sexual violence among refugees: A systematic review. *Revista de Saúde Pública, 53*, 78. doi: https://doi.org/10.11606/s1518-8787.2019053001081

Borges, G. M. (2023). Journey of Violence: Refugee women's' experiences across three stages and places. *International Migration & Integration.* doi: https://doi.org/10.1007/s1234-023-01102-z

Feller, E. (2006). Asylum, Migration and Refugee Protection: Realities, Myths and the Promise of Things to Come *International Journal of Refugee Law, 18*(3-4), 509-536. doi: https://doi.org/10.1093/ijrl/eel016

Larson, R. S. (2020). Book reviews: Silence is my mother tongue. *Colorado Review.* https://www.coloradoreview.colostate.edu/ reviews/silence-is- my-mothertongue/ ?fbclid= IwAR0aQSDHK cqeY6Z8M NojRqSOcv61 usu1X0bmznTzh BvyLBA3LEr7VFMlvPM

Spivak, G. C. (1988). Can the subaltern speak? In: C. Nelson & L. Grossberg (Eds.), *Marxism and the interpretation of culture* (pp. 271-313). University of Illinois Press.

United Nations High Commissioner for Refugees (UNHCR). (2022). *Refugee data finder*. https://www.unhcr.org/refugee- statistics /insights/explainers /100-million-forcibly- displaced.html

United Nations High Commissioner for Refugees (UNHCR). (2002). *UNHCR policy on refugee women and guidelines on their protection: An assessment of ten years of implementation. Format Evaluation and Lessons Learned*. https://reliefweb.int/report/world/unhcr-policy-refugee-women-and-guidelines-their-protection-assessment-ten-years?gad_source=1&gclid=CjwKCAjw5v2wBhBrEiwAXDDoJVfuF3jTK_hg9SzUt-Yk6jf7mr4kquTzx7qdRkVW _8oyI2DMjzbB HxoC7KQQAvD_BwE/

United Nations High Commissioner for Refugees (UNHCR). (1991). *Guidelines on the protection of refugee women*. https://www.unhcr.org/sites/default/files/legacy-pdf/3d4f915e4.pdf

Rebecca, M. M. Wallace. (1996). Making the Refugee Convention Gender Sensitive: *The Canadian Guidelines. The International and Comparative Law Quarterly*, *45*(3), 702–711. http://www.jstor.org/stable/760690

DOI: https://doi.org/10.4038/ouslj.v19i2.7626

RESEARCH ARTICLE

OUSL Journal, 2024
Vol. 19, No. 2, (pp 33-39)

Growth and Yield of Salad Cucumber (*Cucumis sativus* L.) Vine Cuttings Under Protected House Conditions in Low Country Wet Zone of Sri Lanka

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Introduction

Cucumis sativus L., also known as salad cucumber, is one of the most widely grown vegetable crops in the world. It is grown in protected houses to increase its economic worth during off-season farming. It produces edible parthenocarpic fruits. According to Kumar et al. (2020), the phenomenon of parthenocarpy is extremely helpful for fruit development in environments as protected houses, where good pollination and fertilization are not possible. The process of producing parthenocarpic hybrids requires the use of chemicals and plant growth regulators to maintain and multiply parthenocarpic lines. This requires the involvement of high technical know-how and the concurrent construction of protected structures to prevent contamination and deterioration (Kumar et al., 2020).

Salad cucumber vines are trained on plant training threads as a single stem by removing lateral branches continuously to maximize vertical space utilization (Jasim & Abed, 2013). Usually, salad cucumbers are

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(Received 27th March 2024; Revised 14th November 2024; Accepted 26th December 2024, © OUSL)

grown using seeds; but vegetative propagation is not very common. Most often, these pruned lateral branches are considered as waste material (Kumar et al., 2020). However, growing hybrid salad cucumber by seeds is expensive due to high prices of the hybrid seeds, and if pruned lateral branches are used as planting material, it would be of considerable commercial value and reduce the cost of regeneration (Jasim & Abed, 2013). Further, if apical end cuttings can be used for the next crop cycle after one crop cycle, the cost incurred on seedlings can be reduced substantially. Hence, if salad cucumber vine cuttings can be successfully used as seedlings, the costs incurred on purchasing salad cucumber hybrid seeds each time for a new crop cycle can be minimized. However, knowledge on growth and yield performances of salad cucumber vine cuttings is still lacking. Thus, the current investigation was carried out to explore the growth and yield performances of salad cucumber vine cuttings to evaluate their suitability for the next crop cycle.

Research Methodology

This study was conducted in a plant house at the Faculty of Agriculture, University of Ruhuna, Sri Lanka from February to April 2023 to evaluate the growth and yield performances of salad cucumber vine cuttings (Variety: Efdal F1). The experiment was laid out in completely randomized design with four replicates. There were three treatments as apical end cuttings, lateral branch cuttings and control. Salad cucumber seedlings obtained from the seeds were used as control plants. Two nodal cuttings of 20 – 25 cm of length were prepared from lateral branches and apical ends of two-month old salad cucumber mother plants and were used as the treatments. Leaves of the cuttings were removed by pulling them backward and snapping the petioles of the leaves. However, precautions were taken not to damage the buds of the terminal ends. Initial weight of the cuttings was recorded to be between 15 – 17g. Cuttings were dipped in water for a week to induce rooting. After the root initiation, the cuttings were planted in coir grow bags as one cutting per bag. Concurrently, the seeds of salad cucumber were directly seeded in coir grow bags as one seed per bag to obtain control plants. One replicate consisted of two plants. Thus, the sample size of each treatment was eight.

The growth parameters vine length, number of leaves per vine and length of 7th, 14th and 21st internodes were recorded weekly up to six weeks. Fresh weight of fruits, number of fruits and length of fruits were measured at harvesting as yield parameters. The temperature and relative humidity inside the protected house were maintained at optimum levels by an automation system. Recorded data were statistically analyzed using ANOVA, and the means were separated by the least significant difference (LSD) at 5% probability level.

Findings and Discussion

According to the results, there was a significant effect on vine length, number of leaves per vine, fresh weight of fruits and number of fruits between the treatments. However, the length of the salad cucumber fruits was not significantly influenced by the treatments. In addition, there was no significant effect between the treatments in length of 7th, 14th and 21st internodes. Significantly, different higher vine length and number of leaves per vine were recorded by control plants at the end of six weeks (Figures 1 and 2). Although higher vine length values were recorded by the apical end cuttings initially, the plants obtained from the salad cucumber seeds gradually increased their vine length at later stages of growth. This could be due to the potential of salad cucumber seed/seedling to become a complete plant. Cuttings obtained from mother plants may reduce their ability to develop as vigorous plants when they become older. At the initial stage of growth, number of leaves per vine recorded from the control plants showed no significant difference with the number of leaves per vine in plants obtained from cuttings. This might be due to the fast-growing habit of salad cucumber crop. However, at the end of the sixth week, the number of leaves per vine recorded by plants obtained from apical end and lateral branch cuttings were significantly lower than the number of leaves per vine in the control plants. This trend could be due to the potential of salad cucumber seed/seedling to become a vigorous plant over vine cuttings. Kumar et al. (2020) also observed the maximum vine length in salad cucumber plants cultivated *via* seeds over the plants cultivated from pruned side shoots.

Nevertheless, the fresh weight of fruits and the number of fruits at the end of the sixth week were significantly higher in plants obtained from apical end cuttings over control plants. In addition, fresh weight of

fruits and the number of fruits in apical end cuttings were not significantly different with fresh the weight of fruits and the number of fruits in lateral branch cuttings. Moreover, these parameters in lateral branch cuttings were not significantly different with the control plants (Figures 3 and 4). When taking cuttings from the salad cucumber mother plants, those mother plants had reached the reproductive phase of their growth cycle. Salad cucumber plants reached their reproductive growth phase about 21 days after planting (three weeks after planting). Therefore, plants obtained from cuttings were at their reproductive growth phase from the initial stage of planting. According to Figure 1, apical end cuttings have a higher growth rate than lateral branch cuttings. Therefore, apical end cuttings reported significantly higher fresh weight and number of fruits over the control plants which reached the reproductive growth phase three weeks after planting. Kumar et al. (2020) also recommended propagation of greenhouse cucumber cultivars *via* pruned side shoots for getting a comparative yield.

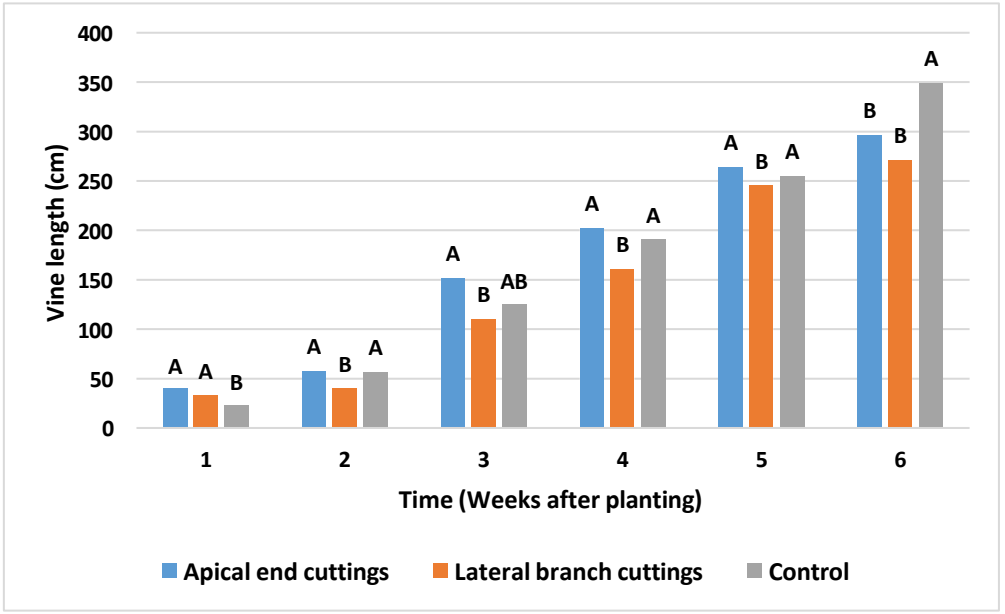

Figure 1. Vine length of salad cucumber vines in different treatments. Mean values indicated by the same letters are not significantly different at $\alpha=0.05$

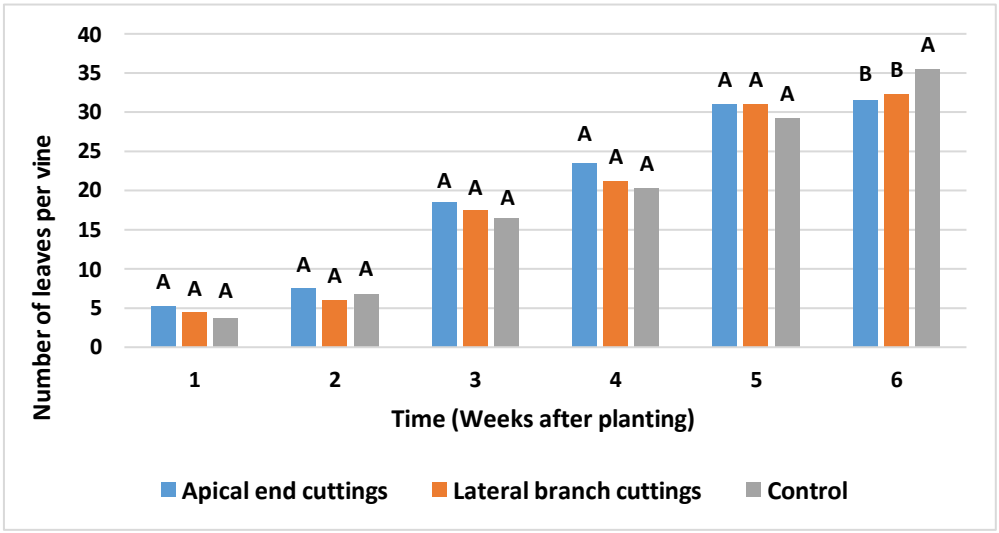

Figure 2. Number of leaves per salad cucumber vine in different treatments. Mean values indicated by the same letters are not significantly different at $\alpha=0.05$

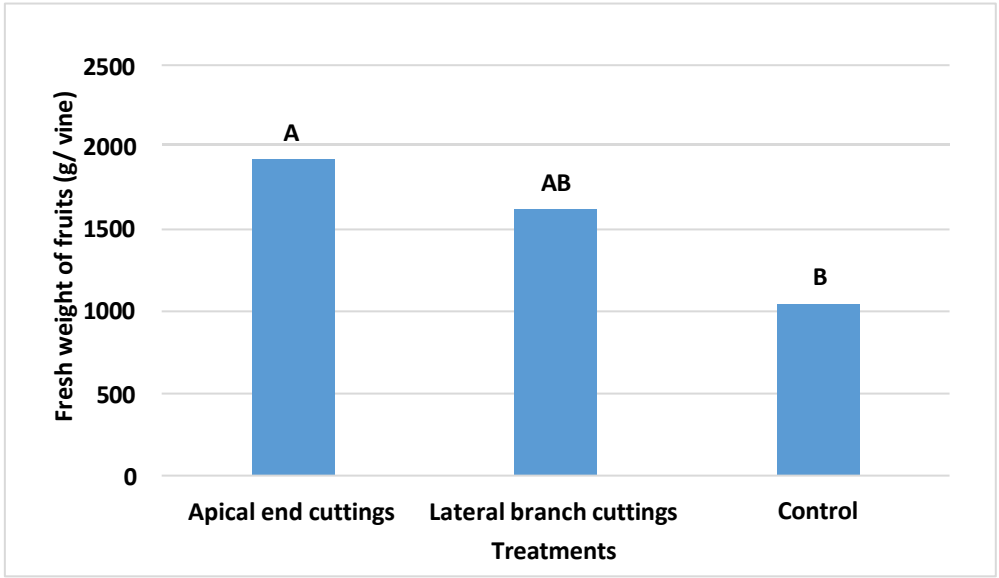

Figure 3. Fresh weight of salad cucumber fruits in different treatments. Mean values indicated by the same letters are not significantly different at $\alpha=0.05$

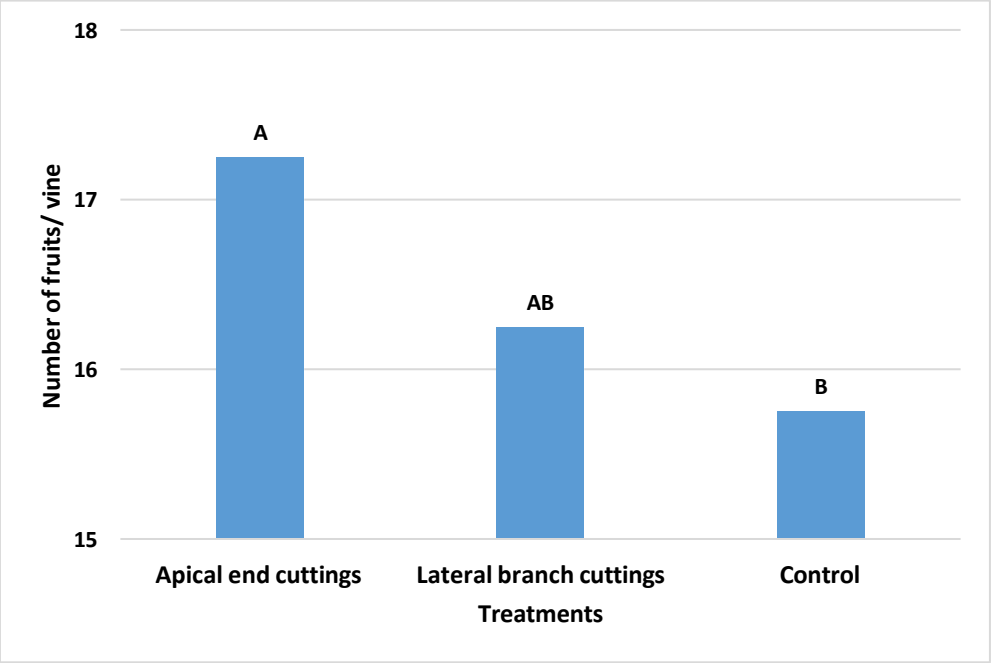

Figure 4. Number of salad cucumber fruits in different treatments. Mean values indicated by the same letters are not significantly different at $\alpha=0.05$

Conclusions

Although the salad cucumber plants obtained from seeds reported significantly higher vine length and number of leaves per vine at the end of the sixth week, the salad cucumber plants obtained from apical end cuttings and lateral branch cuttings reported a higher fruit yield at the end of the sixth week. Therefore, there is a possibility to use those cuttings (apical ends and lateral branches) to obtain new plants without wasting. Thereby, the cost incurred on salad cucumber seedlings can be reduced.

