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Designing User-Centered Exercise Science Education: Integrating HCI Principles to Address Fitness Technology Disparities

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ABSTRACT

Despite explosive growth in the fitness technology sector ($257 billion globally in 2024), digital health and fitness technologies systematically exclude older adults, individuals with disabilities, racial and ethnic minorities, and lower socioeconomic populations. This paper presents a curriculum framework integrating Human-Computer Interaction (HCI) principles into exercise science education to prepare professionals who can evaluate, select, and advocate for accessible, equitable fitness technologies. Drawing on Misericordia University's newly launched Exercise Science program, the framework addresses critical gaps at the intersection of technology, health equity, and professional education through four key domains: user research and persona development; usability testing methodologies; accessibility evaluation; and cultural competency in technology. This model positions exercise science graduates as essential intermediaries between technology developers and underserved populations, transforming their role from passive technology consumers to active advocates for inclusive design and health equity.

Keywords: Technology, Digital health, Older adults, Disabilities, Minorities, Socioeconomic populations, Human-computer interaction, Exercise science, Accessibility, Health equity, Usability testing, Cultural competency, Inclusive design

INTRODUCTION

The fitness industry achieved a global market value of $257 billion in 2024, with projected annual growth of 5.6% (Recibas and Recibas, 2025). While this growth trails sectors like AI and healthcare technology (14–37% growth rates; Learning Routes, 2025), it substantially exceeds real estate (2%), manufacturing (1–2%), and GDP growth (3.2%; IBISWorld, 2024). However, despite booming innovation in fitness technology, accessibility gaps persist. According to the World Health Organization (2023), approximately 16% of the world's population faces significant disabilities that impact daily life activities. Yet, only 40% of this population exercises regularly due to barriers such as cost, poor design, and inaccessible equipment (Jamieson and Wijesundara, 2024). Without intentional focus on inclusive design, technological advancement risks widening existing health disparities through the digital divide and algorithmic bias.

Despite the explosive growth of fitness technologies, digital health and fitness platforms often fail to account for the needs of older adults, individuals with disabilities, racial and ethnic minorities, and those from

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lower socioeconomic backgrounds (Petek et al., 2023; Shin, An, and Oh, 2025). Mainstream wearables and fitness platforms remain inaccessible due to costs, lack of adaptive features, limited language and cultural options, and technological limitations that render physiological measurements less reliable for individuals with darker skin tones or disabilities. These technologies are predominantly adopted by younger, wealthier, more digitally-literate users. At the same time, lower SES, minority, rural, and disabled populations face significant structural barriers and are often excluded from clinical research and digital interventions (Holko et al., 2022; Chandrasekaran, Sharma, and Moustakas, 2023).

A significant contributor to these disparities is the lack of Exercise Science professionals trained in Human-Computer Interaction (HCI) principles. When individuals enter the field without a foundational understanding of usability, accessibility, and user-centered design, they may unknowingly reinforce exclusivity and bias in technology-enhanced health efforts. This demands interdisciplinary training to prepare future professionals to integrate HCI concepts throughout the design, implementation, and evaluation of health technologies.

PURPOSE AND SIGNIFICANCE

This project presents a curriculum framework for exercise science education that integrates HCI principles to prepare future professionals to evaluate, select, and design fitness technologies that are accessible, equitable, and effective across all populations. The curriculum fosters: (1) critical technology evaluation skills, (2) inclusive design thinking, (3) cultural competency in technology-mediated interventions, (4) empathy for diverse user experiences, (5) accessibility assessment competencies, (6) evidence-based technology recommendation skills, (7) user research and needs assessment capabilities, (8) professional advocacy for health equity, and (9) interdisciplinary collaboration skills.

This framework fills critical gaps at the intersection of technology, health equity, and professional education. The fitness technology industry has expanded rapidly, yet exercise science graduates often lack the skills to critically assess digital tools that increasingly influence client interactions, resulting in both a workforce-readiness gap and a health equity issue. By embedding HCI principles into exercise science education, this framework positions graduates as vital intermediaries between technology creators and diverse users. Instead of becoming obsolete in an automated fitness landscape, they become essential experts who evaluate whether technologies appropriately serve target populations and advocate for inclusive design.

