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Design Thinking in Higher Education Case Studies: Disciplinary Contrasts between Cultural Heritage and Language and Technology

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Abstract: Design thinking is a set of cognitive, strategic, and practical procedures used in innovation. This article argues that this approach varies across disciplines. The contexts for this study are two higher educational frameworks where language and technology have different aims and target unique skill sets and where transdisciplinarity is crucial. In our contrastive case study, we use a four-step model to compare two contexts. QUAN(qual) → QUAL mixed methodology is used which includes a quantitative and a qualitative comparative analysis. Context one takes place in an education faculty and focuses on developing cultural heritage. Context two takes place within a research project on linguistics and telecommunications involving linguistic analysis and bioelectrical measurement. Our findings indicate that there are clear and specific differences between the two domains when approaching design thinking. We observe that engineers seem to have a tangible final product in mind at each step of the process, while in the social sciences, the construct is more humanistic in its approach and works towards multiple tangible goals, including an examination of the existing needs in the community. The novelty of the study is the applied approach it takes in treating transdisciplinarity as a skill that is essential both in research as well as in the teaching–learning process.

Keywords: higher education; transdisciplinarity; design thinking; language and machine learning; cultural heritage

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1. Introduction

Education research explores processes that shape educational outcomes. In educational plans, transdisciplinarity includes skills that are crucial both in research as well as in the teaching–learning process. Many studies [1,2] call for the inclusion of non-academic aspects in the process of knowledge production, but perhaps we are redefining what academic aspects should include.

We argue that design thinking should form part of graduates' skill sets and present this both in a research and teaching context. Rather than supporting the content learning of a single discipline, transdisciplinary design thinking addresses the problem to be solved by crossing disciplinary boundaries in the search for solutions in practice. Many authors have documented that people are already learning in different ways [3–5].

Clearly, experiential learning includes both formal and informal aspects. Formal learning is an organized activity in a classroom, while informal learning is unstructured, spontaneous, and, very often, unintentional. However, if informal learning has a defined purpose, it becomes non-formal learning. This difference of 'intended purpose' is salient for non-formal learning as the learner makes a conscious decision to master a skill or area of knowledge.

Our approach is grounded in both formal and non-formal learning in two disciplinary contexts and will highlight transdisciplinary skills with a student-led defined purpose. For this study, the focus is on how language and technology are combined and how different disciplines use design thinking to develop this combination. While both contexts involve language and technology, each aspect can be considered individually within each case. In this study, we focus on transdisciplinary teaching in social science as compared to interdisciplinary research between linguistics and engineering. It is our intention to create a contrastive study to explore key similarities and differences using design thinking.

1.1. Context and Clarifications

We find it necessary to clarify the idea of disciplines and transdisciplinarity by contrasting interdisciplinary and transdisciplinary approaches which will help formulate the definition. Research [1] discusses a three-tiered collaborative hierarchy and highlights the 'complicated systems' of research across the disciplines. Collaborative research is often conceptualized as consisting of three levels: first, multidisciplinary research, which can be construed as less integrated and the least cooperative form of collaborative research. The second level is interdisciplinary research, where greater emphasis is given to cooperation between researchers with a common purpose. The third level, transdisciplinary research, is considered the most integrated form of collaboration and oftentimes includes stakeholders from different research fields or from outside the research process itself [6–8].

Indeed, it is challenging to find common ground across the disciplines, for each setting is unique, but each brings something different to the table. What each case has in common is that they each involve multiple disciplines and design thinking. The present goal is to pick out salient contrasts and comparisons in each context and to explore the interplay between qualitative and quantitative approaches as applied to each disciplinary context. Although both design thinking cases will deliver tangible final projects and are decidedly student-led, the way they approach research design, language, and technology varies significantly.

Context one (C1) brings transdisciplinary research into the classroom and focuses on developing digital skills and intergenerational dialogue in social sciences, while context two (C2) solves a specific interdisciplinary research problem combining language and technology tied to machine learning.

C1, transdisciplinary teaching, takes place within a specific subject. In the first part of the study, questionnaires, including a convenience sample of 96 students, were presented. Student participants were divided between those studying for a graduate degree in primary education (50 participants) and those studying for a Master's degree in secondary education (49 participants). In this study, the second stage was carried out with only the 50 participants from the primary education degree in which students purposefully created intergenerational dialogues. These dialogues were later presented in videos.

In C2, interdisciplinary research, the project explored the effects of online platforms and attention. The present study focuses on beta brain waves using bioelectrical measurements (electroencephalogram, EEG), as these signals can correlate to attention in subjects. This interdepartmental collaboration is led by English studies and telecommunications and deals with speech analysis and machine learning. The students are both undergraduates and postgraduates in English and undergraduates in telecommunications.

1.2. Benefits of Transdisciplinarity and Design Thinking

Action research methodology is grounded in practice and informed by theory. Transdisciplinary approaches look outside the university to take a worldview, aiming to integrate students into the workplace. There are clear pedagogical implications of transdisciplinarity. Learners are encouraged to understand the 'why' of learning through engagement, to see the 'what' of learning as contents and contexts are presented in different ways, and to value the 'how' of learning with clear goals and ways to express knowledge. Nowadays, the problems being investigated are increasingly more complex, and multiple perspectives must be considered in applied contexts for both research as well as for teaching.

1.2.1. Benefits of Transdisciplinarity

For research, transdisciplinary teams may be able to tackle complex societal problems that monodisciplinary researchers are unable to. Disciplines may, especially when sharing related goals, rely on each other for 'problem feeding' by generating hypotheses and solutions [8,9].

For teaching, the intentions of transdisciplinary learning and problem-based learning overlap to create an extremely useful pedagogical practice. Transdisciplinarity is increasingly included in course syllabi, but its implementation is not clear within specific fields. There are clear opportunities, but challenges remain [10,11]. How transdisciplinary design thinking should be organized to scaffold learning has yet to be fully developed; and we hope to shed some light on the topic through this contrastive case study.