References

Jasim, A. H., & Abed, H. M. (2013). Effect of some treatments on rooting of cucumber cuttings (*Cucumis sativus* L.). *Euphrates Journal of Agriculture Science*, *5*(4), 11-16. https://api.semanticscholar.org/CorpusID:90147581

Kumar, S., Patel, N. B., & Saravaiya, S. N. (2020). Pruned side shoots as planting material: Opening new dimensions for sustainable greenhouse cucumber production system. *Indian Journal of Horticulture*, *77*(2), 307-314. doi: http://dx.doi.org/10.5958/0974-0112.2020.00042.0

DOI: https://doi.org/10.4038/ouslj.v19i2.7652
RESEARCH ARTICLE
OUSL Journal, 2024
Vol. 19, No. 2, (pp 41-64)

Anxiety and Depression among Officer Cadets during the Army Basic Training in the Sri Lankan Army

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Abstract

Depression and anxiety are common mental health conditions among the Army cadet officers that have been extensively studied in the world across varying populations. They are vulnerable enough to develop such conditions due to the military training process and adjustment issues. However, mental health conditions of the Army officer cadets have seldom been studied in Sri Lanka. The current study was conducted to examine the prevalence of depression and anxiety among Army officer cadets during basic army training and associated factors. A cross-sectional study was conducted among 236 officer cadets, ranging in age from 18 to 27 years who have had the training recently. A self-reported questionnaire which included the Depression, Anxiety and Stress Scale- 21 and General Health Questionnire-30 was used to assess the prevalence of depression and anxiety. Prevalence of anxiety was 43% while the depression was reported 22% among the studied cadet officers. Findings suggest the

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(Received 03rd January 2024; Revised 20th December 2024; Accepted 25th December 2024, © OUSL)

importance of providing mental health support for these individuals during basic army training. Implementing tailored mental health support programmes that provide accessible resources, counseling services, and coping mechanism training will help officer cadets improve their mental well-being.

Keywords: *Depression, anxiety, military life*

Introduction

Military training marks a critical juncture in an individual's life, encompassing transformative experiences and significant life outcomes (Martin et al., 2009). However, the military environment introduces a multitude of occupational stressors that can profoundly affect mental well-being of individuals, potentially leading to the development of anxiety and depression (Kumar et al., 2013). Research has highlighted a higher prevalence of anxiety and depression among military personnel when compared to the general population (Warner et al., 2007; Warner et al., 2007). These mental health challenges are influenced by various factors such as separation from loved ones, exposure to the hardships of war and the demanding nature of military life (Gaziano et al., 2016).

Military basic training, a transition period for officer cadets from civilian life to Army life, seems to be tough and stressful for them. Army recruits entering basic training are exposed to stress in the form of rigorous mental and physical training (Clemons, 1996; Skomorovsky & Sudom, 2011). New cadets to the Sri Lanka Army can benefit from the Army's initial entry training programme after finishing their basic training in the civilian sphere. Armed forces recruits undergo a rigorous physical and mental training from the beginning of their service environment (Gold & Friedman, 2000). Research conducted during basic training gives a unique look into how people think when they are ready to join a new group and how they handle stress (Larson et al., 2001).

Despite the growing body of literature on the mental health of military personnel, there remains a dearth of research specifically examining officer cadets during basic Army training in Sri Lanka. Limited

attention has been given to exploring the prevalence and impact of anxiety and depression in this population. Given that military training represents a unique and challenging period in an individual's life, understanding the mental health experiences of officer cadets during this crucial phase is of utmost importance.

By focusing on officer cadets undergoing basic Army training, this study aims to address this research gap and contributes to the understanding of anxiety and depression in military settings. Officer cadets encounter a distinct set of stressors during their training, which necessitates a dedicated examination of their mental health status. Gaining insights into the prevalence of anxiety and depression among officer cadets can inform the development of tailored interventions and support systems to foster their psychological well-being. Identifying the prevalence and correlates of anxiety and depression in this population can help military institutions create proactive strategies to support their mental health needs. By implementing effective interventions and support mechanisms, the Sri Lanka Army can enhance the resilience and overall well-being of officer cadets throughout their training and subsequent service.

Hence, this study aimed to examine the prevalence of anxiety and depression among officer cadets during basic Army training, their interrelationship, and the influence of factors like training duration and education level.

Review of Literature

The Sri Lanka Army basic training is a basic training experience that introduces troops to military life. Basic training for military cadets is intense and includes tough mental and physical exercises, which introduce stress. Complaints of mood problems are typical in the opening weeks due to these pressures. As a result, mood disorders are common among them during the first few weeks (Clemons, 1996; Larson et al., 2001; Lovering et al., 2013). Military personnel are more likely to suffer from a common mental condition (CMD) than the general population (Goodwin et al., 2015). Service members' mental health is influenced by a variety of factors, including combat and

deployment as well as military lifestyle stresses like relationship conflict, parental challenges, employment tensions and integration problems (Wilcox et al., 2013). The prevalence rate of mental illness among soldiers in the military is higher than the prevalence among the general population (Nazami et al., 2017; Rona et al., 2005). Particularly, anxiety and depression are commonly seen among army personnel (Kumar et al., 2013; Zubair, 2014; Larson et al., 2001).

Anxiety and depression

Anxiety is presently considered as a complex multidimensional construct embodying a series of interrelated cognitive, affective, somatic and behavioural reactions. Depression is a negative affective state, ranging from unhappiness and discontent to an extreme feeling of sadness, pessimism and despondency that interferes with daily life (American Psychological Association, 2020). It is characterized by a pervasive low mood, low self- esteem and loss of interest or pleasure in normally enjoyable activities which affects a person's family, school or work life and other social networks, sleeping and eating habits and general health (World Health Organization, 2001).

Stress associated with military training leads newcomers to fail in military training and being discharged from the service because of psychological difficulties. The military environment, especially strenuous military training, may also be characterized by a high prevalence of depressive symptoms (Xiong et al., 2005). Depression and anxiety are associated with attrition during initial military training (Lerew et al., 1999). In addition, stressful life experience may play a role in the occurrence leading to increase of suicide among solders, given the severity stressful experiences associated with military training (Nock et al., 2013). Depression seems to be related to verbal abuse, duration of the training, marriage, education level, worrying about the future, inadequate social support, gender, family history of mental illness and family history of alcohol abuse (Al-Amri & Al-Amri, 2013; Warner et al., 2007; Zubair, 2014).

Theoretical perspectives of anxiety and depression

According to Freud's Psychodynamic Theory, anxiety is an outcome of the ego's inability to mediate the conflict between the id and the superego (Freud, 1923). Individuals may experience aggressive and impulsive drives as unacceptable resulting in repression. These repressed drives may break through repression, producing automatic anxiety. Beck's Theory highlights the role of perceived vulnerability in anxiety disorders. Vulnerability is assumed to result in developing anxiety and depression, particularly in the context of high level of stressors (Schmidt et al., 1995).

Cognitive Theory describes anxiety as the tendency to overestimate the potential for danger. The tendency to overestimate the likelihood of a negative outcome is one of the hallmarks of anxiety. As a result, individuals who suffer from anxiety disorders have a strong preference to avoid engaging in situations or undertaking pursuits that they consider to be hazardous or unsettling for them (Ehring, 2014; Davis, & Valentiner, 2000; Wells, 1995).

Seligman (1973) considered depression as the "common cold" of mental health because of the high prevalence of it. According to Behavioural Theory, behaviour is acquired through observation, imitation and reinforcement. Therefore, depressed people learn to adapt in ways that reduce their chances of experiencing reinforcement and reward. Reactive depression has a clear cause; so, theories of behavioural/learning make sense (McLeod, 2015).

Physiological response to chronic stress may function as a vulnerability factor, linking environmental stress to the etiology of depression (Tonon et al., 2020). Coyne's Interpersonal Theory emphasized that interpersonal behaviours, in particular, reassurance seeking, play a role in developing depression. Reassurance seeking leads to severity and eventually, rejection by others, social isolation and subsequent depression (Joiner, 1994).

According to Beck (1967), depressed persons judged experiences negatively. He identified three depression pathways: Triad of cognition (of negative automatic thinking), negative self-schema and logic errors (*i.e.* faulty information processing). The cognitive triad is a series of

three negative (helpless and critical) beliefs about oneself, the world and one's future (Alloy et al., 1999). Depressed people often perceive themselves as helpless, useless and incompetent, and believe that they do not have hope for the future (Beck, 1967).

Mental wellbeing and military life

Due to its strict hierarchical organization, significant training requirements and sense of segregation, the military is a unique form of group. Armed forces are immediately confronted with a fresh set of challenges as soon as they depart their familiar social and physical environments. The stringent rules and hierarchical structure of this new environment necessitate a lifestyle shift from what one is used to in the civilian sector. People's personal freedom and job options are severely restricted while serving in the military (Al-Amri & Al-Amri, 2013). According to prior research, depressive disorders are a widespread problem among the military population. The percentage of soldiers with "depressed symptoms" was higher than the general population (Nasioudis et al., 2015).

Maintaining mental wellbeing is critical for military troops during their training period; however, poor mental health develops during training season owing to a variety of psychological disorders. Young people from lower socioeconomic origins are disproportionately represented in the armed forces. Thus, they may be vulnerable to psychological problems due to high levels of stress (Walker, 2010). There is a correlation between depression and stress levels throughout the basic training. Stress levels varied among basic trainees increasing after the first week. Mental health issues, like depression, afflict a larger percentage of military people (Rona et al., 2004).

Anxiety and depression among military personnel

The level of depression among entry-level male soldiers seems to be higher than the lifetime prevalence rate in the general population (Warner et al., 2007). There was a high prevalence of depression among military medicine cadets in Greece (Nasioudis et al., 2015). Also, rates of anxiety, depression and psychiatric illness among Iran soldiers were higher than the prevalence among youth and the general

population (Nazami et al., 2017). In South Asia, there is a high prevalence of depression among military recruits during the military training in the Pakistan Army (Bin Zubair et al., 2015) and anxiety was commonly seen among Indian Army soldiers (Kumar et al., 2013). In Sri Lanka, stress, adjustment disorder and adjustment reactions were the main psychological problems among army personnel (Perera et al., 2004).

Impact of anxiety and depression on military personnel life

As cadets transition from civilian to armed forces life, the Army's basic officer training appears to be a critical and stressful time for them. Training for Army soldiers in basic training includes both mental and physical stress (Clemons, 1996; Partonen, 1994; Skomorovsky & Sudom, 2011). As a result, during the first few weeks, they often complain of mood issues (Clemons, 1996; Larson et al., 2001; Lovering et al., 2013). Soldiers have a higher prevalence of mental health issues and are more likely to suffer from anxiety and depression than civilians (Kumar et al., 2013; Larson et al., 2001; Nazami et al., 2017; Rona et al., 2005; Zubair, 2014).

Military personnel who undertake physically taxing training, may be more susceptible to depressive symptoms (Xiong et al., 2005). Attrition, sorrow and anxiety are linked in basic military training (Lerew et al., 1999). Military training and soldiers' prior life experiences may contribute to an increase in suicide rates (Nock et al., 2013). Most military professionals with psychological problems do not get help as they are afraid to ask for help (Sharp et al., 2015). Due to mental health concerns, many enlistees in the military forces are leaving (Cigrang et al., 1998; Hoge et al., 2002; Larson et al., 2001).

Associated factors of anxiety and depression among military personnel

Characteristics of military environment such as austere discipline, rigid hierarchical structure, physical training, strict rules and separation from family and isolation from the familiar civilian setting from long periods of time are associated with depressive symptoms (Tonon et al., 2020). Moreover, history of previous psychiatric treatment and verbal or physical abuse were associated with

depression among soldiers (Warner et al., 2007). There was a link between depression and military service length, smoking and factors such as post-traumatic stress disorder and lack of close social support (Vilhjalmsson, 1993; Xiong et al., 2005).

Depression is more common among married military people and those who have problems in their relationships with their superiors or family members (Al-Amri & Al-Amri, 2013). Family income and fear of the future were also associated with depression symptoms (Zubair, 2014). Considering anxiety, the duration of the recruit training is associated with anxiety (Martin et al., 2006). Women are more likely to suffer from anxiety than males (Bruce et al., 2005; McLean & Anderson, 2009). There was a link between anxiety and the level of education of Indian Army soldiers (Kumar et al., 2013). Limited research has examined the linked elements of psychological problems among Army personnel in Sri Lanka. Hence, this study intended to examine the prevalence of anxiety and depression among officer cadets during basic Army training in the Sri Lankan Army.

Methodology

Research design

A cross-sectional study design was employed to investigate the prevalence of anxiety and depression among officer cadets during basic Army training.

Participants

The study population consisted of officer cadets in a military academy in Sri Lanka. The study population consisted of 479 officer cadets from various intakes. To determine the appropriate sample size, the formula developed by Krejcie & Morgan (1970) was employed. This method is widely used for determining sample sizes in finite populations. Based on this formula, a minimum sample size of approximately 214 participants was required for the study. To ensure robust representation and account for potential non-responses, a final sample of 236 officer cadets was randomly selected. The age ranged from 18 to 27 years (*Mean age* = 22 yrs). There were 97% of

males and 3% of females and 99.6% of the sample was of Sinhalese. The majority (94%) had completed their education up to Advanced Level, and 6% of cadet officers possessed Higher National Diploma (HND) education. The sample was restricted to those who were students in the Sri Lanka Military Academy. The cadets who were diagnosed with mental illness and who cannot read and understand Sinhala Language were not included in the study.

Measures

Anxiety

Anxiety was measured using the Anxiety Subscale in the Sinhala version of the Depression, Anxiety and Stress scale-21 (DASS-21) (Aththidiye, 2012). The items were rated using a 4- point Likert- type scale (0 = *Never* to 3 = *Almost always*). In previous studies, internal consistency for the Anxiety Subscale was α =.76 (Aththidiye, 2012). In the present study, internal consistency of the Anxiety Subscale of the original DASS 21 was α = .84. In addition, the Sinhala version of the Anxiety Subscale in the General Health Questionnaire-30 was used to assess anxiety (GHQ-30) (Abeysena et al., 2012). The items were rated using a 4- point Likert- type scale (1= *Never* to 4 = *Almost always*). The sensitivity of GHQ-30 was 67.5% (Abeysena et al., 2012). In the current study, internal consistency for this scale was α = .71.

Depression

Depressive symptoms were measured using the Sinhala version of the Depression Subscale in the Depression, Anxiety and Stress scale-21 (Aththidiye, 2012). The items were rated using a 4- point Likert scale *(0= Never to 3= Almost always*). In previous studies, internal consistency for the Depression Subscale was α = .83 (Aththidiye, 2012). In the present study, internal consistency was α = .93. In addition to the Depression Subscale, the Sinhala version of the depression items in the General Health Questionnaire -30 (Abeysena et al., 2012) was used to assess depression. The items were rated using a 4- point Likert- type scale (1 = *Never* to 4 = *Almost always*). In this study, internal consistency for this scale was α =.77.

The DASS-21 is designed to measure clinically significant emotional states (Lovibond & Lovibond, 1995). It contains seven items for each

of the subscales that measure depression, anxiety, and stress. The scores for the three subscales are calculated by summing up the scores for the relevant subscale and multiplying the result by two. The cut-off scores for the original version and the validated Sinhala version of DASS 21 (Aththidiye, 2012) are similar. The cut-off scores for the three subscales are presented in Table 1.

Table 1. *DASS 21 Severity Cut-off Scores*

Severity	Depression	Anxiety	Stress
Normal	0-9	0-7	0-14
Mild	10-13	8-9	15-18
moderate	14-20	10-14	19-25
Severe	21-27	15-19	26-33
Extremely severe	28+	20+	34+

In addition, a demographic questionnaire was used to collect data on the participants' gender, duration of the training, worrying about the future, family history of mental illness, family history of alcohol abuse and history of verbal abuse. To accommodate the language preferences of the participants, the questionnaires were provided in both Sinhala and English languages.

Procedure

Ethical clearance for the study was obtained from the Ethical Review Committee of the Faculty of Graduate Studies, University of Colombo (Reference No: ERC/FGS/2021/015). Prior to data collection, all participants provided informed written consent and an information sheet was distributed to them. Participants participated in this study

voluntarily. The researcher briefly explained the purpose of the study and provided necessary instructions prior to data collection. The confidentiality of the organization as well as the respondents were protected at all stages of the research.

Data analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS). An assessment of the normality of the data was conducted using the Shapiro-Wilk test. The results indicated that the data were not normally distributed. Descriptive statistics were used to summarize and describe the results related to demographic factors and the prevalence of anxiety and depression among cadets. The symptoms of anxiety and depression were grouped into five groups: normal to extremely severe based on the recommended cut-off scores (Lovibond & Lovibond, 1995). As the data did not follow a normal distribution, Spearman's rank correlation was used to examine the relationship between the variables.

Results and Discussion

Socio-demographic characteristics

The sample included 236 officer cadets from the Military Academy, ranging in age from 18 to 27 years. The majority (97%) were males and 99.6% were Sinhalese. In addition, 94% of the sample completed their education up to Advanced Level, and 6% possessed Higher National Diploma (HND) education.

