TRANSFORMING CURRICULUMS FOR AN AGE OF MULTI-MODAL EDUCATION: A 5 PHASE APPROACH (PRACTICE)

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ABSTRACT

The pandemic has accelerated the trend towards online and hybrid learning with many educational institutes pivoting their education to online learning environments and has subsequently transformed societal expectations. There have been many benefits associated with these changes (e.g., multi-dimensional interactions, flexibility and deep learning). As we move into more online education due to changing needs and demands from students, how best to adapt our education for multi-modal learning environments can be a challenge. Getting our education ready for a multi-modal age is bringing about disruptive changes forcing us to rethink what we teach and how we teach it. **Thus, the objective of this paper is to present a framework that will allow for the evaluation of curriculums and enable educators to create sustainable, flexible educational environments relevant for multi-modal learning environments while remaining at the forefront of educational needs.** In this paper, we present the 5-phase approach that we used to assess our programme and redesign our curriculum. The five phases include: Inventory, Analysis, Evaluation, Design and Implementation. We will present the highlights from our experience and the challenges we have had to overcome. The framework that we present is applicable to different computer science, spatial and data engineering programmes that require a mix of theoretical and hands-on practicals.

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1 INTRODUCTION

1.1 Background

The pandemic forced educational institutes to pivot their education to online learning environments and has subsequently transformed societal expectations. With the advancement of digital technologies, we can provide very rich and multi-dimensional learning environments. Although there have been many benefits associated with these changes (e.g., multi-dimensional interactions, flexibility and deep learning) there are still many challenges that can result in poor and often inadequate educational experiences. Since staff have had to convert their courses to make them fit for online delivery, which served an immediate purpose, there now has been time to reflect and see room for improvement.

At the same time that educational transformations are taking place, so too are transformations within our own discipline of geospatial information and earth observation sciences due to advances in technologies and the integration of machine learning and artificial intelligence methods. A key part of the skills students require are those of data, software and spatial engineers that range from the creation and fusing of data to make data useable and operational or software and technological engineering. These advancements highlight the need for us to update our curriculum so that we can incorporate new skills, methods, technologies, knowledge and competences as they relate to the geospatial field and the needs for this profession while also transforming how we teach. As we move into more online education, due to changing needs and demands from students, the question now is how best to adapt our education for multi-modal learning environments and create a high-performing digital education ecosystem that is flexible. **Thus, the objective of this paper is to present a framework that will allow for the evaluation of curriculums and enable educators to create sustainable, flexible educational environments relevant for multi-modal learning environments while remaining at the forefront of educational needs.**

1.2 Online education

In 2020, all face-to-face (f2f) education around the world closed. The ad-hoc necessity to provide online education affected all aspects of education (Blanford et al. 2021) that required transitioning learning environments in a short-period of time (Bryson and Andres 2020). Staff were required to transform, adapt and develop infrastructure, curriculum, pedagogy and skills (e.g. digitalization of education and incorporation of video, videoconferencing and other media (Smolle et al. 2021)) to make courses ready (e.g. (Bogdandy, Tamas, and Toth 2020)) instantly. Many challenges were faced that included barriers due to technology, internet connectivity and availability (Demuyakor 2020, USAID 2020, Cullinan et al. 2021), ethical concerns (see references within (Turnbull, Chugh, and Luck 2021)) related to privacy (Rajab and Soheib 2021), inclusion (Parmigiani et al. 2021) and inequality (Pittman et al. 2021). Although the transition to online education started as a response to the pandemic, finding the balance between f2f and online learning is the next step in developing resilient educational systems (e.g. (Schultz and DeMers 2020)).

Many master's degree programmes are available in a variety of formats (full-time, part-time, face-to-face, blended, online). Online is increasing in popularity with working professionals who are unable to move to the education facility full-time due to family obligations and are in a good job. Flexible study options via part-time and online provides many professionals the opportunity to continue to advance their existing competences and develop new skills and knowledge. Different modes of education can include **blended learning/flipped classroom** (combines face-to-face classroom time with online learning) or b**lock mode learning** which involves intense face-to-face study over a fixed period, often weekends or consecutive days allowing students to book time off work in advance. In this paper we focus on education in fields that merit from the benefits of online education but are also greatly dependent on hands-on learning by doing such as lab-work and field

experiments, often requiring physical presence of students. For education in these fields, we need to find an optimal mix of multiple education modes.

