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Art, music, and play as a teaching aid: applying creative uses of Universal Design for Learning in a prison science class

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Science, technology, engineering, and mathematics (STEM) subjects can be rigid in their teaching structure, creating barriers to education for students with more complex learning needs. As a result, there has been an increased need for compassionate pedagogy and adaptive education practices to provide multi-modal learning experiences—often referred to as Universal Design for Learning (UDL). Here, we outline our work in teaching science in prison that applies UDL principles to create different educational access points which are not solely focused on rote learning and reading text (which some students struggle with). We use creative practices, including art, music, and play, as a teaching aid for science subjects such as climate change, sleep, and space exploration. The key findings here being that the application of UDL principles combined to produce a positive classroom experience in a science class—with students feeling more that science is for everyone of every neurotype. Although our work here is tailored to the restrictive prison environment, the application of its core principles to education are fundamental practices that could be beneficial to a wide audience.

KEYWORDS

science communication, neurodiversity, education theory, Universal Design for Learning, science education

1 Introduction

STEM (science, technology, engineering, and mathematics) fields have traditionally faced challenges in being inclusive and accessible to students from diverse backgrounds (Holmes et al., 2018). In addition, rigid teaching methods in these subjects can create obstacles for students with more complex learning needs. Lately, a need for compassionate strength-focused pedagogy and tailored education practices is increasing recognised, embracing Universal Design for Learning (UDL) principles that provide multi-modal learning experiences (Meyer et al., 2014; Dolmage, 2017; Capp, 2017; Hamilton and Petty, 2023; Lambert et al., 2023).

The fundamental underpinning to UDL is an acknowledgement that student cohorts within most educational contexts have diverse learning needs and backgrounds, and that truly inclusive teaching must cater for this diversity (Titchkosky, 2011; CAST, 2018). This is implemented by departing from traditional models within education, by which learners or educators must identify and request adjustment to remove barriers to access reactively, instead

of pre-emptively focusing on how the learning needs of cultural and neurologically diverse classrooms may be met through inclusive design (Spaeth and Pearson, 2023).

Although most classrooms have students that have diverse learning needs (e.g., neurodiverse and culturally diverse students), one education setting where it is prominent is in prison education. Indeed, there are higher rates of neurodiversity in prison cohorts when compared to the general public (Young et al., 2018; ADHD Foundation, 2022). Given that UDL principles emphasize removing barriers for learners of all neurotypes by providing accessibility and choice, in this paper we provide practical examples of how such principles may be implemented to meet the learning needs of a diverse group within highly constrained environments.

We focus on the implementation of UDL principles into STEM subjects following calls for further exploration of how these may be implemented within educational settings (Schreffler et al., 2019), and congruent with our aim to improve access to STEM subjects for learners in prison education settings (Heron and Williams, 2022). Below, we describe in more detail neurodiversity in general, UDL as a principle, and the context of prison learners, before outlining our work in creating accessible and inclusive science education outreach.

1.1 Accessible and inclusive education for neurodiverse students

Neurodiversity is an umbrella term to describe the naturally occurring variation in all human brains across many domains. For instance, there is growing acceptance that individual learners will perceive and process incoming sensory and social information differently, as well as direct subsequent attention resources differently, owing to their neurological variability (Rogers and Ozonoff, 2005; Steele et al., 2012; Dunn et al., 2016). Put simply, individuals perceive and respond to the world differently, explained by natural diversity throughout humankind, and this extends to educational contexts (Kapp et al., 2013).

We adopt Kassiane Assaumasu's definition of 'neurodivergent' as referring to individuals whose neurocognitive processing, perception, and, consequently, life experiences differ from the dominant societal norms of the 'neuromajority' (Walker and Raymaker, 2021). This group represents the most typical and privileged neurotype within a given society at a specific point in time. Naturally, all societal norms, including neuromajority, are social constructs, and the composition of the neuro majority, along with those who diverge from it, will vary across cultures, locations, and time periods (Chapman, 2023).

Neurodivergent people may encompass those diagnosed or identify with the following examples of neurodivergence: autism, ADHD, OCD, Dyspraxia, Dyslexia, Dyscalculia, Developmental Language Disorder (see Botha et al., 2024 for a comprehensive discussion). Dominant in Western societies since the 19th century, Medical Model perspectives of disability conceptualize neurological differences as pathological deficits, requiring intervention at an individual level to 'treat' (or suppress) expressions of neurodivergence within fixed environments (Chapman, 2019). In contrast, the Neurodiversity paradigm, emerging from neurodivergent communities, disability advocates, and Critical theorists, emphasizes that neurodivergence represents natural and valuable cognitive diversity, resisting clinical pathological definitions (Walker, 2021). Through this lens, social and physical environments

that neglect to accommodate diverse processing styles hinder access to education, employment, health, and well-being and, therefore, require adjustment (Chapman, 2019). To address this, UDL provides educators with a framework identifying innovative methods that support diverse processing needs by providing multiple means, or 'access points', to engagement, representation, and action/expression for all students (we'll explore this in more detail below but for a detailed overview see Botha et al., 2024).

