INTED 2024

18th International Technology, Education and **Development Conference**

4-6 March 2024
Valencia (Spain)

CONFERENCE PROCEEDINGS

Sharing the Passion for Learning

INTED2024 Proceedings
18th International Technology, Education and Development Conference
March 4th-6th, 2024
Valencia, Spain

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These proceedings are published by IATED Academy. The registered company address is Plaza Legión Española 11, 46010 Valencia, Spain.

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PLAYING FOR THE FUTURE. ENRICHING DESIGN STUDENTS' USER RESEARCH SKILLS FOR SUSTAINABLE TOY DESIGN

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Abstract

Since 2030 is approaching, the United Nations' Sustainable Development Goals (SDGs) agenda has gained urgency and relevance in recent years. Thus, industrial product design becomes crucial in promoting sustainable behaviour and sound design principles.

This idea is the core of the Laboratorio di Sintesi Finale, section P2, of the Politecnico di Milano Bachelor course in Industrial Product Design: the students design toys for kids that promote sustainable practices and behaviours linked to the SDGs. The multidisciplinary teaching team identifies three primary phases: research and analysis, concept, and product development.

The initial part of the course underwent modifications during the first semester of the 2023/24 a.y. Specifically, the goal was to support the students in approaching the user analysis and research phases in a more structured way.

Two meetings were crucial to educating students on play, child development, and behavioural dynamics. The first, a theoretical lecture on child development, was organised by professionals providing a worksheet for arranging observational tasks. Students, as passive or active observers, then designed activities to observe kids' behaviour in specific situations tied to the selected SDG after their initial investigation. The second meeting consisted of Neurodevelopmental Therapists' support in reviewing and supervising the observation worksheets.

Through the observation worksheet, students could organise their activities more effectively and recognise the values they could depend on. After this procedure, students received approval to complete the task at a Milan primary school.

This process made it possible to make the user analysis phase more organised. Thanks to the observation sheets, the students could modify and adapt to any issues or unexpected circumstances in conducting the activities. When deriving conclusions from the observations obtained and creating the brief, the support of the worksheets was also helpful.

The processed product is a structured user observation worksheet that enables the activities' repeatability and student awareness of their experiences. Ultimately, this process helps narrow the research phase to produce more thoughtful and aware briefs regarding the SDG target user's nature. Thus, the study has demonstrated how the involvement of diverse specialists can help students gain new tools for user awareness and design and practical improvement in their foundational knowledge.

Keywords: sustainable design, education, SDGs, user research, product design, toy design, children's development.

1 INTRODUCTION

In recent years, due to the approaching 2030 and the conditions of the current global context, the United Nations' agenda of Sustainable Development Goals (SDGs) has become urgent and relevant. In this scenario, industrial product design is a significant vehicle for good design practices and for conveying sustainable behaviour. It is precisely on this thought that the Laboratorio di Sintesi Finale, section P2, of the Bachelor course in Industrial Product Design, run for several years at the Politecnico di Milano, puts its basis. During the course, students design children's toys that convey sustainable behaviours and practices related to the SDGs.

The design and teaching process follows the scheme presented at the 2022 INTED conference [1]. The three-level course objectives let the students design products that:

- Educate and raise consumer awareness of sustainability (awareness-raising),

- Be designed through sustainable materials and technologies (product development)
- Be included in a sustainable product system (strategic-systemic design).

Starting from those bases, the Lab has evolved each year, deepening design aspects with activities and initiatives focusing on course-specific phases.

The multidisciplinary team supporting the course consists of professionals active in toy design, professors and researchers focused on strategic design, user research, materials selection and sustainability.

During the first semester of the academic year 2023/24, the teaching team decided to deepen the user research aspect. This permits a more conscious knowledge of the target and generates a more structured brief. Two Neurodevelopmental Therapists (NTs) made the main specific contribution. Their theoretical contribution permitted them to create more awareness among the students, which was helpful for the user analysis phase.