1.2.2. Design Thinking

Numerous studies [12,13] have identified a gap between graduates' skills and capabilities and the demands of the work environment in an increasingly globalized society. Graduates often lack the strategies to organize and apply their specific skills to new situations or perspectives. Design thinking fosters applied reflection, creativity, and uses a holistic approach that is based on an understanding of the experiences of those involved [14–16]. The strategic application of thinking skills is, indeed, the goal of education itself.

Design thinking has a solid foundation for divergent and convergent thinking [5,7,17,18], for both analysis and synthesis [19], and, more recently, for visual research methodologies (VRMs) [20,21]. Often presented as a series of actions in steps, there is no one model. In fact, some authors [22] identify fifteen different models for design thinking. Figure 1 presents three that will help create our analysis.

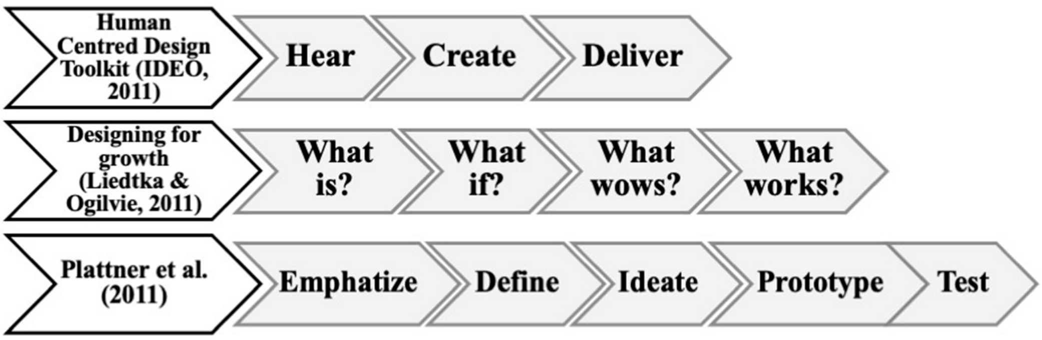

Figure 1. Three models for Design Thinking adapted from [23–25].

For this case study, we will adapt IDEO's [23] model (as cited in [22]) by adding a final step: 'assess'. We include [24]'s model as it allows for the utopian 'what if', while remaining grounded in the final product, 'what works'. And finally, Hasso Plattner Institute's model [25] includes two ideas that underscore the process itself, where 'defining' the problem and 'assessing' the final product are included.

One author [26] describes case study as an inquiry which investigates a real-life context. This author underscores that case study is not a method of data collection, but rather a research strategy. Our research strategy is a comparative case study of transdisciplinarity and design thinking.

2. Materials and Methods

The design thinking approach is common to both, but when applied and examined using the case study method, new insights are revealed. As can be anticipated with two distinct cases, the procedures vary, although both will be analysed using the design thinking framework using a QUAN(qual) → QUAL mixed methodology [27,28]. Table 1 outlines the procedures for each context.

Table 1. Procedures for each context.

	Social Science	Engineering/English
Data collection procedure	The main instruments were 96 questionnaires, and then 50 semi-structured interviews.	This process begins with interdisciplinary design thinking. Data are collected with an EEG cap. The team selects variables and data sets making each step of the process more correlated and better defined.
Role of language	Language is a tool. The value of intergenerational dialogue has been interpreted and transferred to a digital representation of cultural patrimony.	Language and its relationship to attention are the object of the study. Students create a linguistic map of video stimuli to correlate features with EEG responses.
Role of technology	Technology is a tool. Students create videos using visual research methodologies (VRMs) and transfer narratives to a digital format.	Using the EEG cap makes technology part of the research. Students create specific technological applications that improve reliability of the data set by identifying brain regions tied to stimuli.
Final goal	The final goal is to explore cultural heritage using transdisciplinary design thinking to reach out to the community outside the university. From 63 videos, 13 videos were selected and specifically reinforced the value of people and patrimony.	The final goal is a series of tangible goals: first to filter EEG activity using software design in the Matlab app created for this purpose; next to correlate linguistic features to attention an ensure reliability; and, ultimately, to use this reliable data to 'train the machine' in future research.

In order to contrast each case, four variables have been selected. These include the instruments of data collection, language, technology, and final expected outcomes. We observe QUAN-qual cases are quantitatively driven, although qualitative interpretation takes place at different steps in each process.

The research in case one is highly contextualized in its approach, and it has been confirmed by previous studies [29]. First, questionnaires were used for inquiry research; second, semi-structured interviews related to cultural heritage and intergenerational dialogue were collected; finally, visual research methodologies (VRMs) were developed using digital support.

The research in case two focuses on solving specific research problems involving linguistic analysis, artificial intelligence, and bioelectrical measurements. Design phase one examined how language is a stimulus for attention as measured by EEG signals. The human sample is small (13 subjects), but the raw data collected are enormous. This research can be replicated, and preliminary data are beginning to show correlation. Case two has been approved by the proper ethical committee as it involves experimentation on humans.

In this comparative case study, the contrasts are key as they suggest that all research must explore both quantitative and qualitative design. Some researchers [30] (p. 4) describe the multiple directions of qualitative research as "a back-and-forth movement in which the investigation first operates inductively from observation to hypothesis and then deductively from the hypothesis to their implications". In our contrastive case study, we will use a 4-step model to describe the two distinct communities of practice.

The IDEO [23] model highlights that human-centered design lies at the crossroads of empathy and creativity. In Figure 2, each context is set into a design thinking model adapted from this model; the authors have added the final assessment step.