The framework's significance extends beyond individual institutions through its scalable, adaptable structure, which is suitable for programs with varying resources. Its four-domain model provides guidance for other exercise science and health professions, including occupational therapy, physical therapy, and athletic training. The timing is especially urgent given rapid AI advancement and pandemic-driven virtual fitness growth, which could exacerbate health disparities without trained professionals to evaluate technologies through an equity lens.

BACKGROUND AND THEORETICAL FRAMEWORK

Fitness Technology and Health Disparities

Digital health innovations and self-monitoring tools, such as wearables and apps, are increasingly popular, especially in developing countries and among women with high motivation, driven by factors like performance and health awareness (Haider, Hashmi, and Maryam, 2024; Pandey et al., 2021). However, disparities persist due to poor design, high costs, and infrastructural gaps, which disproportionately affect older adults, low-income populations, and disabled users, those with the most need (Sullivan and Lachman, 2017). Accessibility issues—such as small fonts and complex interfaces—create barriers, often excluding vulnerable groups and compounding existing health inequalities (Alanazi, Salah Alanazi, and Benlaria, 2025). Many technologies lack accommodation for ethnically and linguistically diverse users (Wilson et al., 2024). Cultural factors, including skin tone and tattoos, can also impair the accuracy of technology, underscoring the need for more inclusive design (Chandrasekaran, Sharma, and Moustakas, 2023). Cost barriers—subscription fees, recurring costs, and exclusive device purchases—limit adoption among low-income individuals, leading to early dropout or non-engagement (Zitkus, Clarkson, and Duarte, 2025). Marginalized or rural populations face lagging infrastructure, hampering access to innovative health technologies (Alanazi, Salah Alanazi, and Benlaria, 2025).

HCI Principles and Exercise Science Integration

Human-Computer Interaction (HCI) emerged to improve the interface between humans and technology, emphasizing user-centered design, usability, and accessibility (Carroll, 2003). User-centered design involves understanding users' needs and involving them throughout the development process, ensuring that fitness technologies cater to diverse populations. (Mao et al., 2005). User-Centered Design (UCD) emphasizes end users' needs, abilities, and limitations rather than developers' technological preferences (Mao et al., 2005). ISO 9241-210 defines UCD as understanding and explaining the context of use, determining user requirements, designing products to meet those needs with user involvement throughout, and refining design based on user-centered evaluations (*Ergonomics of human-system interaction: Human-centred design for interactive systems. Part 210*, 2019). In fitness technology, this means designing with diverse populations in mind rather than relying on assumptions.

Usability refers to the extent to which specific users can use a system to achieve defined goals through effectiveness, efficiency, and satisfaction (Deniz-Garcia et al., 2023). Nielsen's (1993) heuristic evaluation methods—including system status visibility, real-world matching, user autonomy, and minimalist design—enable objective assessment of whether fitness technologies serve diverse user populations.

Accessibility ensures technology is usable by individuals with diverse abilities and disabilities. Web Content Accessibility Guidelines (WCAG) provide widely recognized standards based on four principles: perceivable, operable, understandable, and robust (*Web Content Accessibility Guidelines (WCAG) 2.1*, 2025). For fitness technologies, this guarantees individuals with visual, hearing, motor, or cognitive impairments have equal access to information and functionality.

Traditional exercise science curricula emphasize biological sciences (anatomy, physiology, kinesiology, biomechanics), behavioral sciences (psychology, motor learning), and applied skills (exercise prescription, assessments; American College of Sport Medicine, 2025). Accreditation standards from organizations like the Commission on Accreditation of Allied Health Education Programs (CAAHEP) specify competencies in exercise physiology, pathophysiology, health appraisal, exercise programming, and behavioral strategies, but contain minimal requirements for technology evaluation or design (*CAAHEP | Standards and Guidelines*, no date). This traditional focus prepared professionals for a fitness landscape dominated by face-to-face interactions and basic equipment. However, the dramatic shift toward technology-mediated fitness interventions—accelerated by the COVID-19 pandemic—has created a competency gap (Torous et al., 2021).