1.1 Theoretical contribution

The NTs' theoretical contribution was structured on three main topics:

- Child development: definition and development stages divided by areas (motor area, cognitive area, language, social and emotional development)
- The game: description and stages of development of the game
- Observation and evaluation

Each topic is intended to be helpful in the analysis phase, the desk research, the design of the user observation, and the interaction and children evaluation.

1.1.1 Child development

Child development occurs through a series of modifications of an organism's structures, functions and organisations from its origin to its end. The organism is a continuous transformation and development system, which is an interaction of the genetic heritage with the environment. This interaction includes organic aspects (the structures), functional aspects (motor skills, language, intelligence) and the organisation of the relationship between structures and related functions. Fundamentals represent the inherent traits and characteristics that individuals inherit from birth, while culture encompasses all the knowledge and skills that individuals need to acquire to integrate into their society [2], [3].

The developmental stages are fixed in time, while the developmental pace is strictly variable from subject to subject. Knowing the sequence of events that follow one another in the child's growth is fundamental, as it always remains [2]. Particular attention was paid to the school-age group most interested in the student project.

Starting from motor skill development is characterised by a continuous bidirectional interaction between the maturation of structures and experience-dependent factors [2].

After an initial explanation of motor development in the child in the early years, the more complex kinetic acquisitions of the preschool child, such as crossing patterns, jumping and throwing the ball, were explored. Explaining the various stages of a child's motor development within distinct age groups heightened awareness regarding the specific requirements imposed by the game [2], [3], [4].

Particular attention was paid to the development of fine motor skills, which allows the child to use objects in an initially exploratory and, subsequently, more finalised way. The functional use of fine motor skills and objects favours the acquisition of autonomy and, thus, of grapho-motor skills [2], [3], [5].

Turning attention to the social aspect of a child, language and emotions emerge as essential components of interaction. Language is a cognitive process that develops in a social context and is acquired during an interaction with sensitive and responsive adults [2]; it can be defined as acquired both in terms of quality and quantity (vocabulary, grammatical and syntactic rules, lexical forms) [3].

Likewise, emotion is a physiological, motivational, cognitive and communicative response, always accompanied by a social dimension [3]. Basic and complex emotions were presented, describing how they develop between the first and third years of life. It explains how children at scholar age feel more than one emotion simultaneously or towards the same object and how they decode emotions and represent them during their emotional development [3].

As regards the cognitive area, Piaget's theory was exposed according to which development occurs through the process of assimilation, in which the child internalises new knowledge through the sensory organs, and through the process of accommodation, in which pre-existing cognitive schemes are modified in response to new stimuli provided.

Finally, particular emphasis was given to executive functions—skills essential for addressing conflicting or challenging situations—implemented to accomplish a goal. These encompass inhibiting automatic responses, flexibility, planning, working memory, and attention [6].

1.1.2 The game

The second part of the lecture was focused on the game. The game was presented as an experiential dimension defined as an action free from purposes and objectives that arise for the pleasure of playing itself [5], [7], [8].

The game is affected by several factors:

- Individual variability (biological and psychological components of the child, e.g. Cognitive conditions, age, etc.)
- Sociocultural conditions
- Characteristics of the network surrounding the child and relational methods
- Media and child experts (e.g. social media, paediatrician, teacher who advises the parent)

Therefore, culture influences the children's play patterns and is mediated by the interpersonal relationship with the adult, which will combine with the individual's characteristics [8].

The game's development was exposed, starting from the importance of bodily experimentation and explaining how the body can be a privileged place of knowledge and the development of the ego. Next, the body-conveyed games were introduced, wherein the child initially repeats actions, mirroring them, to internalise the process. Subsequently, the child generalises these actions and categorises them into mental images [8], [9].