Prevalence of anxiety among officer cadets

Of the sample, 43% had anxiety. Among those with anxiety, 20% had moderate levels of anxiety symptoms and 8% had a mild level of anxiety. Further, 7% had a severe anxiety level while another 7% had an extremely severe anxiety level (Table 2).

Table 2. *Levels of Anxiety of Officer Cadets According to DASS-21*

Level of anxiety	Percentage (%)
Normal	57
Mild	8
moderate	20
Severe	7
Extremely severe	7

Prevalence of depression among office cadets

Of the sample, 22% of the participants had depression. Of them, 4% had a moderate level of depression and 18% had a mild level of depression (Table 3). Results suggested that none of the participants reported severe or extremely severe levels of depression.

Table 3. *Levels of Depression of Cadet officers According to DASS-21*

Level of depression	Percentage (%)
Normal	77
Mild	18
moderate	4

The relationship between anxiety and depression among officer cadets

Correlational analysis was conducted to examine the relationship between the variables. Results revealed that there was a positive linear relationship between depression and anxiety among them ($r=0.47$, $p < 0.001$).

Factors associated with anxiety and depression among the cadet officers

Results suggested that levels of anxiety and depression did not vary depending on the duration of training. Also, the level of anxiety did not vary depending on the level of education. However, there was a significant negative relationship between the level of depression and the level of education ($r = -.04$, $p < .05$).

The main purpose of the current study was to examine the prevalence of anxiety and depression among officer cadets during their basic army training in the Sri Lanka Army. The findings of the present study revealed that officer cadets in the Sri Lankan Army experience moderate levels of anxiety and depression during their basic training. These findings align with previous research highlighting the higher prevalence of anxiety and depression among military personnel compared to the general population (Zandi et al., 2011; Bryan & Heron, 2015; Hartley et al., 2013). The prevalence of anxiety symptoms among them was 43% of the sample. This rate was comparatively higher than those reported by several studies both in Asia and globally (Nazami et al., 2017; Zandi et al., 2011).

The military setting exhibits certain stereotypes of military traits as high internal locus of control and low emotional stability. Furthermore, the military needs a committed service member who is strongly attached to his or her military service and to his or her unit as an organization (Allen, 2003). For all this the military must have a high self-concept, because self-concept does not appear to be instinctive, but it is a social product developed through experience, it processes relatively boundless potential for development and actualization. Previous research shows that anxiety level directly influences the self-concept of army personnel (Kumar et al., 2013).

In the present study, the prevalence of depression was 28% of the sample. This rate was comparatively lower than those reported in previous studies conducted in Asian countries and European countries (Bin Zubair et al., 2015; Warner et al., 2007). However, these findings were similar to few studies in globally (Tekbaş et al., 2003; Hoge et al., 2004; Zandi et al., 2011). A possible reason for these findings could be that participants were in mid and later part of their training. Some studies have been conducted in first part of the military training (Hoge et al., 2004; Nazami et al., 2017). In addition, the environment may have contributed to the low levels of depression in the current study. Previous studies that found high prevalence of depression had been conducted in urban areas (Kessler et al., 2015; Nazami et al., 2017).

Additionally, the present study found a positive linear relationship between anxiety and depression. Previous studies have also revealed the relationship between anxiety and depression, (Kalin, 2020; Kessler et al., 2015; Beesdo et al., 2009). Anxiety and depressive disorders are among the most common psychiatric illnesses and they are highly comorbid with each other (Kalin, 2020). With respect to major depression, a worldwide survey reported that 45.7% of individuals with lifetime major depressive disorder had lifetime history of one or more anxiety disorders (Kessler et al., 2015). The present findings provide further evidence for the relationship between anxiety and depression.

The positive relationship between anxiety and depression suggests that a comprehensive approach is necessary to target both conditions simultaneously. Mental health support programmes and interventions tailored to the specific needs of officer cadets can contribute to improving their psychological well-being and resilience. Although no significant associations were found between anxiety and depression levels and the education level or training duration, it is important to consider other factors that may contribute to mental health outcomes among officer cadets. Future research could explore additional factors such as social support, coping strategies and the impact of specific training experiences on anxiety and depression symptoms.

The present study found a significant negative correlation between the level of depression and the level of education among cadet officers. This is consistent with previous research findings. Previous studies have suggested that individuals with higher levels of education are less likely to experience mental health problems (Mirowsky & Ross, 2003; Ross & Mirowsky, 2013). Higher levels of education provide individuals with better problem-solving skills and coping strategies, which help them to deal with stressors more effectively (Mirowsky & Ross, 2003). Therefore, it is important to provide educational opportunities for cadet officers to improve their problem-solving skills and coping strategies which help prevent psychological problems.

Conclusions and Recommendations

In conclusion, this study revealed the prevalence of anxiety and depression among officer cadets during basic army training. Findings of this study suggest the need for targeted mental health support during this critical period. The positive relationship between anxiety and depression underscores the importance of comprehensive interventions addressing both conditions simultaneously. Early detection and intervention through screening processes can identify at-risk cadets and provide timely support. Integrating resilience-building and stress management training into basic army training can equip cadets with effective coping strategies. Implementing tailored mental health support programmes that provide accessible resources, counseling services and coping mechanism training will be useful to enhance mental well-being of officer cadets.

Collaboration and open communication between military authorities, mental health professionals and officer cadets are essential to create a supportive environment that reduces stigma and encourages help-seeking. Further research is needed to explore additional factors influencing anxiety and depression among officer cadets. By implementing these recommendations, the Sri Lankan Army can prioritize the mental health of officer cadets ensuring their successful training completion and long-term well-being in their military careers.

Future research should consider exploring the underlying mechanisms that contribute to the development of anxiety and depression among cadet officers during basic army training. Studies

could explore factors such as social support, coping strategies, personality traits and pre-military mental health status that may influence the development of anxiety and depression among cadet officers.

Furthermore, future research can focus on exploring the effectiveness of interventions aimed at reducing anxiety and depression among cadet officers during basic army training. Interventions could include psychoeducation, cognitive-behavioural therapy, mindfulness-based interventions and physical exercise interventions. The effectiveness of these interventions could be evaluated using a randomized controlled trial design.

Overall, the present study provides important insights into the prevalence and predictors of anxiety and depression among cadet officers during basic army training in Sri Lanka. Nevertheless, further study is required to determine what factors contribute to the onset of mental health issues among cadet officers so that effective treatments may be created to lower the rates of anxiety and depression.

References

Abeysena, C., Peiris, U., Jayawardana, P., & Rodrigo, A. (2012). Validation of the Sinhala Version of 30-Item General Health Questionnaire. *International Journal of Collaborative Research on Internal Medicine & Public Health, 4*(7), 1373-1381. doi: https://doi:10.4038/jpgim.7859

Al-Amri, M., & Al-Amri, M. D. (2013). Prevalence of depression and associated factors among military personnel in the air base in Taif region. *American Journal of Research Communication, 1*(12), 21-45. http://www.usa-journals.com/wp content / uploads /2013 /11/ Al-Amri_ Vol112.pdf

Allen, N. (2003). Organizational Commitment in the Military: A Discussion of Theory and Practice. *Military Psychology, 15*(3), 237-253. doi: https://doi.org/10.1207/S15327876MP1503_06

Alloy, L. B., Abramson, L. Y., Whitehouse, W. G., Hogan, M. E., Tashman, N. A., Steinberg, D. L., Rose, D. T., & Donovan, P. (1999). Depressogenic cognitive styles: Predictive validity, information processing and personality characteristics, and developmental origins. *Behaviour Research and Therapy, 37*(6), 503–531.
doi: https://doi.org/10.1016/S0005-7967 (98)00157-0

American Psychological Association. (2020). *American Psychological Association Dictionary of Psychology.*
https://dictionary.apa.org/depression?amp=1

Aththidiye, R. (2012). *Adaptation and Validation of the Depression, Anxiety and Stress Scale-21 (DASS-21) among students in the University of Colombo.* Master's thesis, University of Colombo, Colombo.
http://archive.cmb.ac.lk:8080/xmlui/handle/70130/3898

Asad Zandi, M., Sayari, R., Ebadi, A. & Sanainasab, H. (2011). Frequency of depression, anxiety and stress in military Nurses. *Iranian Journal of Military Medicine Summer, 13*(2), 103-108.
doi: https://doi.org/10.30491/ijmr.2020.217384.1076

Beck, A. T. (1967). *Depression: Causes and treatment* (2 ed.). Philadelphia: University of Pennsylvania Press.
doi: https://doi.org/10.4236/jhepgc.2021.71006

Beesdo, K., Knappe, S., & Pine, D. S. (2009). Anxiety and anxiety disorders in children and adolescents: developmental issues and implications for DSM-V. *The Psychiatric clinics of North America, 32*(3), 483–524. doi: https://doi.org/10.1016/j.psc.2009.06.002

Bin Zubair, U., Mansoor, S., & Rana, M. H. (2015). Prevalence of depressive symptoms and associated socio-demographic factors among recruits during military training. *Journal of the Royal Army Medical Corps, 161*(2), 127–131.
doi: https://doi.org/10.1136/jramc-2014-000253

Bruce, S. E., Yonkers, K. A., Otto, M. W., Eisen, J. L., Weisberg, R. B., Pagano, M., Shea, M. T., & Keller, M. B. (2005). Influence of psychiatric comorbidity on recovery and recurrence in generalized anxiety disorder, social phobia, and panic disorder: a 12-year prospective study. *The American Journal of Psychiatry, 162*(6), 1179–1187. doi: https://doi.org/10.1176/appi.ajp.162.6.1179

Bryan, C. J., & Heron, E. A. (2015). Belonging protects against post deployment depression in military personnel. *Depression and Anxiety, 32*(5), 349–355. doi: https://doi.org/10.1002/da.22372

Clemons, E. P. (1996). Monitoring anxiety levels and coping skills among military recruits. *Military Medicine, 161*(1), 18-21. doi: https://doi.org/10.1093/milmed/161.1.18

Cigrang, J. A., Carbone, E. G., Todd, S. L., & Fiedler, E. (1998). Mental Health Attrition from Air Force Basic Military Training. *Military Medicine, 136*(12), 834-838. https://corescholar.libraries.wright.edu/sopp/56

Davis, R. N., & Valentiner, D. P. (2000). Does meta-cognitive theory enhance our understanding of pathological worry and anxiety? *Personality and Individual Differences, 29*(3), 513–526. doi: https://doi.org/10.1016/S0191-8869 (99)00211-1

Ehring, T. (2014). Cognitive theory. In: P. Emmelkamp & T. Ehring (Eds.), *The Wiley handbook of anxiety disorders*, Vol. 1. *Theory and research;* Vol. 2. *Clinical assessment and treatment* (pp. 104–124). Wiley Blackwell.

Freud, S. (1923). The Ego and the Id. In: J. Strachey et al. (Trans.), *the Standard Edition of the Complete Psychological Works of Sigmund Freud,* Volume XIX (pp. 1923- 1925). Hogarth Press.

Gaziano, J. M., Concato, J., Brophy, M., Fiore, L., Pyarajan, S., Breeling, J., Whitbourne, S., Deen, J., Shannon, C., Humphries, D., Guarino, P., Aslan, M., Anderson, D., LaFleur, R., Hammond, T., Schaa, K., Moser, J., Huang, G., Muralidhar, S., Przygodzki, R., & O'Leary, T. J. (2016). Million Veteran Program: A mega-

biobank to study genetic influences on health and disease. *Journal of Clinical Epidemiology, 70*, 214–223. doi: https://doi.org/10.1016/j.jclinepi.2015.09.016

Gold, M. A., & Friedman, S. B. (2000). Cadet basic training: an ethnographic study of stress and coping. *Military Medicine, 165*(2), 147–152. https://psycnet.apa.org/record/2000-13972-005

Goodwin, L., Wessely, S., Hotopf, M., Jones, M., Greenberg, N., Rona, R. J., Hull, L., & Fear, N. T. (2015). Are common mental disorders more prevalent in the UK serving military compared to the general working population? *Psychological Medicine, 45*(9), 1881–1891. doi: https://doi.org/10.1017/S0033291714002980

Hartley, S., Barrowclough, C., & Haddock, G. (2013). Anxiety and depression in psychosis: a systematic review of associations with positive psychotic symptoms. *Acta Psychiatrica Scandinavica, 128*(5), 327–346. doi: https://doi.org/10.1111/acps.12080

Hoge, C. W., Lesikar, S. E., Guevara, R., Lange, J., Brundage, J. F., Engel, C. C., Jr, Messer, S. C., & Orman, D. T. (2002). Mental disorders among U.S. military personnel in the 1990s: association with high levels of health care utilization and early military attrition. *The American Journal of Psychiatry, 159*(9), 1576–1583. doi: https://doi.org/10.1176/appi.ajp.159.9.1576

Hoge, C. W., Castro, C. A., Messer, S. C., McGurk, D., Cotting, D. I., & Koffman, R. L. (2004). Combat duty in Iraq and Afghanistan, mental health problems, and barriers to care. *The New England Journal of Medicine, 351*(1), 13–22. doi: https://doi.org/10.1056/NEJMoa040603

Joiner, T. E. Jr (1994). Contagious depression: Existence, specificity to depressed symptoms, and the role of reassurance seeking. *Journal of Personality and Social Psychology, 67*(2), 287–296. doi: https://doi.org/10.1037/0022-3514.67.2.287

Kalin, N. H. (2020). The critical relationship between anxiety and depression. *American Journal of Psychiatry, 177*(5), 365-367. doi: https://doi.org/10.1176/appi.ajp.2020.20030305

Kessler, R., Sampson, N., Berglund, P., Gruber, M., Al-Hamzawi, A., Andrade, L., & Wilcox, M. (2015). Anxious and non-anxious major depressive disorder in the World Health Organization World Mental Health Surveys. *Epidemiology and Psychiatric Sciences, 24*(3), 210-116. doi: https://doi.org/ 10.1017/S2045796015000 189

Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. *Educational and Psychological Measurement, 30*(3), 607-610. doi: https://doi.org/10.1177/001316447003000308

Kumar, U., Parkash, V., & Mandal, M. K. (2013). Stress in extreme conditions: A military perspective. In: S. C. Pandey & D. M. Pestonjee (Eds.), *Stress and Work: Perspectives on Understanding and Managing Stress,* (pp. 101–128). Sage Publications.

Larson, M. R., Ader, R., & Moynihan, J. A. (2001). Heart rate, neuroendocrine, and immunological reactivity in response to an acute laboratory stressor. *Psychosomatic Medicine. 63*(3),493–501. doi: https://doi.org/10.1097/00006842-200105000-00020

Lerew, D. R., Schmidt, N. B., & Jackson, R. J. (1999). Evaluation of psychological risk factors: prospective prediction of psychopathology during basic training. *Military Medicine, 164*(7), 509–513. https://psycnet.apa.org/record/1999-03268-002

Lovibond, S. H. & Lovibond, P. F. (1995). *Manual for the depression anxiety stress scales (2nd ed.).* Sydney: Psychology Foundation. doi: https://doi.org/10.1037/t01004-000

Lovering, M. E., Proctor, S. P., & Heaton, K. J. (2013). A retrospective study of anxiety disorder diagnoses in the military from 2000 to 2009. *Journal of Anxiety Disorders, 27*(1), 25-32. ISSN 0887-6185, doi: https://doi.org/10.1016/j.janxdis.2012.10.003

Martin, P. D. Williamson, D. A., Alfonso, A. J., & Ryan, D. H. (2006). Psychological Adjustment during Army Basic Training. *Military Medicine, 2,* 157-160.
doi: https://doi.org/10.7205 /milmed.171.2.157

Martin, A., Sanderson, K., and Cocker, F. (2009). Meta-analysis of the effects of health promotion intervention in the workplace on depression and anxiety symptoms. *Scandinavian Journal of Work, Environment & Health, 35*(1), 7–18.
doi: https://doi.org/10.5271/sjweh.1295

McLean, C. P. and Anderson, E. R. (2009) Brave Men and Timid Women? A Review of the Gender Differences in Fear and Anxiety. *Clinical Psychology Review, 29*, 496-505.
doi: https://doi.org/10.1016/j.cpr.2009.05.003

McLeod, S. A. (2015). *Psychological theories of depression*. https://www.simplypsychology.org/depression.html

Mirowsky, J., & Ross, C. E. (2003). *Education, social status, and health*. Aldine de Gruyter.
doi: https://doi.org/ 10.4324/9781351328081

Nasioudis, D., Palaiodimos, L., Dagiasis, M., Katsarou, A., & Ntouros, E. (2015). Depression in military medicine cadets: a cross-sectional study. *Military Medical Research, 2*, 28.
doi: https://doi.org/10.1186/s40779-015-0058-x

Nazami, M., Gholinezhad, V., Farahi, S. M. M. M., Kashani, S. R., & Moslemi, H. G. (2017). Comparison of psychological disorders among soldiers in two military units. *European Online Journal of Natural and Social Sciences, 6*(1), Special Issue on Economic and Social Progress, ISSN 1805-3602.
https://www.researchgate.net/publication/317401576_Comparison_of_Psychological_Disorders_among_Soldiers_in_Two_Military_Units

