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Knowledge-Building Environments

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ABSTRACT
Despite the innovative features that many sophisticated products offer, they seem to have created new challenges instead of simplifying people's lives. Neophytes or people with cognitive deficiencies, for example, seem particularly uneasy when facing complex user interfaces. Designing for people involves getting to know the user and his perception of the environment of use, which necessitates a broader perspective and extended knowledgebase.

The paper will discuss how design education attempts to address the need for teaching interdisciplinary skills and systemic thinking. A case study will illustrate an experimental teaching framework and the implementation of an interdisciplinary learning environment that merges researchers, graduate and undergraduate students from different disciplines in a joint project. The paper will conclude with an assessment of this teaching experience and offer recommendations for future consideration.

Categories and Subject Descriptors
H.1 [**Models and Principles**]: H.1.2 User/Machine Systems– *human factors, and* H.5 [**Information interfaces and presentation**]: H.5.1 Multimedia Information Systems – *artificial, augmented, and virtual realities.* H.5.2 User interfaces – *user-centered design, theory and methods.*

General Terms
Design, Human Factors, Theory.

Keywords
Design theory, design education, intelligent living environment, user interaction, interdisciplinary design practice.

1. INTRODUCTION
Information and communication technologies (ICT) are part of complex systems and environments. They brought along significant implications for society at large, evolving from information and data management tools, to means of social interaction. Indeed, intelligent products have penetrated peoples' homes and claim to make their lives easier. Are they really? Not only many of them come with their own set of operating rules, they are often accompanied by a remote control, operating manuals and an increased complexity. Many appliances for example have become highly sophisticated and loaded with questionable features. The information overload is saturating user's perceptual capacity, making it difficult for many to single out the essential. As H. Hoffmann, a famous American artist once said, *"the ability to simplify means to eliminate the unnecessary so that the necessary may speak."*

These implications orient design intervention into new territories. The focus on meaning and understanding user experience has become a fundamental notion in designing user interfaces. As Rolston [21] emphasized, since the physicality of a digital product becomes secondary, the role of design is to ensure that semantic cues of a product align with the software interface in order to make the product's use truly intuitive. In exploring these new territories, design extended its disciplinary limits and drew closer to other disciplines. These trends have been extensively discussed in design research during the last years.

In the following section, the paper highlights the design perspectives that have contributed to redefining the discipline and describes how design education has been impacted since. The third section explains the setting and implementation of an experimental educational framework, designed to teach undergraduate students interdisciplinary skills. The process of knowledge-building and the approach to creative problem-solving is described in section four while illustrated using a student design project. : The interdisciplinary project will also illustrate the design process and design argumentation. The topic of the student project is: *Engaging and assisting people with cognitive deficiencies in activities of daily living through virtual interaction*. The paper will conclude by pointing out challenges, limits and opportunities identified during the process.

2. EVOLVED DESIGN THINKING

2.1 Redefining design
So, how is design being defined today? Needless to say that design and its definitions have considerably evolved over time, and, with it, design's subject matter. It no longer polarizes on objects or symbols alone; it has shifted its interest towards the actors, the environment of use, as well as the user experience.

In the course of its short history, definitions have prompted debates on the very nature of design. Theorists such as B. Fuller, Ch. Jones, V. Papanek, D. Norman, K. Friedmann, H. Simon, R. Glanville, R. Buchanan, W. Jonas, K. Krippendorff, only to name a few, have contributed greatly to these debates and the (re)definition of the discipline. Even though each of them seems to offer their own interpretation, they agree, though, on what design is not: neither a simple act of form giving, nor the physical outcome of the design process. [7]

Today, design is defined as the very process of creative problem solving and a "conscious effort to impose meaningful order", as Papanek [20] suggested. Design is context-sensitive and seeks to understand how people perceive their environment with the ultimate goal to anticipate needs and to envision a future. For this reason, designers are increasingly concerned with users' cognitive processes and how they derive meaning. Such insight allows them to "articulate the interface between artefact and user". [1]

