CDHub 2.0: Laying the Foundation for an Online Repository for Capstone Design

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Keith Stanfill holds the academic rank of Engineer and serves as the Director of the Integrated Product and Process Design (IPPD) Program for the University of Florida (UF) College of Engineering. He received his B.S., M.E., and Ph.D. degrees in mechanical engineering from UF in 1985, 1991 and 1995, respectively. He joined the UF Industrial and Systems Engineering faculty in 1999 as the IPPD Associate Director and was promoted to IPPD Director in 2001. In Fall 2013, he joined the Engineering Innovation Institute.

IPPD is an experiential multidisciplinary design program where teams of students complete real projects for sponsoring companies and agencies. Dr. Stanfill has recruited over 300 industry-sponsored projects and directed the efforts of over 1900 senior-level engineering and business students for the IPPD program. In 2003, he helped create the Integrated Technology Ventures (ITV) program and serves as Chair of the ITV Board of Directors. The ITV program exposes students to the realities of technology start-up companies while assisting UF researchers in commercializing their technological innovations. Virtual companies comprised of engineering, business, and law students identify market opportunities, develop business plans, and produce prototype systems. Each ITV team is led by an experienced entrepreneurial CEO and features hands-on guidance from engineering, business, and law faculty.

Prior to joining UF, Dr. Stanfill spent ten years with United Technologies where he designed fighter aircraft gas turbine hardware for Pratt & Whitney, served as a key resource to the Carrier Corporation New Product Development Council Steering Committee, facilitated Design for X (DFx) workshops internationally, developed business process linkages between new product development and lean manufacturing, and developed and implemented manufacturing systems software. His interests include technology transfer, product development, design education, DFx, and entrepreneurship.

He is a registered professional engineer in the state of Florida and is a member of the American Society of Mechanical Engineers, the American Society of Engineering Education, the Institute for Industrial Engineers, the UF Faculty Senate, the UF Sustainability Committee, and the UF College of Engineering Faculty Council. He is the faculty advisor for the UF Men's Soccer Club and for the Engineering Leadership Circle. He has served on the organizing committee for the 2007, 2010, 2012 and 2014 Capstone Design Conference. He volunteers his time as a judge in the Alachua Region Science and Engineering Fair and the Junior Science, Engineering and Humanities Symposium. He recently served as the booster club president and volunteer goalkeeper coach for the Buchholz High School Lady Bobcats soccer team.

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Abstract

The capstone design community includes faculty, administrators, industry representatives, students, and other stakeholders involved with capstone design courses across the U.S. and internationally. The Capstone Design Hub ("CDHub") is a recent initiative to support and grow a robust online resource for the capstone design community that promotes shared practices and collective discussion, while remaining adaptive to the changing needs of the community. Community reaction to the CDHub 1.0 pilot, which was launched in 2012, validated the community desire for such a resource, but also identified the need for a broader, expandable hub. This paper reports on the development of the next hub iteration, CDHub 2.0. The development process included collecting stakeholder needs, developing design requirements, characterizing and framing the hub foundation, identifying initial topics, preparing resource-specific metadata, populating and troubleshooting the hub, and soliciting initial feedback from beta testers within the capstone community. Subsequent hub modification and directions for future growth will be informed by continued use and feedback from the capstone design community.

Introduction and Motivation

The Capstone Design Conferences (2007, 2010, 2012, 2014) have provided a rich, interactive setting for the capstone design community (faculty, administrators, industry representatives, students, and other stakeholders) to disseminate effective practices, share successes and challenges, and network in person. One outcome of the 2010 conference was the recognition of a need for an online presence - a capstone design "hub" - for the capstone community to support connections, conversations, and resource sharing in a sustained and ongoing manner. Following the 2010 conference, a group of capstone educators applied for and received funding from the Engineering Information Foundation to develop an initial Capstone Design Hub (CDHub 1.0) and test the hub concept within the capstone design community.

The hub development team researched other online hub formats and platforms, noting characteristics of interest. Simultaneously, the team surveyed the capstone community regarding what aspects of a hub would be important to them and how they could envision using the hub.[1] Based on this input, the development team built the CDHub 1.0 pilot on a WordPress[2] platform and populated it with sample resources. This pilot hub focused on communication (per the requirements of the funding agency) and included multiple files and strategies related to capstone design communication such as project definition, project management, and intellectual property.