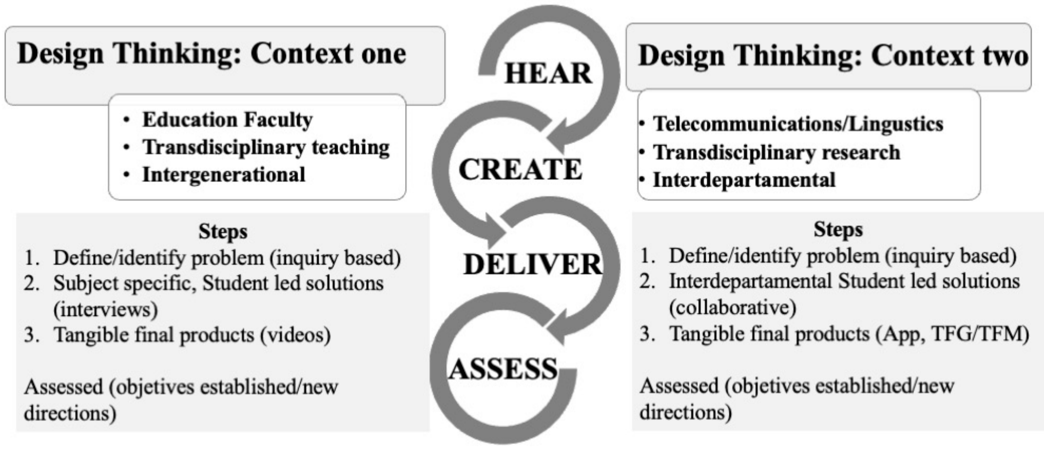

Figure 2. Contrastive case study Design Thinking (based on IDEO [23] and adapted by authors). Note: In Figure 2, TFG stands for *Trabajo Fin de Grado* (Final Degree Project), and TFM stands for *Trabajo Fin de Máster* (Master's Thesis).

2.1. Case Study Contexts

C1, transdisciplinary teaching took place in the Education Faculty where 50 national and international undergraduate students explored digital thinking skills and intergenerational dialogues. The main aim of this study has been an inquiry-based educational practice regarding cultural heritage [31–33]. Students' design problems explored people's life stories and how these play a role in the emerging community of practice. Following this idea, the activity highlighted the value of cultural narratives in educational processes through interviews and design thinking. Interaction with the community was a key goal. Technology and language worked together in students' videos and encouraged cultural heritage awareness.

C2, transdisciplinary research, took place in the Engineering Faculty where the process began with an existing research problem in a project about language processing and electroencephalogram (EEG) signals. The objective was to see if online discourse can cause the same attention response as live face-to-face speech and then use the results for machine learning. The student engineers worked closely with undergraduate and postgraduate students in English studies who oversaw the mapping of the texts and identifying stimuli for the research design. The students effectively created an interface between natural language stimuli and machine coding, so that the data could be interpreted statistically and verified as viable for machine learning and text interpretation. This reinforced the connection between natural language and technology with the emerging research.

2.2. Design Thinking Steps

This section will elaborate on each context using the four steps and contrasting each design thinking context. First, we will define the design thinking step and then develop the process within each case.

2.2.1. Step One: Hear

Because there are multiple perspectives to be considered, stakeholders must connect to each other. In C1 they connect across the generations, while in C2 this is carried out across the disciplines. Through this 'hearing' process the purpose begins to be defined.

In C1 the aim was to raise students' awareness of tangible and intangible cultural heritage. Each student chose an elderly person to interview. Interviews had a basic script detailing the type of cultural heritage selected and a brief description of the interviewee's experience and identifying why the example was considered relevant for the classroom and for the community. The results showed that respondents were usually relatives from the maternal line, either mothers or grandmothers, with fewer men. Descriptions might show: a recipe, the town or village square, etc., and narrate why this is important to preserve. The main teaching objective was to create the connection between people and patrimony [34], exploring intergenerational cultural identities. Students were invited to create a platform where these people were given a voice through the videos created from language to technology.

In C2, human language and machine learning overlapped. To carry out this project, an electrode cap was used to observe the EEG signal of the users while 6 subjects were exposed to video stimuli. The initial conflict was specifically how each discipline approached the research project. Preselecting features was something that the engineers needed to anticipate, while the linguists wanted to collect and analyze after. The design thinking problem began with data selection, for it is not necessarily true that more features lead to better models. The engineers wanted to statistically manage an enormous quantity of data, while the linguists wanted to delve deeper into the correlation of specific features with specific electrodes related to attention. In fact, irrelevant features can impact the learning process, leading to overfitting when training the machine for artificial intelligence (AI). Overfitting is a concept in data science, which occurs when a statistical model fits exactly to its training data. When this happens, the algorithm cannot be used in machine learning. It was something to be avoided, that the linguists had not anticipated.

2.2.2. Step Two: Create

This step is student-led using design thinking. In both contexts, creativity was the joining of perspectives through knowledge transmission, language, and technology. These processes include both cognitive and strategic planning for transdisciplinary design thinking. In C1, the process involved a creative representation of cultural narratives, while in C2 the process focused on creative problem solving.

In C1, students used digital skills to interpret and translate cultural knowledge into short videos of 1–3 min related to experiences and identities from respondents. Oral and written language was collected and transformed into a digital format. These videos clearly visualized the older generations' point of view, effectively representing the intergenerational dialogue and narrative adaptations. Far from manipulating the information, students formed part of the creative narration and understood the need to preserve this heritage, giving voice to their elders.

In C2, transdisciplinary collaboration formed an essential part of the creative step. The engineering student helped quantify intensity and frequency of responses, but not all the data could be directly tied to an attention response in the subjects. Furthermore, the original video stimuli were too long, yielding irrelevant data. In turn, the language students had to reformulate the stimuli with shorter videos and by anticipating variables and mapping the stimuli to identify features. Without going into the technical aspects, what this means is that there was quite a bit of filtering necessary to discover which signals were associated with significant, identifiable stimuli as opposed to those which were merely representative of normal brain functions. In addition, language students identified which stimuli created an emotional or attention response in the sample. So, at this stage what is noteworthy is the selection of the stimuli [35], together with the identification of brain regions tied to EEG responses.

2.2.3. Step Three: Deliver (Preliminary Results)

In both projects students produced tangible projects. For C1, these include interviews and videos, while for C2, students produced an app, a final degree project in telecommunications, and a master's thesis in English studies. Without a doubt, research and learning melded together with students taking the lead.

In C1, delivery included 96 questionnaires, 50 interviews, and 63 videos. Questionnaires were conducted through the Google Forms platform, carried out from January to June 2023, with an approximate duration of 15 min. The reports are organized with 5 questions related to sociodemographic variables and 16 questions related to the perception and use of cultural heritage variables. Questions had closed answers, 'YES/NO', and open answers to justify choices. The report was designed by the researchers of the study and assessed by 2 external experts in educational sciences and research methods.