With this in mind, the reflections moved on to symbolic play, which, between the ages of 2 and 7, can manifest itself at various levels:

- Presymbolic
- Self-symbolic schemes
- Decentralised symbolic game
- Combinatorial symbolic game
- Hierarchical symbolic game

After the age of 3, imaginative play emerges. The differences with symbolic play are in content, in social participation from the ego to the dyad, and finally to the social and in the presence of shared rules, shared "plot", roles and methods. This is the typical game of preschool age and continues for several years; the mental plan ultimately manages it.

Towards the conclusion of preschool age, the introduction of rule-based games emerges, characterised by a predefined set of regulations and competitive elements. Unlike the fantasy game, the rules represent the game's fulcrum and are mostly stable and pre-established. It is much less flexible than fantasy play because a shared goal is to win. From the age of 6 onwards, coordination games are also observed, in which there is an effective use of movement to measure, compete, and obtain a result; and representation play, with material manipulation activities, modelling, graphics, painting, construction, writing, stories, music, etc. [8].

1.1.3 Observation and evaluation

In the third section of the lecture, the discussion revolved around observing and evaluating the child.

Observation is not a generic look but a focused gaze. The characteristics of a good observation are selectivity (evaluates only one thing), planning (who, where, and when to observe), documentability and the fact that it can also be consulted by third parties [10].

There are different evaluation types. The standardised assessment compares a behaviour with standard values of a normative sample representative of the reference population. These rating scales compare

the child with other children of the same age, social status, culture, and education. This model proposes a hierarchy of acquisitions, stages that follow one another in a pre-established order [10], [11].

There are also several recording tools:

- Closed: scales, grids, checklists, tests
- Open: descriptive cards, diaries, narratives
- Audio-visual: recordings, videos, photos.

Another evaluation method can be the spontaneous play observation, which can involve different methods:

- Spontaneous adjustment: what does the child play with and how?
- Induced adjustment: an instruction is given that urges the child to act with an object without telling him what to do
- Global free adjustment: through a delivery that encourages the use of objects according to the desired purpose, without defining the execution methods (e.g. take a ball and throw it into the circle) [5], [12].

During observation, emphasis should be placed on factors such as time, place, and the established 'atmosphere', recognising that a child's actions always occur in a specific context and involve interacting with or for someone. It is crucial to recognise the influence of the observer on the observed. Furthermore, during observation, it is essential to be aware that what is perceived is filtered through unconscious bias [5], [11], [13].

After training the students with peculiar notions of child development, it was possible to proceed with tools to apply what had been learned and drop it into the project. Specifically, worksheets were constructed to guide the child's observation to outline a conscious design context.

2 METHODOLOGY

2.1 Course structure

The Laboratorio di Sintesi Finale, section P2, has been active for over five years, focusing on kids and toy design. The course aims to exploit Project-Based Learning (PBL) to teach students sustainable design approaches and precepts [14]. The long experience of the course has allowed the methodology, tools, and different facets of the subject to be developed and refined over time. The multidisciplinary teaching team consists of academics specialised in design for sustainability, with a focus on materials and strategic-systemic design, academics on user studies and anthropometry and professional toy designers. The course is structured in three macro-phases:

- Research and analysis: aimed at introducing students to the two key aspects of the course, i.e. the SDGs (from which they will have to choose a goal and one or more sub-goals) and the target (children aged 6 to 11);
- Concept design: the aim is to embed research into the construction of a brief and the preparation of multiple product concepts that meet the project question;
- Product development: after selecting the most promising concept, students engineer the product and develop the surrounding system (communication and services).

2.2 User research

2.2.1 Course research phase design and methods

During the first phase, after selecting their SDG, students use various research methods to define the project space, specifically a brief and a project question. The research aims to enable the student to analyse the topic and the user. In line with the spirit of PBL, students are free to define the topics, methods and means to conduct the analysis. Students are encouraged to use multiple desk and field research methods at this stage. Desk research applies methods such as literature review (academic and grey literature) [15] and blue sky research [14], [16].