1.3 Geospatial Engineers and Spatial Data Engineers

Geospatial engineers and Spatial Data engineers require a variety of competencies that include a range of workplace, academic and personal skills alongside a range of technical skills (see (Blanford et al. 2020) for competencies). In essence the types of skills needed by geospatial professionals include:

- Data engineering
- Data Visualisation and Exploration
- Spatial Analysis
- Modelling and scripting that may extend to software engineering with the creation of new technologies and applications.
- Machine Learning & Artificial Intelligence
- Big Data Analytics
- Open Science, Ethics & Governance

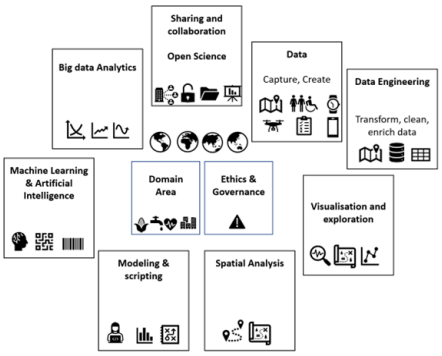

Fig 1: *Overview of the skills needed by geospatial professionals.*

With technological improvements, dealing with increasing amounts of data in different velocities, volumes and validity (V's), big data analytics and processing is of increasing importance alongside the need for using different types of information across a variety of domains such as responsible GeoAI, Disaster Resilience, Resource Security and GeoHealth. Students need to learn these skills to enhance decision making, develop solutions and for achieving the many sustainable development goals across a variety of disciplines.

The master's programme that we offer, enables graduates to address worldwide challenges in a local context using the core knowledge areas of Geo-Information Science and Earth Observation. The programme aims at providing graduates with the skills and knowledge that enable them to provide solutions that contribute to the sustainable development of societies. We have created an international multi-cultural educational environment that brings together students and staff from around the world. Through this diverse learning environment, we provide a rich learning experience that enables for the co-creation of geospatial solutions for addressing global challenges and provide solutions for sustainable development.

2 METHODOLOGY

2.1 Framework for redesigning the curriculum.

Redesigning of curriculums or educational programmes requires many aspects of the programme to be (re)considered, which all start with creating and updating measurable learning outcomes, selecting appropriate and effective teaching strategies to enhance learning experiences and aligning assessment methods with learning outcomes.

In general, redesigning of curriculums is a multi-staged process that involves (i) *analyzing* the current educational situation by gathering information, (ii) *designing* a new curriculum, (iii) *implementing* of updates and changes, and (iv) *evaluation* of the updates (Nomme and Birol 2014). We have adapted these stages to fit our needs and created a 5-phase approach (Figure 2). The information gathered during Phases 1-3 will serve as input to Phase 4, designing the curriculum. Once the design phase is completed and the courses updated, we can enter Phase 5, the implementation phase. For this study we will mainly report on Phase 1-3.

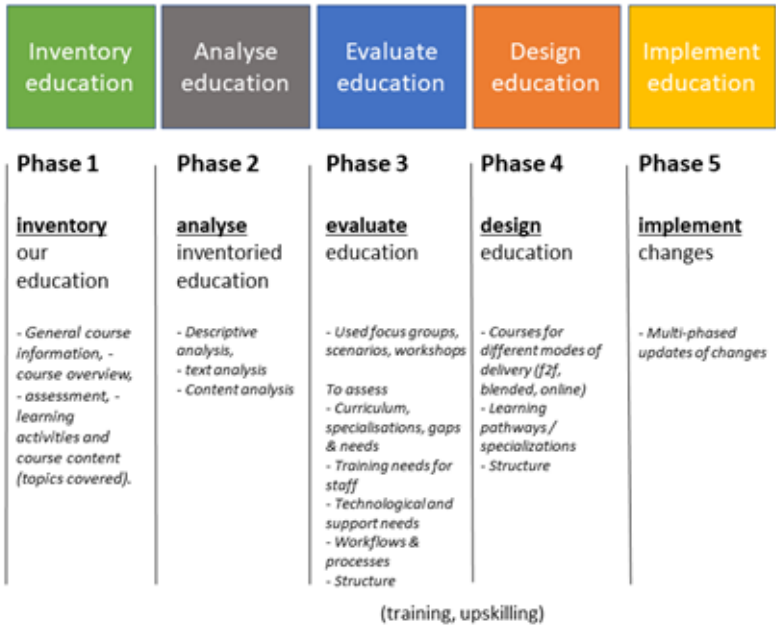

Fig 2: *Overview of the 5-phased approach for innovating the curriculum in a degree programme.*