Students developed cultural heritage concepts using questionnaires for inquiry research. Firstly, to explore intergenerational dialogues, 50 semi-structured interviews were held with older members of the community, relatives, etc. Then, 50 short videos (1–3 min) were created individually describing experiences that older people had in relation to patrimony. Finally, in groups, students created 13 videos (3–5 min) focusing on a patrimony topic to bear in mind for their learning and for the community.

In relation to videos, these were shown in the classroom, encouraging discussion of heritage issues from both a national as well as from an international perspective. Of the 63 videos, 13 were created at a secondary stage in groups and specifically reinforced the value of people and patrimony. Student products showed a deep understanding of the value of ancient wisdom passed on through the generations and highlighted regional music, food, and popular sayings. The products effectively transferred oral narratives into a more visual, digital format.

The initial inquiry of 96 students found that 97.9% recognized the importance of cultural and natural heritage to both local and universal identity (Figure 3).

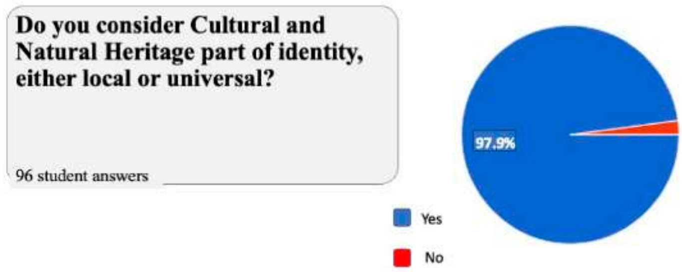

Figure 3. Considering Cultural and Natural Heritage as part of identity.

Regarding the sources used for the visual research methodologies (VRMs) tool in Figure 4, 52.1% of the sample created their own versions of the videos, while 47.9% used external sources (internet).

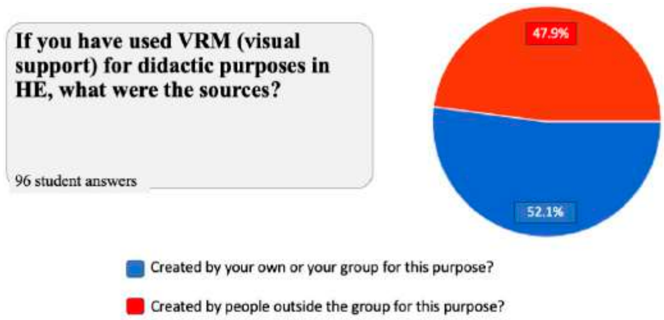

Figure 4. Sources for VRMs.

In contrast, Figure 5 shows that 71.9% had thought about using VRMs before taking this subject as compared to 28.1% that had not. These findings indicate that the students have used VRMs to relate cultural heritage and intergenerational dialogue. The stories in the interviews prior to the videos are a meeting point between the oral legacy of the biographical narratives and the final VRM.

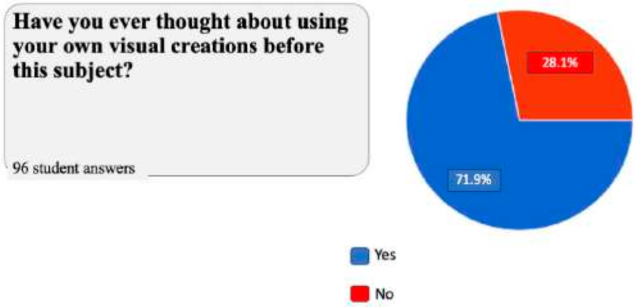

Figure 5. Assessing the visual creations' impact.

In C2, delivery included three concrete products. First, a Matlab application [36] was developed to visualize the signal and perform a statistical analysis. As the researchers learned which responses could be considered 'noise' and, contrarily, which were correlated with identified variables, the data set became more significant. Additional deliverables for assessment include two final projects for telecommunications and a master's thesis for multilingual communication.

In Figure 6 [36], a sample of activity during the experiment is shown. Findings show higher intensity in the occipital region related to emotionally charged stimuli, while the main areas for attention are located in between the temporal and frontal regions. These all have been correlated with specific moments in the video and were found in the 6 participants in the preliminary study. What is true, however, is that over 80% of the data collected were disregarded as not connected to attention or emotion and correlated to linguistic stimuli. But thanks to a student's [36] software, student design thinking played a crucial role in moving the project further.

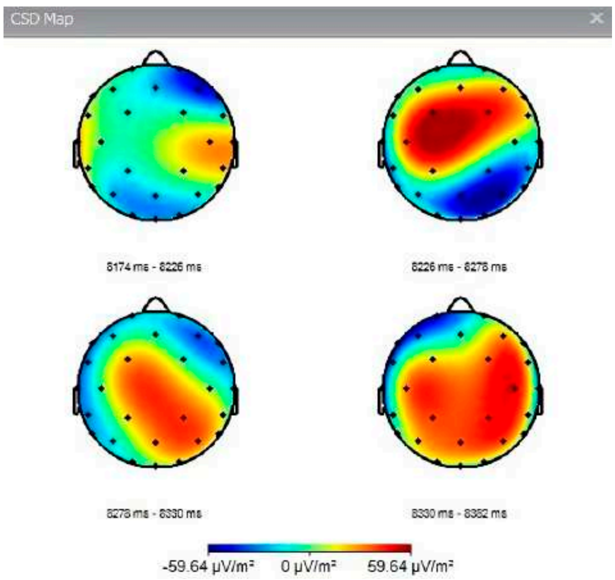

Figure 6. Brain activity subject 9 [36].

In Figure 7, responses are correlated with specific brain regions and classified as follows: eye movement, noise, brain, heart, muscle, and other in one subject viewing a video under 2 min. This discrimination of areas of the brain correlated to the video stimuli effectively allowed for post coding to filter the data associated with the stimuli adapted by another student [37]. Each image is related to an electrode location. The colors identify impedance. Impedance is measured in ohms (Ω) and is used in AC circuits to describe the total opposition to the flow of current.

