Deep learning: a study on marine renewable energy and sustainability education in an Irish context

Pauline Logue[1], Róisín Nash[2], Micheál Walsh[1], Michael Faney[1], Dearcán Ó Donnghaile[1]
[1]Department of Creative Education, Atlantic Technological University, Ireland, [2]Department of Natural Resources and the Environment, Atlantic Technological University, Ireland.

Abstract

In 2020-2022 a select group of Irish educators, marine renewable energy proponents and sustainability stakeholders entered into dialogue with a view to enhancing post-primary educational resources. The paucity of educational resources in this field was highlighted, most notably Irish language resources. This dialogue led to the development and piloting of a bilingual (Irish and English) cross-curricular programme of learning - a Transition Year Unit - targeted at students aged 15-17. This pilot study aims to evaluate the effectiveness of the learning unit with respect to enhancing knowledge in these novel areas. The methodology is a mixed methods case study. Data gathering processes include student questionnaires, stakeholder focus groups, and expert interviews. The main finding is the importance of stakeholder input into curriculum development to ensure the effectiveness of the Transition Year Unit of Learning, and to enhance learner engagement. Furthermore, the study recommends that dissemination include a web-based 'Deep Learning' educational platform with downloadable resources to enhance nationwide impact.

Keywords: Global citizenship; marine renewable energy; sustainability education; transition year programme.

1. Introduction

There is evidence of a growing body of literature in the fields of sustainable development education (SDE) and global citizenship education (GCE) (Gorben & Yemini 2017). Marine renewable energy (MRE) is one dimension of SDE which entails harnessing sustainable energy from wind, tides, waves and ocean currents. MRE is much debated, not least because of the complex technical, ethical, environmental and ecological challenges that it entails (Borthwick 2016; Weiss et al. 2020; Kulkarni & Edwards 2022). MRE education, which addresses the complexities of MRE, is pertinent for Ireland, an island nation with limited energy resources and a view to increasing indigenous production of renewable electricity. Irish MRE research, education and training is currently facilitated by an number of Irish organisations, not least the Marine Institute, BlueWise Marine and Sustainable Energy Authority of Ireland (stakeholders aligned with this study). The Marine Institute (2017), for example, speaks of the 'marining' of education. A prior study by the authors of this paper, incorporated exploratory dialogue with these and other selected Irish organisations with an interest in MRE. That study identified the need for educational resources for Irish language medium post-primary schools (*Gaelscoileanna*) and for Irish MRE educational research outputs (Logue et al. 2023). Building on this research, the aim of this paper is to evaluate the effectiveness of one strategic educational initiative pertaining to MRE education, piloted in a post-primary Irish language medium school (*Gaelscoil*), in the west of Ireland, in 2022. The methodology is a case study and the data gathering methods include a stakeholder focus group, student questionnaires and expert interviews.

2. Context

In 2015 the United Nations published 'Transforming our World: The 2030 Agenda for Sustainable Development', in which sustainable development goals (SDGs) were identified. Following this, the Irish Government began a process of curriculum reform and re-design in order to incorporate SDE into the Irish curriculum (Department of Education and Skills 2020). The Irish Teaching Council also set out its expectation of GCE training in initial teacher education (Teaching Council 2020, p.14). In light of these developments, in the period 2020-2022, a collective of Irish educators, MRE stakeholders, and academic researchers, in the west of Ireland, entered into exploratory conversations around enhancing bilingual (Irish and English) educational resources, in the areas of SDE, GCE and MRE, in Irish post-primary schools1. It was established during these exploratory conversations that Irish language medium schools were the most negatively impacted schools, given a significant lack of Irish-language educational resources relating to SDE, GCE and MRE

[1] The project stakeholders and funders are Atlantic Technological University, Marine Institute/Foras naMara, BlueWise Marine Ltd, Sustainable Energy Authority of Ireland, Údarás na Gaeltachta, and Coláiste Chroí Mhuire gan Smal, Spiddal, Ireland.

nationally. This dialogue led to the development and piloting of a bilingual (Irish and English) cross-curricular programme of learning, namely a 'Transition Year Unit' (TY Unit), targeted at senior level post-primary students in the Irish education system, aged 15-17 years. The TY Unit was in the form of a 10-week planning scheme, incorporating subject specification learning outcomes, STEM-related curriculum content, teaching and assessment strategies, weekly lesson plans, bilingual lesson resources and wider supporting educational resources. It was agreed by the stakeholders that this MRE educational output would be piloted in one west of Ireland, Irish language medium school (Gaelscoil) in close proximity to a marine research testing site, where MRE public debates are in evidence.

