



# Biodesign application aiming interdisciplinary modeling of hybrid prototypes, focused on formative evaluation of competences in healthcare: an experience report


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**Abstract** The objective was to prototype new hybrid models for formative evaluation of health competencies, exploring the potential of biodesign. The activities were developed in an inter-unit college discipline called Development of Medical-Hospital Solutions, having biodesign as the conceptual framework. Multidisciplinary teams from Universidade de São Paulo (USP), Brazil were involved, with Health Sciences, Performing Arts, Design and Engineering backgrounds, representing 50 undergraduate students, 3 postgraduate students, 5 faculty members and 3 external faculty members. The students worked in interdisciplinary groups during 28 synchronous virtual meetings, guided by active methodologies. The students identified and validated real needs, developing 6 innovative and applicable prototypes, focused on hybrid learning and evaluation of interpersonal communication, healthcare planning, interprofessional sharing, ethics, decision-making, patient safety and remote simulation of physical examination. The results demonstrated the potential of biodesign for prototyping new evaluation processes, such as building spaces for the application and learning of competencies.

**Descriptors:** Educational Measurement. Competency-Based Education. Social Skills. Clinical Competence. Human Health Resources.

## Aplicación del biodiseño con miras al modelado interdisciplinario de prototipos híbridos, enfocado a la evaluación formativa de competencias en salud: reporte de experiencia

**Resumen** El objetivo fue prototipar nuevos modelos híbridos para la evaluación formativa de competencias en salud, explorando el potencial del biodiseño. Las actividades se desarrollaron en una disciplina universitaria interunidad llamada Desarrollo de Soluciones Médico-Hospitalarias, teniendo al biodiseño como marco conceptual. Participaron equipos multidisciplinarios de Universidade de São Paulo (USP), Brasil con antecedentes en Ciencias de la Salud, Artes Escénicas, Diseño e Ingeniería, representados por 50 estudiantes de pregrado, 3 estudiantes de posgrado, 5 miembros de la facultad y 3 miembros externos de la facultad. Los estudiantes trabajaron en grupos interdisciplinarios durante 28 reuniones virtuales sincrónicas, guiados por metodologías activas. Los estudiantes identificaron y validaron necesidades reales, desarrollando 6 prototipos innovadores y aplicables, centrados en el aprendizaje híbrido y la evaluación de la comunicación interpersonal, la planificación de la atención médica, el intercambio interprofesional, la ética, la toma de decisiones, la seguridad del paciente y la simulación remota del examen físico. Los resultados demostraron el potencial del biodiseño para prototipar nuevos procesos de evaluación, así como para crear espacios para la aplicación y el aprendizaje de competencias.

**Descriptores:** Evaluación Educativa. Educación Basada en Competencias. Habilidades Sociales. Competencia Clínica. Recursos Humanos en Salud.

## Aplicação de *biodesign* visando modelagem interdisciplinar de protótipos híbridos, com foco em avaliação formativa de competências em saúde: relato de experiência

**Resumo** O objetivo foi prototipar novos modelos híbridos para avaliação formativa de competências em saúde, explorando o potencial do *biodesign*. As atividades foram desenvolvidas em uma disciplina universitária interdisciplinar chamada Desenvolvimento de Soluções Médico-Hospitalares, tendo o *biodesign* como arcabouço conceitual. Equipes multidisciplinares da Universidade de São Paulo (USP), Brasil foram envolvidas, de formação em Ciências da Saúde, Artes Cênicas, Design e

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Engenharias, representadas por 50 alunos de graduação, 3 alunos de pós-graduação, 5 docentes membros da Universidade e 3 docentes externos. Os alunos trabalharam em grupos interdisciplinares durante 28 encontros virtuais síncronos, guiados por metodologias ativas. Os alunos identificaram e validaram necessidades reais, desenvolvendo 6 protótipos inovadores e aplicáveis, focados em aprendizagem híbrida e avaliação de comunicação interpessoal, planejamento de saúde, compartilhamento interprofissional, ética, tomada de decisão, segurança do paciente e simulação remota de exame físico. Os resultados demonstraram o potencial do biodesign para prototipar novos processos de avaliação, assim como construir espaços para a aplicação e aprendizagem de competências.

**Descritores:** Avaliação Educacional. Educação Baseada em Competências. Habilidades Sociais. Competência Clínica. Recursos humanos em saúde.