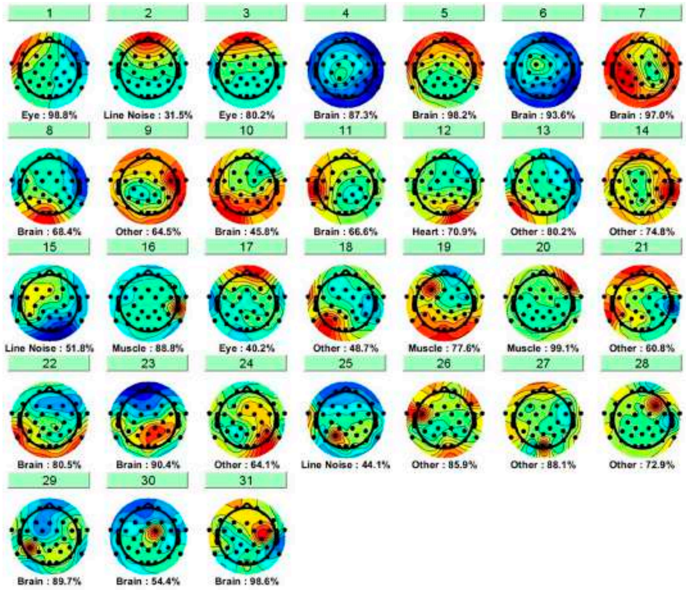

Figure 7. Brain areas identified during video projection, subject 13 [37].

- Red is impedance higher than 35 kΩ.
- Orange is impedance between 35kΩ and 20 kΩ.
- Yellow is impedance between 20 kΩ and 10 kΩ.
- Green is impedance less than 10 kΩ.

The colors are significant to the measurement of tension per m^2, when area is identified as 'brain'; all others (eye, heart, muscle, other, line noise) are filtered. This colorful representation is specific to data interpretation and becomes extremely useful when looking for correlations in the sample in relation to specific regions in the brain across subjects in relation to similar stimuli. In turn, the research can then identify the areas of attention and emotion and then correlate with the sample participants in order to begin to verify findings and increase reliability.

2.2.4. Step Four: Assess

The final step is to evaluate objectives. In effect, we are discussing what worked and the project assessment before discussing possible new directions for each context.

Assessment for C1 related to cultural heritage learning objectives and reflective teaching. Using the students' video representations, assessment was based on the following indicators:

- Depth of intergenerational dialogue [34] collected and quality of interview.
- Use of visual thinking strategies [20] and digital skills in the videos.
- Classroom debate regarding all projects with international insight from students.
- Degree of adequacy for dissemination of videos for educational purposes.

Assessment for C2 points back to a research problem. The initial goal was to determine a specific data set to avoid overfitting. The research identified specific variables qualitatively related to stimuli and attention in subjects and has begun to see repeated correlations in preliminary data. Research goals were assessed with the following indicators:

- A Matlab application was developed to perform statistical analysis [36] and avoid overfitting by filtering. This prototype is currently being improved upon [37].
- The research identified which electrode was responsible for attention and then limited the stimuli to measure the response correlation.
- Specific linguistic artefacts were correlated with the attention electrode. Findings indicate that pauses or changes in intonation are 'attention getting' in EEG measurements [35] in the preliminary sample.

3. Results

Many of the results have been addressed in the final steps of the design thinking model (deliver and assess). In this section, we will draw specific comparisons as we point to additional findings and new directions for each context.

3.1. Additional Findings and New Directions for Context One

Regarding the 50 videos obtained after the 50 interviews, the students documented the narratives that support and strengthen the permanence of cultural heritage in the local community [24]. The groups tried to find solutions to community needs and traditions, like making soap, or those related to festivities so that these traditions are not lost. The challenge is to implement these initiatives that the students detected and made them visible through the VRM.

New directions include human-centered learning as a goal in cultural heritage resignification, preservation, and didactic dissemination. There are growing calls for universities to become more civically engaged and socially relevant in their local regions [6]. Student production will continue to form part of the collective memory and uniquely link communities and cultural patrimony with a more tangible archive. Future research will encourage students to detect the needs of the community itself to develop joint initiatives. The challenge is to identify new communities of practice and a decisive move towards engaged learning. In the multiplicity of ways to engage, the one constant is a commitment to reciprocity between the students, universities, and communities [28].

3.2. Additional Findings and New Directions for Context Two

What has been significant to this combination of language and technology and student-led design thinking is that the project continues to evolve to solve new problems and improve the ways to interpret the very large data set. How to define what happens in the brain as related to attention and emotion has far-reaching influence on teaching, on communication, as well as in training artificial intelligence using human data. A student [37] has contributed to the next stage of the research by visualizing key correlations between EEG data and linguistic features.

Figure 8 [37] shows a correlation between language and attention in subject 9 as seen at the top left. The graphs capture where at one particular moment 82% of brain activity was observed in areas of the brain associated with language and attention (top left) and collected simultaneously with the time stamp of the video stimuli in the scrolling activity (top right). Continuous data (bottom left) are observed but not analyzed at this time. However, there is a precise identification of beta waves shown in the power spectrum (bottom right) as correlated with frequencies below 30Hz.

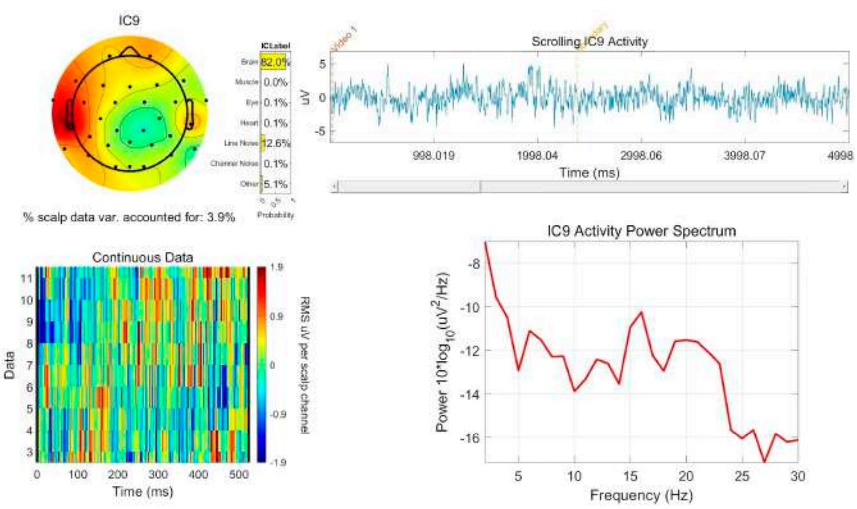

Figure 8. Correlated findings visualized for subject 9, video 1 [37].