The hub developers held a workshop at the 2012 Capstone Design Conference to demonstrate the hub functionality and solicit user feedback. The 60 attendees were overwhelmingly supportive of the hub concept and offered numerous suggestions to expand the hub to provide additional value. These suggestions collectively pointed to the need for a broader framework to enable continued growth beyond the communications focus. The CDHub 1.0 chapter ended with the conclusion of the initial grant funding following the 2012 conference. With support from a small NSF grant,

a new team of capstone educators is pursuing CDHub 2.0, the next iteration of the capstone design hub platform.

Scope and Timeline

The scope of the CDHub 2.0 initiative was to plan, develop, and pilot test the next version of the online capstone design hub, as illustrated in the timeline in Figure 1. Unlike its predecessor, CDHub 2.0 was intended from the outset to provide a foundation for long-term hub evolution. As such, the planning stage involved collecting input from the capstone design community and analyzing the data to extract an overarching framework and governing design requirements. In parallel with site development, the team then identified initial focus areas within the framework and selected resources to contribute. A key value-add for CDHub 2.0 was the creation of resource-specific metadata to enable easy search and cataloguing. The CDHub 2.0 team conducted the initial pilot testing on the full site; a sub-group of the capstone design community specifically interested in the CDHub idea provided additional user testing and feedback. The current site includes basic functionality and an initial set of resources in a framework that can be easily expanded over time.

Task	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Innovation Canvas Preparation	■	■									
Data Collection: User Needs		■	■								
Data Analysis + Site Framework			■	■							
Design Requirements				■	■						
Metadata Preparation					■	■					
Site Platform + CDHub Brand					■	■					
Site Development						■	■	■	■		
Initial Testing/Modification									■	■	
Secondary Testing/User Feedback										■	■

Figure 1 - Timeline of CDHub 2.0 Development (2014-2015)

Problem Framing: User Needs, Site Framework, Design Requirements

The core of the revamped CDHub 2.0 is its overall site framework, informed by user needs yet designed for flexibility and future expansion. To develop this framework, the CDHub 2.0 leaders solicited feedback from the 2014 Capstone Design Conference attendees in two poster sessions and a working lunch discussion. To spur dialogue and capture feedback, the CDHub 2.0 leaders developed a modified Innovation Canvas[3] template, which is a derivative of the Business Model Canvas[4] that combines engineering and business content in a tool for product and business development. The complete Innovation Canvas includes five main areas (value, explore, ideate, design, market), each of which is sub-divided into multiple subsections. For the

CDHub 2.0 development, the modified Innovation Canvas included the five main areas with leading questions, as shown schematically in Figure 2.
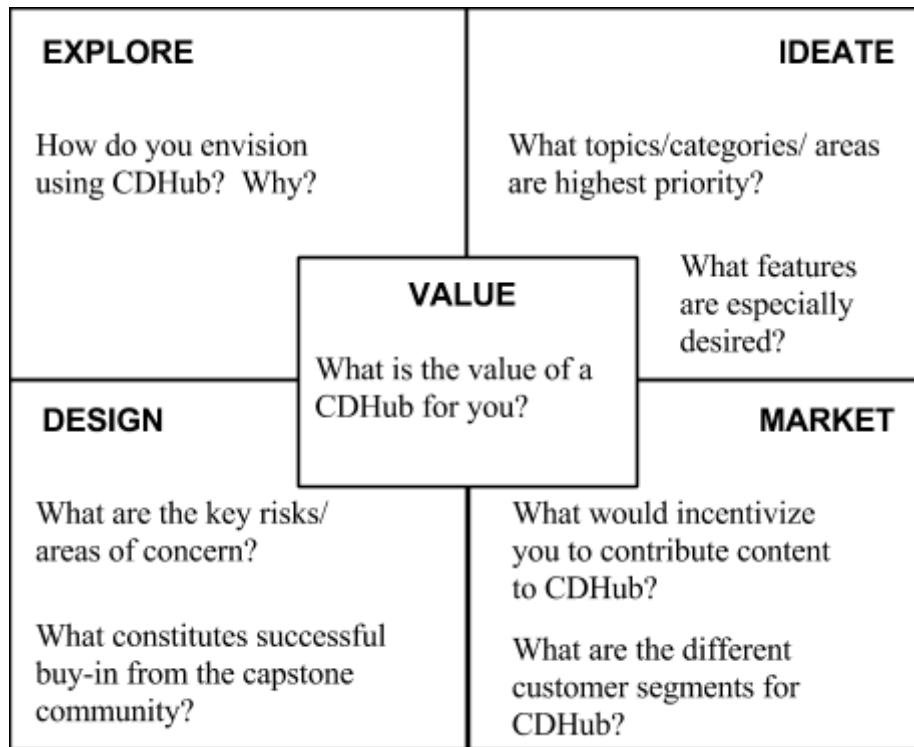