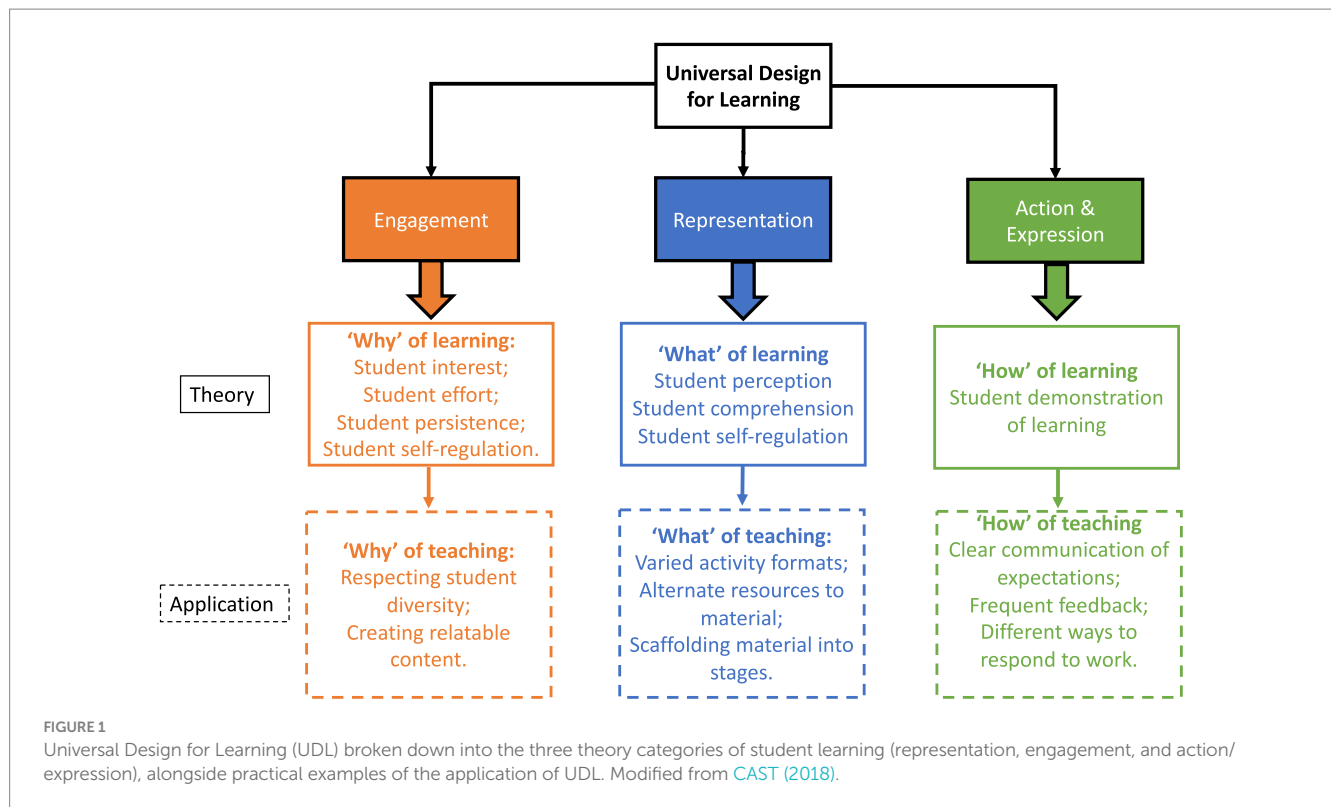
Mainstream approaches to education in the Global North have been suggested to elicit feelings of stigma that relate to their race, gender, sexuality, or other intersecting cultural factors (e.g., 'minority stress'), inhibiting learning and academic achievement (Meyer, 1995; Parker and Jones, 1999; Mendes, 2019; Dowe et al., 2021). In addition, research suggests that students who believe themselves not to "fit" into educational settings are more likely to perform poorly or to withdraw due to the impression that they do not match the profile of students who usually succeed (e.g., 'stereotype threat') (Steele and Aronson, 1995; Pennington et al., 2016). Whilst in its infancy, the application of UDL principles to teaching methods, curriculum design, and assessment practices, encourage providing greater opportunities to meaningful, satisfying, and effective learning for all students, especially those who have experienced educational trauma or belong to minoritised groups (Boothe et al., 2018; Soek et al., 2018; Mendes, 2019). This is particularly advantageous to those within a neurominority group that often diverge most from assumed learner profiles and encounter more barriers when compared to their neuromajority peers (Spaeth and Pearson, 2023; Mallory and Keehn, 2021).

The application of art, music, and games as a teaching aid is often used in education across different settings to stimulate learning and interaction (e.g., Bresler, 1995). For example, several studies have previously used climate change games as a driver for teaching. Given that board games are engaging and entertaining, participants are more likely to retain information and maintain interest in the topic (Pfirman et al., 2021; Illingworth, 2023). Music is an established teaching aid in primary school education (Killian and Wayman, 2015), with many modes of integration with material (Bresler, 1995). In particular for science education, outreach activities can couple science material with art to create a connection to a landscape or region (e.g., Nesci and Valentini, 2020). Indeed, applying art-based pedagogy has been shown to improve retention of material (Hunter and Frawley, 2023) and improve confidence in a subject (Hunter and Frawley, 2023). Specifically for prison education, a recent study shows that an arts-based approach to exploring harm and accountability (e.g., transformative justice) can improve social cohesion for reintegrating women with convictions into their communities (Havard et al., 2024).

In this work, we explore applying art, music, and games with the fundamental Universal Design for Learning principles of *engagement*, *representation* and *action/expression* to allow multiple access points to education for neurotypical and neurodivergent students (Figure 1). To better understand what the UDL principles are, we will offer a definition of *engagement*, *representation* and *action/expression* below.

1.2 Multiple access points to education in UDL

Multiple access points to engagement refers to the 'why' of learning, relating to how interest, effort and persistence, and



self-regulation are experienced in the classroom. The 'why' of learning is aligned with the brain's emotional response to learning, task-salience and motivation (CAST, 2018). Examples of the 'why' of learning can be by acknowledging and respecting student diversity and by creating relatable content relevant to the students' 'real world' experience (e.g., Heron and Williams, 2022).

Multiple access points of representation refer to the 'what' of learning, relating to student perception and comprehension within learning contexts. Active engagement and meaningful representation are fostered by facilitating student participation in learning activities by implementing (Boothe et al., 2018; CAST, 2018):

- varied activity formats;
- providing alternative and accessible resources for content (audio, visual, text-based, interactive), which adjust for visual and auditory processing differences;
- scaffolding 'chunked' activities into clearly described stages;
- encouraging collaborative, co-operative and dialogic learning;
- highlighting critical information;
- supplying notes and summaries of material in varied formats;
- the use of assistive technology for participation and notetaking (Figure 1).

Providing multiple access points to action and expression refers to the 'how' of learning and concerns how students demonstrate their learning. Positive student action and expression can be supported by implementing features such as (Boothe et al., 2018; CAST, 2018):

- clear communication of expectations;
- frequent strength-focused feedback opportunities;

- differentiated ways to respond (verbally, online, written, discussion boards) in class and with tutors;
- flexible and clearly outlined summative assessment matching to strengths aligned with core competencies;
- approachable and available tutors, who can be contacted in a variety of ways;
- scaffolded formative assessments and opportunities for practice without judgment.

1.3 Neurodiversity and prison education

A specific reason why we focus on UDL principles here rather than other pedagogical pathways is the complex needs of prison learners. By offering multiple access points as outlined by the UDL principles above (Figure 1), barriers to students accessing education, which may or may not have been identified, can be removed without the demand for self-advocacy (Gurbuz et al., 2019; Hamilton and Petty, 2023). This is linked to improved outcomes in educational attainment, employment, mental health and psychiatric unit admission, self-esteem, lifespan and overall quality of life, which can be poorer for neurodivergent people (Sala et al., 2020; Morina and Biagiotti, 2022; Hotez et al., 2023).