Together, the information in these figures captures the correlation. The scrolling activity corresponds to a particular time stamp related to a specific region in the brain that can be correlated to a specific stimulus. In Fig 8 the scrolling activity refers to IC9 (language and attention) and in Fig 9 it refers to IC13 (emotion). Each of these is correlated to the video stimuli presented as seen at the scrolling activity time stamp identified as 'boundary'. Each of these is presented the targeted beta frequencies as seen in the activity power spectrum. What is key is that a student [37] created a specific way to present this visual data as statistically measurable and precisely correlated to specific features related to attention and emotion.

Figure 9 [37] shows correlation to an emotional response in the brain in subject 13 that registered less brain activity as compared to the previous figure but is also correlated with the under 30 Hz frequency of beta waves and associated with a specific moment of emotional response to a specific moment in the stimuli. What both Figures 8 and 9 show is that these responses are common in the small sample. More research is needed to verify these findings; we include them here to demonstrate that all research seems to be built on previous findings while continuing to interpret new findings.

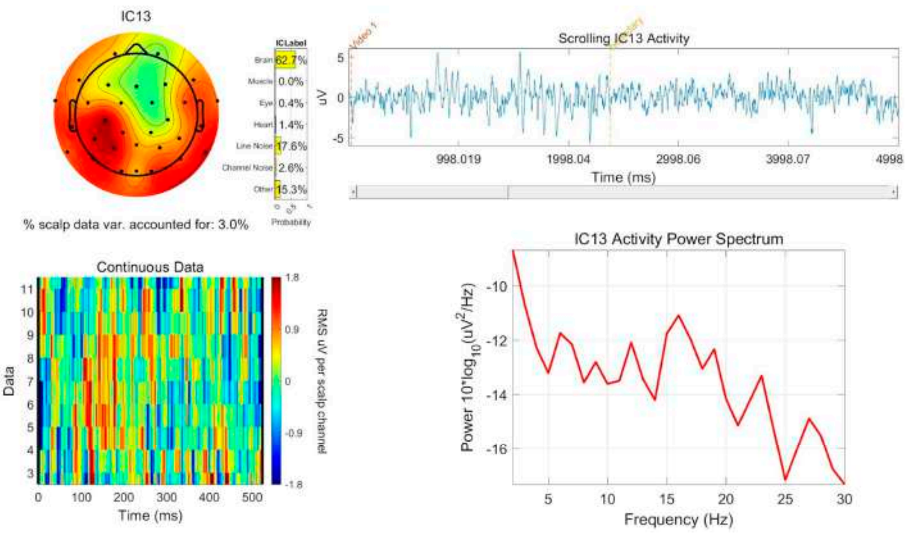

Figure 9. Correlated findings visualized for subject 13, video 1 [37].

New directions will address the limitations of this project by continually focusing the stimuli to examine new features correlated to brain activity and will increase the sample to test machine learning. Nowadays, cognitive science is looking to the brain (auditory, visual, and language processing) as a way to better train artificial intelligence as well as to begin to tackle some of the existing challenges for machine learning. Linguists and engineers will continue to approach the project in divergent ways, and it is essential that the transdisciplinary approach allows for a 'close-knit' interdepartmental collaboration in this emerging community of practice. New directions have focused on attention and emotion and continue to refine the interpretation of a large data set, while increasing the human sample in data collection.

4. Discussion

Is design thinking a qualitative or a quantitative process? This varies across disciplines, but the main idea is that all research must collect observable data and then interpret these data to create true knowledge integration. What seems to vary is the sequence itself when applied to education. Case one follows a more action research approach and pursues a more holistic goal. Case two seems to move back and forth between quantitative and qualitative approaches, but the sequence is highly focused as the research progresses. Research has suggested that problem solving and design thinking go hand in hand [5,7] and have far-reaching potential in education as well as in research.

According to these authors [30], the dichotomy between traditional research and action research can be expressed in many different ways. For example, traditional research abstracts one or two factors for attention and holds to a constant definition of the problem until the experiment is concluded, but action research attempts to comprehend all the factors relevant to an immediate problem whose nature continually changes as events proceed. In this way, each design thinking case is, in itself, dynamic. Where empirical research requires a clear and constant purpose, action research and case study are tentative, non-committal, and adaptive. While empiricism perceives the present in the context of final outcomes, action research focuses on the next step and breaks the problem into manageable segments.

Consequently, traditional research tends to focus on the product and not the process itself. There is undoubtedly a dilemma in this dichotomy. But, like all dichotomies, the truth lies somewhere in the middle. However, with action, the future evolves out of present opportunities. It is dynamic and ever changing and that is why a design thinking model can be used in both cases and across multiple disciplines. What we should be asking ourselves is not if this research is reliable or valid but if it is indeed valuable for education. Contrastive case study has allowed us to portray these differences not as mutually exclusive but rather as forming part of the thinking process itself.

Highlighting the contrasts of design thinking in these two cases shows that there is no one case that would effectively be applied in the same way. Design thinking is an approach, not a method. Although both design thinking cases have delivered tangible final projects and are decidedly student-led, the way they approach research design, data collection, language, and technology has varied.

Indeed, this is how design thinking truly leads to unique outcomes both for research and for applied learning [14,21]. There is no one model that will fit every context or every discipline, but the more we cross disciplinary boundaries the richer the experience. Perhaps the inability to apply one model is its biggest limitation, while at the same time this adaptability holds enormous potential.