Despite wearable technology and mobile exercise apps ranking as the top fitness trends for 2025 and 2026 (American College of Sports Medicine, 2025), exercise science curricula provide minimal preparation for evaluating these technologies. The absence of formal training in usability evaluation, accessibility assessment, and inclusive design leaves professionals ill-equipped to critically assess digital health tools, often relying on popularity or marketing rather than evidence-based evaluation (Brickwood et al., 2019). This training gap is particularly problematic for accessibility competencies, as professionals cannot identify barriers faced by diverse populations without specific instruction in accessibility standards and evaluation methods.

Theoretical Framework

This framework connects exercise professionals with technology by positioning them as mediators of effective human-technology interaction, emphasizing the integration of social and technical factors. It draws on Socio-Technical Systems Theory, which advocates for optimizing both social and technological aspects to achieve better outcomes (Trist & Bamforth, 1951; Baxter & Sommerville, 2010), and Activity Theory, which focuses on how tools enable goal achievement within specific social contexts (Engeström, 2001). Universal Design principles further underpin this approach, promoting inclusive fitness products usable by all without modification, thereby fostering equity and accessibility in digital health initiatives. (Mace, 1985; Story, Mueller, and Mace, 1998). The seven principles—equitable use, flexibility in use, simple and intuitive use, perceptible information, tolerance for error, low physical effort, and size and space for approach and use—provide frameworks that exercise professionals can apply when evaluating fitness technologies (Connell et al., 1997).

Role of Exercise Professionals

Integrating HCI principles transforms exercise science professionals from technology consumers to technology evaluators and advocates. This expanded role encompasses:

Technology Assessment: Systematically evaluating fitness applications, wearable devices, and digital platforms using established HCI frameworks. Rather than accepting developer claims, professionals apply heuristic evaluation, usability testing, and accessibility auditing (Shneiderman et al., 2016).

Personalized Technology Matching: Assessing individual client characteristics—technological literacy, disability status, cultural preferences, motivational factors, resource constraints—to recommend appropriate technological tools or determine when technology is inappropriate (Mercer et al., 2016).

Advocacy for Inclusive Design: Interacting with technology developers and vendors to advocate for design changes that reduce barriers and expand accessibility, including providing user feedback, requesting features for underserved populations, or declining to recommend exclusionary technologies (Shinohara and Wobbrock, 2011).

Client Education and Support: Helping clients navigate technological barriers, troubleshoot usability issues, and make informed decisions about technologies aligning with their goals and values, including education about data privacy, algorithmic bias, and when technology recommendations may not serve their interests (Lupton, 2014).

Bridging Research and Practice: Critically evaluating emerging fitness technology research, distinguishing between studies with diverse versus homogeneous samples, and understanding how usability and accessibility factors influence intervention effectiveness (Direito et al., 2014).

This reconceptualized role positions exercise professionals as essential actors in ensuring the fitness technology revolution serves all populations equitably. The curriculum framework presented here prepares students for this expanded professional identity by systematically integrating HCI principles throughout their educational experience.

CURRICULUM FRAMEWORK

Program Context

Misericordia University's Exercise Science program, launched in Fall 2025, represents a strategic institutional commitment to preparing health professionals addressing contemporary challenges in fitness and wellness. The program emerged from the recognition that traditional exercise science education, while providing strong foundations in the biological and behavioral sciences, inadequately prepares graduates for the technology-saturated modern fitness practice. With anticipated enrollment of 20 students in the inaugural cohort and projected growth to 30 students by Year 3, the program serves both the university's expanding athletic population and students seeking careers in diverse fitness and clinical settings.

Student career preparation encompasses immediate employment opportunities and long-term professional development. Graduates will be prepared for roles as personal trainers, fitness program instructors, corporate wellness coordinators, and clinical exercise professionals, with added competency in technology evaluation and recommendation. The curriculum prepares students for professional certifications, including ACSM Certified Exercise Physiologist (CEP) and NSCA Certified Strength and Conditioning Specialist (CSCS), while positioning them for emerging roles as fitness technology consultants and inclusive design advocates.

Four Key HCI Domains

Domain 1: User Research and Persona Development

Learning Objectives: Students develop competencies in understanding diverse user needs, motivations, and barriers to fitness technology adoption, including: (1) identifying characteristics influencing technology usability across demographic groups, (2) conducting structured user interviews gathering qualitative data about technology experiences, (3) synthesizing research findings into representative user personas, and (4) applying persona-based thinking to technology evaluation and recommendation decisions.