Each of the five phases are described briefly below:

- **Phase 1: Inventory** our education captures different elements associated with teaching and learning (content, assessment, community). These include general course information, course learning outcomes, how students are assessed and what learning activities are used, what topics are covered. Pedagogical information for each course was obtained from course coordinators. Each course coordinator was provided with a form for their course pre-populated with existing information from the study guide. All coordinators checked the information and provided missing or incomplete information on learning activities, learning outcomes and information on content.

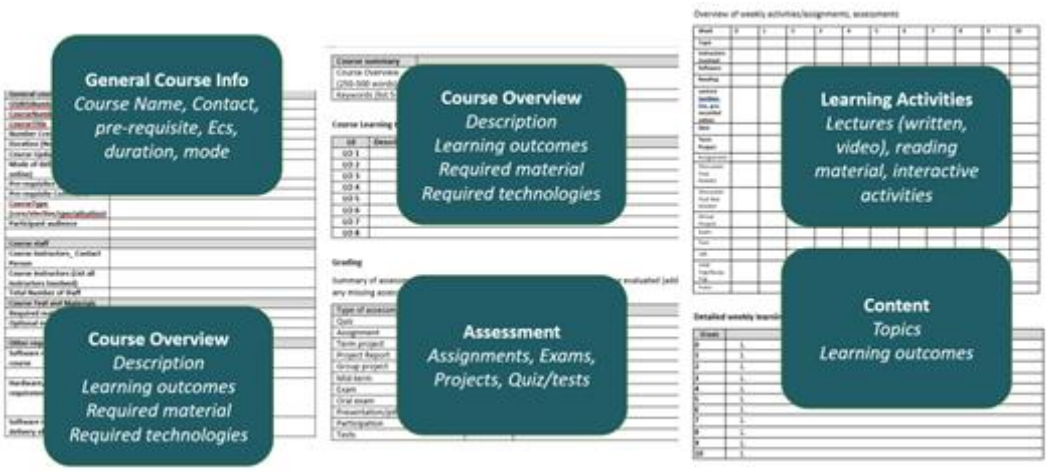

Fig 3: *Example of a form used to capture detailed course information. The elements were transferred to an excel spreadsheet and later used to populate a database.*

- **Phase 2: Analyze** the data captured in the inventory (what didactic methods were being used; what assessments were used; what topics were being taught). The inventoried information was analyzed using descriptive statistics. Voyant Tools (https://voyant-tools.org/) was used to analyze text and included creating word clouds. Thus, we examined the curriculum, relationships between courses, identified gaps or isolated topics (Fig 4) and evaluated the programme and how what we offer relates to the geospatial competencies required in this field.

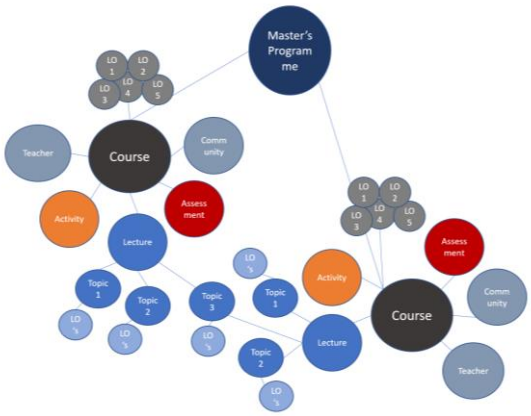

Fig 4: Conceptualisation of course components for the master's programme and how courses may be connected.

- **Phase 3**: **Evaluate** our education. We further evaluated our education using findings from Phase 1 and 2, combined with external inputs from, for instance, our professional advisory board. These served as input to discussions and activities during workshops, interactive focus groups and collaborative design sessions. Internal and external surveys were used for additional data gathering and polls to finalize decisions and clarify ambiguities during sessions. We included students and staff during workshops and discussions. The findings from Phase 1-3 will serve as input for developing training and designing the programme.