On the other hand, for field research, mainly surveys, interviews, observations and designed play activities are applied [17], [18], [19]. This freedom allows them to be active or passive observers of the child. User research has been performed through several tools, from desk research to participant observation and user tests, in the conviction that a mix of different methods is necessary to grasp the complexity of reality, given that each method sees the phenomena from a different perspective. As Denzin [20] argues, a single method cannot adequately solve the problem of rival causal factors, and each method discloses various aspects of empirical reality. While questionnaires and interviews with parents and teachers help grasp the explicit needs and expectations of secondary users, the direct involvement of children in play activities helps to empathise with them and to elicit their tacit needs [21].

To understand the characteristics and needs of the primary users, namely children between 6 and 11 years, students started by analysing existing scientific literature. In coordination with his group, each student identified references such as peer-reviewed articles, books, and master's or PhD theses on pedagogical and educational theories, children's abilities and behaviours, play typologies, and goals. The references were recorded in a given format and collected in a shared folder to allow knowledge exchange inside the class community. As mentioned above, students are encouraged to make free observations. Free observations of the child's behaviour occur mainly in public environments such as playgrounds, public transport and shops to highlight improper use and secondary adaptation of products as signals of danger or innovation hints. During the lectures, students were introduced to participant observation [19] and contextual inquiry techniques [22] to go beyond a mere rapid ethnography approach [23].

To strengthen the students' knowledge regarding children's development, behavioural dynamics, and the role of play during the a.y. 2023/24, neurodevelopmental therapy experts in the healthcare sector were invited. The professionals and students interacted in the following four main steps:

- Theoretical lecture by the neurodevelopmental therapists to provide specific insights on children's psycho-motor development and to share the methodology and observation analysis worksheet with the students;

- Design of the activity by the students to observe the children's behaviour in situations related to the analysis carried out on the selected SDG and contextualisation of the analysis form;

- Review of the student-designed activity with the neurodevelopmental therapists and suggestions on the contextualisation of the analysis form;

- Run of play activities by students in a primary school in Milan and use of the observation worksheets.

2.2.2   Observation worksheet

Building on case studies [24] and on the practice with the NTs, students developed play activities and contextualised the worksheets for the structured observation activities.

The elements that constitute the worksheet are:

- Location: Indicating whether the activity (and the observation) takes place indoors or outdoors and in a particular setting (e.g. on a table, on a bench, in a room, etc.)

- Materials required: i.e. the tools needed by the students for the activity

- Duration: The amount of time planned for the activity

- Number of participants: The number of children who took part in the activity

- Age: The age of the children who participated (may indicate specific ages or an average)

- Activity: Narration of the activity to be carried out (may also include graphs and diagrams)

- Mode of presentation: Indicates how the students presented the game activity to the children (e.g. through an explanation of the rules, a practical demonstration, etc.)

- Aids: Tools or methods prepared to support the children if they experience difficulties in the activity

- Criticality: Passages or elements that may compromise the game because of particularly complex

- Observable competencies: the child's abilities and skills that can be observed through the activity. These are further subdivided into four areas from which one can choose (Cognitive area, behavioural and relational area, motor area, play mode)

- What is not observable: the child's abilities and skills that cannot be observed through the proposed activity

It should be emphasised that each group had the flexibility to add other parameters and elements according to their needs, such as the tools used, the role of the components, specific rules of the activity, areas of interest, the particular purpose of the observation, photos, etc. In addition, each group had the opportunity to represent the worksheet graphically, as shown in Figure 1, also using several pages.

Io sono un cibo che...