Despite its general acceptance today, design identity is subject to perpetual change, as is society and the context in which design intervenes. Jonas [11] therefore asserts that design will have to constantly re-define itself and align its discourse with the evolving contextual environment. He is convinced that we should not expect a "stable identity but only a dynamic one". According to him, design as a "…way of projective thinking, planning and communicating, not based on a set of universal values and objectives, but on criteria of appropriateness and process quality". [11]

Though some critics interpret this changing nature of design as an identity crisis, others, such as Buchanan, see it as a sign of maturing, suggesting, "design continues to expand in its meanings and connections, revealing unexpected dimensions in practice as well as understanding". [4]

Design is reflecting on its practices and is attempting to position itself as a discipline among others. In spite of divergent views, if design should be considered a field, a discipline or even a science, [5] its cross-disciplinary nature has been emphasized numerous times: "design as an agent of reconciliation", "an expert discipline for relating and connecting floating fields" [11], a "gap-filler" [12], a "transdiscipline" [2], an "integrative discipline at the intersection of several other fields". [7] These characteristics affirm design's unique ability to relate to other disciplines and to extract critical knowledge that helps provide a holistic viewpoint. The question remains, how have these modern views affected design education?

2.2 Impact on Design Practices

In professional practice, collaborative approaches are omnipresent and user-centered qualitative user research methods are critical marketing tools. Traditional design approaches focus too much on economic aspects, which drive the product development process within R&D or Marketing, and neglect looking at a problem context in a larger sense. Even though, progressive-minded companies have understood design's strategic role, advocating design approaches and 'out-of-the-box thinking, others still perceive design as a *form-giving* activity. As a result, the evolved role of design still remains ill-perceived, and their creative problem-solving ability underutilized.

2.3 Evolving Design Education

Many design schools substantiate the need for extending knowledgebase and introduced advanced design studies to their offered programs. Social sciences have found their way into to the graduate design curricula, putting emphasis on user-centered research methods and the implication of the user in the creative process. [22] Other schools offer multidisciplinary graduate programs, allowing students to obtain hybrid degrees.

It becomes increasingly important to make students reflect on the impact design interventions may have on people and society. Designers have to learn to be responsible and efficient in their responses, sensitive to socio-cultural problems, and address issues such as sustainability and ethics. Designers need to be taught to confront the rapidly changing society, how to respond creatively without losing their main focus: addressing people's real needs and desire. [3]

Obviously, this cannot be the task of one discipline. Nonetheless, by assuming the role of a 'transdiscipline', design schools need to teach students how to connect with other disciplines and how "to use expertise without being an expert". [7] Learning to relate to other expert fields, allows designers to establish a structure for systemic thinking, which is fundamental for the acquisition of design knowledge. Depending on the subject matter, design may involve expertise from various domains. Friedman's [7] taxonomy *of design knowledge domains*, groups them in *theoretical fields*: natural sciences, humanities and liberal arts, as well as social and behavioral sciences, and *practical fields:* human professions and services, creative and applied arts, and technology and engineering.

Despite the noticeable changes in graduate programs and design research, undergraduate education however has barely progressed. Indeed, basic skills continue being taught in a traditional manner without adequately addressing systemic thinking. Without a doubt, basic design skills are important. Nonetheless, actions driven by a limited perspective cannot solve real problems. Since intellectual skills and the ability to relate to other disciplines become imperative, academic institutions start looking into collaborative teaching methods and multidisciplinary learning environments.

3. COLLABORATIVE APPROACHES

At this point, it is necessary to sum up the differentiating characteristics of multi, inter-, and transdisciplinarity.

Multidisciplinarity is cumulative in nature and regroups several disciplines around a subject matter. Each discipline addresses the subject matter from its disciplinary angle while focusing on a specific fragment of a problem. Collaboration is restricted to sharing key findings without really leaving much room for common concepts to emerge.

Interdisciplinary approaches are more than just a juxtaposition of multiple expertise. They seek real interaction, integration and sharing of methods and tools. Such intertwining of disciplines makes the discovering of common epistemological concepts possible. Multiple disciplines converge their viewpoints, thus providing a more realistic picture.