Notably, disproportionate levels of addiction and imprisonment have been identified in autistic, ADHD and otherwise neurodivergent groups, a pathway directly linked to unmet educational needs in earlier life reflected in higher rates of school exclusion and referral in ADHD (Barkley et al., 2007; Regan, 2010; Cheesman et al., 2022), and autistic children (Guldberg et al., 2021). Indeed, recent research into neurodivergence in prisons has suggested increased risks of imprisonment in diagnosed and undiagnosed neurodivergent people,

with over 25% of imprisoned people in the UK meeting ADHD diagnostic criteria thresholds - with 5-7% diagnosed autistic and 19% demonstrating high prevalence of autistic traits (Young et al., 2018; ADHD Foundation, 2022). This far exceeds the national averages of ADHD (3-4%) and autism (1-2%) in the general population (NHS England, 2021). Furthermore, over 50% of prison populations are thought to be dyslexic and over 80% to have a specific speech, language or communication need (McNamara, 2012).

Consistent with increases of ADHD and autism assessment waiting list figures and increasing acknowledgement of high misdiagnosis and underdiagnosis rates in wider society (Doyle et al., 2023; O'Nions et al., 2023), unrecognized neurodivergence is still disproportionately higher within prisons (HM Inspectorate of Prisons, HM Inspectorate of Probation, HM Inspectorate of Constabulary and Fire & Rescue Services, 2021; The Justice Gap, 2023). This is critical, as diagnosed and undiagnosed neurodivergent people have increased rates of reoffending, unsuccessful rehabilitation into society, incidents of aggression, co-occurring substance abuse, conduct, personality and psychiatric disorder diagnoses, poor mental health, self-harm and suicide (Chaplin et al., 2021; HM Inspectorate of Prisons, HM Inspectorate of Probation, HM Inspectorate of Constabulary and Fire & Rescue Services, 2021). Mental health and educational programs are less likely to positively impact imprisoned neurodivergent people, due to sensory, processing and communication barriers (Rowe et al., 2019; Chaplin et al., 2021).

UDL approaches have been suggested to remove such barriers across all educational contexts (e.g., not just for neurodivergent students), improving the recognition and support of individuals learning needs, and result in better overall outcomes (Craddock and McNutt, 2017; Grillo, 2021). The fundamental principles of UDL approaches are not solely for neurodivergent students, and all learners could potentially benefit (e.g., neuromajority individuals could still be positively impacted by the actions). However, there is lacking research evaluating UDLs implementation into contexts beyond primary and secondary school education, with limited studies evaluating its use with adult learners in further or higher education and/or exploring the use of UDL approaches within prison education.

In this study, we outline our approaches to apply UDL principles to teaching science in prison, and describe how we implement art, music, and play as teaching aids.

2 Methods

2.1 Case description

Our STEM outreach course, *Think Like a Scientist*, began in English prison in 2017 (Heron and Williams, 2022), continued to Canada in 2023 and now in Western Australia in 2024. In our teaching in prison, we are conscious of creating different educational access points as students in prison classrooms have diverse learning needs and the classroom presents numerous barriers (sensory, communication, processing, and regulation). This particularly impacts those considered with forms of neurodivergence (e.g., autism, ADHD, OCD, dyslexia, etc.). As a result, we engage in more creative practices of engagement (e.g., images, art, music, games) and allow significant room for discovery through discussion (e.g., Heron et al., 2023). Another conscious choice in our prison education framework is to create science content that is relatable to our student body (Heron and

Williams, 2022), allowing easier access to topics such as climate change, sustainability, and artificial intelligence.

In this submission, we will discuss our work in the Canadian version of *Think Like A Scientist*, where we fostered a collaborative space between student and artist to create unique art and music that stimulates learning and engagement. This program had seven different sessions between June and August 2023, each lasting an average of 2.5 h. In general, our classes are usually between 5 and 20 students. In this case study, we had approximately 10 students each week. We covered a different scientific topic each session, including the science of sleep, climate change, plate tectonics, space missions, and artificial intelligence. For this example, we will focus on the work during the science of sleep and climate change sessions.

It is important to note that we do not ask if a student is neurodivergent and in most cases we do not know a student's neurotype. As a result, we focus on individual student's specific environmental needs, rather than focusing on any diagnosis or neurodiversity. However, in this course a number of students self-identified as neurodivergent and therefore the group was of mixed neurotypes.

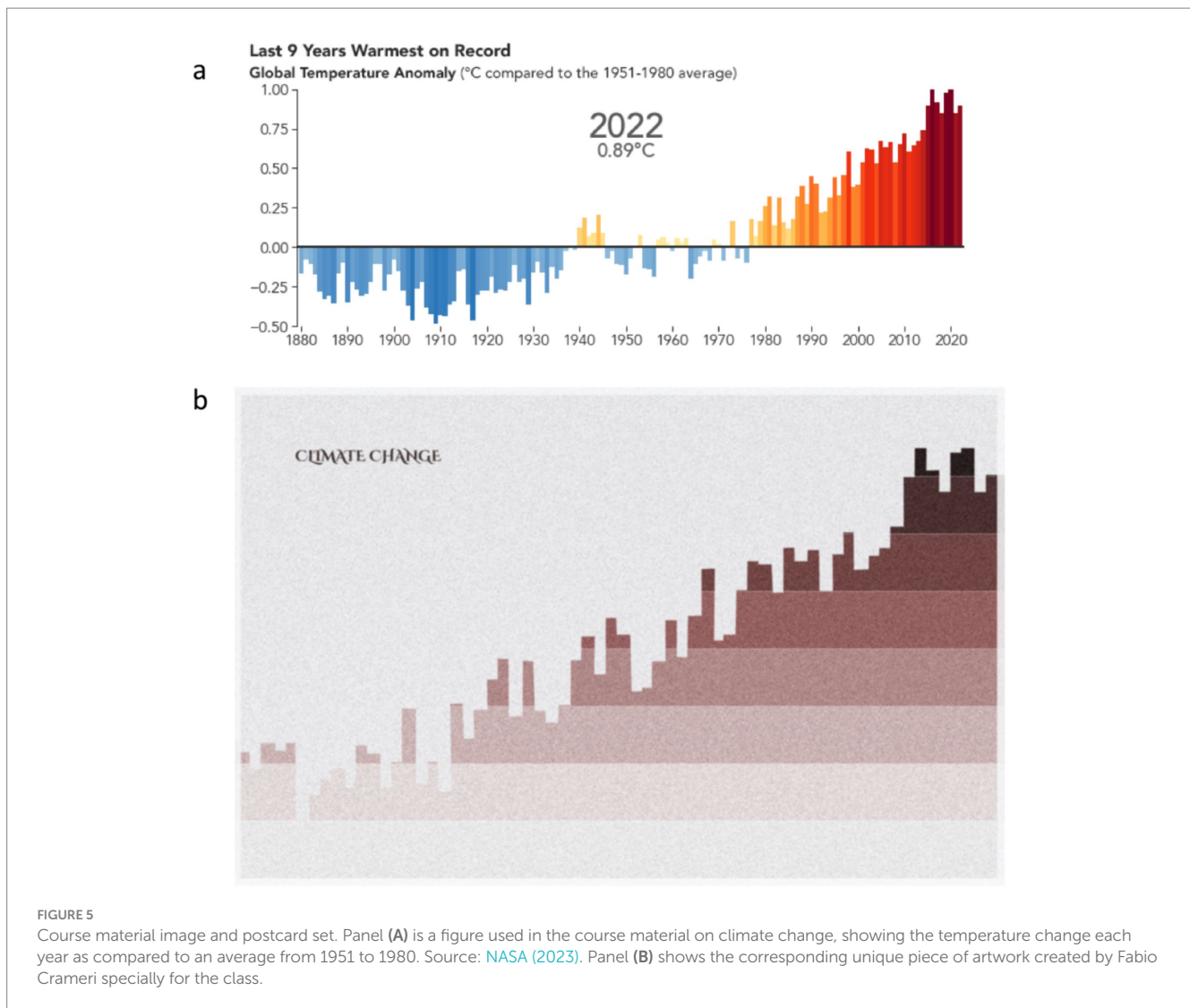
In our regular classroom, we apply UDL principles through considering:

- How are learners given choice in how they accessed and responded to activities?
- How is language adapted and different ways of participating modeled?
- How are visual, auditory, kinesthetic and sensory cues provided?

Specifically, our fundamental teaching approach is dialogic—focusing on discussing what we do not know about a subject rather than testing what we do know (e.g., Heron and Williams, 2022; Heron et al., 2023). Our feedback forms provide a method in assessing what people need (section 2.2), which allows us to adapt through explaining in different ways, such as drawing on board, modifying language, and using meaningful cultural references (for example). Furthermore, in our regular teaching class we do not have prescriptive expectations of how students take part in the activities, or what form of participation should look like (spoken, written, acted, etc.) which fits within UDL principles. The examples of art (section 2.3), music (2.4) and play (2.5) as teaching aids that we describe here are extensions of the UDL principles that form the foundation of our sessions, rather than (token) additions or 'nice-to-have' activities.

2.2 Student feedback forms

At the end of each class, we handed out feedback forms as shown in Figure 2. Given the classes are over 2 h long, we asked what material has stuck with the students over that long timeframe (e.g., what do you remember?) and what the student's emotions were during class (e.g., what were you feeling in the classroom?). The first question allows instructors to understand what material is having an impact and the second question gives an opportunity for students to share any hidden moods not captured by the instructor. An example of this being feedback from one student that wrote: "*struggle with perfume makes me frustrated and angry have a headache.*" This difficulty related to olfactory sensory processing (e.g., sense of smell) was prohibiting the student from



A final role of the song was to have the students hear their own words repeated back to them in an original piece—another way of giving students a voice in their education (Demetriou and Wilson, 2010; Halliday et al., 2019; Conner et al., 2024).

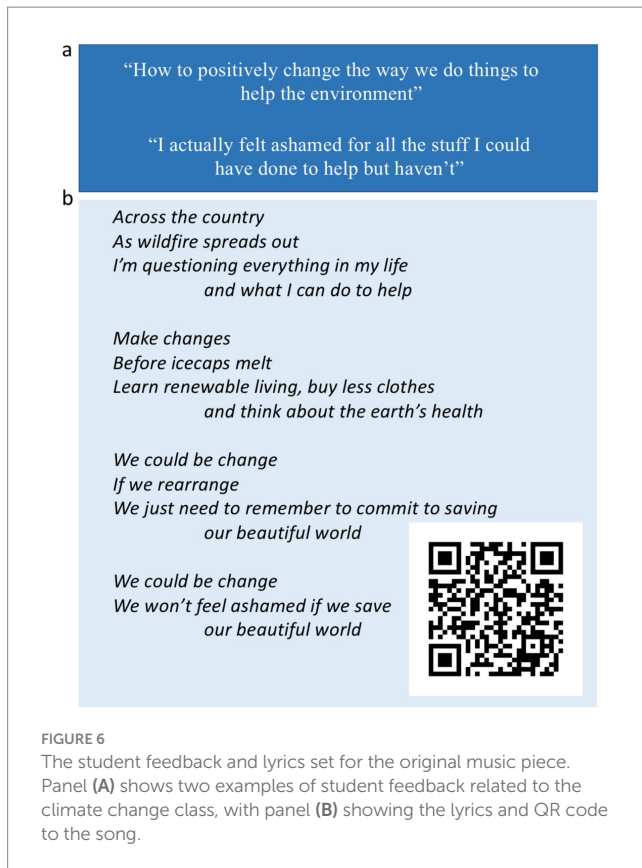
2.5 Play as a teaching aid

In order to foster a strong sense of community, we introduced two areas of play into our outreach program based around course material. The first was related to our session on the science of sleep. After learning about the different stages of sleep (Figure 4) and reading several studies related to sleep and education (e.g., Dimitriou et al., 2015), we spent time discussing the current best practices on how to get a good night's sleep. From here, we (Janeesa Lewis-Nimako) created a tabletop board game based around sleep (Figure 7). The premise being that the player(s) start at the beginning of the board holding eight sleep cards (representing a recommended 8 h of sleep). The player(s) then must roll the dice and navigate a number of squares where you could lose sleep cards or gain sleep cards.

For instance, Figure 7A shows that if you roll a number 5, the player will land on a square with a symbol of a coffee cup. This signifies the player had an extra cup of coffee late in the day, and as we learned that caffeine can impact the quality of your sleep, the player loses a sleep card (signifying one less hour of sleep). As well as negative impacts (noisy neighbors, bingeing Netflix show, etc.), there are positive cards where best practices can gain you a sleep card back (e.g., exercising during the day).

The goal of the game is to have the most cards at the end of the day—signifying the best quality sleep. The board game is setup so that even with good intentions of getting 8 h of quality sleep, little things can happen during the day that may ultimately create a negative (or positive) impact. This was an engaging way to bring the information to the class, especially in a competitive atmosphere.