3. Methodology and Methods

A case study methodology was employed and data gathering was a three-phase sequential process involving a stakeholder focus group, expert interviews, and student questionnaires.

3.1. Qualitative Research: Focus Group

Phase one consisted of a stakeholder focus group comprised of six funding representatives from Irish organisations with expertise in marine science, marine renewable energy research, STEM education, and the Irish language. The focus group was held online, using MS Teams. It commenced with a brief presentation on the research aims, after which guiding questions were used to explore participants' perspectives on MRE education, SDE and GCE educational resource development, and bilingual resource development. As part of the focus group, a first-version TY Unit (iteraton one) was critically assessed. This first iteration was informed by literature research and the specifications of the Irish post-primary STEM curriculum. This iteration was circulated to the focus group participants prior to the focus group in order to maximise the quality of the discussion. The primary role of this discussion was to provide guidance on the further enhancement of the TY Unit. Following the focus group, the original TY unit was re-designed by the research team (iteration two).

3.2. Qualitative Research: Expert Interviews

Phase two entailed five expert interviews which were conducted with selected Irish experts in the fields of marine renewable energy, oceanography, and sustainability. The first interview was a pilot interview which was co-reviewed by academics with attention to validation and enhancement. As with the prior focus group, the interviews were online, and recorded, using the MS Teams platform. A primary focus of the interview was a critique of the TY Unit (itertation two), which had been circulated in advance of the interview, along with guiding questions. Subsequently, the TY Unit was amended (iteration three).

3.3 Mixed Methods Research: Student Questionnaire

In phase three, this third version of the TY Unit was further reviewed by representatives of the host case study pilot school (including management, STEM teachers and students). Following this, a final version was drafted (iteration four) that was a agreed by all parties. Subsequently, the TY Unit was delivered by a member of the research project team: a qualified bilingual post-primary teacher-researcher. The pilot delivery of the TY Unit took place in the host school weekly, over a 10-week period, February to May, 2022. Purposeful and convenience sampling was employed. The TY students in the pilot school (Gaelscoil) were invited to participate, and all opted in voluntatily as research participants to the study (n=30). Demographically, in terms of nationality, 28 students identified as Irish, one identified as Brazilian and another as Irish/Somalian, the gender profile was 17 female and 13 male, and the age range was 15-18 years. Ethical approval for data gathering was obtained from the host school, in loco parentis, since some of the participants were as yet 'minors'. A student questionnaire, generated using MS Forms, and containing 30 questions, was utilized to capture students' perspectives. The questionnaire included open and closed questions, of a variety of types - Likert Scale, yes/no, selection options, and opinion/example-type questions, including specific questions relating to MRE education- coded below as MREE [Qs 8-19]. The questionnaire, which was anonymous, was distributed at the commencement of the TY Unit (a baseline questionnaire) and again at the conclusion of the unit of learning, (a final questionnaire), in order to monitor learning.

4. Findings and Analysis

A concise analysis of the dominant findings of the study is presented below with reference to the data and to relevant literature. Firstly a brief account of the data analysis methodology is provided with respect to the qualitative research methods in the case of the focus group and expert interviews. Following this, a mixed methods analysis is provided with respect to the student questionnaires. themes and related sub-themes were generated: teaching of MRE, public relations within MRE, marine industry perspectives, and sustainability and society

4.1. Qualitative Research: Data Analysis Methodology

A thematic analysis was applied to the qualitative data arising from the focus groups and expert interviews, based on an adaptation of the inductive six-stage model of coding and analysis articulated by Braun and Clarke (2021). This six-stage model includes: familiarization with data, generation of initial codes and categories, identifying themes, reviewing themes, defining and naming themes and producing the report. Manual colour coding of data transcripts and related notations were used to identify first level codes and categories within the data sets. Co-coding was facilitated by an academic researcher (>10% of data). MS Word and MS Excel tools were utilized to chunk, cluster and refine related

themes to the point of saturation, where all codes were accounted for in a final re-organisation of data. At this point the four dominant themes were geerated (see above).

4.2 Qualitative Research: Focus Group and Expert Interviews

In the following discussion of the generated themes, stakeholder participants are coded as S and numbered (S1, S2, S3, etc.), the pilot expert interview is coded as P, and further expert interviewees are coded as E, and numbered (E1, E2, E3, etc.).

With respect to the teaching of MRE in the TY Unit, sub-themes included teaching methodologies, factors in delivery of content, types of resources and important concepts/messages. Active, collaborative and reflective teaching and learning approaches were advocated, as well as field trips and guest inputs, demonstrating an awareness of the target audience (E4). One interviewee emphasised the need for educational programmes and resources to "develop learners' understanding of the community that they're in, of the properties of the local environment, the local heritage of how it relates to them, and how they live their lives" (P). This point was built upon by another interviewee who spoke of "thinking global and acting local"(E1). Also, empowerment of learners was highlighted, specifically youth (E4).