Transdisciplinarity can be described as the ability to think without being limited by disciplinary boundaries and to reconstitute knowledge-bases into one holistic view. As Nicolescu [18] stresses, transdisciplinarity is a state of mind that refuses a singular discourse and accepts the existence of multiple realities.

The Design school at the University of Montreal (UdeM) wishes to implement settings that facilitate exploratory methods and collaborative practices. Even though the existing studio class settings were instated to provide such an environment, they did not offer a framework for interdisciplinarity. [16] Hence, design education is placing today more emphasis on teaching what is appropriate, necessary or meaningful to a user or society, how to think critically, as well as how to recognize the (right) problem or needs in the first place.

In fact, over the course of the last few years, the design program structure has been adjusted, offering senior design students the option to integrate multi-, and interdisciplinary project teams during their last year of study. In some cases, such teams are composed of students, professors and researchers from multiple universities. Some work on ongoing research programs, while others work on real-life projects proposed by industrial partners.

By stretching out the final project over the period of two semesters, the students involved are given time and flexibility to adjust their respective schedules. Senior students explore in such settings other domains, while experiencing interdisciplinary team dynamics. These learning environments are not only unfolding new forms of knowledge acquisition, they also reveal new opportunities for design intervention. They offer design students access to other expertise and provide deeper insight into complex systems. One of such interdisciplinary learning environments is being described in the following section.

4. PROJECT DESCRIPTION

4.1 Project Environment - DOMUS

Researchers from the University of Montreal, the University of Sherbrooke and the University of Trois-Rivières in Canada, have been, over the past few years, collaborating on several projects that are part of a larger HCI research program. DOMUS, a multidisciplinary research lab at the University of Sherbrooke, is dedicated to research in the area of demotic and mobile computing. The research aims at assisting people who suffer from cognitive deficiencies, such as early stages of Alzheimer-type dementia, schizophrenia or cranial trauma. As a result, DOMUS research team collaborates closely with health professionals, psychologists, psycho-educators and ethicists in the research on promoting self-determination. [9, 17]

The DOMUS lab has been set up as a unique infrastructure and testing ground, designed to simulate an intelligent living environment (IE) for research purposes. The research also intents to provide personalized(able) user interfaces and to integrate all technical elements as naturally as possible in an intelligent home environment, for example. Motion detectors, thermal captors, water-flow or level indicator, and weight-sensitive flooring are some of the components that can be implemented. They capture the situation within the IE, register user patterns, alert the user if abnormalities are detected, and, if desired, allow the system to intervene (example: turning-off a stove). Based on the sensor-provided information, the computer system is able to infer activities, actions or sequences and compare them with the user's usual habits. Captors are placed strategically around windows, doors, closets or drawers, providing feedback about their state or recent use. They allow the IE to register if a person has omitted to initiate certain activities within a reasonable delay *(for example, the intake of medication, or the initiation of a morning routine)*. The IE is set up to propose corrective measures if needed, desired or requested.

The assistance in completing every-day tasks is of great value, especially for people suffering from minor memory loss. The IE can not only detect, for instance an unusual sequence of activities, it also can be set-up to intervene actively or passively on different levels, varying its signal from subtle to explicit and incite actions if the user's safety is at stake. [9]

DOMUS has been investigating user experience and satisfaction of the IE in the past, involving people that suffer from cognitive deficiencies due to head trauma. These early studies have been encouraging, confirming that IE can increase the user's sense of security, autonomy and independence, thus improving psychosocial aspects of his life. [17]

Evidently, the subject matter calls for collaborative approaches and the contribution from several expert disciplines: computer science, psychology, health science, ethics and design. DOMUS has recognized design as an asset in this undertaking, particularly with respect to its visionary nature and user-centered thinking.

The student project that will be described in the following section looks not only at functional features of IE; it also attempts to address a person's psychosocial needs. The student assignment builds upon previous research and student projects. Therefore, design students commence where others have left off.

4.2 Framework

The design project has been spread over a two-semester period. During the first semester, students were required to familiarize themselves with the overall context, to observe and discover critical information, and to elaborate a problem definition. They learned to extract critical data, establish and prioritize design criteria, as well as justify the design intent. The conceptual phase has been initiated with a series of ideation sessions, followed by scenario building and preliminary concept generation. The first semester results have been presented and evaluated by a jury composed of professors, researchers and students, assessing the academic aspects including progress, methodology, knowledge assimilation and team dynamics.