However, our sleep board game was setup for a generic (non-prison) audience (e.g., references to Netflix). As a class assignment, we gave the students a blank board game and asked them to write down any negative or positive activities that could impact sleep within their own environment. The students then discussed a number of these activities and collected their own information to be placed on the board. Figure 7B shows the new sleep board game

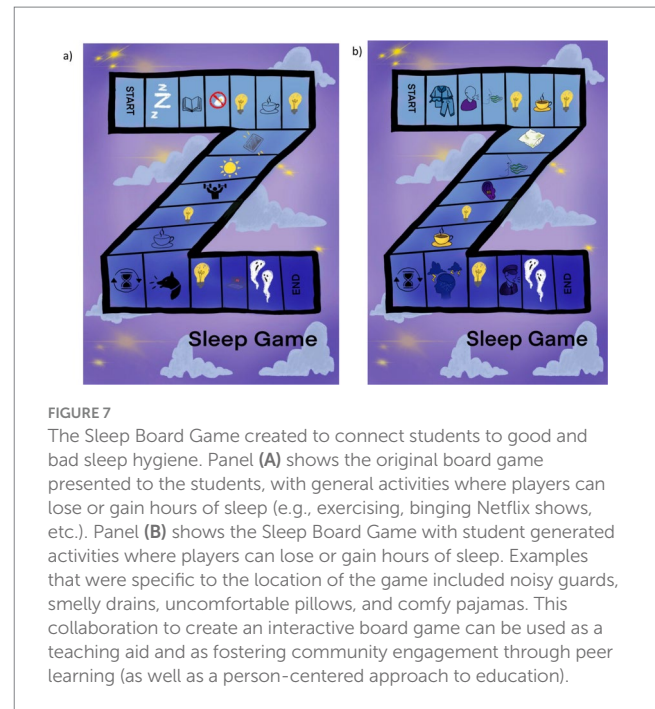


that is unique to their class, with the positive and negative activities generated by the students, which was left at the facility for the rest of the prison to play and learn together.

In our class on space missions, we discuss astronauts and their scientific experiments in space. We also discuss missions to Mars and whether there should be human exploration to the planet. In this discussion, we read a quote from Canadian astronaut David Saint-Jacques in which he states (Psychology Today, 2019): “The problem you develop here is that everything is a little bit the same every day. It can be depressing sometimes if you’re not careful. You’re very, very far away from the people you love on Earth and that can make you sad perhaps. You’re always with the same people on board, so if conflict arises, you have nowhere to go.” This connects students to astronauts as space missions sound similar to prison sentences, creating a relatable context to the science topic.

One game we play together is mental health Jenga, where we take Jenga blocks that have written on them activities that astronauts might do to keep their mental health in a positive state while away for long periods of time (Figure 8A). We play this game as a group, with each student taking a turn to take out a block and read the activity an astronaut may do (e.g., write letters home, eat healthy, exercise, etc.). The goal here is to show that there are several things we do to keep our mental health in a positive state each day, but sometimes we can miss a day of exercise. However, the game shows that one missing activity (e.g., a block) is not important until coupled with a number of missing blocks, and then the tower (e.g., your mental health) can tumble.

Similar to the sleep board game, this mental health Jenga game is also very engaging and competitive, with students focused on not toppling the tower and on the reward of reading out loud the activity

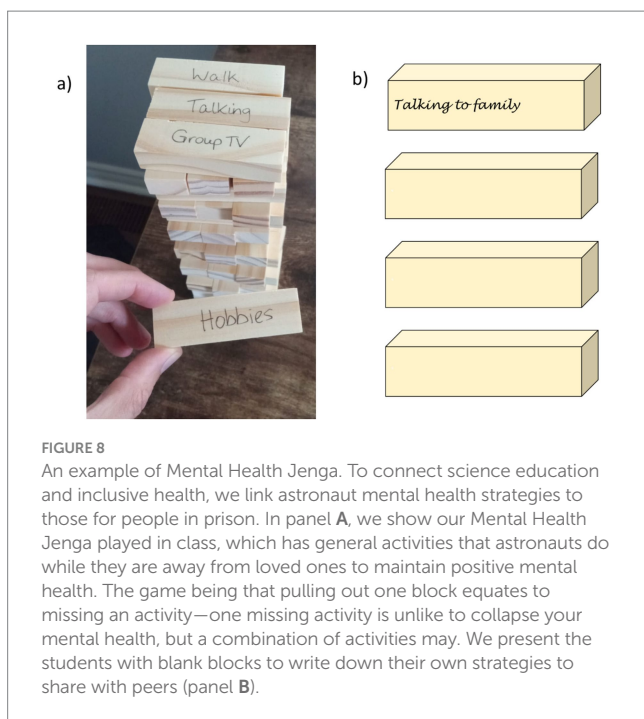


block they have successfully removed. However, we also provide a blank set of Jenga blocks for each student to write down on some of the blocks the activities they do to keep their own mental health in a positive state each day/week/month. Here, the students then add their blocks to the pile, and a unique game focused on mental health in prison can be created for their specific environment. This person-centered approach to mental well-being is also a form of peer-learning, whereby the activity of play the students can learn about each other’s strategies for positive mental health.

3 Results

In this section, we present a selection of the student feedback as it relates to the course ran in the summer of 2023. At the beginning and end of the program, we provide feedback forms, which the students are encouraged to fill in. This feedback allows us to get a basic insight into the distance traveled by the students. There are also a number of sections for the students to provide written feedback on several topics. Examples of our feedback forms can be found in Supplementary material, and we have also provided the anonymized information (see Supplementary material). However, the overall impact for this work is difficult to capture in our standard end-of-course feedback forms, as we are looking for impact over long timescales. Despite this, we provide here some of our findings on student impact of our teaching method and the use of art and music as teaching aids.

In Figure 9, we present all of the student responses to the question ‘does the artwork and/or music help you remember course content? Do you like them?’ Here we see a positive response from all the students who responded (9 out of 10). The feedback ‘I am an art person, so this helps me thrive’ links well with our original goal of giving students different access points to education. In other areas of our feedback forms, we found a few comments related to the art and music, including



- “*More arts and music please*” to the question: How can we help you learn better?
- “*The art shared with us*” to the question: What was the best part of the course?
- “*Song created a vision of commercial to bring awareness and encourage change and appreciation for Mother Earth*” to the question: Thinking back, what are the most memorable parts of this course?
- “*... the music, the art*” to the question: Thinking back, what are the most memorable parts of this course?
- “*The music, art, discussions*” to the question: Thinking back, what are the most memorable parts of this course?
- “*... the song*” to the question: Thinking back, what are the most memorable parts of this course?