Luogo: spazio ampio e libero da oggetti (es. palestra)
Materiali: Immagini cibi (procurate da noi), scotch (per dividere la stanza in aree), gettoni e scheda gettoni
Durata: 10-15 minuti
Numero partecipanti: 8-10 bambini
Età: 7+
Come presentarlo: spiegazione delle regole, assegnazione dei cibi e un turno di prova
Aiuti: fornire immagini di cibi conosciuti semplici e dai colori ben distinti
Criticità: difficoltà nell'errore (competitività), memorizzazione delle aree, difficoltà visivo-spaziali

Competenze che puoi osservare:
- Conoscenza degli alimenti: provenienza, consistenza, stagionalità, origine (animale, vegetale etc.)
- Conoscenze sulla produzione: cibi preparati, cibi coltivati etc.
- Consapevolezza alimentare: frequenza di consumo e gusti
- Confronto con gli altri (scambio di opinioni)
- Immedesimazione (fantasia)

Cosa non puoi osservare:
- Abilità motorie fini
- Differenze cibi salutari o no (causa numero di cibi limitato)

Figure 1. Example of observation worksheets by group 10.

3 RESULTS

According to the abovementioned methodology, this research phase resulted in approximately 24 observation worksheets of structured activities. Free and structured observation supported students to conceive meaningful and appropriate product concepts. The students, who were very interested in the more theoretical aspects, could experiment and apply the knowledge they acquired during the lectures. Once the observation worksheets were created, the students could organise the necessary material for the field observation. A helpful step in defining the timing and logistics of the organised activities was verifying what they had planned in the classroom. One day of the Lab lesson was dedicated to prototyping and testing the activities with other colleagues. The students received direct and constructive feedback on their work from their colleagues.

After preparing materials and delineating all observation aspects, they proceeded to the primary school in Milan, where dedicated time was allocated for this activity.

Some groups got beneficial feedback and insights from the observations, while others needed further work to refine and verify the elements they wanted to check through the observations.

In particular, group 7, which was working on SDG 12 - sustainable consumption and production - devoted itself to two types of observation: the passive observation of children and their dynamics of free play within a park and the participatory observation of two activities within the school. The two activities consisted of building towers, one as tall as possible and one with as few pieces as possible but to reach a set height. The students intended to observe the handling of frustration concerning rules, interaction and collaboration with peers, the development of fine motor skills, and reasoning and problem-solving skills. Starting from the observations made at school, the students created a map (Fig. 2) identifying elements that could be useful in their projects: the need to improve the ability to manage the material available, the possibility of helping the development of fine motor skills, and the improvement of the attention threshold towards the game itself. Combining the observation part with desk research and interviews with parents and teachers, the students arrived at the definition of three project trajectories:

- Designing a game that, starting from the reduction part of SDG 12, uses a few physical elements to extend the child's imagination based on interpretation and creative expression. (Using the material one has available)

- Using the methodology of tinkering, which teaches learning by doing, introduces the child to the maintenance and care of objects by making them familiar with the process. Improve their attention to their toys and raise awareness of consumption and the prevention of waste creation. (Development of fine motor skills)