The second semester was dedicated to concept refinement, and design development and visualization. How to simulate HCI without developing the actual software? Obviously, the challenge industrial design students were facing was that they needed to find appropriate tools to explain the design intent. In our case, one student chose to learn the *Virtools* software in order to simulate the proposed HCI within the IE using a *Panoscope360°* (www.panoscope360.com).

The *Panoscope360°* tool is a single channel immersive display composed of a large inverted dome, a hemispheric lens and projector, a computer, and a surround sound system. From within the *Panoscope360°*, one can navigate in a real-time, virtual 3D world using a handheld 3-axis pointer.

The interdisciplinarity has been addressed by integrating the design team in the DOMUS research group. In this setting, design students explored and experienced the IE prototype first hand, as well as familiarized themselves with the ongoing research projects and took advantage of the expertise of the associated team members. Critical work and review sessions scattered over the two- semester period allowed the team to ideate, to discuss ideas and to assess methods and results. These work sessions exposed the team members to each other's cultures and encouraged transdisciplinary thinking.

The students' academic schedule allocates 70% of its time to senior projects, including fieldwork, work sessions, internal progress review meetings with the professor, complementary conferences and individual exploration. During the remaining time, students take other compulsory theory classes that are part of the standard curriculum in design.

4.3 Design Approach

Students structured their project into three phases: analysis, projection and synthesis. During the first phase, they gathered empiric data about the subject matter by reviewing previous research data and by listing and organizing questions into categories (ID, ICT, IE, HCI, communication process, perception and cognition, user profiles, design trends, etc.). These categories provided them with an initial structure for information gathering, scientific literature search etc. Phenomenological inquiries and qualitative research about user context, perception and experience helped design students relate theoretical aspects to their specific topic. Subsequently, students tackled problem modeling [23], hence isolating design opportunities and design criteria. The conceptual mapping allowed design students to learn how to logically interrelate key findings.

Scenario building was the preferred tool that served design students throughout the entire design process. During the investigation phase, students generated analytical scenarios with the help of drawings, photos, flow charts, tables, and diagrams in order to illustrate related issues, and isolate problem areas. User scenarios then helped to explore possibilities and generate various HCI concepts during the projection phase. During the synthesis phase, a context scenario was proposed, illustrating the preferred outcome. Overall, scenario building also revealed itself useful as a transition tool between all three phases.

The following paragraphs describe students' summary of the problem situation, their argumentation and design intent.

4.4 Problem Definition

The social context

The Canadian senior population (65 and older) has increased by two thirds since 1981 and is expected to reach 6.7 million in 2021. The public healthcare system, highly aware of the upcoming challenges is looking for viable alternatives to institutionalization. At-home care, for example, is one of many alternatives that are increasingly favored. Yet, with a rapidly decreasing workforce, other alternatives such as remote-assistance, telemedicine and intelligent living environments become another option.

Studies on psychosocial dynamics surrounding people with physical or intellectual deficiencies reveal that those affected often react to their conditions by retreating or isolating themselves from social life, afraid to disclose their 'handicap' to others *(even to their loved-ones),* insecure and afraid to make mistakes. This can lead to a loss of confidence or even depression.

The apparent need to motivate, stimulate and encourage people to tackle more complex tasks, to boost their confidence and to promote self-determination, drives researchers worldwide to explore technological solutions able to accomplish these tasks.

However, every user is different and the level or form of assistance desired or needed varies as well. Hence, highly flexible systems capable to adapt to different users' needs are necessary. People with ID, for instance, may display limitations with regards to problem solving, planning, and abstract thinking. IE should support the user to overcome these limitations and to affront complex tasks.

Psychosocial wellbeing, too, is crucial. If neglected, it can be a cause of loneliness and mental decline leading to problems such as negligence of personal hygiene, insomnia, loss of appetite, etc. Staying active and socially connected is essential in order to counter self-neglect.