Figure 2 - Modified Innovation Canvas Template for CDHub 2.0

The CDHub 2.0 leaders prepared a poster-sized version of the Innovation Canvas template with blank space below each of the main questions. They seeded it with a few suggestions from surveys for the initial CDHub 1.0. The poster was displayed as an interactive exhibit in both open poster sessions at the 2014 Capstone Design Conference, where attendees were invited to contribute ideas of their own using permanent markers and Post-It™ notes.

Small-size versions of the Innovation Canvas template were also prepared for a working lunch session at the same conference. In this session, attendees were divided into groups and assigned two of the five main areas for more in-depth discussions. Scribes from each group captured the main ideas. Several attendees also provided additional feedback on the Innovation Canvas template as a whole.

The CDHub 2.0 leaders then analyzed the qualitative data captured from the many respondents to identify themes and an organizational scheme for CDHub 2.0. What emerged from this process was a four-part framework (informally referred to as the "TACO" model) that spans the space of capstone design. Figure 3 shows the overall framework, the scope of each quadrant, and the initial focus areas selected for the pilot version of CDHub 2.0. The initial resources for the Teaching and Administration quadrants ("assessments" and "sponsor agreements", respectively), were chosen based on the prevalence of user input to the Innovation Canvas template. The CDHub 2.0 leaders also validated this model with the newly formed CDHub 2.0 team, recruited from those interested at the 2014 Capstone Design Conference.

TEACHING	ADMINISTRATION
Resources for capstone design pedagogy Initial focus: *Assessment Resources*	Logistics supporting capstone design Initial focus: *Sponsor Agreements*
COMMUNITY	**OTHER**
Connections across the capstone design network Initial focus: *Directory of users and capstone programs*	Existing resources elsewhere online Initial focus: *Relevant conferences, journals, and capstone organizations*

Figure 3 - Overall "TACO" Framework for CDHub 2.0

In addition to developing and validating the overall framework, the CDHub 2.0 team also identified and specified the governing design requirements for the site. To do this, the team first collated the user needs captured in two different sources: the 2011 survey responses about the initial CDHub concept and the Innovation Canvas template comments at the 2014 Capstone Design Conference. After sorting and organizing these needs by theme, the CDHub 2.0 team translated the needs into specifications for the site. The team then collectively prioritized these final requirements according to whether they should be a target for the initial CDHub 2.0 site or a future revision. Table 1 lists the final set of design requirements for the initial site by category.

Table 1 - Design Requirements for Initial CDHub 2.0 Site

Category	Initial Design Requirement
Access	Website access is restricted to registered users; registration requires users to submit basic directory information.
	Website requires login to download, upload, and/or edit resources.
Content	Resources (e.g. assessments, templates, etc.) are accompanied by a predetermined set of metadata to enable indexing and comparisons within similar resources.
	Resources are useful to others (e.g. downloadable, editable, identified with suggested use).
	Resources contributed are identified with their original author by default.
	Website includes user-posted content in addition to links to already existing web resources.
	Copyright of resources is attributed to original author
Navigation	Website complies with common navigation/usability protocols used by computers of various platforms.
	Website includes a basic search function.
Sustainability	Website access is initially free of charge to all users.
	Initial website features provide immediate value to a broad set of users with small investment.
	Website includes date stamps when resources are posted.
	Website requires minimal maintenance to add new categories or resources.