- Teach children to respect nature's time and to see it not only as a resource but as a companion to be cared for. Help them to recover a symbiotic relationship with nature, to be considered in a perspective of exchange, in which if you take something, you must also give (and thus produce) something. (Keep the focus on something to be taken care of)
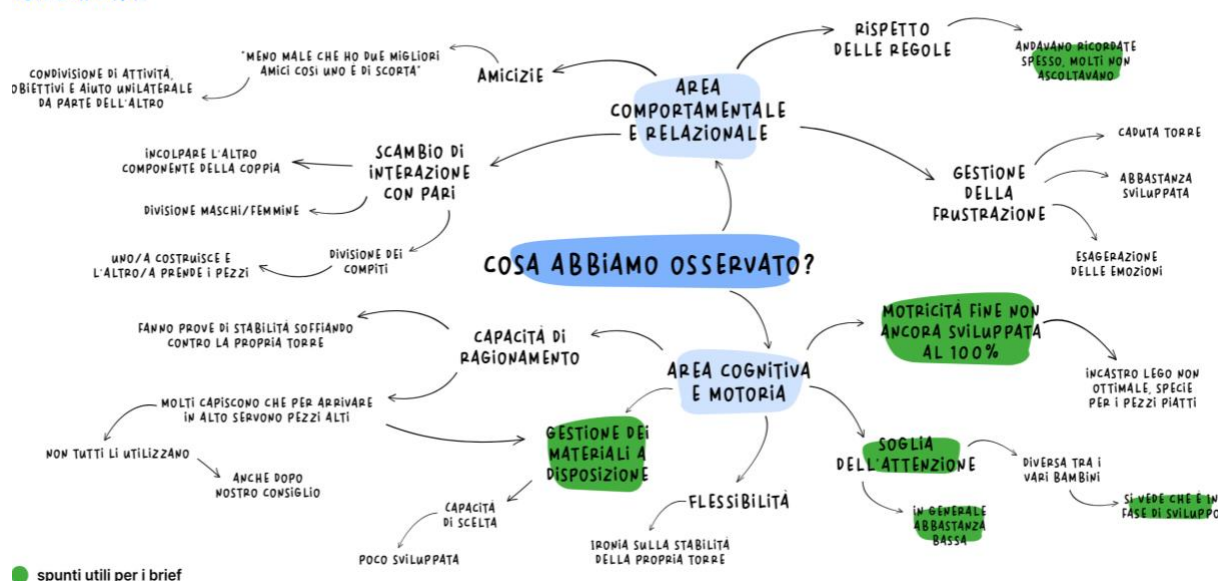

Figure 2. Mind map about the observation, group 7.

Another group that fully developed the research and observation part was Group 1, which dealt with SDG 14 concerning life underwater. As in the previous group, the students started with non-participatory observations of the child's play, where they could emphasise the aspects of amazement, creativity, the desire to collect and the constant misuse of toys/objects. After the first research part, they organised a more individual activity with a few children at the civic aquarium and a more collective one at the school. From the observation at the aquarium, conducted through observation and drawings, the children's desire for storytelling, the search for interaction with the marine world, the continuous search for visual stimuli, and curiosity about a new environment emerged.

On the other hand, the school activity was more active and focused on creativity in the marine environment (Fig. 3). The students wanted to observe manual skills related to creating artefacts, artistic skills and creativity. They also wanted to investigate knowledge about the marine world and its association with more practical aspects, such as shapes and colours, and associations with personal knowledge, emotions and experiences. All this is done while sharing a creative moment with other children.
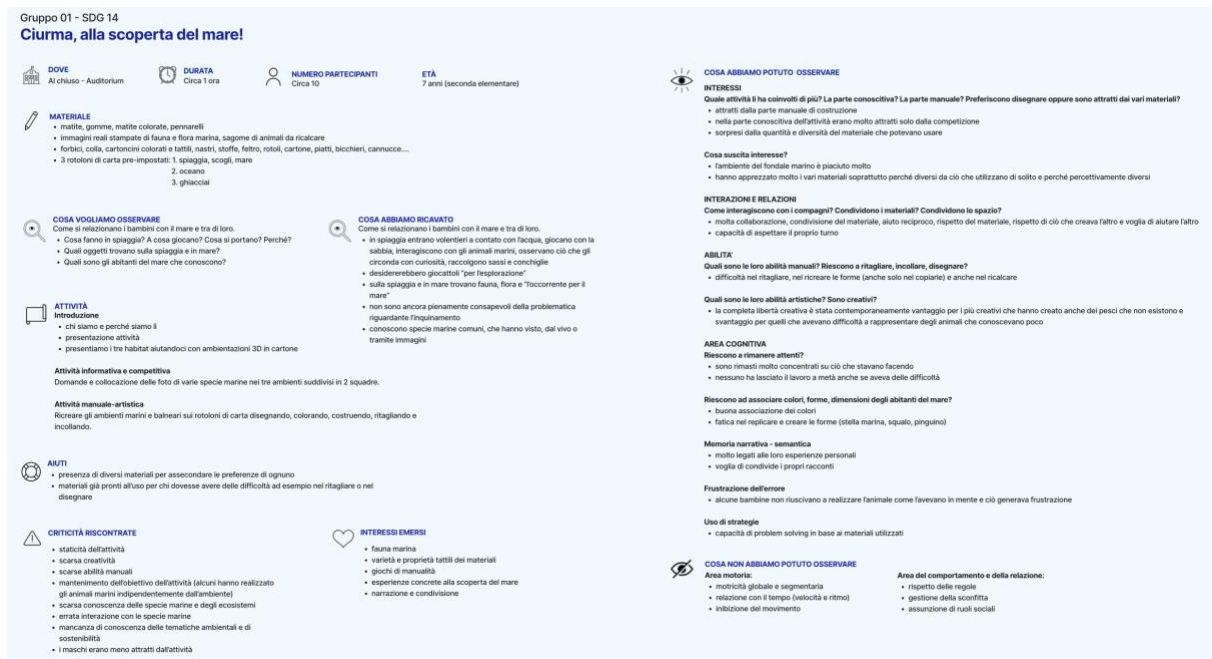
Figure 3. The observation worksheets designed by group 1.