Before the end of the course (week 5 out of 7), we also surveyed the students specifically on the sleep art (Figure 4A). Of our 9 respondents, 100% answered yes to the question ‘do you like the art?’ (see Supplementary material). Figure 10 shows the individual responses to the question ‘what do you remember from the sleep class based on the images?’ Our goal here was to see if the art can trigger any memories from the class that was several weeks prior. All nine respondents chose to answer this question and write something about the class. Testing memory recall based on using art or images as a trigger is something that we are interested in exploring in more detail in the future (with more quantitative or qualitative measurements).

A goal of our outreach course is to increase confidence of the student in education (e.g., Heron and Williams, 2022), as well as creating an accessible and inclusive environment for science teaching (e.g., Heron et al., 2023). As a result, we wanted to focus on the process of being a scientist where perceived failure in the pursuit of knowledge is expected and accepted. Figure 11 outlines the statement given in our pre- and post-course evaluations on ‘Science is for everyone’ and shows a shift to all respondents agreeing with the statement by the end of the

Does the artwork and/or music help you remember course content? Do you like them?

Yes, music has colours, colours build intrigue and curiosity

Yes, I love the way you taught sleep curves and the importance of changes.

Yes, I enjoy the artwork = it remind me of our overall sleep and science can be put into art, as well as music = I try and find the words used that I put in

Yes, music and art are great

Yes. I am an art person so this helps me thrive

Yes, the art and music was great

Art and music always help me recall content and I appreciate and enjoy them.

Yes I like to see what it is we did put in to art/music

Yes! I always find music helps with everything and I love them

FIGURE 9

Presented here are all of the student responses to the to the question ‘does the artwork and/or music help you remember course content? Do you like them?’ from the end of course survey.

program. Furthermore, a number of written feedback comments highlight the impact that the Think Like A Scientist program has on our students, with several respondents indicating the positive aspects of learning about critical thinking and the scientific method. Figure 12 shares some of the positive descriptions to the feedback on the end of course question ‘Has the course helped you in any way?’. Here, we see students talking about critical thinking, failure, and sharing information with their communities (e.g., response 2 on talking about the course with their son).

4 Discussion

The work here takes the main principles of Universal Design for Learning (UDL, Figure 1) and applies them to a prison classroom setting. The overall impact of integrating art, music, and games as a teaching aid has been positive. However, it must be noted that UDL principles are not just based around sensory memory triggers—our work here is just a sample of UDL in practice and below we provide a practical example of how a regular classroom could achieve UDL principles based on the work we have conducted here.

4.1 Application of broad UDL principles in science communication

If we consider teaching climate change in a regular classroom, UDL principles could be utilized to provide students with different access points to the same information, based on their processing preferences. For example, we could allow students to choose if they would like to listen to a talk on the content, read an article, watch a video (with text-captions), or access an interactive website (Hamilton and Petty, 2023). In our prison teaching, we are often restricted by the method by which the material can be presented (e.g., a lack of video

and websites). However, we do provide in-person lectures as well as text-based handouts. This fundamental UDL principle of multi-modal content is a priority for our future work in prison education.

In our prison education class, we adopt UDL principles in the way we teach subject topics, where we focus on 15-min sections of activities or teaching. For example, our class on climate change in prison could be directly mapped into a regular classroom through adopting this 15-min time to focus on different aspects of the topic. The instructor and resources provided would make explicit links between the topic being taught and experiences that the students had encountered or observed in their lives, also referring to current news stories or well-known social media threads (as we do in our prison education). All resources and discussions would be recorded for later access, and a summary document of the key points would be provided in a short video, a written document, and an infographic.

Following this, students may then be offered a choice between discussing the topic with their peers, documenting their learning through a written account or quiet reflection, or presenting a short presentation alone or in a group. We implemented this method into our prison education classes through offering a variety of choice for homework. This framework outlined above would correlate well with

the basic principles of UDL—engagement, representation, and action and expression (Figure 1).

4.2 Wider application of the work

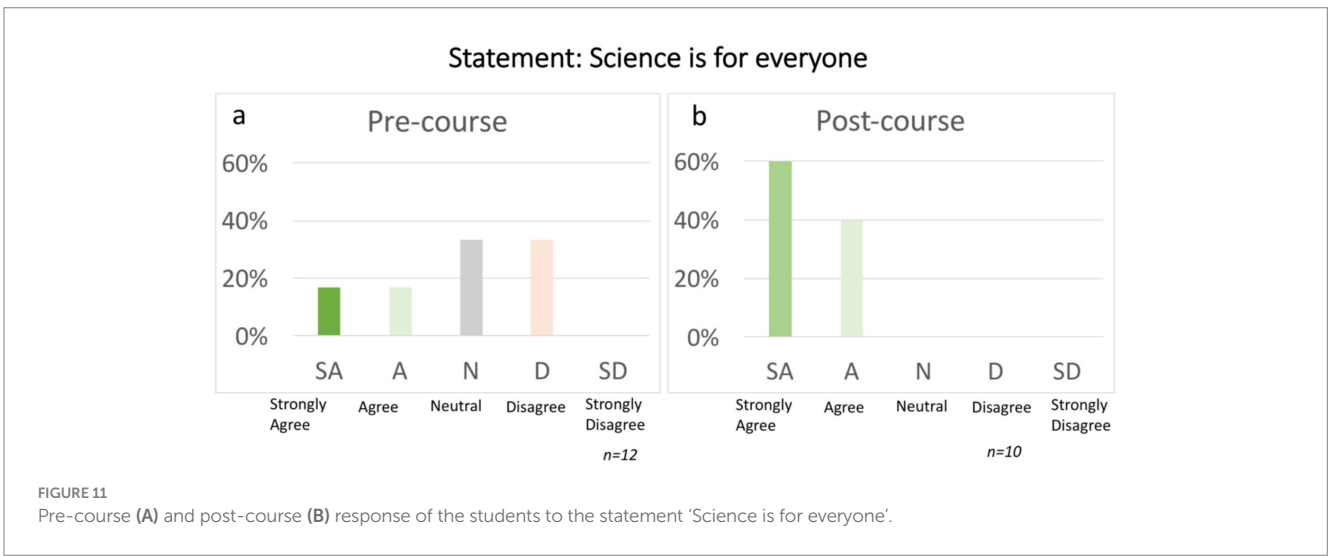
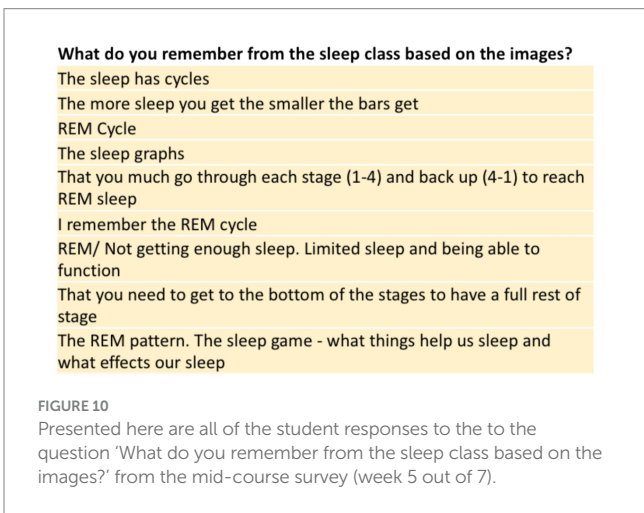
As outlined above, in this outreach course, we created unique art and music to help provide different access points to education, as well as to generate visual and aural pieces to trigger a memory of the course material (Figures 4–6). We also created student specific games to center the student in the course material (Figures 7, 8). In terms of wider application, the games are easily transferable to most classrooms and outreach events. The mental health blocks can be linked to multiple scenarios (e.g., exam preparation strategies) where students can prepare their own blocks to be shared with the community. The sleep board game can be also transferred to children and adults across the education spectrum, with the group of students creating their own activities or events that can improve or reduce the quality of their sleep.