## INTRODUCTION

In the healthcare field, competence is the ability to acquire cognitive, interpersonal and clinical knowledge and skills, necessary for professional qualification<sup>1</sup>. In this context, developing and accessing competence are fundamental steps in teaching and learning, which is why this model has been requested and accepted as a curricular structure<sup>1,2</sup>.

However, the development of competences is a complex process that involves behavioral and attitudinal aspects, traditionally mediated by the progression of practical experiences and responsibilities, which would increase the technical competence, safety and qualification of students, in order to produce adequate results<sup>2</sup>.

Therefore, competence-based education proposes that one should intentionally prepare students to deal with real practice scenarios that are constantly changing, bringing a change in philosophy and educational actions, enabling innovation in the education of healthcare professionals<sup>3</sup>.

Despite this, traditional education still follows a fundamentally content-based model. Many training programs focus on offering a broad volume of theoretical resources, with learning being assessed by the ability to reproduce this content. This approach tends to neglect other performance results; but evidence of competence can be collected through multiple sources and methods<sup>3,4</sup>.

The American Dental Education Association's (ADEA) Commission on Change and Innovation categorized six possible competency domains for dental education: 1-critical thinking, 2-professionalism, 3-communication and interpersonal skills, 4-health promotion practices, 5-management and informatics, 6-patient-centered care (assessment, diagnosis, planning, and maintenance), and confidence in case management<sup>1,5,6</sup>.

In Brazil, the first National Curricular Guidelines (DCN) for the Dentistry Undergraduate Course, was approved in 2002, by federal Resolution No. 3 of February 197, to orient the curricular organization of Higher Education Institutions in the country. The new DCN was approved in 2021, reinforcing the importance of competence based education<sup>8</sup>. This emphasizes the relevance of academic environments that lead to the acquisition of better competences, which reflect the real needs of those involved, ultimately developing higher cognitive skills and promoting student autonomy<sup>3</sup>.

Recognizing the importance of this new educational perspective, the Interdisciplinary Academic Consortium for Excellence in Undergraduate Education of the Universidade de São Paulo (CAEG/USP), resulting from the PRG 01/2020-2021 Notice from the Office of the Vice-Rector for Undergraduate Studies, involved the areas of Health Science (Medicine, Nursing and Dentistry), Performing Arts and Engineering, seeking to develop new hybrid models of formative assessment, clinical and socio-emotional competencies in healthcare.

Interprofessional teamwork in healthcare is essential for improving patient care quality. It highlights that interdisciplinary teams, comprising professionals such as physicians, nurses, pharmacists, and others, can provide a more holistic and coordinated approach, necessary for addressing the complexities of modern healthcare<sup>9</sup>. Effective collaboration within these teams can lead to reduced hospital readmissions, shorter length of stay (LOS), and increased patient safety, despite ongoing challenges like communication barriers and cultural resistance<sup>9</sup>.

Furthermore, the potential of emerging technologies, such as telehealth and artificial intelligence, can strengthen interprofessional work, facilitating better communication and coordination among health professionals<sup>9</sup>.

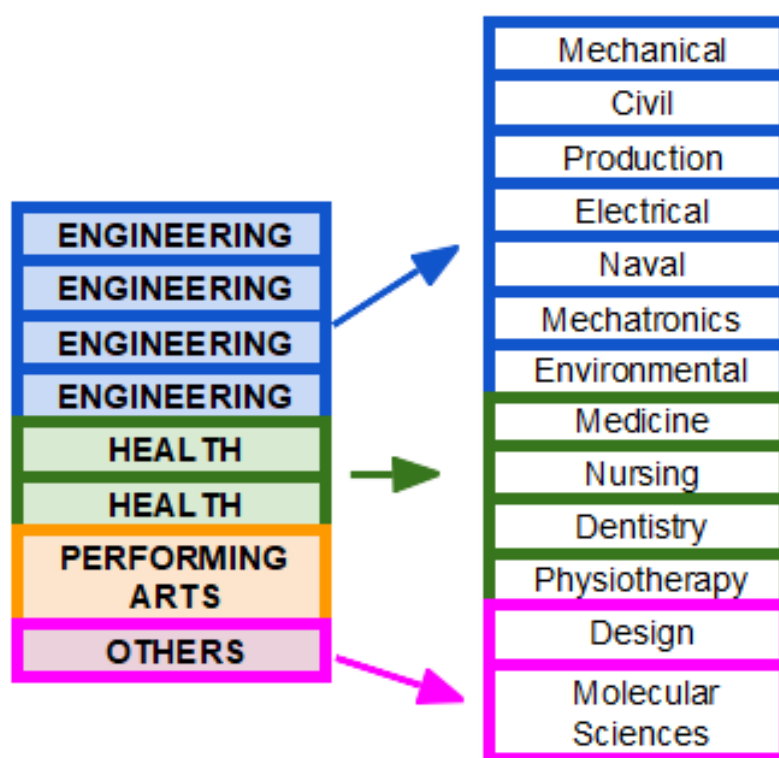
By offering an optional discipline, with the participation of undergraduate and graduate students from the 5 courses, the project promoted a space for collaborative learning of common and simultaneously specific competencies, with emphasis on autonomy, dialogic relationship, proactive participation of students in the teaching-learning process, interdisciplinary training and interprofessional education.