Teaching Methods: The curriculum emphasizes user research methodologies and personalized approaches throughout multiple courses. In EXS 102: Introduction to Exercise Science, students examine how diverse populations engage with fitness technologies, analyze case studies of failed applications, and learn interview and observational techniques for understanding user experiences. EXS 101: Health and Wellness focuses on developing detailed user personas that reflect factors like age, ability, cultural background, socioeconomic status, and health conditions, grounded in research and community interviews. This foundational knowledge informs subsequent courses: in EXS 210 and 211: Health and Fitness Assessment I & II, students tailor assessment protocols to accommodate diverse physical abilities and technological literacy. In EXS 320 and 321: Exercise Prescription I & II, they design individualized exercise programs that match users' profiles, ensuring technology use is effective and inclusive.

Example Assignment: Students create 3-5 detailed user personas representing diverse fitness technology users, including demographics, physical traits, tech profile, culture, goals, and pain points. Students present personas visually, justifying design with research. This usually occurs in EXS 101 in the first semester, fostering a user-centered mindset for future courses.

Domain 2: Usability Testing Methodologies

Learning Objectives: Students develop systematic approaches to evaluating fitness technology effectiveness and usability, including: (1) applying Nielsen's usability heuristics to fitness technology interfaces, (2) conducting structured usability testing sessions with representative users, (3) identifying specific usability issues and severity levels, (4) documenting findings using standardized reporting formats, and (5) generating evidence-based recommendations for usability improvements.

Teaching Methods: The courses integrate heuristic evaluation and usability testing to enhance students' assessment of fitness technologies. In EXS 210, students critique the usability of tools like heart rate monitors and fitness apps, ensuring they are accessible to diverse populations. In EXS 211, they conduct formal heuristic evaluations of comprehensive fitness tracking systems. Courses EXS 320 and 321 expand this evaluation to exercise demonstration videos and workout planning tools, emphasizing both scientific accuracy and user accessibility. Through guided practice, students learn Nielsen's ten usability heuristics—such as visibility of system status and error prevention—and apply observational methods to identify user challenges, fostering the integration of usability skills into professional practice.

Example Assignment: Students conduct heuristic evaluations of three fitness apps (e.g., MyFitnessPal, Nike Training Club, Strava) using Nielsen's 10 heuristics. They identify compliance or violations, provide evidence, assess severity, explain impact on user groups, and suggest improvements. The evaluation results in a prioritized report that ranks issues and recommends the best app for different users, such as athletes or older adults.

Domain 3: Accessibility Evaluation

Learning Objectives: Students develop specialized competencies in identifying and addressing accessibility barriers excluding people with disabilities from fitness technology benefits, including: (1) understanding legal requirements and ethical obligations regarding digital accessibility, (2) applying WCAG standards to fitness technology evaluation, (3) testing fitness technologies with assistive technologies (screen readers, voice control, switch access), (4) identifying specific accessibility violations and their impact on users with disabilities, (5) generating detailed, actionable recommendations for accessibility improvements, and (6) advocating for universal design principles in fitness technology selection and development.

Teaching Methods: Accessibility education begins by raising awareness of disability diversity—covering visual, auditory, motor, cognitive, and neurological differences—and exploring assistive technologies for digital interaction. Students examine how screen readers interpret fitness app interfaces, test voice-control systems, and navigate touchscreen devices with limited fine-motor control. Through community partnerships, they engage with individuals with disabilities to gain an authentic understanding of access barriers.

The curriculum emphasizes WCAG standards as the global framework for digital accessibility, teaching its four principles—perceivable, operable, understandable, and robust—and their success criteria across Level A, AA, and AAA. Instead of rote memorization, students apply these standards to real fitness technologies, conducting hands-on audits using tools like WAVE, axe DevTools, Lighthouse, and assistive technologies such as NVDA, JAWS, and VoiceOver. Courses such as EXS 101, 102, and 440 (Risk Management and Professional Responsibilities) frame accessibility as essential, legal, and ethical, highlighting that inaccessible technologies can be discriminatory. In EXS 410, Advanced Exercise Prescription, students evaluate fitness tools for individuals with chronic conditions and disabilities to ensure recommendations are inclusive and practical. **Example Assignment:** Students conduct accessibility audits of fitness technologies, producing reports documenting barriers and suggestions. They select a technology (app, site, or wearable) claiming to serve diverse users. Evaluation includes: (1) automated testing with WAVE and axe DevTools for WCAG violations, (2) manual keyboard and screen reader testing, color contrast, and text size, (3) user testing with individuals with disabilities or persona walkthroughs, and (4) compliance review against WCAG 2.1 Level AA. The final report features an accessibility summary, findings by WCAG principles, violations with examples, severity and impact analysis, prioritized recommendations, and a rating (from " inaccessible to fully accessible).