- **Phase 4**: **Design** education for multi-modal learning environments. During this phase we will conceptualize the curriculum and assemble the pieces using the information collected during Phase 1-3. To aid in designing the programme we have developed a set of small pilots that will allow us to test new approaches, workflows and processes so that we can assess the feasibility of incorporating these changes and identify challenges. The pilots include:
    - (i) *appreciation for online teaching:* develop workshops and training to promote digital education skills and enable staff to develop skills for designing courses for online delivery.
    - (ii) *assessments*: evaluate variety of testing types to achieve more efficient and effective testing.
    - (iii) *designing courses and a curriculum* that use different didactical methods with the aim of achieving the same or higher learning results.
    - (iv) *create new learning pathways/specialisations*: design a new learning pathway for online delivery.

  For the design of courses and curriculum we will incorporate design elements and use storyboarding to aid in visualizing a course and the elements that make up a course (lecture, learning activity, assessment, interaction) (Laurillard 2021) to help us visualize what we are teaching and how. We will also apply these when designing learning pathways / specialisations to gain an overview of our programme and check how they contribute to the overall programme learning outcomes. We will create scenarios to examine changes in structures and how they impact different modes of learning and course flows - how courses fit together and how sequence of courses translate between different modes (face-to-face <- – -> online).

- **Phase 5: Implementation** of new courses and curricula. Changes and updates will be phased in. In particular for a multi-year master's programme, this phase can be more challenging. One-year master's programme can be changed with little consequences for new or previous cohorts of students. Multi-year programmes need to plan for curriculum changes well in advance in order to anticipate effects on students that will start or finish up to at least three years from 'now'.

3 RESULTS

We assessed all courses in our programme (N=68). The mode in which courses were delivered are predominantly face-to-face, with some online (N=3) and hybrid (N=5). On average, courses ran for 10 weeks with some running for 5 or up to 12 weeks. A variety of software is used that ranges from open source to proprietary software (Figure 5). A summary of the findings from the inventoried courses are captured in Table 1.

Fig 5: Word cloud of software utilized during the programme.

Table 1: Summary of findings from inventory

Topic	Findings	Adjustments and improvements needed
general course information	- Most details were provided - Course names not very informative - Mode of delivery is predominantly f2f - Duration of courses predominantly 10 weeks - Course levels (introductory, advanced) are not clearly defined.	- Course names could be improved - Ability to deliver in multiple modes (face-to-face, hybrid, blended, online) needs to be addressed.
overview of courses	- Course descriptions varied in detail - Learning outcomes provided for courses - Pre-requisites not defined for all courses	- Course descriptions need to be standardized. Information needs to be more concise and informative. - Learning outcomes for courses need to be refined.
assessment: how students were evaluated	- Variety of assessments are used. - Terminology of assessments varied. - Assessments were predominantly based on assignments, group projects and tests.	- Standardization of definition and naming of assessments. - Balance type of assessments - Balance individual and group-based assessments
learning activities	- Emphasis is on contact hours - Learning activities consist predominantly of lectures and supervised practical's/tutorials	- Need to balance the use of different learning activities/types to encourage more active learning. - storyboard courses and view breakdown of types of learning activities used (acquisition, discussion, investigation, collaboration, practice, production and assessment) (Laurillard 2002, Laurillard 2021) to enhance learning activities.
details about the content	Mixed level of details	Additional details are needed, and a minimum set of standards need to be defined
	Geospatial Software (open vs propriety) *Good – use a variety of software, providing software resiliency*	*None*
	Duplication of content - *Identified several courses offering similar content.* ***Fragmentation -*** *Fragmentation of topics and lack of clarity of depth of topics or skills* ***Gaps -*** We identified some gaps in the curriculum	*Need to consolidate similar content.* *Need to clarify depth of topics and evaluate.* *Need to develop new courses to add to the curriculum to cover knowledge gaps.*
	Core courses - *Cover a large range of topics some of which are complex topics/skills.* *Newer technologies, data sources and methodologies not visible or not covered*	*Need to re-organise and design.* *New information sources, technologies and methodologies need to be made more visible. Scripting and programming are essential and needs to become part of the core.*
	Internationalisation *Some topics and case study's capture Internationalisation. Not explicitly captured.*	*Additional exploration will be needed to make this visible in the content. Explore how to evaluate or monitor.*

In our analysis and evaluation, we predominantly examined the relationships between courses and identified gaps or redundant topics and evaluated these in combination with the input we gathered from our professional advisory board and our internship hosts. During workshops and interactive sessions, we identified challenges associated with changes in the curriculum and barriers to developing and delivering multi-modal learning environments.