Conceptual Design: Metadata, Site Platform, and CDHub 2.0 Brand

The CDHub 2.0 was designed specifically to associate relevant metadata with each uploaded resource, so as to facilitate searching and comparison across resources at a level beyond what is currently possible in journal archives and conference proceedings. Through several iterations, the CDHub 2.0 team collectively determined relevant metadata for the selected resources (assessment instruments and sponsor agreements) and for registered users and capstone programs. In preparing the resource-specific metadata, the team identified a set of general metadata that would apply to all resources. Table 2 shows the full set of metadata prompts for each of the five types: general, assessment specific, sponsor agreement specific, registered users, and capstone programs.

Table 2 - Metadata for CDHub 2.0 Resources, Users, and Capstone Programs

Metadata Type	Metadata Prompts
General (for all Resources)	Title, Primary author, Originating institution, Disciplines in which used, Type(s) of institutions in which used, Capstone course duration, Nature of capstone projects connected with resource, Timing of resource usage in capstone, First year that the resource was used in capstone, Notes/observations/constraints/advice
Assessment Specific	Category(s) of outcomes assessed, Types of student responses required, Rubrics for scoring, Number of students typically assessed at one time with the resource, Instrument testing, Scoring consistency by multiple raters, Validity or accuracy in measuring what was intended
Sponsor Agreement Specific	Scope of agreement, Sponsor type covered by agreement, Specification of sponsorship fee, Specification of sponsorship duration, Coverage of specific costs, Coverage of intellectual property ownership, Coverage of liabilities, Articulation of project constraints, Specification of project mentors, Specification of sponsor responsibilities, Quantification of project scope, Specification of project team deliverables
Registered Users	Name, Preferred title, Email/phone/address, Institution name, Department(s), Role in capstone, First year involved with capstone, Industry experience, Personal statement (optional)
Capstone Programs	Institution name, Institution location, Institution type(s), ABET accreditation, Disciplines of capstone program, Nature of capstone projects, Duration of capstone course, Average number of students per project, Average number of projects per course, Standard fee, Additional notes (optional)

In parallel with metadata development, the CDHub 2.0 leaders also selected a web platform for CDHub 2.0 and collaborated with a graphic designer to establish a brand and logo for the initiative. The leaders evaluated two primary web platforms, WordPress and HubZero, and ultimately chose WordPress for its ease of installation, maintenance, and customizability, in addition to the wide range of available and modifiable plug-ins. For consistency and sustainability, the CDHub 2.0 leaders moved CDHub to the same hosting service as the Capstone Design Conferences (see www.capstoneconf.org) and the new Capstone Design Community site (see www.capstonedesigncommunity.org). The new CDHub 2.0 logo, shown in Figure 4,

identifies CDHub 2.0 as an initiative that is connected to the capstone design community (the mountain logo is a reference to the Flatirons in Boulder, CO, where the initial Capstone Design Conference was held) but also stands on its own. Moreover, the use of the "2.0" identifies this particular phase of the overall CDHub development.

Figure 4 - CDHub 2.0 logo/brand

Design Development: Site Creation, Population, and Revision

Development of the CDHub 2.0 site started with selection of a WordPress theme ("Fruitful"), layout of the basic site and navigation, and population of the Home, Links, and Contact pages. The CDHub 2.0 leaders explored unsuccessfully a number of modifiable plug-ins to enable the resource upload, metadata storage, and cross-search functionality, ultimately hiring a web developer to code a back-end database and the associated user interface. The web developer built the remaining portions of the site in an iterative manner, with continuous input from the CDHub 2.0 leaders, using a combination of new code and some modified plug-ins.

Once the basic site functionality was ready, the CDHub 2.0 leaders invited the rest of the CDHub 2.0 team to pilot test the site and provide feedback. Members of the team created accounts as registered users, entered capstone program information, browsed the site, tested download functionality, and uploaded resources. Feedback from the team during this interactive phase led to additional revisions and site iterations, including a more straightforward user registration process, sortable displays of uploaded resources and capstone programs, and a more prominent search functionality. Figures 5-8 depict screenshots of several pages of the CDHub 2.0 site after these modifications.