Nock, M. K., Deming, C. A., Fullerton, C. S., Gilman, S. E., Goldenberg, M., Kessler, R. C., & Ursano, R. J. (2013). Suicide among soldiers: A review of psychosocial risk and protective

factors. *Psychiatry: Interpersonal and Biological Processes, 76*(2), 97–125. doi: http://dx.doi.org/10.1521/ psyc.2013.76.2.97

Partonen, T. (1994). Effects of morning light treatment on subjective sleepiness and mood in winter depression. *Journal of Affective Disorders, 30*(1), 47–56. doi: https://doi.org/10.1016/0165-0327 (94)90150-3

Perera, H., Suveendran, T., & Mariestella, A. (2004). Profile of psychiatric disorders in the Sri Lanka Air Force and the outcome at 6 months. *Military Medicine, 169*(5), 396–399. doi: https://doi.org/10.7205/milmed.169.5.396

Rona, R. J., Jones, M., French, C., Hooper, R., & Wessely, S. (2004). Screening for physical and psychological illness in the British Armed Forces: I: The acceptability of the programme. *Journal of Medical Screening, 11*(3), 148–152. doi: https://doi.org/10.1258/0969141041732193

Rona, R. J., Hyams, K. C., & Wessely, S. (2005). Screening for psychological illness in military personnel. *Journal of the American Medical Association, 293*(10), 1257–1260. doi: https://doi.org/10.1001/jama.293.10.1257

Ross, C. E., & Mirowsky, J. (2013). The sense of personal control: Social structural causes and emotional consequences. In: C. S. Aneshensel, J. C. Phelan, & A. Bierman (Eds.), *Handbook of the sociology of mental health* (pp. 379–402). Springer Science + Business Media. doi: https://doi.org/10.1007/978-94-007-4276-5_19

Schmidt, N., Joiner, T., Young, J., & Telch, M. (1995). The Schema Questionnaire: Investigation of psychometric properties and the hierarchical structure of a measure of maladaptive schemas. *Cognitive Therapy and Research, 19*, 295-321. doi: https://doi.org/10.1007/BF02230402

Seligman, M.E. (1973). Fall into Helplessness. *Psychology Today, 7*, 43-48. doi: 10.4236/psych.2015.67087

Sharp, C., Wright, A. G. C., Fowler, J. C., Frueh, B. C., Allen, J. G., Oldham, J., & Clark, L. A. (2015). The structure of personality pathology: Both general ('g') and specific ('s') factors? *Journal of Abnormal Psychology, 124*(2), 387-398. doi: https://doi.org/10.1037/abn0000033

Skomorovsky, A., & Sudom, K. A. (2011). Psychological well-being of Canadian Forces officer candidates: the unique roles of hardiness and personality. *Military Medicine, 176*(4), 389–396. doi: https://doi.org/10.7205/milmed-d-10-00359

Tekbaş, Ö. F., Ceylan, S., Hamzaoğlu, O., & Hasde, M. (2003). An investigation of the prevalence of depressive symptoms in newly recruited young adult men in Turkey. *Psychiatry Research, 119*(1-2), 155-162. doi: https://doi.org/10.1016/s0165-1781 (03)00125-2

Tonon, A. C., Carissimi, A., Schimitt, R. L., de Lima, L. S., Pereira, F. D. S., & Hidalgo, M. P. (2020). How do stress, sleep quality, and chronotype associate with clinically significant depressive symptoms? A study of young male military recruits in compulsory service. *Revista Brasileira de Psiquiatria (Sao Paulo, Brazil: 1999), 42*(1), 54–62. doi: https://doi.org/10.1590/1516-4446-2018-0286

Vilhjalmsson, R. (1993). Life stress, social support and clinical depression: A reanalysis of the literature. *Social Science & Medicine, 37*(3), 331–342. doi: https://doi.org/10.1016/0277-9536 (93)90264-5

Walker, S. (2010). Assessing the mental health consequences of military combat in Iraq and Afghanistan: a literature review. *Journal of Psychiatric and Mental Health Nursing, 17*(9), 790-796. doi: https://doi.org/10.1111/j.1365-2850.2010.01603.x

Warner, C. H., Breitbach, J. E., Appenzeller, G. N., Yates, V., Grieger, T., & Webster, W. G. (2007). Division mental health in the new brigade combat team structure: Part II. Redeployment and postdeployment. *Military Medicine, 172*(9), 912–917. doi: https://doi.org/10.7205/MILMED.172.9.912

Warner, C. M., Warner, C. H., Breitbach, J., Rachal, J., Matuszak, T., & Grieger, T. A. (2007). Depression in entry-level military personnel. *Military Medicine, 172*(8), 795–799. doi: https://doi.org/10.7205/milmed.172.8.795

Wells, A. (1995). Meta-cognition and Worry: A cognitive Model of Generalised Anxiety Disorder. *Behavioural and Cognitive Psychotherapy*, *23*(3), 301-320. doi: https://doi.org/10.1017/S1352465800015897

Wilcox, S. L., Redmond, S., & Davis, T. L. (2013). Genital Image, Sexual Anxiety, and Erectile Dysfunction Among Young Male Military Personnel, *The Journal of Sexual Medicine, 12*(6), 1389-1397, ISSN 1743-6095, doi: https://doi.org/ 10.1111/ jsm.12880.

World Health Organization. (2001). *The World health report: 2001: Mental health: new understanding, new hope. World Health Organization.* https://iris.who.int/handle/10665/42390

Xiong, H., Zhang, X., Zhang, Y., Ma, F., Li, Y., & Li, L. (2005). An investigation of the prevalence of depressive symptoms in soldiers during military training, *Preventive Medicine, 41*(2), 642-645, ISSN 0091-7435, doi: https://doi.org/10.1016/j.ypmed.2005.01.010.

Zubair, U. B., Mansoor, S., & Rana, M. H. (2014). Prevalence of depressive symptoms and associated socio-demographic factors among recruits during military training. *Journal of Royal Army Medical Corps,* 1-5. doi: https://doi.org/10.1136/jramc-2014-000253

DOI: https://doi.org/10.4038/ouslj.v19i2.7664

RESEARCH ARTICLE

OUSL Journal, 2024
Vol. 19, No. 2, (pp.65-91)

Assessing Flipped Classroom Techniques for Business Management Education in Bangladesh

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Abstract

In the 21st century, Business Management students are becoming increasingly aware of the economic, technological, societal and global market dynamics shaping their fields. In response, educators must adapt to these evolving needs to effectively meet the demands of modern learners. Traditional teaching methods must be updated to foster the higher-order skills that are in high demand by employers. To engage students and cultivate these critical skills, a variety of pedagogical strategies are being implemented. One such strategy is the flipped classroom, which emphasizes application-based learning and active student participation, promoting higher-order thinking skills through a blended learning approach. This study seeks to assess the applicability of the flipped classroom strategy in Business Management classrooms in Bangladesh, ensuring alignment with the country's university curriculum. The research primarily draws on secondary data from various literature sources to explore both the significance and challenges of implementing the flipped classroom approach in Business Management education in Bangladesh. A critical evaluation of current practices highlights their limitations and

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(Received 01st November 2024; Revised 13th December 2024; Accepted 30th December 2024, © OUSL)

underscores the potential of the flipped classroom in fostering higher-order thinking skills. Additionally, the study presents a lesson plan, and rubrics developed based on the flipped classroom model, informed by the existing literature. The research also identifies potential challenges to implementation and explores how the flipped classroom strategy can support the development of higher-order skills among students. It is anticipated that this study will benefit tutors, academic institutions, education policymakers and administrators in Bangladesh by offering insights and strategies to enhance the employability skills of Business Management graduates.

Keywords: *flipped classroom, blended learning, higher-order skills, Business Management*

Introduction

The classroom, traditionally, the center of formal learning, is undergoing a shift in educational practices, especially with the widespread use of Web 2.0 tools like Facebook, WhatsApp, YouTube, Zoom and Google Forms. 21st-century learners are adept at sourcing information from open platforms, which is transforming how education is delivered. In Bangladesh, however, formal learning still relies heavily on traditional, classroom-based systems that face numerous challenges. These include large class sizes, limited class time, heavy coursework, inadequate infrastructure, outdated performance evaluation methods, an underdeveloped curriculum and a lack of teachers trained in modern teaching techniques (Chowdhury et al., 2020). As a result, student absenteeism is on the rise, further hindering the delivery of quality education. Many educators continue to use the conventional, lecture-based, teacher-centered approach, which often fails to engage students effectively. Without activity-based teaching methods, it is increasingly difficult to capture students' attention and keep them engaged with the course material.

The conventional teacher-centered learning approach offers several advantages, such as better control over large class sizes and the ability to cover a significant amount of content in a limited time. However, it also presents notable drawbacks, as pointed out by Chowdhury. Moreover, Anisha (2017) identifies several factors that undermine the effectiveness of traditional classrooms, including a lack of adequate teaching resources, an inability to adapt to evolving

learning styles, failure to incorporate both print and digital media, poor classroom management, weak communication skills and teachers' limited capacity to integrate new educational technologies. In many traditional classrooms, instructors rely heavily on lectures and rarely incorporate interactive or participatory activities. As a result, students often struggle to apply their learning to real-world contexts, hindering the development of higher-order skills such as analysis, evaluation and creativity. This issue is particularly prevalent in Bangladesh's tertiary education system, especially, in fields like Business Management (Islam & Paul, 2019). To address these challenges and improve the learning environment, it is essential for educators and administrators to adopt teaching methods that foster higher-order cognitive skills. A promising solution is the flipped classroom model, which can enhance classroom engagement, foster critical thinking and promote problem-solving and creativity among students.

Objectives of the study

This study primarily aims to evaluate the applicability of the flipped classroom strategy in the context of Business Management classrooms in Bangladesh, based on the country's university curriculum. Additionally, the study has several supporting objectives:

- To explore the significance of the flipped classroom strategy in skill development.
- To design a lesson plan based on the flipped classroom strategy.
- To identify the key challenges associated with implementing the flipped classroom approach.

Review of Literature

The flipped classroom is an innovative instructional strategy that has emerged in education as part of blended learning systems. Wang (2017) defines the flipped classroom as an "inverted classroom" model, where the instructor first addresses key aspects of the course material, combining clear explanations with personal experiences and new knowledge, then records a video summarizing the lecture content. Students watch this video before attending class allowing them to use

class time for interactive activities such as engaging in discussions with the instructor and peers, sharing critical insights and participating in collaborative learning. Afterward, students take part in a pre-prepared test designed by the instructor to assess their understanding and learning progress. This approach ensures that students are introduced to new concepts outside of class and actively participate in group discussions, cooperation with peers and dynamic interactions with the instructor.

Flipped classroom strategies serve three primary purposes: (1) to increase student engagement in the classroom, (2) to enable students to familiarize themselves with the course material at home, and (3) to involve students in real-time problem-solving during class (Roehling & Bredow, 2021). The flipped classroom is a relatively new concept in the Bangladeshi education system, offering a significant opportunity for a pedagogical shift from a focus on quantitative learning to a more qualitative approach (Afroze, 2024). In traditional classrooms, instructors deliver lectures focused primarily on the curriculum, without engaging students in interactive academic activities, often resulting in the development of only lower-order cognitive skills. Generally, tutors in Bangladesh are not aware of students' preparation before they join a class. The focus tends to be primarily on the in-class time, during which conventional lectures are delivered. However, these lectures are often unattractive to students because they don't have ample opportunities to engage with the course content. In this context, implementing a flipped classroom strategy could help transform the education system in Bangladesh by fostering greater student involvement and enhancing learning outcomes. Nwosisi et al. (2016) describe the flipped classroom process as a form of blended learning where students engage with specific academic topics through both online and offline methods. The authors identify the roles of both teachers and students in a flipped classroom across three stages: before class, during class and after class. These roles are outlined as follows (Table 1):

Table 1. *Roles of students and tutors to implement flipped classroom strategy*

Time	Role of Tutors	Role of Students
Before Class	✓ Prepare lecture content using PowerPoint, MS Excel or MS Word. ✓ Record a video lecture focused on the academic curriculum. ✓ Share the video lecture with students through Web 2.0 platforms.	• Watch the video before attending the in-person class. • Identify key areas of the lecture where they have misconceptions or misunderstandings.
During Class	✓ Address students' misunderstandings through discussion. ✓ Organize activities that promote higher-order skills, such as application, evaluation and creation of knowledge. ✓ Continuously monitor student engagement and activity.	• Share their misunderstandings with the instructor. • Participate in various academic activities assigned by the instructor. • Support and collaborate with peers in their learning.
After Class	✓ Assign homework that encourages the development of higher-order thinking skills, providing clear instructions for completion at the learner's own pace.	• Complete assigned exercises to develop higher-order thinking skills while maintaining regular communication with course instructors.

Significance of flipped strategy

Information and Communication Technology (ICT) has significantly reshaped the working patterns across various sectors with education being no exception. The advancement of ICT has profoundly impacted traditional learning environments, enhancing the integration of digital tools and technologies. These innovations have had a major influence on educational concepts such as flipped classrooms, e-learning, collaborative learning and online learning. Khan & Abdou (2021) argue that the flipped classroom model can serve as a valuable alternative to conventional teaching methods. According to their study, this approach facilitates active learning by providing students with immediate support from instructors, using the taxonomy of Web 2.0 tools. For this to be effective, it is essential for both tutors and students to adapt to the Web 2.0 framework. Sharma et al. (2014) emphasize that this approach is centered on application-based learning, allowing students to engage actively in solving real-world problems related to course content. Unfortunately, such active problem-solving participation is largely absent in the Bangladeshi education system. Pallathadka & Pallathadka (2020) identify several advantages of the flipped classroom which traditional methods often fail to provide. These include creating applicable content during sessions, offering platforms for simultaneous practice and learning, fostering creativity, promoting team-building skills and improving classroom management for more efficient use of time and resources. The flipped classroom strategy also has a positive impact on Learning Management Systems (LMS). Ugwoke et al. (2017) found that the flipped strategy has a more favourable influence on LMS compared to the traditional face-to-face (F2F) method. Their study identified three key types of interaction in flipped classrooms: student-to-student interaction, collaboration between tutors and students and the use of interactive features in the LMS, alongside continuous active mentoring by instructors. These interactions are crucial for creating an effective learning environment. In traditional classrooms, however, students often miss out on opportunities for meaningful interaction with their peers and instructors due to various factors, such as limited class time, large class sizes and heavy course content.

Blended learning approach for flipped classroom

Blended learning is highly valued for its positive impact on student satisfaction, the effectiveness of in-class activities and the better utilization of class time (Karmaker, 2021). However, both tutors and learners must adapt their mindsets to align with this new style of learning. According to Srinivasan & Kumar (2019), both educators and students need to shift their perspectives to effectively implement the flipped classroom strategy which encourages reactive learning and fosters the development of higher-order skills among students. There is ongoing debate among researchers regarding the appropriate level at which the flipped strategy should be applied in the education sector. Dominguez (2021) argued that the flipped classroom model is more beneficial in secondary and higher education than in primary education. Furthermore, Altemueller & Lindquist (2017) noted that implementing the flipped classroom technique can be particularly challenging in certain disciplines, such as Medical Science, Programming, Physics and Machine Learning. However, they also suggested that this approach works more effectively in the classrooms of disciplines like Arts, Social Sciences and Business Studies.

Challenges of implementing the flipped strategy

The implementation of the flipped classroom technique comes with several mandatory requirements that can pose significant challenges. These challenges often stem from three key stakeholders in the formal learning environment: students, teachers and teaching administrations. Vuong et al. (2018) identified several common obstacles to implementing the flipped strategy, including the lack of self-regulated learning skills, excessive academic workload, insufficient logistical support and the unavailability of ICT devices and internet access. These issues are particularly relevant in the context of Bangladesh's educational institutions. Additionally, Fedistia et al. (2019) found that students often have a negative attitude toward participating in the flipped classroom process, largely due to the lack of technological support. According to their findings, transitioning to a flipped learning system requires both time and investment to effectively adapt all stakeholders—students, teachers and administration.

There are also challenges on the teacher's side when implementing the flipped classroom strategy. Tutors require training and time to familiarize themselves with this innovative learning approach (Apriska & Sugiman, 2020). Additionally, they need access to digital technologies such as smartphones, computers, laptops, reliable internet and a continuous electricity supply. These technological needs represent significant challenges, as many educational institutions in Bangladesh are often limited in these resources. Furthermore, the flipped strategy can lead to an increased workload for teachers. Resistance from students may also arise due to unfamiliarity with this new approach to learning.

Research gap

The literature review reveals that the flipped classroom strategy is a unique approach in making classrooms more engaging and attractive to students. Unfortunately, this method of classroom management remains relatively unknown in the Bangladeshi education system, particularly in the field of Business Management Education at the tertiary level (Afroze, 2024). While some departments within the Arts and Science faculties have adopted this strategy, it is yet to be integrated into the learning management systems of Business Management programmes. Additionally, there is a lack of research on the applicability, challenges and potential benefits of implementing the flipped strategy among Bangladeshi academics. Although some studies have been referenced in the literature, most of the findings originate from international academic contexts. This study aims to explore the challenges of creating a conducive learning environment and to provide a logical justification for applying the flipped classroom strategy in business management to foster the development of higher-order skills.