5. Limitations of Present Study and Suggestions for Future Research

Each case has been presented using a design thinking model, while at the same time there are unique limitations to each one. Contrastive case study is descriptive, explanatory, and exploratory. Firstly, description begins with what each case has in common: they each involve multiple disciplines, are student-led, and use a design thinking sequence. Next, the explanatory results shed light on salient contrasts and comparisons across the disciplines as developed in the design thinking steps and previously detailed in Sections 3.1 and 3.2. Finally, the exploratory part of case study discusses limitations and new perspectives as seen in Table 2.

Table 2. Student-led design thinking: differences in each context.

Disciplinarity	C1 is transdisciplinary, student group is large and includes community. C2 is interdisciplinary, student group is small and focused on a series of research problems.
Research approach	C1 began with QUAN(qual)→QUAL data validated by the number of interviews, but led to further qualitative interpretation as students designed their videos. C2 began with quantitative data that required qualitative interpretation. By preselecting variables to prove specific correlations between brain activity and linguistic input, the approach moved from quantitative to qualitative interpretation. The human sample is small (13 subjects), but the raw data collected are enormous.

Table 2. *Cont.*

Language	C1: Language is a tool. The value of intergenerational dialogue was interpreted and transformed into a digital representation of cultural patrimony learning and divulgation. C2: Language and its relationship to attention and emotion are the object of the study.
Technology	C1: Technology is a tool to develop VRM. C2 Technology is a tool with the EEG measurements, but at the same time is developed in an applied way to solve research problems and better fit the data to a reliable model.
Outcomes and perspectives	Used for teaching: C1: Tangible products are quite wide ranging and in this selection the research looks to the past to explore how people and patrimony come together for present and future social understandings. Used for research: C2: The student-led projects moved the research forward. Research looks to the future to use this reliable model to 'train the machine' for AI using human responses.

In C1, the transdisciplinary research is more valid than reliable as each product is unique and hard to replicate. In C2, students' interdisciplinary implication in the process impacted reliability and this quantitative selection made the research more reliable than valid. As the sample is still small, validity will only be achieved with a larger sample.

6. Conclusions

This study has taken a novel approach with its application. We have seen that transdisciplinarity is a skill that is essential both in research as well as in the teaching–learning process. Transdisciplinary design thinking initiates non-formal learning by transitioning between departments and the greater community to be used as areas of shared understanding and reciprocity. The construct facilitates joint projects in which participants can both contribute their specific skills and learn from each other. This, in fact, is what both of our case studies demonstrate. Each case study produces tangible products, is student-led, and deals with contemporary digital technologies, human capital, and educational practices. The social science model of C1 is perhaps more formal learning, but also more transdisciplinary, in that it reaches out to a community outside the university. In contrast, the research in C2 leans toward non-formal learning and is decidedly more collaborative across disciplines. We have observed that engineers approaching design thinking seem to have a tangible final product in mind, while in C1 the construct is more humanistic in its approach.

Design thinking is adaptive and, as such, neither case is better or worse than the other; rather, each case applies design thinking but pursues different skill goals for students. Each case does not only have different outcomes but variation in the process itself. What all transdisciplinary initiatives have in common, despite their differences, is that they seek to connect learning in terms of both professionally relevant skills and social maturity with current real-world challenges. Learners must discover their own tools as they adapt to new situations through direct experiences and by sharing the experiences of others. Crucially, this is only achieved through application and the creation of new communities of practice. This positioning article is about creating communities that fully support transdisciplinary approaches and that purposefully foster a culture of co-creation and knowledge exchange to clearly address society's more pressing problems through design thinking.

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References

1. Dalton, A.; Wolff, K.; Bekker, B. Interdisciplinary Research as a Complicated System. *Int. J. Qual. Methods* **2022**, *21*, 16094069221100397. [CrossRef]
2. Rigolot, C. Transdisciplinarity as a discipline and a way of being: Complementarities and creative tensions. *Humanit. Soc. Sci. Commun.* **2020**, *7*, 100. [CrossRef]
3. Abrahamson, D.; Sánchez-García, R. Learning is moving in new ways: The ecological dynamics of mathematics education. *J. Learn. Sci.* **2016**, *25*, 203–239. [CrossRef]
4. Hickey, D.T.; Uttamchandani, S.L.; Chartrand, G.T. Competencies in context: New approaches to capturing, recognizing, and endorsing learning. In *Handbook of Research in Educational Communications and Technology*; Bishop, M.J., Boling, M.J., Elen, E., Svihla, J., Eds.; Springer: Cham, Switzerland, 2020; pp. 547–592. [CrossRef]
5. Chin, D.B.; Blair, K.P.; Wolf, R.C.; Conlin, L.D.; Cutumisu, M.; Pfaffman, J.; Schwartz, D.L. Educating and Measuring Choice: A Test of the Transfer of Design Thinking in Problem Solving and Learning. *J. Learn. Sci.* **2019**, *28*, 337–380. [CrossRef]
6. Alvargonzález, D. Multidisciplinarity, Interdisciplinarity, Transdisciplinarity, and the Sciences. *Int. Stud. Philos. Sci.* **2011**, *25*, 387–403. [CrossRef]
7. Geitz, G.; Geus, J.D. Design-based education, sustainable teaching, and learning. *Cogent Educ.* **2019**, *6*, 1647919. [CrossRef]
8. Griffith, M. (Ed.) *Engaged Learning: Voices Across Europe*; IDC Impact Series; Maklu Publishers: Antwerpen, Belguim, 2022; Volume 5, Available online: https://www.cast-euproject.eu/news/new-cast-anthology-now-available/15/ (accessed on 30 November 2022).
9. Winskel, M.; Ketsopoulou, I.; Churchouse, T. URWKC Interdisciplinary Review: Research Report. (Report No. NE/ G007748/1). UKERC. 2015. Available online: https://ukerc.ac.uk/ (accessed on 20 September 2023).
10. Siedlok, F.; Hibbert, P. The organization of interdisciplinary research: Modes, drivers and barriers. *Int. J. Manag. Rev.* **2014**, *16*, 194–210. [CrossRef]
11. Stentoft, D. From saying to doing interdisciplinary learning: Is problem-based learning the answer? *Act. Learn. High. Educ.* **2017**, *18*, 51–61. [CrossRef]
12. Yunus, K.; Li, S. Matching Job Skills with Needs. In *Business Times, 1*; (1 October 2005); As cited in Thi Van Pham, Anh and Thi Thu Dao, Huong, The Importance of Soft Skills for University Students in the 21st Century; Association for Computing Machinery: New York, NY, USA, 2020; pp. 97–102. [CrossRef]
13. Alfaro-Ponce, B.; Patiño, A.; Sanabria-Z, Z. Components of computational thinking in citizen science games and its contribution to reasoning for complexity through digital game-based learning: A framework proposal. *Cogent Educ.* **2023**, *10*, 2191751. [CrossRef]
14. Cross, N. *Design Thinking: Understanding How Designers Think and Work*; Berg Publishers: Oxford, UK, 2011.
15. Von Thienen, J.P.A.; Weinstein, T.J.; Meinel, C. Creative metacognition in design thinking: Exploring theories, educational practices, and their implications for measurement. *Front. Psychol.* **2023**, *14*, 1157001. [CrossRef] [PubMed]
16. Novo, C.; Tramonti, M.; Dochshanov, A.M.; Tuparova, D.; Garkova, B.; Eroglan, F.; Uğraş, T.; Yücel-Toy, B.; Vaz de Carvalho, C. Design Thinking in Secondary Education: Required Teacher Skills. *Educ. Sci.* **2023**, *13*, 969. [CrossRef]
17. Khalil, R.Y.; Tairab, H.; Qablan, A.; Alarabi, K.; Mansour, Y. STEM-Based Curriculum and Creative Thinking in High School Students. *Educ. Sci.* **2023**, *13*, 1195. [CrossRef]
18. Peng, F. Design Thinking: From Empathy to Evaluation. In *Foundations of Robotics*; Herath, D., St-Onge, D., Eds.; Springer: Singapore, 2022; pp. 63–81. [CrossRef]
19. Brown, T. *Change by Design*; Harper Collins: New York, NY, USA, 2009.
20. Hidalgo-Standen, C. The use of photo elicitation for understanding the complexity of teaching: A methodological contribution. *Int. J. Res. Method Educ.* **2021**, *44*, 506–518. [CrossRef]