Social interactions and homeboundness seem contradictory at first thought, yet digital communication devices have proven to accomplish the unimaginable: connecting people without the need of leaving their homes. In fact, people have never been so *'chatty'* since the arrival of mobile phones, which have impacted user's communication habits. Some do even insist on staying at home because of social online obligations (chatting, gaming).

Even though the ability of ICT to facilitate communication and exchange is apparent, fear and aversion of constantly changing technology seem to be destabilizing for many senior users. The digital divide is real and caused in part by the disparity of revenues and variable education level of the senior population. Nonetheless, the ubiquity of ICT is apparent, even among seniors. According to Statistics Canada: "Between 2000 and 2003, the share of individuals ages 65 to 74 using the Internet, more than doubled from 11% to 28%. The same upward trend was evident among seniors age 75 and older." [25]

Advanced technologies promise unlimited opportunities for intuitive HCI: multi-touch input systems, flexible, organic light-emitting diodes screens, projected keyboards, and voice- and motion-activated controls, interactive and touch-sensitive working surface, luminescent fabrics, these are only a few of the numerous technologies presented over the course of the past years. Yet, technology needs to be integrated, *invisible*, without imposing itself or complicating someone's life. [19]

Design argumentation

The well-being of an elderly resides not only in a good personal hygiene but also in a healthy life style. The transition from an active to a more passive life represents for some a dramatic change. Every effort should be made to attenuate this transition. Staying socially active and adopting a daily routine can contribute significantly to maintaining a person's interest in life. Thus, the revitalization of sociability among seniors, especially those living alone in their homes, could transit by the vital need that is *nutrition*. Cooking is a perfect activity that not only is or should be part of one's daily routine, but it also contributes to a person's well being. Indeed, a growing popularity of cooking magazines and cooking TV-shows validates people's interest in entertainment that brings gastronomy and the art of fine dining into their homes. These are excellent means of motivating and stimulating an audience while teaching them healthy eating habits and new techniques.

Based on these observations, it can be assumed that gathering and engaging people not only in cooking but also in sharing the meal can add purpose and meaning to the simple act of nourishing oneself. The process of preparing and sharing a meal could turn into a potentially entertaining, social experience. Therefore, the intention is to build an *interaction gateway* that engages and enables people of various levels of autonomy and cognitive abilities in a variety of activities. Also, people that just wish to socialize would benefit from such a tool.

Yes, without a doubt, ICT have expanded our social networking options but they require certain proficiency, representing an impenetrable world for neophytes. Therefore, easy to use, non-ambiguous user interfaces are crucial for the success of product or service, especially when addressing the needs of a population challenged by new interfaces, new language or codes.

But are virtual interactions capable of attaining the same level of sensibility and responsiveness as direct human contacts do? Should the development of virtual interactions aim to attain a level a sensibility and responsiveness that equals that of real-life contact or should it be defined as a new mode of communication and evolve in that sense?

The design intends to explore ICT opportunities to engage, assist and entertain a user through activities of daily living. The ICT shall promote autonomy, self-determination and social interaction while taking users' physical and psychosocial needs into consideration.

4.5 Concept Development

The ideation session has been initiated by reviewing the following questions:

- What are we trying to accomplish?
- Who will benefit from it?
- Why is it important?
- How can it be done?

During the ideation session, the design team used various techniques to kick off the idea search: scenario building, listing of synonyms/antonyms, free associations/metaphors, etc. [16]

For example, by looking at *how to engage someone,* ideas such as the gathering in interest groups and virtual catering to special interest, virtual rendezvous, programmed phone calls or virtual invitations have been proposed. Several of these ideas have been integrated into a user scenario. Figure 1 shows such a user scenario developed by the design team.

During the projection phase, the team explored a variety of possibilities that focus mainly on social aspects, such as how to engage a user in a cooking activity, how to incite him to participate. The IE should not only assist the user in preparing for this event, it needs also to accompany him during the activity using multi-sensory HCI.