Two sub-themes were generated relating to MREE and public relations, namely, the wider promotion of MREE and the need for sensitivity in regard to inter-relations with public stakeholders, e.g. local community representatives, fisheries representatives, local heritage groups, environmental groups. Local sensitivity and the need for local trust-building was identified as a significant factor: one stakeholder spoke of the need to develop learners' understanding of their community they live in and stressed necessary community education in relation to MRE, including test sites and local heritage interests (S2).

With respect to marine industry perspectives, sub-themes included marine types and technologies, career opportunities, factors impinging the marine environment, and marine legislation and policy. One stakeholder identified specific technological curriculum content, devices and technology necessary to inform learners on the TY Unit (S3). Examples were spelt out: engineering, finance, computers, artificial intelligence, and graphic design (S1). Potential marine careers were highlighted, and the need for the TY Unit to get learners "interested in research and marine careers more generally, and maybe increase their knowledge because a lot of the time they wouldn't be aware of the different careers that are in the marine area"(S3). The multifactted and multi-disciplinary nature of MREE was discussed, including the need for integrated mathematics, science, engineering, and local heritage, in the context of a life-long learning model, commencing at pre-school level (E2).

Finally, regarding sustainability and society, two sub-themes were generated: society and the marine, and integrated sustainability factors, the latter emphasising GCE, SDE, the marine

ecosystem and climate action. The need for reformed legislation was noted (E2; E3). One interviewee stated that "Ireland is actually changing at the moment so we're reforming our legislation that covers marine development"" (E3). In the context of climate change, local knowledge and local politics was commented upon, in the context of developing the TY Unit: "…try and bring it down to a local level to show students what they can and can't have control over" (E4).

4.3. Mixed Methods Research: Student Questionnaire

Focusing on MRE (Q.s 8-19), it was demonstrated that the TY Unit resulted in increased MRE knowledge, including greater marine or ocean literacy precision. Learners explicitly acknowledged increased learning as a result of engaging in the TY Unit (Q.10). With respect to Q.8, while in the baseline questionnaire students had a vague and somewhat confused understanding of MRE potential, in the final questionnaire, students cited a number of very specific possibilities for MRE in Ireland, given its geographic location, as part of the reason for it being important. In addition, they cited the ability to reduce use of fossil fuels, reduce dependence on other countries for energy, the need for a more sustainable source of energy and the goal to reduce fossil fuel usage in general (Q.12). These more insightful responses accounted for half of the cohort (50%), with the remainder also giving answers containing some insight (Q.12). With respect to the environmental impact of MRE (Qs.13 & 14), in the basline questionnaire, 70% of respondents indicated that they did not know if there was an impact on the environment, as a result of MRE. In contrast, in the final questionnaire, while there was still no consensus regarding the impact of MRE on the marine ecosystem - with 'yes', 'no' and 'maybe' equally represented – answers were more nuanced. Students could now provide more technical arguments on both sides and certain answers given were more detailed, reflecting increased knowledge in the area: "…some of the underwater equipment can be dangerous for marine life. For example, propellers that use the waves" and "…if anything, some of the machines can serve marine life in an advantageous way such as one machine that acts like a reef and helps ecosystems in that way". In general, more expanded understandings of environmental concerns (including marine) was in evidence in responses to Q. 17. This more nuanced and informed understanding of the complexities involved mirrors recent literature, where the complexities of sustainability ethics, and the need to negotiate trade-offs between competing sectors and interests are highlighted (Kulkarni and Edwards, 2022; Galparsoro, et. al, 2022). See Figure 1 where non-renewable energy (NRE), offshore fishing (OF), plastic pollutants (PP) climate change (CCC), all /other options are explored and where a shift in understanding is evident.
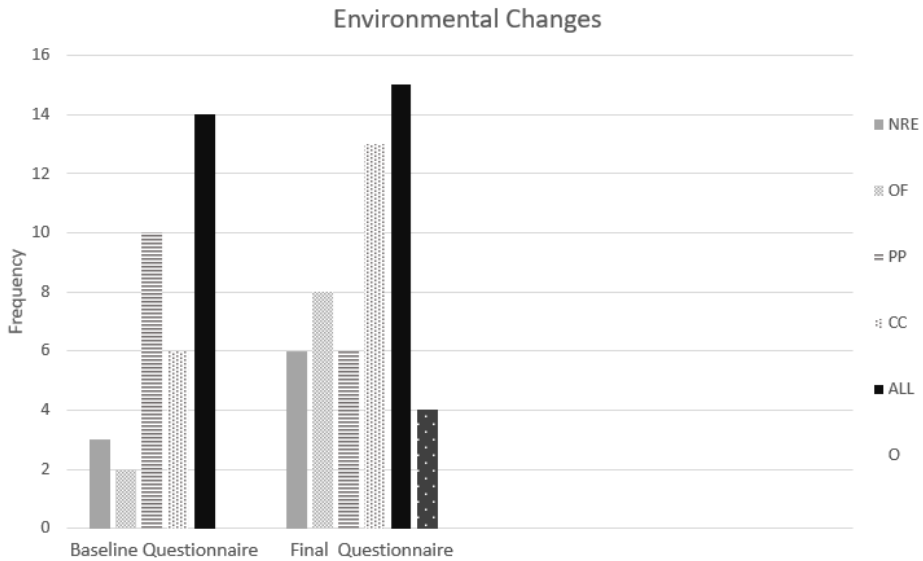
Figure 1. Environmetal concerns today: baseline and final questionnaire