The methodological approach used combined innovative teaching activities and models, through digital information and communication technologies (virtual assessment) or hybrid strategies, exploring interactive technological solutions and the biodesign approach, conceived at Stanford University - USA, to conduct quick digital prototyping, which could contribute to creating solutions for education and evaluation.

## EXPERIENCE REPORT

Based on experiences with practical tests of clinical skills and interprofessional education, college teachers from USP Polytechnic Engineering School, School of Medicine, School of Dentistry, School of Nursing and School of Communication and Arts, held a series of remote meetings to plan actions and work topics, considering the epidemiological profile of the population, ethical demands, patient safety and labor relationships.

The project involved 50 students from different undergraduate courses of engineering, performing arts, medicine, nursing, dentistry, and design (Figure 1). They were divided into 6 heterogeneous and interdisciplinary groups, identifying and validating interprofessional and socioemotional clinical competencies. As a reference for the group activities, competencies in the cognitive, practical and attitudinal dimensions were included, as well as the practice scenarios to be considered and prioritized in the modeling and development of the prototypes, promoting collaborative learning.



**Figure 1.** Basic Organization and diversity available for each work group.

The activities were carried out within the scope of a discipline called “Development of Medical-Hospital Solutions”, over 28 synchronous virtual meetings of 1 hour and 40 minutes each, guided by the Identification and Invention stages of the biodesign process.

In the Identification stage (Figure 2), organized into action roles of organizer, thinker, builder and clinician, each member of the group identified challenging health needs, defining motivations, contextualization and critical deepening of the problems identified. Each need was characterized and inserted into the thematic scopes established by the teachers, and one of those needs was chosen as the strategic focus of the group.

Through active methodologies such as Team Based Learning, Problem Based Learning, Case Study, Flipped Classroom, Design Thinking, Field Research, Storytelling, Role Play and Peer Assessment, the students modeled clinical simulations and presented them to teachers, specialists and stakeholders, for validation regarding reliability and reproducibility. Being made official with the assembly of the staged situation, with the support of the performing arts students, in 3 to 5 minute videos, presented to the other groups for a discussion to understand the collective needs and validate the skills involved.

In the Invention stage (Figure 2), the groups modeled different practice scenarios for developing technological solutions. Based on consolidated models for assessing clinical skills, such as the Objective Structured Clinical Examination (OSCE), the prototyping ideas were tested by exposing students to simulated situations and measuring the potential for acquiring skills at each evaluation station.