21. Murillo-Ligorred, V.; Ramos-Vallecillo, N.; Covaleda, I.; Fayos, L. Integration and Scope of Deepfakes in Arts Education: The Development of Critical Thinking in Postgraduate Students in Primary Education and Master's Degree in Secondary Education. *Educ. Sci.* **2023**, *13*, 1073. [CrossRef]
22. Kueh, C.; Thom, R. Visualising Empathy: A Framework to Teach User-Based Innovation in Design. In *Visual Tools for Developing Cross-Disciplinary Collaboration, Innovation and Entrepreneurship Capacity*; Griffith, S., Carruthers, K., Bliemel, M., Eds.; Common Ground Research Networks: Champaign, IL, IL, USA, 2018; pp. 177–196.
23. IDEO. The Human-Centered Design Toolkit. 2011. Available online: https://www.ideo.com/post/designkit (accessed on 30 October 2023).
24. Liedtka, J.; Ogilvie, T. *Designing for Growth: A Design Thinking Tool Kit for Managers*; Columbia University Press: New York, NY, USA, 2011.
25. Plattner, H.; Meinel, C.; Leifer, L. (Eds.) *Design Thinking. Understand-Improve-Apply*; Hasso-Plattner-Institute for Software Systemtechnik; Springer: Berlin/Heidelberg, Germany, 2011. [CrossRef]
26. Yin, R.K. *Case Study Research: Design and Methods*, 4th ed.; SAGE Publications: Thousand Oaks, CA, USA, 2009.
27. Morse, J.; Niehaus, L. *Mixed Method Design: Principles and Procedures*; Left Coast Press Inc.: Walnut Creek, CA, USA, 2009.
28. Åkerblad, L.; Seppänen-Järvelä, R.; Haapakoski, K. Integrative Strategies in Mixed Methods Research. *J. Mix. Methods Res.* **2021**, *15*, 152–170. [CrossRef]
29. Lechuga-Jiménez, C.; Kurantowicz, E. (Eds.) *Together for Cultural Heritage Booklet of Recommendations for Social Partners*; Lower Silesia University Press: Wroclaw, Poland, 2021. [CrossRef]
30. Cohen, L.; Manion, L. *Research Methods in Education*; Routledge: Oxfordshire, UK, 1989.
31. Estrada-Chichón, J.L.; Sánchez-Cabrero, R. Cultural Awareness in Pre-Service Early Childhood Teacher Training: A Catalogue of British Cultural Elements in Peppa Pig. *Educ. Sci.* **2023**, *13*, 1021. [CrossRef]
32. UNESCO. Culture. Protecting our Heritage and Fostering Creativity. Available online: https://www.unesco.org/en/culture (accessed on 4 March 2020).
33. Griffith, M.; Lechuga-Jiménez, C.; Santos Diaz, I. Málaga: Multiple Directions for Engaged Learning. In *Communities and Students Together (CaST) Piloting New Approaches to Engaged Learning in Europe*; Marsh, C., Kilma, N., Anderson, L., Eds.; Maklu Publishers: Antwerpen, Belgium, 2022; pp. 99–122.
34. Fontal-Merillas, O.; Marín-Cepeda, S. Nudos Patrimoniales. Análisis de los vínculos de las personas con el patrimonio personal. *Arte Individuo Y Soc.* **2018**, *30*, 483–500. [CrossRef]
35. Rodríguez-Chicano, N. Rhythm and Intonation in Listener's Attention Span: An Approach through Electroencephalogram Analysis. Master's Thesis, University of Málaga, Málaga, Spain, 2022.
36. Yébenes-Gálvez, L. Matlab. Software Design in Attention in English Oral Discourse in International Settings: Linguistic Analysis Supported by Bioelectrical Measurements. Bachelor's Thesis, University of Málaga, Málaga, Spain, 2023.
37. Villarejo Soler, C. Herramienta de Preprocesado y Extracción de Características Para Señales de EEG/ /A Tool for Preprocessing and Extracting Characteristics for EEG Signals. Bachelor's Thesis, University of Málaga, Málaga, Spain, 2023.