For most classrooms, the creation of unique art and music pieces to help trigger course memories may be difficult due to time and expense (in our program, we reimburse artists for their work). The improvement of artificial intelligence in the creation of art and music may provide a future pathway for a cost-effective widespread implementation of this teaching aid.

However, we have been implementing a version of using art as a teaching aid in a final year university course. In the final 5 min of every class (2-h lecture), we invite the students to guess the four most important images that were displayed during the lecture (Figure 13A). In this time, we encourage students to not look at their notes and try to recall what images have connected with them during the session. We ran this activity for 12 weeks (with approximately 20 students per class) and then surveyed the students at the end of the course (Figures 13B,C).

The overall positive response to this activity indicates that this no cost version of a UDL principle could be applied in even the most restrictive of classrooms. An avenue for further exploration would be to build in a figure or an image theme for each section of the course, with exam questions building from the image to assess the level of understanding.

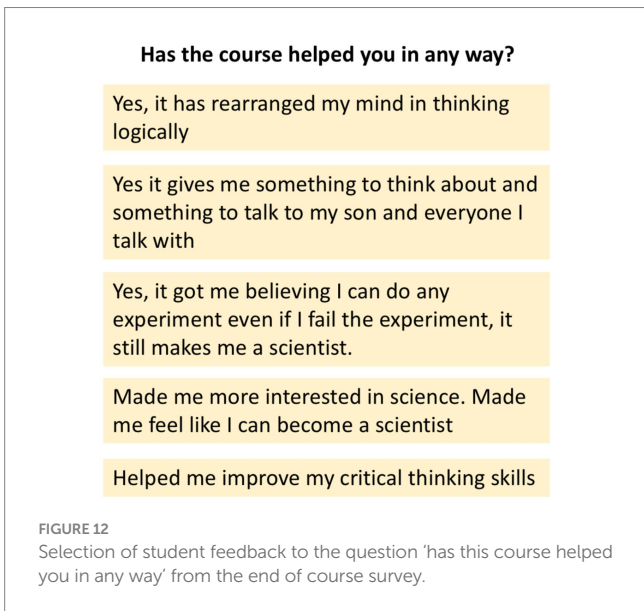
In terms of applying music to education scenarios, we also created a song based on a climate security workshop in Helsinki, Finland



(Climate Security Festival, 2023). During the first day of the event, we collated discussion points, activities, and eco-poetry related to the workshop and produced a song (Figure 14). We presented this original piece on the second day of the event, to highlight the methodology of participant-centered material.

When trying to build discussion on topics that may be divisive across communities (e.g., climate change), we try to create material that can be accessed by everyone. In this case, through art and music.

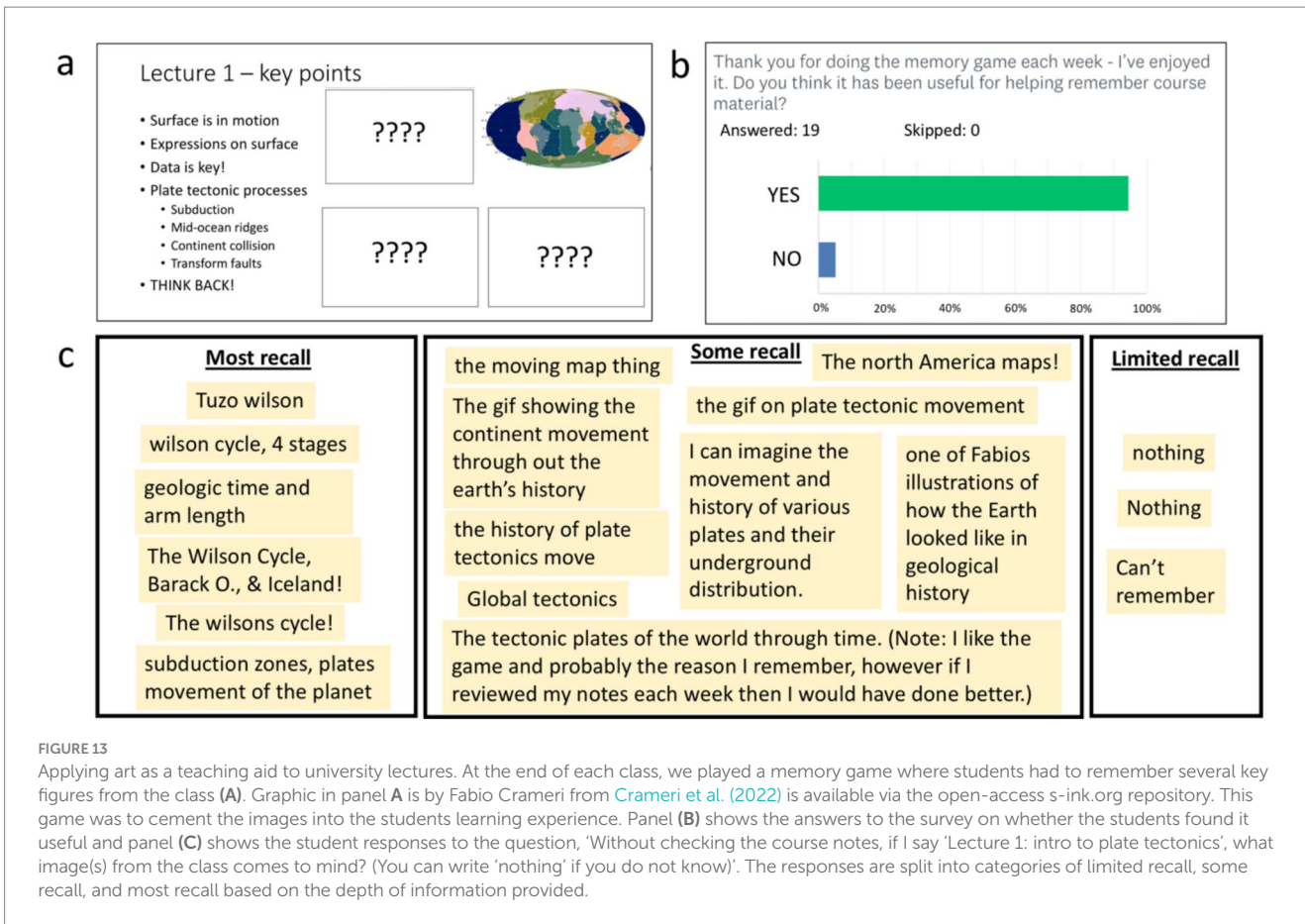
In this specific example as shown in Figure 14, we were attempting to create spaces for an open and equal climate discussion with and between people in different sectors and life situations. The art and music were conduits for creating tools for hosting discussion spaces that combine improving understanding of scientific topics to sensitivity of participants' individual needs. Future work will be conducted in this realm of using art, music, and games to promote learning and discussion space for challenging topics.