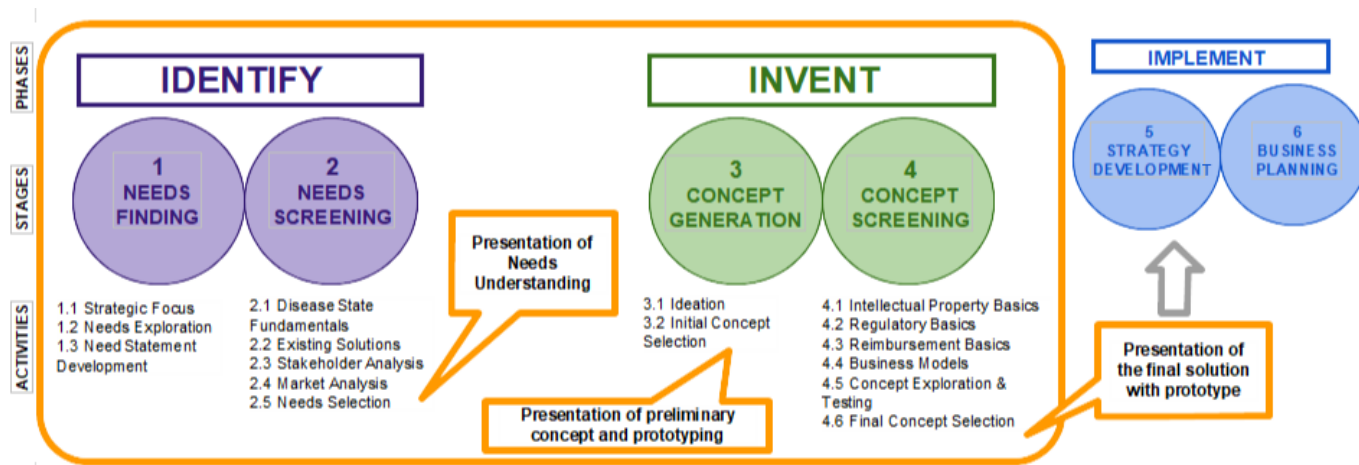
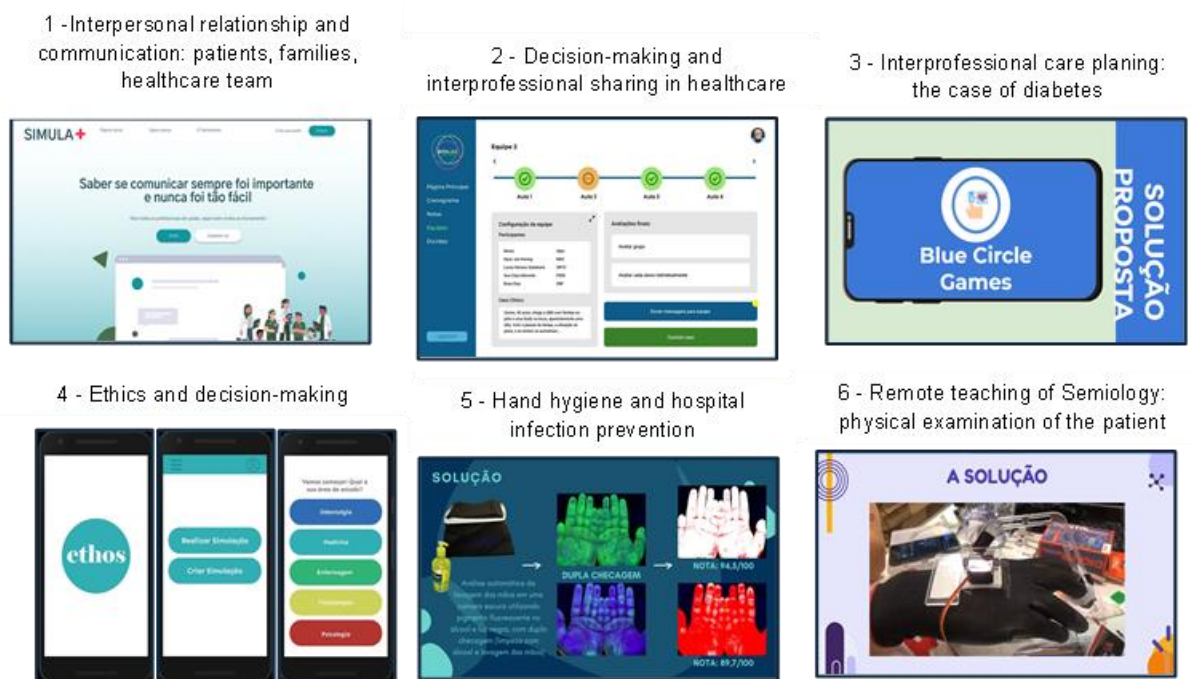


Figure 2. Biodesign phases from Stanford used in the work process (adapted from Yock et al (2015)<sup>10</sup>).