4 SUMMARY AND ACKNOWLEDGMENTS

The most reassuring logical outcome of our evaluation was that the input from our current students and alumni matched very well with that from the organizations interested to hire our graduates. There is a consensus that the programme should invest more in, for instance, learning at least one programming language and should also offer space for professional development skills, such as communication skills and project management. This analysis and evaluation provided us with the necessary input to move into the design and implementation phases and enable us to make choices on which should become, for instance, mandatory subjects in the curriculum.

Challenges - We are in a perfect storm of change where technological advancements are changing how we work, teach and learn. Change is never easy and based on the psychology of change involves five stages (Gatersleben and Appleton 2007, Prochaska, Diclemente, and Norcross 1992): **Pre-contemplation**: lack of awareness of the problem; **Contemplation**: awareness of a problem, but ambivalent about making any changes. Pros and cons of change are perceived as approximately equal resulting in no commitment to change; ***Preparation****: preparing to* commit to make changes. Intent on taking actions to make changes or already starting to make small changes; **Action**: making the change. Accepting the changes needed and taking action for making changes; **Maintenance**: sustaining change. Our goals are to reach a state of maintenance where we can sustain regular ongoing changes to our curriculum. The 5-phase approach we presented here are not only useful for evaluating a course and an academic programme but also provides for management and staff to work through the different phases of change and provide time for reflection as one moves through each of the five stages of change. This also provides programme management opportunities to reflect, monitor progress and identify challenges so that they can aid in preparing for change and develop solutions to support the necessary changes needed.

C*reating an appropriate learning environment, regardless of delivery method (face-to-face, online or blended), requires a significant amount of preparation, planning and design (Palmentieri 2022).* To achieve this requires upskilling of staff and changing how we work. In cooperation with the instructional designers and e-learning staff we have developed workshops and training sessions to enable for staff to improve their didactical skills so that they can adapt their courses for multi-mode learning. This will be an ongoing process that will require continual adjustments to be made. Storyboarding of courses is useful for visualizing courses and can be used for providing suggestions for improvements, focusing discussions and providing suggestions for how to change or create more active learning.

Next steps - We are entering phase 4 – the design phase of our curriculum and programme. We anticipate this will be an ongoing process in the upcoming year. Similar to Phase 3, we are facilitating discussions between staff so that we can consolidate courses, re-organise courses and initiate new course developments to fill knowledge and competency gaps. In addition, we will conduct several pilots that will help us refine our curriculum (see methodology phase 4 for details). Once we have completed phase 4, updates can be implemented (phase 5).

With the recent technological advancements, we now have the ability to provide very rich and multi-dimensional learning environments. To do so requires engineering educational learning environments that will enable us to do so. The inventory of our courses and design of our inventory provides the basis for this. All of our course information is now available in a structured format that makes it easy to search for courses and topics; visualise and analyse content; evaluate content, trends and relationships; evaluate learning activities; and create

personal and flexible learning pathways that can link to professional competencies (e.g. (UCGIS)). In summary we can assess what we are teaching and how we are teaching it so that we can make continual and gradual improvements.

5 SUMMARY AND ACKNOWLEDGEMENTS

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REFERENCES

Blanford, J., F. Bowlick, A. Gidudu, M. Gould, A.L. Griffin, B. Kar, K Kemp, M. de Róiste, S. de Sabbata, D. Sinton, J. Strobl, N. Tate, F. Toppen, and D. Unwin. 2021. "LOCKDOWN LESSONS: an international conversation on resilient GI science teaching." *Journal of Geography in Higher Education*:14. doi: 10.1080/03098265.2021.1986687.

Blanford, J., P. Kennelly, B. King, D. Miller, and T. Bracken. 2020. "Merits of capstone projects in an online graduate program for working professionals." *Journal of Geography in Higher Education* 44 (1):45-69. doi: 10.1080/03098265.2019.1694874.