Domain 4: Cultural Competency in Technology

Learning Objectives: Students develop a sophisticated understanding of how cultural values, beliefs, and practices influence fitness technology acceptance, use, and effectiveness. Specific objectives include: (1) analyzing cultural dimensions that affect health and fitness behaviors, (2) identifying cultural assumptions embedded in fitness technology design, (3) evaluating fitness technologies for cultural responsiveness and appropriateness, (4) adapting technology recommendations to align with diverse cultural contexts, (5) conducting culturally sensitive technology evaluations considering diverse perspectives, and (6) advocating for culturally inclusive fitness technology development.

Teaching Methods: Cultural competency education extends beyond superficial multicultural awareness to critically examine how dominant cultural assumptions influence technology design. Students learn to identify Western individualistic values—such as personal achievement, competition, and self-optimization—that may conflict with collectivist cultural priorities, such as family wellness and community health. The curriculum includes case studies of diverse adoption patterns, critical app audits for cultural biases, and comparative analyses of how technology accommodates different cultural perspectives on body image, food traditions, and health values. Students evaluate fitness technologies for language accessibility, cultural representation, inclusivity of food databases, exercise diversity, motivational styles, privacy concerns, and economic accessibility.

Throughout the program, cultural competency is integrated into coursework:

- EXS 101 explores multicultural health promotion via readings and films,
- EXS 220 addresses cultural food preferences and app limitations,
- EXS 320/321 focuses on culturally appropriate exercise prescriptions through client case studies,
- EXS 440 emphasizes ethical, culturally sensitive service delivery to prevent health disparities.

Example Assignment: Students perform cultural technology audits on fitness apps like MyFitnessPal, Nike Training Club, and Peloton, assessing language ease, visual diversity, food database inclusivity, exercise options, motivational design, privacy practices, and affordability. They record examples with screenshots, analyse different cultural experiences, suggest improvements, and reflect on their own biases.

IMPLEMENTATION AND PEDAGOGY

The pedagogy emphasizes experiential, community-based learning through authentic research and case-based analysis. Students engage in real-world needs assessments, user interviews, and iterative design projects focusing on inclusive fitness technology. Instructional methods include project-based and case-based learning, complemented by usability testing using free and commercial tools aligned with industry standards. Resources encompass popular fitness apps and devices, accessibility evaluation tools, and digital portfolio platforms. Faculty development and interdisciplinary partnerships support scalable integration, fostering inclusive, practical HCI training within exercise science contexts.

PRELIMINARY EVALUATION AND DISCUSSION

The evaluation employs multiple data collection methods, including rubrics for assignments, pre/post surveys, portfolio reviews, and faculty observations, to comprehensively track and assess student growth in HCI competencies. These diverse approaches provide a well-rounded understanding of student progress and learning outcomes. Major anticipated impacts of the program include significantly improved usability evaluation skills—students will evolve from merely identifying basic interface problems to applying advanced heuristics and accessibility standards effectively. Additionally, there will be a marked increase in students' empathy for diverse users, fostering more inclusive design practices. Students are expected to develop proficiency in detecting WCAG violations, testing assistive technologies, and creating comprehensive, culturally responsive, inclusive design recommendations tailored to various user needs.

Challenges faced during implementation include variability in students' prior technological literacy, which may affect their learning pace, and evolving instructional approaches that require continuous adaptation. Limited access to evaluation tools during initial phases can also pose difficulties. Key lessons learned emphasize the importance of conducting early baseline assessments to benchmark skills, providing ongoing formative feedback throughout the course, and employing flexible teaching strategies to adapt to emerging needs. These strategies are crucial to support continuous improvement in both student learning and instructional effectiveness.