Context and Current Practice

Context

This study focuses on business education at the National University of Bangladesh, the third-largest affiliating university in the world in terms of student enrolment. The university plays a vital role in providing tertiary education across the country. It has 2,257 affiliated

government and non-government colleges, with a total enrolment of 2,089,909 students. These colleges offer a variety of academic programmes at the tertiary level including pass courses, Honours, Masters, Preliminary Masters, Postgraduate Diplomas, Diplomas and professional courses. Additionally, the central campus offers advanced programmes such as the 4-year Honours course, Master of Business Administration (MBA), Master of Advanced Studies, Postgraduate Diplomas, Master of Philosophy (MPhil) and Doctor of Philosophy (PhD) programmes (NU, 2022).

Current practice

The academic curriculum at National University (NU) follows a conventional, teacher-centred, lecture-based classroom management system with little to no academic tasks or student engagement during class time. While this approach offers several advantages—such as easy class control, the ability to cover extensive lecture content, teacher-centred delivery, minimal preparation time for instructors and ease of presenting material to large class sizes—it also has notable limitations. These include limited opportunities for student engagement, low interaction with the course content, increased absenteeism and a failure to promote higher-order thinking skills. To address these limitations, it is essential to move away from traditional classroom management methods and adopt more innovative approaches, such as the flipped classroom or blended learning, to better engage students and foster deeper learning.

Critical reflection on current practice

The conventional teacher-centred lecture method is commonly used in Business Management classrooms at National University (NU). Class sizes are typically large, ranging from 50 to 100 students, with class durations varying between 45 and 60 minutes. The courses are usually worth 3 credits, and the content load is often heavy. As a result, instructors primarily rely on delivering lectures with minimal student engagement in practical activities, making it challenging to maintain student attention and concentration. Furthermore, a traditional, centralized, paper-based examination system is used to assess students' performance, in accordance with strict university policies. This system limits the students' ability to demonstrate

creativity and innovation.

While this traditional approach offers certain advantages, such as easy classroom management, straightforward lecture preparation, the ability to cover large volumes of content and a simple evaluation process, it also has significant drawbacks. The main issue is the limited student involvement in the learning process. Factors such as time constraints, heavy course content, large class sizes, overcrowded classrooms, student diversity, ineffective evaluation methods and the potential for personal bias, all hinder student engagement.

Under the current system, the students' role is largely passive—they listen to lectures, memorize the material for exams and focus on understanding the content to achieve good grades. However, this approach fails to encourage students to apply, analyze or create in real-life situations. Additionally, the centralized examination system primarily fosters lower-order thinking skills. These issues are deeply rooted in the traditional education system in Bangladesh as well as the prevailing mindset within the teaching community. To assess academic performance, the Business Faculty typically follows a fixed structure for each course, which tutors are required to adhere to. This structure includes the following activities (Table 2):

Table 2. *Present practices regarding evaluation*

Contents		Allotted Marks
Class attendance	:	05
Mid-term examination	:	20
Assignment/ presentation/ quiz	:	05
Semester final course work written examination	:	70
Total	:	**100**

(NU, 2022)

Under the current system, students typically face written, paper-based, centralized exams where they are required to recall and write

their memorized knowledge within a specific time frame. This structure leaves little room for instructors to use alternative forms of assessment such as case reviews, literature reviews, brainstorming sessions, group discussions, behaviour modelling, simulations and collaborative group work. Additionally, today's 21st-century learners are highly adept in areas like technology, finance and communication, and they are eager to explore new ideas. They are creative, adaptable and capable of adjusting to new systems. Therefore, a more dynamic and engaging approach to classroom design is needed—one that can be achieved through blended learning which encourages greater student involvement.

Unfortunately, many instructors still rely solely on basic tools like PowerPoint, Microsoft Word and Excel in their classrooms which fail to meet the diverse needs of modern learners. As a result, these methods struggle to generate student enthusiasm for the lectures. In contrast, incorporating a variety of Web 2.0 tools—such as Facebook, YouTube, Twitter, Google Forms, Zoom, Google Meet, Google Drive and Messenger—can significantly enhance student engagement and involvement in both classroom and academic activities (Bedir, 2019).

Feelings about present practice

The current practices in classroom management often leave both tutors and students feeling exhausted due to various limitations that make it difficult to engage students effectively. The traditional approach, which focuses primarily on delivering lectures and covering academic content, tends to promote lower-order skills such as memorization and comprehension. As a result, this method often becomes tedious for students, leading to disengagement and a lack of interest in the class. To address this, instructors should reconsider and modify their teaching methods to make the classroom more engaging and enjoyable for students. In this context, the flipped classroom strategy offers a promising solution, enabling tutors to shift from a teacher-centred to a student-centred, blended approach to classroom management. This strategy emphasizes the efficient use of class time through a variety of academic activities, rather than relying solely on traditional lecture-based methods (Milman, 2012).

Evaluation of current practice

The current education system often fails to maintain the students' attention throughout the entire class, primarily due to its reliance on lecture-based teaching without engaging students in various academic activities such as case studies, group work, problem-solving, role-playing, mind games, brainstorming and behaviour modelling. As a result, many students resort to internal communication with their peers, further complicating efforts to keep them focused. Additionally, performance evaluation plays a crucial role in assessing the students' abilities against established standards. According to DeCenzo & Robbins (2010), the performance appraisal process begins with setting performance standards aligned with strategic goals. This evaluation can be either centralized (paper-based) or decentralized incorporating different academic tasks.

However, the traditional centralized, paper-based evaluation system has several inherent flaws such as the potential for cheating, manipulation by teachers, sharing of answers during exams and the lack of real-world application in the assessments. To address these issues, students should be presented with practical tasks in the classroom that allow them to apply their learning to real-life situations. In this context, the flipped classroom strategy could play a key role in reducing the distortions in current evaluation practices, making assessments more meaningful and relevant.

Analyse

To address the limitations of current practices, it is essential to shift away from the traditional lecture-based teaching style and incorporate more interactive class activities such as group work, behaviour modelling, mind games, case studies, simulations and journal reviews. These activities will foster significant improvements in the cognitive, affective and psychomotor domains of learners. Additionally, they will provide a more effective means of performance evaluation compared to the conventional, paper-based centralized exams. This transformation will also enable more efficient use of class time by integrating Web 2.0 tools, sparking excitement and engagement in students. By encouraging students to apply, analyse and create new knowledge, it will promote the development of higher-order skills.

For this shift to be successful, the university's current policies on classroom management and student evaluation need to be updated. The transformation will require resources such as time, funding, training and technology to support the adoption of new systems. If implemented effectively, this approach will help students relate their learning to real-life situations. When tutors design lessons that reflect real-world contexts, students will be more motivated and enthusiastic about classroom activities, enhancing their higher-order skills. To achieve this, the instructors must be well-prepared and strategically plan their classes, incorporating innovative pedagogical strategies like the flipped classroom model.

Action Plan

Introducing the flipped strategy into the Business Management class

A well-organized plan is essential to implement a flipped classroom that addresses key requirements and fosters higher-order thinking skills. This task should be carried out by tutors in collaboration with the teaching administration. Additionally, students must be well-informed and adequately prepared to engage in the various activities organized by the tutor. In this context, the tutor should structure class time to include a range of innovative academic activities such as group problem-solving, group discussions, group presentations, literature reviews, behaviour modelling, mirroring, simulations and case studies to ensure that students are engaged and motivated in the learning process. Tutors should also prepare teaching materials—such as PowerPoint presentations, videos and Word documents on specific topics—and share them via digital platforms, such as a messenger group, to enhance accessibility. Below is a sample lecture format on the topic of Leadership (Table 3). Rubrics for summative assignment are given in Table 4.

Table 3. *Sample lesson plan by addressing the flipped strategy*

Instructor	**:**	*********
Subject	**:**	BBA in Management
Course name	**:**	Principles of Management
Date	**:**	-------
Duration	**:**	45 min.
Lesson title	**:**	**Planning**
Learning objective	**:**	The purpose of this class is to share the **definition**, **comparison** between the features of planning and the **steps** to develop an ideal plan among the learners.
Learning outcomes (LO) After the end of the class, the learners will be able to:		
Before class	**:**	LO.1 Define plan.
In-class	**:**	LO.2 Compare the features of plan.
After class	**:**	LO.3 Develop a plan for starting a new product.
Before class learning journey (work with LO.1) (The learners have to study before joining the class to the following contents.)		
Learning Resource Management		
Learning resources : i. **Recorded video lectures link :** ✓ https://youtu.be/cIviNyZJTVY?si=cb4wbEPm-Fapn1pH ✓ https://www.youtube.com/watch?v=FUXJarjPBfo		

ii. **PDF copy on planning :**

- ✓ https://www.scribd.com/document/238970132/Characteristics-of-Planning
- ✓ https://www.scribd.com/document/387600234/Nature-and-Characteristics-of-Planning-docx

iii. **2 samples of plan document :**

- ✓ https://www.smartsheet.com/content/simple-business-plan-templates;
- ✓ https://www.smartsheet.com/content/one-page-business-plan-templates

Learning management system :

i. Use of Zoom platform;

Digital tools:

i. WhatsApp group
ii. Mail
iii. YouTube
iv. Websites

Learning activities:

Student's activity :

i. Student have to **watch the videos** before entering into classroom.

ii. They should **take notes** on the videos where they had any confusion.

iii. They should **read the PDF files** and also take notes.

iv. They should **share** their confusion at the beginning of the class.

Formative assessment:

After watching the video class and reading PDF file, the learners will face a KAHOOT test including the following questions having 20 sec. for each:

KAHOOT Link: https://create.kahoot.it/details/1925bd6c-93ee-449e-a481-295a1765def1

Questions are:

Which is not a feature of plan?

a. Time oriented
b. Budget oriented
c. Fully imaginary
d. All

True or false?

Plan is the reflection of future.

Gap Fill

Planning involves the allocation of the _____ of the organization.

In-class learning journey (work with LO.2)
(The learners will participate in classroom activities)

Stages	Timing	Activity
Introduction	10.00 am to 10.10 am	✓ Welcoming ✓ Stimulating the learners with asking their confusion ✓ Discussion
Description of the activities with guidelines to practice	10.10 am to 10.20 am	**Group work** ✓ Students are directed to participated in **5** groups having **6** members in each

		✓ Group will be formed by **mixing** male and female, also high and low performers ✓ Groups are assigned to **identify** the features of a good plan based on their before class activities ✓ Then they will **compare** the features of planning based on **criterion** i.e. time, crisis, standard situation ✓ Prepare a **PPT** covering the all instructions
Assessment plan	10.20 am to 10.50 am	**Presentation:** ✓ Group-1 will be assigned to present and Group-3 will be assigned to ***comments critically*** on the findings of Group 1 and ***vice versa****;* ✓ Group-2 will be assigned to present and Group-4 will be assigned to ***comments critically*** on the findings of Group 2 and ***vice versa****;* ✓ **Group 5** will be assigned to summarize the whole presentation; *(Each group will have to present within 3 minutes and commentary will be conducted for 2 minutes. Group 5 will summarize within 3 minutes.)* *After the end of the presentation, as an instructor, I will also provide my own observations (if necessary)*

		Then, a short quiz through Google Form will be conducted to assess the learner's achievement. **The link of the Google Form is: https://forms.gle/ezkz6wcgHgUsVccHA** **Feedback:** Soon after the end of the test, I will clarify the correct answers of the questions that will help the learners who failed to get the correct answers.
Reflection and closure	10.55 am to 11.00	**Q/A session :** At this stage, I'll ask two learners to define plan and identify 2 most significant features of plan to reflect their understanding through a **question-answer** session.

After-class learning journey (work with LO.3)

(Name and clear guidance of the activity)

Summative assessment plan

Students are directed to complete an assignment on

Prepare a business plan to embark carrot juice

They should cover the followings :

i. Identifying the market
ii. Budget and costing
iii. Return on Investment
iv. Factory location
v. Promotional work

Operational instructions:

- ✓ Must be submitted within 3 days after the class
- ✓ This assignment will carry 5% total marks for the course
- ✓ Must include the vital steps of plan development
- ✓ Identify the probable challenges with solutions
- ✓ Use of real-life data with references
- ✓ Word limits are 500
- ✓ Submit through mail (nahidnu014@gmail.com)

After getting the plan, a detailed feedback will be given to the learners to improve the plan and will also allow more 2 days to update it. ✓ Finally, they will send it back again through mail as final submission
Assessment
✓ The assignment will be graded on the basis of selected rubric. *The rubric is attached in the Appendix section.* ✓ The grade will be added for total performance evaluation.

Table 4. *Rubrics for summative assignment*

Performance criteria	**Weight**	**Ratings**				**Score** (Weight* learner's performance ratings)
		Excellent	Good	Average	Needs Improvement	
		(4)	(3)	(2)	(1)	
Contents and instructions:	3	The plan **thoroughly** showcases **all** the steps of forming the plan. It exceptionally provides **multiple** details of the steps, **examples, breakdown** of activities	The plan showcases **all** the steps of forming a plan**, examples, activities** of market identification, budgeting, ROI, determination of location, promotio	The plan showcases the **steps** of forming plan But lacks the **examples, activities** of market identification, budgeting, ROI, determination of location,	The plan lacks **some** of the steps of forming plan along with the **examples, activities** and **evidence**	3*4=12

		i.e. *market identification, budgeting, ROI, determination of location, promotional work supporting* **details** and **evidence**	nal work and **evidence.**	promotional work and **evidence**		
Organization and Linkage	4	The constructed plan is **exceptionally** well-structured with a **clear** *introduction, body* and also identifying the **probable challenges** while applying into practices. The stages of the plan **logically flow**	The constructed plan is **well-organized** covering the **introduction**, **body** and **probable challenges** to apply. The stages are presented **logically**	The plan is somewhat constructed but **lacks** a clear introduction, body, challenges and logical sequence.	The plan **lacks** a clear introduction, body, challenges making it difficult to understand.	4*4=16

Relevancy of the Data	2	The constructed plan has used **exceptionally** realistic data with **well** citation, from **authentic** sources including **home** and **abroad**	The constructed plan has used realistic **data** with **citation**, from **different** sources including **home** and **abroad**	The constructed plan has lack of **realistic data**, **citation**, and representation of sources from both home and **abroad**	The constructed plan has lacking of the **realistic data**, **citation,** and representation of sources.	2*4=8
Adaptability	1	The constructed plan exceptionally showcases **flexibility** by **identifying** the alternatives, along with **probable problems** and **solutions** which make the plan **more adaptable**	The constructed plan showcases the **flexibility** by identifying **few** alternatives, along with **probable problems** and **solutions** which make the plan **adaptable**	The constructed plan lacks the f**lexibility** due to lacking **acceptable** alternatives that makes difficult to make it **adaptable.**	The constructed plan lacks the f**lexibility** due to **having no** alternatives that make it difficult to be **adaptable.**	1*4=4
Total	10					40

Explanation of the ratings

Range		Explanation
1-10	=	Needs improvement
11-20	=	Average
21-30	=	Good
31-40	=	Excellent

Implementation

The implementation of the flipped classroom strategy, alongside Bloom's Taxonomy, to foster higher-order thinking skills requires support from all stakeholders in the educational process as well as sufficient time for adaptation to the new system. However, several challenges may arise when adopting this innovative learning approach. Below are the key challenges associated with implementing the flipped strategy along with the actions required to overcome them.

The mindset of teaching administration is a significant barrier to implementing the flipped classroom strategy. They must acknowledge the limitations of current practices and be motivated to embrace changes in classroom management. To address this, training sessions, seminars and workshops should be organized to highlight the shortcomings of existing practices.

Moreover, the current evaluation system needs to be revised to align with the flipped classroom approach. Relevant teaching authorities must prioritize this issue, as without modifying the evaluation procedures, the flipped strategy will not achieve the desired outcomes. It is essential for administrators, teachers and students to be aware of the limitations of the current evaluation system and understand the benefits of adopting a new approach.

Although the flipped classroom is a form of blended learning, it requires students to adapt to various aspects of digital taxonomy. Additionally, students must have access to digital devices, reliable internet connections, uninterrupted power supply and other logistical support to fully engage in class activities. The tutor needs pedagogical

and ICT skills that may develop through training to perform academic tasks effectively (Mia, 2007). I will communicate officially with the guardians to ensure that adequate logistical support is provided for the students.

The current academic curriculum poses a significant challenge to implementing the flipped classroom strategy. At present, tutors are required to cover a large volume of content within a short period while students tend to focus on memorizing key points for exams. To successfully implement the flipped strategy, this approach needs to be addressed. In this regard, the teaching administration must play a crucial role in changing the current practices.