5. Conslussions and Recommendations

The main conclusion arising out of this pilot study is the effectiveness, on balance, of the research project's TY unit of learning as a MRE and sustainability education resource. Its overall capacity to enhance knowledge of MRE education among post-primary students in the pilot school (*Gaelscoil*) was demonstrated. This was largely attributed to educational inputs from marine experts and educators, who contributed to the curriculum design and content of the newly-developed TY programme. The study acknowledges the need for a balance between theoretical and practical learning in post-primary educational initiatives. It recommends that the educational resource outputs from the study will be more widely disseminated among Irish post-primary schools, not least the Irish language medium schools (*Gaelscoileanna*), in the form of a web-based 'Deep Learning' educational platform with downloadable resources to enhance nationwide impact. Also, ongoing development of further wide-ranging bilingual educational courses and resources, for the post-primary sector, is recommended, such as first year induction or 'taster' courses, and Junior Cycle short courses on MRE education, in the context of GCE and SDE. While this study goes some way to addressing an identified gap in the literature, and in Irish education, it is acknowledged that the sample size is relatively small and, as a case study, the findings are localized and non-generalisable. Furthermore, the focus of this study is primarily MRE- a specialist environmental area, not readily applied to other environmental contexts. However, many of the research project's educational outputs are flexible and adaptable, and may be readily adapted to other post-primary contexts in Irish education.

References

Borthwick, A.G.L. (2016). Marine Renewable Energy Seascape. *Engineering*. Volume 2. Issue 1. Pp. 69-78. At Marine Renewable Energy Seascape (pnnl.gov). Retrieved 21/04/2023.

Braun, V., & Clarke, V. (2021). *Thematic Analysis: a Practical Guide.* SAGE Pub. Ltd.

Department of Education and Skills. (2020). *'Education for Sustainability'. The National Strategy for Education on Sustainable Development in Ireland.* Government of Ireland.

Galparsoro, I., Menchaca, I., Garmendia, J.M., Borja, A., Maldonado, A.D., Iglesias, G., & Bald, J. (2022). Reviewing the ecological impacts of offshore wind farms. *Ocean Sustainability.*1:1. doi.org/10.1038/s44183-022-00003-5. Retrieved

Goren, H. & M. Yemini. (2017). Global citizenship education redefined – A systematic review of empirical studies on global citizenship education. *International Journal of Educational Research,*Volume 82, 2017, Pages 170-183. https://doi.org/10.1016/j.ijer.2017.02.004

Kulkarni, S.S., & Edwards. D.J. (2022) A bibliometric review on the implications of renewable offshore marine energy development on marine species. *Aquaculture and Fisheries,* Vol. 7. Issue 2. https://doi.org/10.1016/j.aaf.2021.10.005

Logue, P., Nash R., Walsh, M., Faney M. & Ó Donnghaile, D. (2023). Deep Learning: The Development of Cross-disciplinary Post-primary Educational Resources to Promote Marine Renewable Energy and Sustainability Education. Paper. ESAI Conference 2023. Stranmillas College, Belfast, Ireland.

Marine Institute (2017). Marine Institute Strategic Plan 2018-2022. At *Marine Institute Strategic Plan* 2018-2022; Building Ocean Knowledge, Delivering Ocean Services.

Teaching Council (Ireland). (2020)*. CÉIM: Standards for Initial Teacher Education.* At ceim-standards-for-initial-teacher-education.pdf (teachingcouncil.ie).

United Nations. (2015) *Transforming Our World: The 2030 Agenda for Sustainable Development*. At 21252030 Agenda for Sustainable Development web.pdf (un.org).