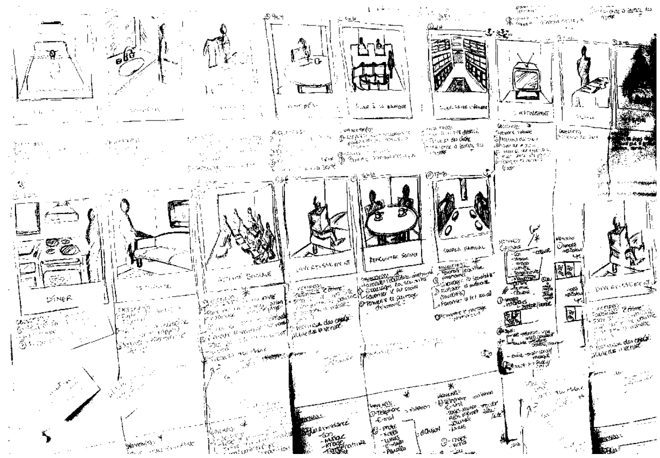

Figure 1. Scenario/ ideation structure: visualizing the daily routine of a typical user, a tool for problem isolation (by C. Donkin with the input of M. Teuwen and T. Leblanc)

Students completed the idea search by developing a taxonomy and visualizing the desired process in form of flowcharts. This layout structured activities in phases (*initiation, planning, preparation, execution…*), possible means of intervention (technological and non-technological), user preferences for IE and different levels of assistance (passive, interactive, persuasive), possible user interfaces (multi-sensory, video, photo realistic, symbolic), possible semantic universe (audio/visual themes), etc.

The concept suggested various modes of participation: passive (entertainment mode), active (participating/ learning mode), interactive (exchange/ conversational mode); also offering choices to the user: to be visible to other participants, not to be seen by others, to be semi-visible (shadow, silhouette or avatar), etc. IE preference settings for the preparation and initiation phase include, for instance, a choice of menu, activation of the cooking session, gathering and ordering produce and assisting in task realization.

Table1. Defining levels of assistance, by M. Teuwen

Action	Level 1 passive	Level 2	Level 3	Level 4 active
Choosing the menu	Menu selected by the user himself	User will appreciate choices proposed by the IE	IE detects that the user did not eat for a certain time and incites by proposing a menu	IE proposes menu according to users preferred setting
Opening a cooking session	By the user himself	IE opens the session and reminds the user of upcoming session	Session is opened automatically by IE and user is being alerted 30min. before	Automatic activation 30min + discrete message for hygiene routine appears
Identifying ingredients and produce required for the chosen menu	User will write his own grocery list	IE will list all ingredients required for the session and identifies necessary produce	Groceries have been identified and an order suggested by IE, user needs to confirm the order	Order has been automatically placed according to chosen menu
IE Assistance in realizing the task	without assistance	User asks for assistance	IE detects the need for assistance and suggests corrective actions	IE automatically accompanies the user step-by-step throughout the activity

Table 1 illustrates students' initial structure on possible levels of assistance in a very simplified way. These initial organizational structures have served the interdisciplinary team as an ideation and decision tool, helping to identify various other modes of assistance, as well as establish desired links to other IE features.

Figure 3 illustrates a kitchen environment and a multi-touch interactive kitchen counter configuration, conceived to accompany a user during a task. The concept was part of last-years' project and uses OLED technologies and projection for display on large surfaces. Weight-sensitive flooring is capable of tracking a user's position in the room and activating the multi-touch countertop interface accordingly.

Figure 2. Visual guide with interactive work surface, by V. Lapointe

Design communication tools

It is important to make HCI understandable through immersion and personal experimentation. Therefore, the current design team had chosen to integrate their design mock-up into their HCI proposal using the Virtools software (www.virtools.com). The proposed concept suggests the use of walls, surfaces of kitchen cabinets or room dividers as transformable display surfaces for information display. These could be used as projection screens during the virtual-cooking-activity and transform afterwards into a dining room extension, joining virtually participants during a meal. If not in use, the surfaces can convert into light emitting wall units, project decorative elements such as digital posters or be used as a TV/ IE control interface.