A common tendency among people is resistance to change. As a result, the implementation of the flipped classroom strategy may face opposition from various groups associated with my teaching, including colleagues, the teaching administration, students and guardians, due to the new approach to classroom management. To overcome this resistance, it will be essential to organize training sessions, seminars and workshops to familiarize everyone with the flipped strategy, helping them understand both the advantages and disadvantages of current practices.

Motivation among learners must be cultivated to engage with the new method by actively participating in various academic activities. They need to be committed to investing their time both in and outside the classroom—watching video lectures, identifying areas of misunderstanding and engaging in the activities assigned by the tutors.

Conclusions

In today's digitalized world, traditional classroom management strategies—primarily teacher-centered and lecture-based—fail to address the needs of students in fostering higher-order thinking skills in Business Management classes. These approaches lack active student involvement through diverse academic tasks which are essential for developing critical skills. To address this, both teaching administrators and tutors must shift their mindset and adopt new pedagogical methods that create an effective classroom environment

conducive to learning. Tutors should implement innovative teaching styles that focus on developing higher-order skills while making the most of limited classroom time given the vast curriculum and academic content. In this context, the flipped classroom strategy offers an ideal alternative allowing tutors to maximize class time by incorporating various academic activities. These activities—such as group work, poster presentations and case studies—provide students with opportunities to engage deeply with the content and stimulate constructive changes in their learning. This approach emphasizes blended learning which promotes the application, evaluation and creation of knowledge. While the flipped classroom strategy presents some challenges in Business Management education in Bangladesh, teaching administrators can invest in educational institutions to provide essential logistical support such as digital resources, reliable internet and uninterrupted electricity. Most importantly, they should organize training sessions for Business Management tutors to help them adapt to the flipped classroom model. Tutors must also be motivated to embrace this new approach and actively engage students in both in-class and out-of-class academic activities. Without their full commitment to changing classroom management practices, achieving higher-order thinking skills will remain difficult. However, investing in transforming classroom practices could lead to significant improvements in the education system. Students will be able to engage in creative tasks that encourage innovation which will be valuable in their professional lives. Additionally, this strategy can reduce dropout rates, enhance student participation, and minimize cheating during exams by ensuring continuous monitoring of students' performance. The flipped classroom can also encourage active student involvement, fostering creativity and innovation. By moving away from rote memorization, this strategy could bring about a major shift in the education system. To realize the benefits of the flipped classroom strategy, a positive mindset among all stakeholders in the teaching management system is crucial. Teaching administrators need to invest in transforming classroom practices which will indirectly contribute to the overall economy by producing skilled graduates with higher-order thinking abilities in Business Management.

References

Afroze, M. (2024). Implementation and Prospect of Flipped Classroom in Government Rajendra College, Bangladesh. *Journal of Social Science, Rajshahi College, 05*(01), 19-24. https://rc.gov.bd/jss/2024/08/14/implementation-and-prospect-of-flipped-classroom-in-government-rajendra-college-bangladesh/

Altemueller, L., & Lindquist, C. (2017). Flipped classroom instruction for inclusive learning. *British Journal of Special Education*, *44*(3), 341–358. doi: https://doi.org/10.1111/1467-8578.12177

Anisha. (2017). Issues and Challenges Facing Educators in Perspective Era. *Educational Quest-an International Journal of Education and Applied Social Sciences*, *8*(1), 23. doi: https://doi.org/10.5958/2230-7311.2017.00004.6

Apriska, E., & Sugiman. (2020). Flipped classroom research trends in mathematics learning in Indonesia. *Journal of Physics: Conference. Series*, *1613*, 012030. doi: https://doi.org/10.1088/1742-6596/1613/1/012030

Bedir, H. (2019). Pre-service ELT Teachers' Beliefs and Perceptions on 21st Century Learning and Innovation Skills (4Cs). *Dil ve Dilbilimi Çalışmaları Dergisi*, *15*(1), 231–246. doi: https://doi.org/10.17263/jlls.547718

Chowdhury, M. H., Absar, M. M. N., & Quader, S. M. (2020). Challenges and Developments in the Higher Education System of Bangladesh. *Handbook of Education Systems in South Asia*, 1–32. doi: https://doi.org/10.1007/978-981-13-3309-5_57-1

DeCenzo, D. A., & Robbins, S. P. (2010). *Fundamentals of Human Resource Management (8th Edt.).* Wiley Student Edition. Pp. 249-250. https://bcs.wiley.com/he-bcs/Books?action=index&itemId=0471656801 & itemTypeId=BKS&bcsId=2055

Dominguez, H. G. (2021). Flipped Classroom in the Educational System: Trend or Effective Pedagogical Model Compared to other Methodologies? *Journal of Educational Technology & Society, 24* (3), 44-60. https://www.jstor.org/stable/27032855

Fedistia, R., Musdi, E., & Yerizon (2019). Advantages and Challenges of the Flipped Classroom Application –Based Learning in Enhancing 10th Grade Senior High School Students' Reasoning Ability. *International Journal of Scientific & Technology Research, 8*(8), 916-919. https://www.ijstr.org/final-print /aug2019/ Advantages-And-Challenges-Of-The-Flipped-Classroom-Application-Based-Learning-In-Enhancing-10th-Grade-Senior-High-School-Students-Reasoning-Ability.pdf

Islam, M. R., & Paul, A. K. (2019). Current Practice of Student-Centred Classrooms for Learning English at Tertiary Colleges in Bangladesh: Issues and Solutions. *Global Journal of Human-Social Science: G Linguistics & Education, 19*(03), 22-31. https://globaljournals.org/GJHSS_Volume19/3-Current-Practice-of-Student-Centred.pdf

Karmaker, P. R. (2021). Flipped Classroom in Bangladesh at Jagannath University: A Critical Reflection. *Rabindra University Journal, 02*, 193-204. https://rbu.ac.in/home/avz9s6ve0gq6/public_html/ckfinder/userfiles/files/Journal%20of%20Education%2C%20Vol_%20-%20XVIII.

Khan, Md. S. H., & Abdou, B. O. (2021). Flipped classroom: How higher education institutions (HEIs) of Bangladesh could move forward during COVID-19 pandemic. *Social Sciences & Humanities Open, 4*(1), 100187. doi: https://doi.org/10.1016/j.ssaho.2021.100187

Mia, M. N. (2017). Measurement of Training Effectiveness: An Empirical Study on National University Teachers' Training Programme. *BUP Journal, 5*(2), 59-79. https://www.academia.edu/40262224/Measurement_of_Training_Effectiveness_An_Empirical_Study_on_National_University_Teachers_Training_Programme

Milman, N. B. (2012). The Flipped Classroom Strategy: What is It and How Can It Best Be Used? *Distance Learning*, *9*(3), 85–87. https://www.academia.edu/22761397/The_Flipped_Classroom_Strategy_What_Is_It_and_How_Can_It_Best_Be_Used

NU (2022). *National University, Bangladesh, At a Glance*. https://www.nu.ac.bd/nu-at-a-glance.php

Nwosisi, C., Ferreira, A., Rosenberg, W., & Walsh, K. (2016). A Study of the Flipped Classroom and Its Effectiveness in Flipping Thirty Percent of the Course Content. *International Journal of Information and Education Technology*, *6*(5), 348–351. doi: https://doi.org/10.7763/ijiet.2016.v6.712

Pallathadka, H., & Pallathadka, L. K. (2020). Flipped Classroom Approach: Opportunities and Challenges. *European Journal of Molecular & Clinical Medicine, 7*(10), 4162- 4168. https://www.researchgate.net/publication/351871237_

Roehling, P., & Bredow, C. (2021). *Flipped learning: What is it, and when is it effective?* https://www.brookings.edu/articles/flipped-learning-what-is-it-and-when-is-it-effective/

Sharma, N., Lau, C. S., Doherty, I., & Harbutt, D. (2014). How we flipped the medical classroom. *Medical Teacher*, *37*(4), 327–330. doi: https://doi.org/10.3109/0142159x.2014.923821

Srinivasan, S., & Kumar, H. (2019). Flipped Classroom Model – A Response to the Emerging Trends in the Teaching Learning Landscape. (2019). *International Journal of Recent Technology and Engineering*, *8*(3S3), 297–304. doi: https://doi.org/10.35940/ ijrte.c1068.1183s319

Ugwoke, E. O., Edeh, N. I., & Ezemma, J. C. (2017). Effect of Flipped Classroom on Learning Management Systems and Face-to-Face Learning Environments on Students' Gender, Interest and Achievement in Accounting. *Library Philosophy and Practice*, *1.* https://api.semanticscholar.org/CorpusID:54045219

Vuong, N. H. A., Tan, C. K., & Lee, K. W. (2018). Students' Perceived Challenges of Attending a Flipped EFL Classroom in Viet Nam. *Theory and Practice in Language Studies*, *8*(11), 1504. doi:https://doi.org/10.17507/tpls.0811.16

Wang, J. (2017). The Application of Flipped Classroom in College English Listening, Viewing and Speaking Class 1. *2nd International Conference on Education, Sports, Arts and Management Engineering (ICESAME 2017), Advances in Social Science, Education and Humanities Research, 123*, 1823-1826. doi:https://doi.org/10.2991/icesame-17.2017.386

DOI: https://doi.org/10.4038/ouslj.v19i2.7669

RESEARCH ARTICLE

OUSL Journal, 2024
Vol. 19, No. 2, (pp 93-106)

Synthesis and Characterization of Iridium(III) Complexes containing $(ppy)_2$Ir-unit and Nitrogen based Donor Ligands

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Abstract

The treatment of 4-dimethylamino pyridine (L^1) with 0.5 equivalent of $[Ir(ppy)_2(\mu\text{-}Cl)]_2$ afforded the neutral yellow complex $[Ir(ppy)_2(L^1)Cl]$ (**1**) in 81% yield (ppyH = 2-phenylpyridine). When four equivalents of L^1 were reacted with an equivalent of $[Ir(ppy)_2(\mu\text{-}Cl)]_2$ in the presence of NH_4PF_6 produced the yellow salt $[Ir(ppy)_2(L^1)_2]PF_6$ (**2**) in 96% yield. Dark brown crystals of $[(ppy)_2ClIr]_2(\mu\text{-}L^2)$ (**3**) with a bridging di(4-pyridyl) acetylene ligand (L^2) was isolated when $[Ir(ppy)_2(\mu\text{-}Cl)]_2$ was treated with one equivalent of di(4-pyridyl) acetylene. Four iridium(III) complexes (**4**)-(**7**) of the type $[Ir(ppy)_2(N^N)]PF_6$ were prepared by reacting $[Ir(ppy)_2(\mu\text{-}Cl)]_2$ with an appropriate bidentate ligand (N^N) in the molar ratio of 1:2 in the presence of NH_4PF_6; the products were isolated in good yields (**4**, 87%; **5**, 92%; **6**, 96%; **7**, 64%) as colored solids. All new complexes were characterized using a combination of

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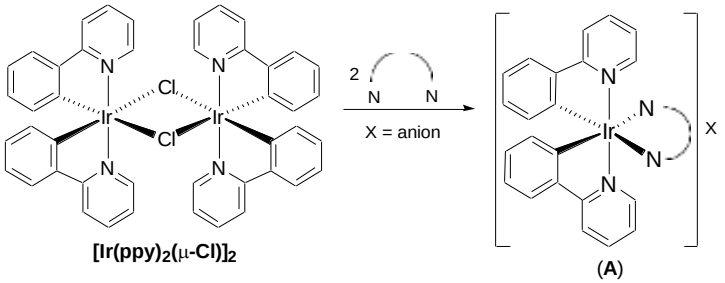
(Received 15th January 2024; Revised 25th November 2024; Accepted 15th December 2024)

IR, NMR, mass spectrometry and elemental analysis. It is important to devise synthetic routes to cyclometallated Ir(III) complexes as they have shown interesting properties in the fields of cancer research, photovoltaic cells, *etc*.

Keywords: *Iridium-complexes, cyclometallation, polypyridine, N-donors, 2-phenylpyridine*

Introduction

Octahedral cyclometallated Ir(III) complexes of the type $[Ir(C^N)_2(N^N)]X$ (**A**) have shown applications in the fields of photovoltaic cells, chemo-sensors, light-emitting devices (LEDs) and phosphorescent dopants in organic light-emitting diodes (OLEDs) (Jing et al, 2024; Amouri, 2023; Yoon & Teets, 2022; Zhang & Ding, 2021). (**A**) can easily be prepared by reacting the $[Ir(ppy)_2(\mu\text{-}Cl)]_2$ dimer with a bidentate ligand (N^N) in the presence a suitable anion X (Scheme 1) (Liao et al, 2021).



Scheme 1. Synthesis of complexes of the type (**A**)

Iridium(III) complexes of the type (**A**) possess important properties such as rigid configurational stability, high emissive quantum yields, long phosphorescence lifetime (in μs), and high electrochemical stability (Jing et al, 2024; Amouri, 2023). Luminescent Ir(III) polypyridine complexes are also candidates for biomolecular and cellular probes (Lo et al, 2011). Parameters such as water solubility, lipophilicity, cytotoxicity, cellular uptake, and intracellular localization could all be tuned by using various cyclometallated (C^N) and polypyridine (N^N) ligands (Zhang et al, 2021; Tan et al, 2021; Liao et al, 2021; Bolitho et al, 2020). Some of the basic and well-studied C^N and N^N ligand types (Lo et al, 2011; Tan et al, 2021) are given in Figures 1 and 2, respectively.

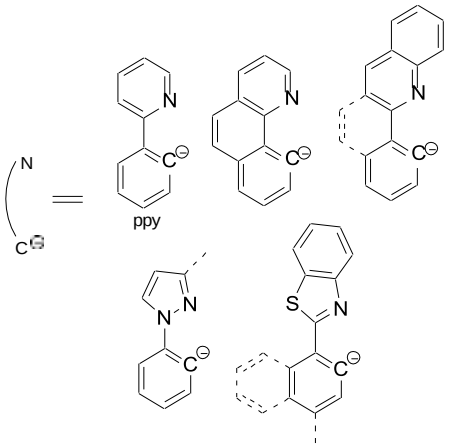


Figure 1. Common C^N ligand types

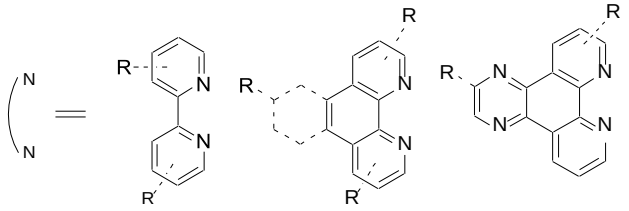


Figure 2. Common N^N ligand types; R = H or organic group

It is of interest to explore the chemistry of monodentate pyridine ligand (L^1), bridging pyridine ligand (L^2) and bulky bidentate bipyridine ligands (L^3 - L^6) with iridium(III) centers in order to prepare neutral complexes of the types $[Ir(ppy)_2(L^1)Cl]$ and $[(ppy)_2ClIr]_2(\mu\text{-}L^2)$, and salts of the type $[Ir(ppy)_2(N^N)]PF_6$, where ppy = 2-pyridylphenyl, L^1 = 4-dimethylamino pyridine (DMAP), L^2 = di(4-pyridyl) acetylene (DPA), and N^N = 6,6′-dimethyl-2,2′-bipyridine (L^3), 6,7-di(4-*tert*-butylphenyl)-5,8-diphenyl-1,12-diazatriphenylene (L^4), 3,4,5,6-tetraphenyl-2,2′-bipyridine (L^5), 7,10-di(4-*tert*-butylphenyl)-9-(2-pyridyl)-8-azafluoranthene (L^6) (Figure 3). This research paper presents synthetic routes and characterization of those complexes.

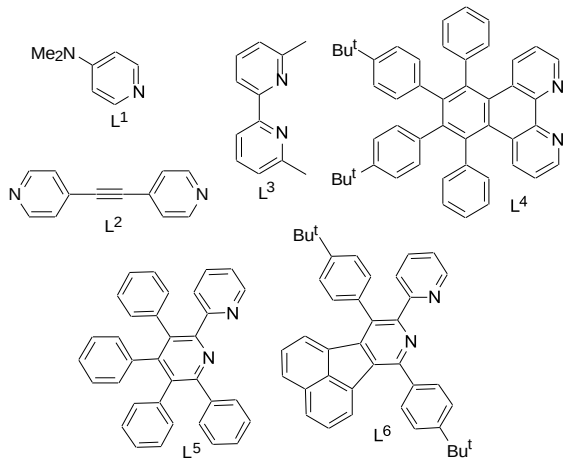


Figure 3. N^N ligands used in the present study.