DISCUSSION AND IMPLICATIONS

Contributions to the Field

The curriculum redesign shifts exercise science education by emphasizing technology's role in addressing health disparities and moving beyond a focus on biological and behavioral aspects. It integrates HCI principles—user research, usability, accessibility, and cultural competency—into undergraduate programs, translating health equity goals into measurable outcomes with standardized rubrics. Additionally, it incorporates community-engaged learning that benefits students and underserved communities, providing authentic assessment data.

Practical Impact

This prepares students for a growing market. The global fitness tech industry exceeds $100 billion, yet there's a shortage of professionals skilled in both technology and human needs. Exercise science graduates with HCI skills can fill roles such as fitness tech consultants, UX researchers, accessibility specialists, and inclusive design advocates, offering competitive salaries and promoting health equity. The impact spans from the individual to the industry level. Trained professionals can identify tech inaccessibility, guide organizations on inclusive tech adoption, and influence product development by serving as consultants or part of development teams. This aligns with industry trends, as organizations like ACSM and NSCA increasingly value technology skills, with new job roles emerging. HCI-trained graduates gain a competitive edge and advance social justice through their practice.

Connection to Broader Trends

The curriculum's timing coincides with several trends, increasing its relevance. The COVID-19 pandemic accelerated fitness tech adoption by about five years, normalizing virtual training and connected equipment that were once niche. Post-pandemic, hybrid models combining in-person and tech services are the norm, making tech-evaluation skills immediately useful. AI's role in fitness raises issues about bias, data privacy, and balancing automation with human judgment—areas where HCI-trained pros excel. As machine learning guides exercise recommendations, evaluators who ensure systems serve diverse populations fairly are vital to prevent health disparities.

The framework aligns with the focus on health equity across healthcare and exercise education, reflected in standards, funding, and diversity efforts. The pandemic highlighted disparities in access to technology and digital literacy, underscoring the need for inclusive design as a health equity priority. Programs addressing these issues show leadership in preparing socially responsible pros. Finally, the framework prepares grads for new career paths. As fitness tech advances, expertise in selecting and integrating appropriate tech becomes more valuable. Those with exercise science and HCI skills will earn higher salaries and contribute to public health and social justice.

Challenges and Refinements

Implementation revealed challenges, including resource limitations—specialized accessibility testing software, diverse wearable devices, and transportation—that limited hands-on experiences. The program uses partnerships, free tools, and students' devices to address these, but gaps remain. Faculty development is ongoing, as exercise science faculty often lack formal HCI training. Online courses, conferences, and expert consultations require time and funding, competing with other responsibilities. Learning communities help share resources, but sustained investment is vital.

Balancing HCI content with exercise science needs careful curricular design. HCI skills enhance, not replace, foundational knowledge. The program embeds HCI within existing courses, requiring ongoing refinement to ensure depth and coverage of CAAHEP standards.

CONCLUSION AND FUTURE DIRECTIONS

Integrating HCI into exercise science educates professionals to make fitness tech accessible, usable, and culturally appropriate. Core HCI skills—user research, usability testing, accessibility, cultural competency—can be embedded in coursework, improving students' ability to identify barriers and create inclusive designs.

This approach fills the gap in preparing professionals to evaluate fitness tech critically and advocate for underserved groups. Graduates act as intermediaries, ensuring digital fitness innovations serve all and reduce disparities. Future research should examine how HCI training influences recommendations, career trajectories, and client outcomes. Expanding this framework into fields such as occupational therapy and health education can equip students with core HCI skills and discipline-specific applications, thereby promoting health equity. As AI apps, VR, and smart devices evolve, curricula must teach fundamental HCI principles alongside emerging technologies, focusing on transferable skills like user research and accessibility.

Partnerships could offer practicums, giving students experience in user research, usability, and accessibility, benefiting both students and companies. All exercise science programs should adopt this framework and integrate technology-evaluation skills; the lack of these skills risks unpreparedness and ongoing disparities. Collaboration among exercise science, HCI, and communities promotes inclusive design and advances health equity. Training professionals to see accessible, usable, and culturally appropriate tech as essential can turn fitness tech into a tool for health equity. The stakes are high; graduates need competencies to ensure technology benefits everyone.

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