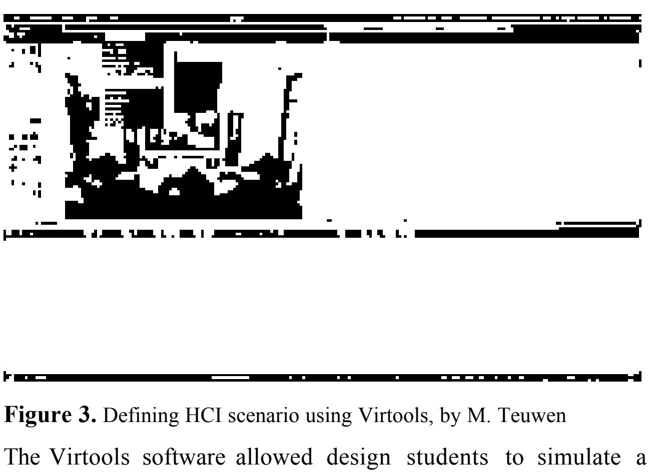

Figure 3. Defining HCI scenario using Virtools, by M. Teuwen

The Virtools software allowed design students to simulate a real-time interactive experience as a large-scaled interactive digital mock-up. This mock-up was projected into the *Panoscope360°*, thus allowing the viewer to immerse and interact with the virtual environment, experience the features of the interactive virtual kitchen and interact with various setups, options and settings via a keyboard, thus consequently reproducing what could be done tangibly on a touch screen.

A design student learned to program action and interaction by using the pre-programmed BuildingBlock functions. (Fig. 3) To visualize the interactive virtual environment, the 3D-model of the previously designed kitchen-counter had been imported from Cinema4D into Virtools, and images of various other environments applied as textures, in order to simulate different styles and setups. (Fig.4)

The interactions within the IE have been illustrated by interrelating different spaces in the house with the system. The system captures and manages all activities and information such as bio-analysis, daily activity schedule reminder, inventory, etc. It then projects this information on displays as needed. Other features have been included to reflect the current IE capabilities such as the multi-sensory mode of communication, including sound or visual cues *(light, images, text)* that are emitted by the IE at any strategic moment, assisting a person, for example, in locating an item by illuminating the specific area *(drawer)*.

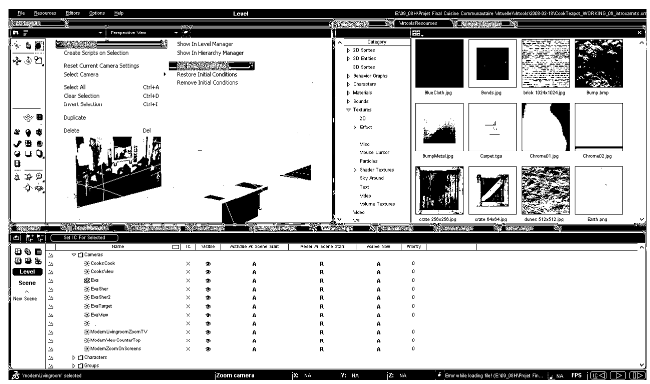

Figure 4. Importing 3D models into Virtools, by M. Teuwen

With Virtools, students are able to simulate the physical environment, the various scenarios and configurations, the interface between the IE and the user, as well as the user-to-user interaction via the system. For example, the IE assistance is represented by using proactive popup actions (pre-recorded explanation). It also proposes screens and projection technology, featuring display of grocery lists, activity updates or online ordering.

Although Virtools has been designed to generate quick mockups, students found the learning of the software rather challenging. Their limited knowledge of the building blocks functions and initial conditions setup led to a loss of time.

Nevertheless, the opportunity to simulate the final concept in the *Panoscope360°* during the student exposition made them work especially hard.

5. CONCLUSIONS

5.1 Project related

The challenge is major, seeing that the elderly population is growing and the lack of infrastructures and workforce require significant changes. ICT seem increasingly potent as a tool when facing the demographic changes. They enable people to manage various daily activities by providing assistance in accordance with the user needs. Yet, ICT are still a cause of worry and stress for a great number of seniors and it is important to work towards their simplification.