Methodology

Elemental analysis was carried out on a Carlo Erba 1006 automatic analyzer. IR spectra were recorded on a Perkin-Elmer Spectrum One spectrometer. Mass spectral data were obtained using a micro-mass LCT electrospray mass spectrometer. MALDI-TOF mass spectra were recorded on a Waters Premier spectrometer using α-cyano-4-hydroxy cinnamic acid matrix. NMR spectra were recorded on a DPX 400 spectrometer operating at 400.13 MHz for ^{1}H, and 100.62 MHz for ^{13}C, and were standardized with respect to TMS. Single-crystal analysis was performed on a Bruker SMART APEX CCD diffractometer using graphite monochromised Mo-Kα (λ = 0.71073Å) radiation and refinements were obtained using SHELXS software. 4-Dimethylamino pyridine (DMAP, L^1), and 6,6′-dimethyl-2,2′-bipyridine (L^3) were purchased from Aldrich. 6,7-Di(4-*tert*-butylphenyl)-5,8-diphenyl-1,12-diazatriphenylene (L^4), 3,4,5,6-tetraphenyl-2,2′-bipyridine (L^5), and 7,10-di(4-*tert*-butyl phenyl)-9-(2-pyridyl)-8-azafluoranthene (L^6) were prepared according to literature procedures (Perera, 2022; Ollangnier et al, 2008; Perera et al, 2010).

$[IrCl(ppy)_2(L^1)]$ (**1**)

A suspension containing $[Ir(ppy)_2(\mu\text{-}Cl)]_2$ (15 mg, 0.0139 mmol) and 4-dimethylamino pyridine (DMAP, L^1) (3.5 mg, 0.028 mmol) in chloroform (3 mL) was refluxed for 2.5 h to give a pale-yellow solution. It was concentrated to a very low volume and triturated with methanol

to give a yellow solid (15 mg, 81%). Found: C, 50.80; H, 4.11; N 7.90, calcd. (%) for $C_{29}H_{26}ClN_4Ir \cdot 0.25CHCl_3$: C, 51.05; H, 3.84; N 8.14. Maldi (acetone, m/z): found: 623.1770; calcd. 623.1787 for $C_{29}H_{26}N_4Ir$, $[M-Cl]^+$. IR (neat): 2959, 1605, 1580, 1476, 1419, 1268, 1024, 830, 758, 730 and 705. ^{1}H NMR (400 MHz, $CDCl_3$): δ 9.95 (d, 1H, ^{3}J(HH) 6.0 Hz, H^{DMAP}), 8.21 (d, 1H, ^{3}J(HH) 6.0 Hz), 7.90 (d, 1H, ^{3}J(HH) 8.0 Hz), 7.74 (t, 1H, ^{3}J(HH) 8.0 Hz), 7.72 (m, 2H, ^{3}J(HH) 7.5 Hz,), 7.57 (d, 1H, ^{3}J(HH) 8.0 Hz), 7.51 (d, 1H, ^{3}J(HH) 8.0 Hz), 7.17 (dt, 1H, ^{3}J(HH) 6.0, 7.3 Hz), 7.02 (t, 1H, ^{3}J(HH) 7.5 Hz), 6.85 (t, 1H, ^{3}J(HH) 7.5 Hz), 6.83-6.71 (m, 6H), 6.35-6.33 (m, 2H), 6.25 (d, 1H, ^{3}J(HH) 7.5 Hz) and 2.96 (s, 6H, NMe_2). ^{13}C NMR (100 MHz, $CDCl_3$): δ 151.2, 149.2, 136.4, 136.2, 132.2, 131.4, 130.0, 129.4, 123.9, 123.8, 121.9, 121.5, 120.9, 120.6, 118.9, 117.9, 107.5 and 39.1.

$[Ir(ppy)_2(L^1)_2]PF_6$ (2)

A solution of NH_4PF_6 (10 mg, 0.061 mmol) in methanol (1 mL) was added to a suspension containing $[Ir(ppy)_2(\mu\text{-}Cl)]_2$ (15 mg, 0.0139 mmol) and 4-dimethylamino pyridine (L^1) (9 mg, 0.073 mmol) in chloroform (2 mL). The reaction mixture was refluxed for 2 h to give a bright yellow solution. It was concentrated to yield yellow crystals (24 mg, 96%). Found: C, 47.13; H, 4.08, calcd. (%) for $C_{36}H_{36}F_6IrN_6P \cdot 0.25CHCl_3$: C, 47.33; H, 3.97. IR (neat): 2957, 1622, 1536, 1476, 1391, 1226, 835 and 762. ESI-MS (MeCN, m/z): found: 745.2599, calcd. 745.2631 for $C_{36}H_{36}N_6Ir$, $[M-PF_6]^+$. ^{1}H NMR (400 MHz, CD_3CN): δ 8.68 (d, 2H, ^{3}J(HH) 5.5 Hz, H^6), 7.99-7.88 (m, 8H, ^{3}J(HH) 7.0, 8.5 Hz, ^{4}J(HH) 1.5 Hz, H^7, H^3 & H^4), 7.59 (dd, 2H, ^{3}J(HH) 7.5 Hz, ^{4}J(HH) 1.0 Hz, $H^{3'}$), 7.38 (m, 2H, ^{3}J(HH) 5.5 Hz, ^{4}J(HH) 1.5 Hz, H^5), 6.92-6.80 (m, 4H, ^{3}J(HH) 7.5 Hz, ^{4}J(HH) 1.0 Hz, $H^{4'}$ & $H^{5'}$), 6.45 (m, 4H, ^{3}J(HH) 7.0 Hz, H^8) 6.33 (dd, 2H, ^{3}J(HH) 7.5 Hz, ^{4}J(HH) 1.5 Hz, $H^{6'}$) and 2.95 (s, 6H, NMe_2). ^{13}C NMR (100 MHz, CD_3CN): δ 150.4 (4C, C^7), 149.3 (C^6), 138.3 (C^4), 132.1 ($C^{6'}$), 130.0 ($C^{5'/4'}$), 124.1 (3′), 123.2 (C^5), 121.9 ($C^{5'/4'}$), 119.3 (C^3) 107.9 (4C, C^8) and 38.4 (NMe_2).

$[IrCl(ppy)_2\{\mu\text{-di(4-pyridyl) acetylene}\}IrCl(ppy)_2]$ (3)

$[Ir(ppy)_2(\mu\text{-}Cl)]_2$ (15 mg, 0.0139 mmol) and di(4-pyridyl) acetylene (DPA, L^2) (2.5 mg, 0.0138 mmol) were dissolved in chloroform (3 mL) and the solution was refluxed for 3 h to give a brown solution. It was concentrated to a low volume (ca. 1 mL) and methanol was added to

yield dark brown crystals (16 mg, 92%). Found: C, 49.73; H, 3.18; N 6.18, calcd. (%) for $C_{56}H_{40}Cl_2Ir_2N_6P{\cdot}1.0CHCl_3$: C, 49.90; H, 3.01; N 6.12. IR (neat): 3039, 2230, 1606, 1581, 1476, 1268, 1213, 1063, 1030, 834, 758 and 730. ESI-MS (dichloromethane, m/z): found: 1217.2235; calcd. 1217.2262 for $C_{56}H_{40}N_6ClIr_2$, $[M\text{-}Cl]^+$. ^{1}H NMR (400 MHz, $CDCl_3$): δ 9.90 (d, 2H, ^{3}J(HH) 6.0 Hz, H^{DPA}), 8.05 (d, 2H, ^{3}J(HH) 6.0 Hz), 7.93 (d, 2H, ^{3}J(HH) 8.0 Hz), 7.81-7.67 (m, 6H), 7.59 (d, 2H, ^{3}J(HH) 7.5 Hz), 7.53 (d, 2H, ^{3}J(HH) 7.5 Hz), 7.19 (t, 2H, ^{3}J(HH) 7.3 Hz), 7.05 (t, 2H, ^{3}J(HH) 7.3 Hz), 6.91-6.74 (m, 12H), 6.35-6.29 (m, 4H), and 6.18 (d, 2H, ^{3}J(HH) 7.5 Hz).

$[Ir(ppy)_2(L^3)]PF_6$ (4)

A solution of NH_4PF_6 (10 mg, 0.061 mmol) in methanol (1 mL) was added to a suspension containing $[Ir(ppy)_2(\mu\text{-}Cl)]_2$ (15 mg, 0.0139 mmol) and 6,6′-dimethyl-2,2′-bipyridine (6 mg, 0.0279 mmol) in degassed dichloromethane (2 mL). The reaction mixture was refluxed for 2 h to give a pale-yellow solution which was concentrated to yield (**4**) as yellow crystals (20 mg, 87%). Found: C, 48.65; H, 3.24; N 6.47; calcd. (%) for $C_{34}H_{28}F_6IrN_4P$: C, 49.21; H, 3.40; N 6.75. IR (neat): 2954, 1606, 1580, 1478, 1458, 1438, 833, 779, 756 and 730. ESI-MS (MeCN, m/z): found: 685.1931; calcd. 685.1943 for $C_{34}H_{28}N_4Ir$, $[M\text{-}PF_6]^+$. ^{1}H NMR (400 MHz, CD_3CN): δ 8.28 (d, 2H, ^{3}J(HH) 8.0 Hz, $H^{3''}$), 8.07 (m, 2H, ^{3}J(HH) 7.8 Hz, ^{4}J(HH) 1.5 Hz, H^3), 8.00 (t, 2H, ^{3}J(HH) 7.8 Hz, $H^{4''}$), 7.92-7.88 (m, 4H, ^{4}J(HH) 1.5 Hz, H^4 & H^6), 7.72 (dd, 2H, ^{3}J(HH) 7.8 Hz, ^{4}J(HH) 1.2 Hz, $H^{3'}$), 7.34 (dd, 2H, ^{3}J(HH) 7.8 Hz, ^{4}J(HH) 0.75 Hz, $H^{5''}$), 7.11 (dt, 2H, ^{3}J(HH) 5.8 Hz, ^{4}J(HH) 1.5 Hz, H^5), 6.96 (dt, 2H, ^{3}J(HH) 8.5 Hz, ^{4}J(HH) 1.2 Hz, $H^{4'}$), 6.77 (dt, 2H, ^{3}J(HH) 7.5 Hz, ^{4}J(HH) 1.5 Hz, $H^{5'}$), 6.12 (dd, 2H, ^{3}J(HH) 7.8 Hz, ^{4}J(HH) 0.75 Hz, $H^{6'}$) and 2.19 (s, 6H, Me). ^{13}C NMR (150 MHz, CD_3CN): δ 150.3 (C^6), 139.5 ($C^{4''}$), 138.5 (C^4), 131.5 ($C^{6'}$), 129.6 ($C^{5'}$), 128.4 ($C^{5''}$), 124.7 ($C^{3'}$), 123.2 (C^5), 122.6 ($C^{3''}$), 122.1 ($C^{4'}$), 119.7 (C^3) and 25.9 (Me).

$[Ir(ppy)_2(L^4)]PF_6$ (5)

A solution of NH_4PF_6 (10 mg, 0.061 mmol) in methanol (1 mL) was added to a suspension containing $[Ir(ppy)_2(\mu\text{-}Cl)]_2$ (15 mg, 0.0139 mmol) and 6,7-di(4-*tert*-butyl phenyl)-5,8-diphenyl-1,12-diazatriphenylene (L^4) (18 mg, 0.0279 mmol) in dichloromethane (2 mL). The reaction mixture was refluxed for 1 h to give a brown

solution. It was concentrated and triturated with methanol to yield yellow crystals (33 mg, 92%). Found: C, 63.47; H, 4.37; N 4.18, calcd. (%) for $C_{70}H_{58}F_6IrN_4P{\cdot}0.5CH_2Cl_2$: C, 63.43; H, 4.45; N 4.19. IR (neat): 2959, 1607, 1582 1477, 1437, 1268, 834, 756, 729 and 705. ESI-MS (MeCN, m/z): found: 1147.4323, calcd. 1147.4291 for $C_{70}H_{58}N_4Ir$, [M-PF_6]$^+$. ^{1}H NMR (600 MHz, CD_3CN): δ 8.07-8.04 (m, 4H, ^{4}J(HH) 1.1 Hz, H$^{4''}$ & H$^{6''}$), 7.95 (d, 2H, ^{3}J(HH) 7.9 Hz, H^3), 7.80 (m, 2H, ^{3}J(HH) 8.3 Hz, ^{4}J(HH) 1.5 Hz, H^4), 7.71 (d, br, 2H, ^{3}J(HH) 7.1 Hz, H^6), 7.21-7.13 (m, 10H, H^{Ph} & H$^{5''}$), 7.09-7.03 (m, 6H, H^{Ph}, H^5 & H$^{4'}$), 6.96 (dt, 2H, ^{3}J(HH) 7.5, ^{4}J(HH) 1.1 Hz, H^5), 6.88 (m, 4H, H^{Ar}), 6.57 (m, 4H, H^{Ar}), 6.37 (d, 2H, ^{3}J(HH) 7.1 Hz, H$^{6'}$) and 1.15 (s, 18H, CMe_3). ^{13}C NMR (150 MHz, CD_3CN): δ 149.1 (C$^{6''}$), 148.7(C^6), 138.6 (C$^{4''}$), 138.2 (C^4), 131.7 (C$^{6'}$), 131.5 (C^{Ph}), 130.9 (C^{Ph}), 130.8 (C$^{5'}$), 130.7 (C^{Ar}), 130.2 (C^8), 128.4 (C^{Ph}), 128.4 (C^{Ph}),124.7 (3′), 124.6 (C$^{5''}$), 123.5 (C^{Ar}), 123.4 (C^5), 122.6 (C$^{4'}$),119.6 (C^3) and 31.4 (C*Me*$_3$).

[Ir(ppy)$_2$(L^5)]PF$_6$ (6)

A solution of NH_4PF_6 (10 mg, 0.061 mmol) in methanol (1 mL) was added to a suspension containing [Ir(ppy)$_2$(μ-Cl)]$_2$ (15 mg, 0.0139 mmol) and 3,4,5,6-tetraphenyl-2,2′-bipyridine (L^5) (14 mg, 0.030 mmol) in chloroform (2 mL). The reaction mixture was refluxed for 2 h to give a yellow-brown solution. It was concentrated and methanol was added to yield an orange solid (30 mg, 96%). Found: C, 58.38; H, 3.27; N 4.12, calcd. (%) for $C_{56}H_{40}F_6IrN_4P{\cdot}0.4CHCl_3$: C, 58.7; H, 3.53; N 3.64. IR (neat): 2962, 1606, 1476, 1425, 1362, 833, 756, 697 and 656. ESI-MS (MeCN, m/z): found: 961.2842, calcd. 961.2820 for $C_{56}H_{40}N_4Ir$, [M-PF_6]$^+$. ^{1}H NMR (400 MHz, CD_3CN): δ 8.05-7.94 (m, 4H), 7.87 (d, 1H, ^{3}J(HH) 8.0 Hz), 7.84 (d, 1H, ^{3}J(HH) 5.3 Hz), 7.70 (d, 1H, ^{3}J(HH) 5.8 Hz), 7.65 (dd, 1H, ^{3}J(HH) 7.8 Hz, ^{4}J(HH) 1.0 Hz), 7.57 (dt, 1H, ^{3}J(HH) 7.8 Hz, ^{4}J(HH) 1.0 Hz), 7.49 (dd, 1H, ^{3}J(HH) 6.0 Hz, ^{4}J(HH) 1.2 Hz), 7.33-7.16 (m, 8H), 7.10 (d, 1H, ^{3}J(HH) 8.5 Hz), 7.07-6.95 (m, 4H), 6.95-6.76 (m, 6H), 6.69 (t, 1H, ^{3}J(HH) 7.0 Hz), 6.58 (dt, 1H, ^{3}J(HH) 7.8 Hz, ^{4}J(HH) 1.2 Hz), 6.49 (d, 1H, ^{3}J(HH) 7.7 Hz), 6.41 (dt, 1H, ^{3}J(HH) 7.5 Hz, ^{4}J(HH) 1.2 Hz), 6.34 (t, 2H, ^{3}J(HH) 7.8 Hz), 5.97 (d, 1H, ^{3}J(HH) 7.0 Hz) and 5.72 (d, 1H, ^{3}J(HH) 7.0 Hz). ^{13}C NMR (150 MHz, CD_3CN): δ 150.1, 149.8, 149.1, 138.8, 138.2, 137.2, 130.9, 130.8, 130.6, 130.4, 130.3, 130.0, 129.9, 129.8, 129.5, 129.0, 128.9, 129.87, 128.4, 127.4, 127.2, 127.1, 126.9, 126.9, 126.7, 126.6, 124.8, 124.6, 123.7, 122.7, 122.4, 120.4, 120.3 and 119.9.