Bogdandy, B., J. Tamas, and Z. Toth. 2020. "Digital Transformation in Education during COVID-19: a Case Study." *2020 11th Ieee International Conference on Cognitive Infocommunications (Coginfocom 2020)*:173-178.

Bryson, J.R., and L. Andres. 2020. "Covid-19 and rapid adoption and improvisation of online teaching: curating resources for extensive versus intensive online learning experiences." *Journal of Geography in Higher Education*:17. doi: https://doi.org/10.1080/03098265.2020.1807478.

Cullinan, J., D. Flannery, J. Harold, S. Lyons, and D. Palcic. 2021. "The disconnected: COVID-19 and disparities in access to quality broadband for higher education students." *International Journal of Educational Technology in Higher Education* 18 (1). doi: ARTN 2610.1186/s41239-021-00262-1.

Demuyakor, J. 2020. "Coronavirus (COVID-19) and Online Learning in Higher Institutions of Education: A Survey of the Perceptions of Ghanaian International Students in China." *Online Journal of Communication and Media Technologies* 10 (3). doi: ARTN e202018 10.29333/ojcmt/8286.

Gatersleben, B., and K. M. Appleton. 2007. "Contemplating cycling to work: Attitudes and perceptions in different stages of change." *Transportation Research Part a-Policy and Practice* 41 (4):302-312. doi: 10.1016/j.tra.2006.09.002.

Laurillard, D. 2021. "Teaching as a Design Science. Building Pedagogical Patterns for Learning and Technology." In: Routledge. https://www.routledge.com/Teaching-as-a-Design-Science-Building-Pedagogical-Patterns-for-Learning/Laurillard/p/book/9780415803878.

Laurillard, D. 2002. Rethinking University Teaching. A conversational framework for the effective use of learning technologies. .

Nomme, K., and G. Birol. 2014. "Course Redesign: An Evidence-Based Approach." *The Canadian Journal for the Scholarship of Teaching and Learning* 5 (1):28. doi: http://dx.doi.org/10.5206/cjsotl-rcacea.2014.1.2.

Palmentieri, S. 2022. "E-Learning in Geography: new perspectives in post-pandemic." *AIMS Geosciences* 8 (1):52-67.

Parmigiani, D., V. Benigno, M. Giusto, C. Silvaggio, and S. Sperandio. 2021. "E-inclusion: online special education in Italy during the Covid-19 pandemic." *Technology Pedagogy and Education* 30 (1):111-124.

Pittman, J., L. Severino, M.J. DeCarlo-Tecce, and C. Kiosoglous. 2021. "An action research case study: digital equity and educational inclusion during an emergent COVID-19 divide." *Journal for Multicultural Education* 15 (1):68-84.

Prochaska, J. O., C. C. Diclemente, and J. C. Norcross. 1992. "In Search of How People Change - Applications to Addictive Behaviors." *American Psychologist* 47 (9):1102-1114. doi: Doi 10.1037/0003-066x.47.9.1102.

Rajab, M. H., and M. Soheib. 2021. "Privacy Concerns Over the Use of Webcams in Online Medical Education During the COVID-19 Pandemic." *Cureus* 13 (2). doi: ARTN e13536
10.7759/cureus.13536.

Schultz, R.B., and M.N. DeMers. 2020. "Transitioning from Emergency Remote Learning to Deep Online Learning Experiences in Geography Education." *Journal of Geography* 119 (5):142-146. doi: 10.1080/00221341.2020.1813791.

Smolle, J., A. Rossler, H. Rehatschek, F. Hye, and S. Vogl. 2021. "Lecture recording, microlearning, video conferences and LT-platform - medical education during COVID-19 crisis at the Medical University of Graz." *Gms Journal for Medical Education* 38 (1). doi: ARTN Doc11 10.3205/zma001407.

Turnbull, D., R. Chugh, and J. Luck. 2021. "Transitioning to E-Learning during the COVID-19 pandemic: How have Higher Education Institutions responded to the challenge?" *Education and Information Technologies* 26 (5):6401-6419.

UCGIS. Geographic information science and its associated technologies (GIS&T) Body of Knowledge. Accessed 17 April 2023.

USAID. 2020. DELIVERING DISTANCE LEARNING IN EMERGENCIES: A REVIEW OF EVIDENCE AND BEST PRACTICE 98. Accessed Nov 29 2021.