After presenting the preliminary conceptualization and experimental applications, 6 final prototypes were developed (Figure 3):

1. An online simulation platform for training interpersonal communication between healthcare professionals and patients. Using a diverse database, students would receive predefined scripts for multiple roles, action instructions for different communication scenarios, as well as discussion forums with an interactive interface and integrated video-call and text sharing features.
2. An application for training interprofessional communication in decision-making, for healthcare teams. The purpose was promoting dialogue using interactive clinical cases, programmed based on decision trees, promoting different outcomes depending on the previous decisions made. The program also generates visualization of consequences, through exams, images, videos and exchange of reports/opinions between professionals.
3. A serious game for interprofessional planning of diabetes care. Students could play in "patient" mode, to recognize the difficulties experienced, and train empathy. Or also play in "professional" mode, training an interdisciplinary approach to healthcare planning.
4. An app for simulating ethical dilemmas in healthcare. The program offers both database simulations and an interface for creating customized simulations. During training, it is possible to evaluate the ethics of users' decisions, like an outcome game, through constructive feedback (ethical feedback).
5. Equipment for automatic analysis of hand washing. Using a darkbox and an attached electronic device, the sites impregnated on the hands with a fluorescent pigment added to a gel alcohol formulation, would be analyzed via algorithm. The proposal was to offer double checking, hand cleaning with alcohol and the actual washing, aimed at workers and patient safety.
6. A glove with haptic feedback for simulated physical examination training. The proposal was to allow the practice of palpation of different semiological conditions, with realistic tactile feedback, reproducing the sensation of tissues, organs, lesions, temperatures and textures.



**Figure 3.** Samples of the 6 developed prototypes.

## FINAL CONSIDERATIONS

Recognizing the complexity of assessing clinical competencies, especially socio-emotional ones, has been a major challenge in the training of dental professionals. These competencies, which are difficult to measure using traditional assessment methods, require a more holistic and dynamic approach, motivating the search for alternatives focused on creating solutions that enable innovation in evaluation processes.

Innovation is defined as a new idea, product or process, as a result of professionals trained in a culture that supports transformative ideas, such as the systematic biodesign program at Stanford University<sup>11</sup>. The proposal is to teach innovation based on needs, through a structured process of identification, filtering, concepts generation, prototyping and implementation of inventions in early stages<sup>11-13</sup>.

This approach demonstrated the potential to stimulate creativity and innovation, with the protagonism of students, and as an active methodology in the teaching-learning process. Considering both the six innovative prototypes of assessment processes based on competencies, and the construction of plural spaces focused on the autonomy and creative process of students. Thus, exercising problem-solving skills, decision-making, interdisciplinary action and collaborative and interprofessional learning.

The structured creation of teams based on the interaction of different personalities, experiences and personal skills favored the distribution of the roles of organizer, thinker, builder and clinician<sup>11,13</sup>. It allowed each member to focus on their areas of expertise and responsibilities, optimizing skills, promoting efficiency and organization, confirming that teamwork is central to the biodesign process<sup>11</sup>.

The strategy of interprofessional and multidisciplinary collaborative action and learning avoided work overload, confusion of responsibilities and redundant efforts, resulting in a more engaged, fluid and effective execution, with excellent results, as can be seen by the 6 prototypes designed by the groups of students. It also favored contact with new information and interactions outside class sessions, intensifying and expanding learning about the various topics of the discipline, in connection with researchers, specialists and stakeholders. This process involves mapping and exploring several alternative routes for problem-solving, combining collaborative thinking, prototyping, market analysis, financing strategies and a quality-focused design<sup>11</sup>, ensuring that the final solution is viable, effective and directed to the real needs of users.

The first two stages of the biodesign resulted in promising, applicable and scalable proposals for formative skills assessment tools. However, considering the one-semester duration of the course, it was not possible to move forward with the implementation phase, beyond its planning. It is worth noting that the challenges involved in this new



potential stage were identified, such as drawing up a detailed plan for practical tests, a viable business model and strategies for marketing the prototypes developed<sup>14</sup>.

This contrast between initial creativity and the practical challenges of implementation reveals that, although innovation programs can improve teaching-learning strategies, their application depends on a series of technical, economic and logistical factors that need to be carefully planned and executed. Furthermore, the implementation of new strategies in dental professional training faces additional challenges, such as resistance to change, course curriculum adaptation and the need for overall infrastructure to support such innovations. The involvement of the USP Polytechnic Engineering School enabled experiences from their resources, such as as Interdisciplinary Center for Interactive Technologies (NAP-CITI-USP), Integrable Systems Laboratory (LSI-POLI-USP), Advanced Virtual Reality Laboratory and InovaLab@POLI, providing essential infrastructure for digital and physical prototyping.

As a conclusion, the results showed the potential of biodesign, not only for innovating evaluation processes, but also for building educational spaces that can systematically exercise competencies and skills, which are essential for developing qualified professionals, who can adapt to the demands of the market and society.

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