To be adopted, IE need to avoid stigmatization. IE, as highly flexible systems, need to be personalized and programmable according to individual user needs. This could lead to a broader use offering services to a larger spectrum of people. Besides the numerous possibilities that home automation offers today, it does not address the problems of solitude that some seniors often experience.

With the help of ICT, it is possible to join people in a virtual manner. The challenges lie, nonetheless, in allowing real time interaction during the course of an activity. To gather virtually in order to cook, assisted by an intelligent environment, all while being entertained throughout the cooking process and meal sharing, can contribute to reinforce the user's autonomy, self-esteem and social interaction. The described design process revealed new perspectives and opportunities for creating such meaningful user experiences for neophytes and people with cognitive deficiencies.

5.2 Design Education related

Design discourses have evolved and so should design education. Although many graduate programs offer already advanced degrees that incorporate problem modeling, user-centered design research and transdisciplinary thinking, undergraduate programs have, in general, remained unchanged. Traditional teaching methods are insufficient in facilitating modern thinking and cross-disciplinary design practices required for the transition into the professional world. Some of the students therefore seek refuge in graduate programs.

Even though creative thinking is increasingly becoming a critical component in studio classes, the problem-solving process remains simplified. An insufficient knowledgebase and a limiting environment often allow problems to be only resolved superficially. Undergraduate settings need to foster exploratory methods and integrative practices, allowing students to develop a higher understanding of complex phenomenon and the ability to argument and justify their interventions.

An environment that promotes project-based learning has proven to be more effective. Students regrouped in small teams show self-determination and self-motivation in their search for answers and significantly better assimilate knowledge. By working in an interdisciplinary setting on projects where others have left off, students had been given an excellent context and a unique responsibility. Not only does it make in-depth investigations possible, it also enables students to relate better to theory.

During auto-evaluation and peer-evaluation, students had the opportunity to critically reflect on their experience and assess the individual progress of each team member. Judging from the gathered comments, this experience was particularly enriching and resourceful. They were able to absorb a tremendous amount of information in a short period of time.

This experience empowered them as designers in a new way giving them access to multiple expertise. They felt that they had made a remarkable progress during the two-semester period. Students also expressed their deep gratification for this interdisciplinary experience and the in-depth exploration of the subject matter. They were quite ambitious in representing their discipline in the best way possible, while demonstrating their capabilities.

Nonetheless, students pointed out several challenges that they encountered during this joint research-design project.

One of the challenges was getting into the mode of interdisciplinarity. Design students tended to consider DOMUS as a 'client', rather than a team member. This led to ambiguity with regards to the decision-making process. Students discovered that DOMUS mostly deals with the computation and technical aspects of the intelligent home that was built on their premises. The lab had not given much attention to the design issues related to HCI.

Therefore, industrial design students were particularly interested in the potential of the virtual interactive kitchen and its future context, rather than the actual situation. Hence, they proposed innovative kitchen configurations and technologies, only realizing that DOMUS seemed more interested in solutions that complemented their current kitchen prototype.

Another challenge students pointed out was the need to visualize a highly flexibility system. It seemed important to them to illustrate how the environment could be personalized. This required a tremendous amount of time and tools that they were not really equipped with.

The third challenge was the ability to adopt an existing project without starting from scratch. Even though students felt it was a unique opportunity and they could see the advantages of such an approach, they still felt more intrigued by an own interpretation, intending to put their own mark on it.

Furthermore, the more students got involved in the project, the more they recognized the complexity of the problem field. They became conscious of the complexity and intertwined nature of the issues at hand, only to come to the conclusion that they have managed only to scratch the surface of the problem.

These phenomena illustrate the growing pains of interdisciplinarity and underline the challenges multidisciplinary teams face while attempting to find a common understanding. These problems can be attributed to difficulties in merging cultures and breaking with conventional disciplinary thinking. This experience only emphasizes that there is great work ahead. Academic institutions need to figure out how to bring disciplines back together, and how to unite disciplinary perspectives into a truly holistic one.

Regrettably, interdisciplinarity is not as common in design education as one would expect. Academic institutions need to make such practices available at the graduate level and also make it a critical part of the undergraduate education.

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