$[Ir(ppy)_2(L^6)]PF_6$ (7)

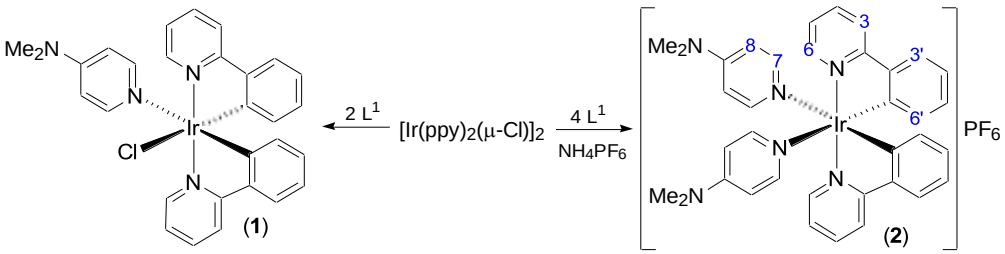
A solution of NH_4PF_6 (10 mg, 0.061 mmol) in methanol (1 mL) was added to a suspension containing $[Ir(ppy)_2(\mu\text{-}Cl)]_2$ (15 mg, 0.0139 mmol) and 7,10-di(4-*tert*-butylphenyl)-9-(2-pyridyl)-8-azafluoranthene (L^6) (15 mg, 0.0275 mmol) in chloroform (2 mL). The reaction mixture was refluxed for 2 h to give a brownish red solution. It was concentrated and triturated with methanol to yield a red solid (21 mg, 64%). Found: C, 60.44; H, 4.24; N 4.46, calcd. (%) for $C_{62}H_{52}F_6IrN_4P{\cdot}0.5CHCl_3$: C, 60.05; H, 4.23; N 4.48. IR (neat): 2961, 1607, 1476, 1423, 1362, 1268, 832, 775, 756 and 655. ESI-MS (MeCN, m/z): found: 1045.3778, calcd. 1045.3821 for $C_{62}H_{52}N_4Ir$, $[M\text{-}PF_6]^+$. ^1H NMR (400 MHz, CD_3CN): δ 8.01 (d, 1H, ^3J(HH) 8.5 Hz), 7.93 (d, 1H, ^3J(HH) 5.5 Hz,), 7.89 (d, 1H, ^3J(HH) 8.0 Hz), 7.87-7.79 (m, 5H), 7.75-7.57 (m, 5H), 7.54-7.48 (m, 2H), 7.42 (d, 1H, ^3J(HH) 8.5 Hz), 7.34-7.27 (m, 1H), 7.24-7.18 (m, 4H), 7.12 (t, 1H, ^3J(HH) 6.0 Hz), 6.98 (d, 2H, ^3J(HH) 7.0 Hz), 6.95-6.87 (m, 2H, ^3J(HH) 7.0, 8.0 Hz), 6.86-6.79 (m, 2H, ^3J(HH) 7.5 Hz), 6.67 (t, 1H, ^3J(HH) 7.5 Hz), 6.49 (t, 1H, ^3J(HH) 7.5 Hz), 6.21 (d, br, 1H, ^3J(HH) 7.5 Hz), 6.11 (d, 1H, ^3J(HH) 7.5 Hz), 5.99 (d, 1H, ^3J(HH) 7.5 Hz), 5.78 (d, 1H, ^3J(HH) 7.5 Hz), 1.50 (s, 9H, CMe_3) and 1.38 (s, 9H, CMe_3). ^{13}C NMR (150 MHz, CD_3CN): δ149.9, 149.6, 149.3, 138.2, 137.5, 137.57, 130.9, 130.4, 129.6, 129.4, 129.1, 128.8, 128.4, 128.2, 127.8, 127.6, 127.4, 127.3, 126.5, 126.1, 125.4, 124.6, 124.4, 124.1, 122.9, 122.7, 122.5, 120.6, 119.7, 119.3, 33.7, 33.8, 31.0 and 30.9.

Results and Discussion

Treatment of DMAP (L^1) with 0.5 equivalent of the dimer $[Ir(ppy)_2(\mu\text{-}Cl)]_2$ afforded the neutral yellow complex $[Ir(ppy)_2(L^1)Cl]$ (**1**) in 81% yield (Scheme 2). The complex (**1**) and other new complexes were characterized adequately by a combination of elemental analysis, IR, Mass, and NMR spectroscopy. The elemental analysis of (**1**) agrees with the proposed structure with the composition $C_{29}H_{26}ClN_4Ir$. Accurate mass spectral data of (**1**) showed a signal at 623.1770 for $C_{29}H_{26}N_4Ir$, $[M\text{-}Cl]^+$. The ^1H NMR spectrum of the unsymmetrical complex (**1**) is complicated, and a proton attached to carbon adjacent to nitrogen of the DMAP ligand appeared at 9.95 ppm, suggesting strong hydrogen bonding between H^{DMAP} and the chloride ligand (Kinzhalov, 2018). In the ^1H NMR spectrum of (**1**), a singlet was

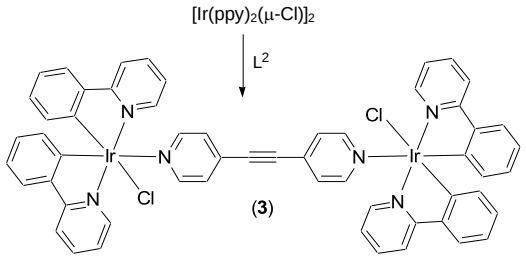
observed at 2.96 ppm for the six protons of the NMe_2 group, whilst its carbon-13 resonance was detected at 39.1 ppm.

When four equivalents of L^1 were reacted with an equivalent of $[Ir(ppy)_2(\mu\text{-}Cl)]_2$ in the presence of NH_4PF_6 produced the yellow salt $[Ir(ppy)_2(L^1)_2]PF_6$ (**2**) in 96% yield (Scheme 2). The presence of two DMAP molecules was confirmed by the accurate mass spectral data at 745.2599 for $C_{36}H_{36}N_6Ir$, $[M\text{-}PF_6]^+$. The proton and carbon-13 chemical shifts of this symmetrical complex (**2**) were identified by ^{13}C-^1H-COSY experiments. The ^{13}C NMR data observed for C^3, C^4, C^5 and C^6 of the 2-pyridyl group are in good agreement with the values reported in the literature (Hii, et al, 1995; Perera, et al, 2010; Perera, 2022). The carbon-13 resonances at 150.4, 107.9 and 38.4 ppm were assigned for C^7, C^8 and C^{Me} of the two DMAP molecules.



Scheme 2. Synthesis of complexes (**1**) and (**2**) with atom labeling

Treatment of one equivalent of di(4-pyridyl) acetylene (DPA, L^2) with one equivalent of $[Ir(ppy)_2(\mu\text{-}Cl)]_2$ gave dark brown crystals of (**3**) with the bridging ligand L^2 (Scheme 3).



Scheme 3. Synthesis of the complex (**3**)

Accurate mass spectral data of (**3**) showed a signal at 1217.2235 for $C_{56}H_{40}N_6ClIr$, $[M\text{-}Cl]^+$. The IR spectrum of (**3**) showed an IR band at 2230 cm^{-1} for the acetylene moiety. The complex (**3**) was not very soluble in common deuterated solvents; δ_H values were not resolved and a doublet at 9.90 with $^3J(HH)$ = 6.0 Hz was assigned to a proton attached to carbon adjacent to nitrogen of the DPA ligand.

Four iridium(III) complexes (**4**)-(**7**) of the type $[Ir(ppy)_2(N\text{^}N)]PF_6$ (Figure 4) were prepared by reacting $[Ir(ppy)_2(\mu\text{-}Cl)]_2$ with an appropriate bidentate ligand (N^N) in the molar ratio of 1:2; the products were isolated in good yields (**4**, 87%; **5**, 92%; **6**, 96%; **7**, 64%) as colored solids.

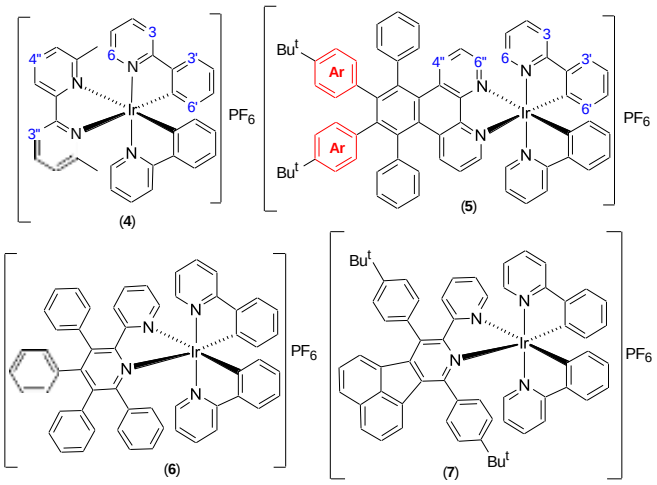


Figure 4. Structures of (**4**)-(**7**) and atom labeling for symmetrical complexes

The NMR data, elemental and mass spectral analyses of the complexes (**4**)-(**7**) are consistent with the proposed structures. Mass spectral data for complexes (**4**)-(**7**) indicated the presence of $[M\text{-}PF_6]^+$ ion. The complex (**4**) was characterized by X-ray crystallography (Figure 5).

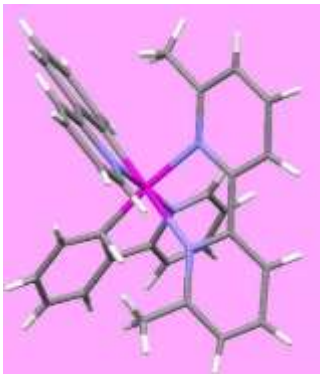


Figure 5. Molecular structure of the complex (**4**)

The proton and carbon-13 chemical shifts of the two symmetrical complexes (**4**) and (**5**) were assigned using H-H and C-H correlation spectroscopy. The ^{1}H NMR spectrum of (**4**) showed resonances at 8.28 (d, ^{3}J(HH) 8.0 Hz), 8.00 (t, ^{3}J(HH) 7.8 Hz) and 7.34 (dd, ^{3}J(HH) 7.8 Hz, ^{4}J(HH) 0.75 Hz) for H$^{3''}$, H$^{4''}$ and H$^{5''}$, respectively for the bipyridyl protons (Figure 6).

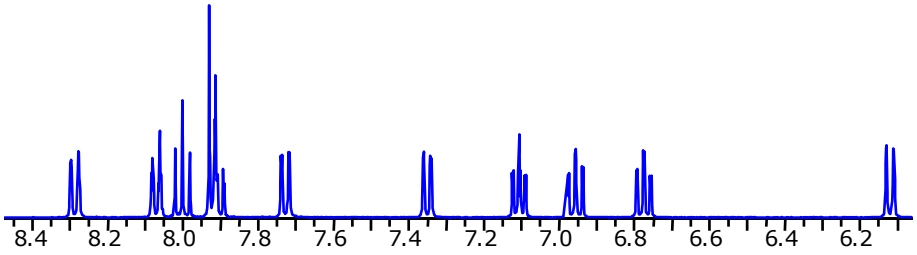


Figure 6. The aromatic region of the ^{1}H NMR spectrum of (**4**), δ_H in ppm

In the ^{1}H NMR spectrum of (**5**), the peaks for the aryl groups showed a second order NMR pattern (Figure 7) with multiplets centered at 6.88 (4H m), 6.57 (4H), and a singlet at 1.15 (18H) ppm for the *tert*-butyl protons.

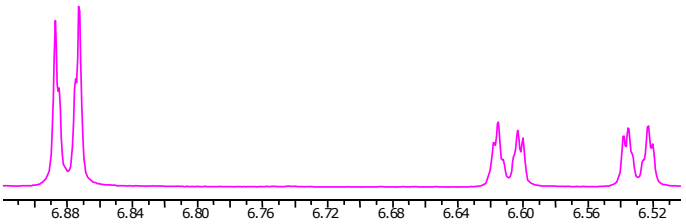


Figure 7. Second order NMR pattern of the aryl groups of (**5**), δ_H in ppm

In the ^{1}H NMR spectrum of (**7**), *tert*-butyl protons appeared as singlets at 1.38 (9H) and 1.50 (9H) ppm whilst the corresponding carbon-13 resonances appeared at 30.9 and 31.0 ppm.

Conclusions

The chemistry of monodentate pyridine ligand (L^1), bridging pyridine ligand (L^2), and bulky bidentate bipyridine ligands (L^3 – L^6) with the dimer $[Ir(ppy)_2(\mu\text{-}Cl)]_2$ was explored. Synthetic routes to complexes of the type $[Ir(ppy)_2(L)Cl]$, $[Ir(ppy)_2(L)_2]PF_6$, $[Ir(ppy)_2(N\text{^}N)]PF_6$ and $[(ppy)_2ClIr]_2(\mu\text{-}L)$ have been devised.

Acknowledgements

The author wishes to thank Trinity College Dublin for a Research Fellowship (2009) and Professor S. M. Draper for laboratory facilities and other support. The author is also grateful to Dr. John O'Brien and M. Ruether for recording NMR spectra; Dr. Martin Feeney for providing mass spectral data; Dr. Thomas McCabe for determining the crystal structure. An abstract of this study was presented at the Ruhuna University International Science and Technology Conference (RISTCON) in 2023.

References

Amouri, H. (2023). Luminescent Complexes of Platinum, Iridium, and Coinage Metals Containing N-Heterocyclic Carbene Ligands: Design, Structural Diversity, and Photophysical Properties. *Chem. Rev. 123*(1), 230–270. doi: https:// doi.org /10.1021 /acs.chemrev.2c00206

Bolitho, E. M., S-Cano, C., Huang, H., H-Portman, I., Spink, M., Quinn, P. D., Harkiolaki, M. & Sadler, P. J. (2020). X-ray tomography of cryopreserved human prostate cancer cells: mitochondrial targeting by an organoiridium photosensitizer. *JBIC Journal of Biological Inorganic Chemistry, 25,* 295–303. doi: https://doi.org/10.1007/s00775-020-01761-8

Hii, K. K., Perera, S. D. & Shaw B. L. (1995). Terdentate (P-N-N) complexes of new a pyridyl azine phosphine *Z,E*-$PPh_2CH_2C(Bu^t)$=N-N=C(Me)C_5H_4N and its deprotonated derivative (an azo-phosphine) with transition metals, *J. Chem. Soc., Dalton Trans.,* 624. doi: https://doi.org/10.1039/dt9950000625

Jing, S., Wu, X., Niu, D., Wang, J., Leung, C.-H. & Wang, W. (2024). Recent Advances in Organometallic NIR Iridium(III) Complexes for Detection and Therapy. *Molecule*, *29*, 256-79. doi: https://doi.org/10.3390/molecules29010256

Kinzhalov, M. A., Popova, E. A., Petrov, M. L., Khoroshilova, O. V., Mahmudov, K. T. & Pombeiroa, A. J. L. (2018). Pnicogen and chalcogen bonds in cyclometalated Iridium(III) complexes. *Inorg. Chim Acta*, *477*(24), 31-33. doi: https://doi.org/ 10.1016/ j.ica.2018.02.029

Liao, G., Peng, X., Li, T., Ye, Z., Xiang, X. & Fu, C. (2018). The Discovery of an Iridium(III) Dimer Complex as a Potent Antibacterial Agent against Non-Replicating Mycobacterium smegmatis. *Polymers*. *10*, 297. doi: https://doi.org/10.3390/polym10030297

Lo, K. K. W., Zhang, K. Y. & Li, S. P. Y. (2011). Design of cyclometalated iridium(III) polypyridine complexes as

luminescent biological labels and probes. *Pure Appl. Chem*., *83*(4), 823–840.
doi: https://doi.org/10.1351/PAC-CON-10-08-20

Ollangnier, C. M. A., Perera, S. D., Fitchett, C. M. & Draper, S. M. (2008). Rhodium and palladium complexes of a pyridyl-centred polyphenylene derivative. *J. Chem. Soc. Dalton Trans*., 283.
doi: https://doi.org/10.1039/B709818A

Perera, S. D. (2022). Synthesis of tricarbonyl Re(I) complexes of N and P donor ligands. *OUSL Journal*, *17*(2), 7-27.
doi: https://doi.org/10.4038/ ouslj.v17i2.7578

Perera, S. D., Quesada, R. & Draper, S. M. (2010). Synthesis and coordination chemistry of N-doped polyphenylenes. *OUSL Journal*, *6*, 57-73. doi: https://doi.org/10.4038/ouslj.v6i0.4114

S. Yoon, S. & Teets, T. S. (2022). Enhanced deep red to near-infrared (DR-NIR) phosphorescence in cyclometallated iridium(III) complexes. *Inorg. Chem. Front*. *9*, 6544–6553.
doi: https://doi.org/10.1039/ d2qi02058k

Tan, C-P., Zhong, Y-M., Ji, L-N. & Mao, Z-W. (2021). Phosphorescent metal complexes as theranostic anticancer agents: combining imaging and therapy in a single molecule. *Chem. Sci., 12*, 2357-67. doi: https://doi.org/10.1039/d0sc06885c

Zhang, L., Geng, Y., Li, L., Tong, X., Liu, S., Liu, X., Su, Z., Xie, Z., Zhu, D. & Bryce, M. R. (2021). Rational design of iridium–porphyrin conjugates for novel synergistic photodynamic and photothermal therapy anticancer agents. *Chem. Sci*., *12*, 5918-25. doi: https://doi.org/10.1039/d1sc00126d

Zhang, L.P. & Ding, D. (2021). Recent advances of transition Ir(III) complexes as photosensitizers for improved photodynamic therapy. *VIEW, 24*, 20200179.
doi: https://doi.org/10.1002/VIW.20200179

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