The result of these observations was the identification of some interests and some critical issues. The students observed that the children were interested in marine fauna, materials with different textures and tactile characteristics, manual games, and recounting and simulating concrete experiences in discovering the sea. However, simultaneously, a need for knowledge of marine species and their ecosystems emerged, especially in their interactions with species, a lack of understanding of environmental and sustainability issues, and the need to develop manual skills to aid creativity. Group 1 then continued the investigation by interviewing parents, teachers and educators. Starting then from the identified critical issues, the students formulated project questions:

- Problem: Wrong interaction with marine species. Project question: How can empathy towards marine species be generated so children can learn how to interact with them?

- Problem: Habit of taking sand, stones and shells away from the beach due to a need for knowledge of environmental and sustainability issues. Project question: How can we teach to protect and preserve beauty so that it is available to all?

- Problem: Children's lack of knowledge about marine species and ecosystems leads to less sensitivity to these issues. Project question: How can children be made aware of marine flora and fauna so that they respect them?

4   CONCLUSIONS

At the end of the research phase, a comprehensive evaluation was conducted to assess the activity structure and its practical utility and identify potential improvement areas.

Concerning the activity structure, articulating the NTs' contributions was optimal. Their deliberate and restrained involvement created an environment where students could focus, optimising their time and directing their attention towards thoroughly exploring the user. A notable advancement from previous years was the significant contribution of the theoretical lecture component, fostering a deeper understanding of the user's profile. Integrating the notions of user research already provided by the teaching team allowed the experimentation of new research and design tools. The provision of observation sheets proved particularly beneficial for groups facing challenges, offering a structured and guided support system, especially for those less inclined towards this type of investigation.

While many students found the acquired knowledge fundamental during this phase, aiding in pivotal project transitions, some experienced difficulties seamlessly making the connection. Therefore, to improve the activity in subsequent years, it might be interesting to create a tool to help the students transition from translating the observed elements into the brief to the project. In general, the balance of

this new activity is positive. The objectives have been achieved by applying a User Centered Design (Norman, Draper, 1986) process with the involvement of users throughout the whole project (questionnaires and interviews to secondary users, rapid ethnography, participant observation of planned activities, and user tests), the refinement of prototypes guided by the evaluation of user needs, and the support of a multidisciplinary team of experts, teachers, and researchers.

This study showed how collaboration and the intersection of different disciplines can enrich the designer's journey. The incorporation of child development experts led to the creation of artefacts. It yielded tangible tools for design research, enhancing the educational experience for students enrolled in a three-year design course. This comprehensive analysis serves as a valuable roadmap for refining and advancing future iterations of the activity.

ACKNOWLEDGEMENTS

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