4.3 Criticism of UDL and future work

It is important to note that the basic principles of UDL have been criticized in several areas. Specifically, prominent criticisms of UDL have focused on lacking generalizable evidence of successful integration into diverse learning settings that directly improve academic outcomes (Rao et al., 2014; Capp, 2017; Roski et al., 2021), alongside practical concerns over how achievable utilizing multi-modal approaches in teaching is when considering the constraints to resources of funds and time facing educators (Katz, 2015; Fovet, 2020). These practical concerns could be identified in our example of teaching climate change above, with teachers now having to provide content in a number of forms (audio, visual, text), and highlighted by our work creating new music, art, and board games for every class.

Furthermore, a reliance on technology (King-Sears, 2009), training (Spooner et al., 2007; Lorenzo-Lledó and Carreres, 2022; Lambert et al., 2023), and a difficulty applying UDL to scientific subject matter (Curry et al., 2006) have also been highlighted.



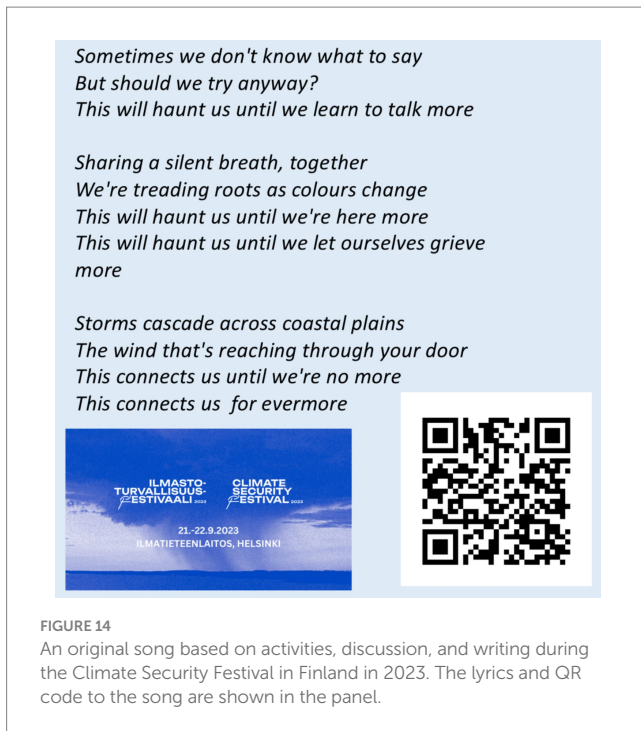


FIGURE 14
An original song based on activities, discussion, and writing during the Climate Security Festival in Finland in 2023. The lyrics and QR code to the song are shown in the panel.

Concerns over a lack of consistency in UDL application to evidence successful implementation (Rao et al., 2014). However, Hess (2023) suggests that without thoughtful and individually focused implementation, which is willing to innovate and combine traditional educational approaches when needed (Frolli et al., 2020), UDL may overlook the individual needs of disabled learners and remove opportunities by which adjustment may be requested.

The new work we present here has successfully applied UDL principles in one of the most restrictive classrooms (e.g., prison). In particular, the application of board games shows a step away from technology and provides hands-on experience to the students. The work we present here is a step toward countering these broad criticisms of UDL principles. However, future work in the area should focus on providing solutions to the practical concerns of implementing UDL principles in all classrooms (e.g., high school and university education), rather than such pedagogies being only available to those educators who have the time and facilities.

The work here has been evaluated using formal feedback forms that could be gathered in a highly time and resource constrained moments. A survey was chosen as it is a practical way to collect feedback (e.g., a format which students would likely be familiar with), which students could fill in without interference from us or others (due to lack of private space). Given the commitment UDL principles of action and expression, an area of future work would be to incorporate different forms of feedback into our evaluation of impact that would be suitable for technologically restrictive settings.

5 Conclusion

Education can be inaccessible to some students due to a number of barriers to learning. In particular, science subjects have often been difficult for some students to access, with the environment to learning being more rigid than other areas. By applying person-centered learning principles (Figure 1), we created unique art (Figures 4, 5), music

(Figures 6, 14), and games (Figures 7, 8) that allow students access to education on their own terms through play and engagement with non-traditional science education tools. The impact on our cohort of students has been positive (Figures 9–12) with our future work focusing on the application of these tools to a wider network of students (e.g., university and high school education, Figure 13) who also feel outside of science education. Finally, our work here provides a practical example of Universal Design for Learning principles in action for science education (Figure 1).

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the participants was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

PH: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. FC: Conceptualization, Formal analysis, Methodology, Visualization, Writing – original draft, Writing – review & editing. EC: Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing. DH: Formal analysis, Methodology, Writing – original draft, Writing – review & editing. SH: Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing. PL: Investigation, Writing – original draft, Writing – review & editing. SN: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing. KO: Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing. RR: Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. JW: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The authors declare that no Generative AI was used in the creation of this manuscript.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/feduc.2025.1524007/full#supplementary-material>

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