Figure 5 - CDHub 2.0 Homepage (www.cdhub2.org)

Figure 6 - Partial Table of Assessment Resources Sorted by Sub-Topic

Figure 7 - Search Returns for Assessment Resources that Assess Teamwork

Figure 8 - General Metadata Required for All Resource Uploads

Design Verification: Confirmation and User Testing

The CDHub 2.0 site provides basic access to all users and increased access/functionality to registered users ("members") who are logged in. Any user can browse the resource pages, search and sort across uploaded resources, explore the links to external organizations, and join the CDHub 2.0 mailing list. Only logged-in members can access community information (members and capstone programs) and download existing resources. When users create an account and/or upload a resource they are prompted to provide the associated metadata; sort and search functionality is available for all resources and capstone programs.

As part of initial site verification, the CDHub 2.0 team conducted a survey of the pilot CDHub 2.0 site with a sub-group of the capstone community who had expressed interest in the CDHub 2.0 initiative. Of the 87 people invited to provide feedback on CDHub2.0, 24 registered on the site and 15 completed some or all of the survey. Survey respondents represent 14 engineering disciplines (some respondents are affiliated with multiple disciplines). Respondents have been involved with capstone design for as little as one year to as many as 21 years, with an average of 9 years.

The survey included sections on browsing, user registration, searching and downloading resources, uploading resources, and future use. The first four sections asked respondents to use a rating scale to evaluate their experience with particular operations and then to provide comments and suggestions for improvement. The future use section captured respondents' perceived

likelihood of using CDHub 2.0 in the future as well as their suggestions for additional site content and functionality.

Respondents were overwhelmingly positive about their interactions with the pilot CDHub 2.0 site and their interest in and likely future use of the site. Table 3 summarizes the user experience questions and average response values (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree) for browsing, functionality across platforms, user registration, and searching/downloading. Only two survey respondents tried uploading a resource; their responses ranged from 3 to 4 across multiple questions about the ease and clarity of the resource upload process. Table 4 summarizes the respondent feedback regarding potential future use of the CDHub 2.0 site.

Table 3 - Average Responses to User Experience Questions
(1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree)

Category	Survey Question	Average Rating
Browsing (n=15)	The overall website is easy to navigate.	3.5
	The overall website is visually appealing.	3.3
	The organizational framework of the website makes sense.	3.5
Platforms (n=14)	The website works effectively on multiple browsers on my computer.	3.6
	The website works effectively on a smartphone.	3.5
Registration (n=14)	The registration tool is easy to find.	3.5
	The registration prompts are understandable.	3.6
	The response choices (check boxes) are clear.	3.6
	The response choices available are appropriate for my information.	3.4
	The distinction between individual information and capstone program information within the directory is readily apparent.	3.3
	The registration process is intuitive.	3.6
	I successfully created an account.	3.3
Searching/ Downloading (n=11)	The search tool is easy to find.	3.6
	The search tool is intuitive to use.	3.6
	The metadata affiliated with the resources are understandable.	3.3
	The metadata affiliated with the resources are comprehensive.	3.3
	The download tool is easy to find.	3.5
	The download process is intuitive to use.	3.4
	I successfully downloaded a resource of my choosing.	3.5

Table 4 - Average Responses to Future Use Questions
(1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree)

Survey Question	Average Rating (n=12)
I am likely to search for and/or download a resource on CDHub 2.0 in the future.	3.6
I am likely to search for people on CDHub 2.0 in the future.	3.2
I am likely to search for a capstone program on CDHub 2.0 in the future.	2.8
I am likely to upload resources to CDHub 2.0 in the future.	2.8
I am likely to recommend CDHub 2.0 to others.	3.4
I would like to see CDHub 2.0 develop as a resource for the capstone design community.	3.8

Survey respondents were also asked what role they thought CDHub 2.0 could have in connecting and supporting the capstone design community. Selected responses to this question are listed below:

Connecting to existing course resources, sharing materials, comparing capstone requirements with other universities.

Hopefully the site will instigate multi-institutional capstone projects

Research and techniques dissemination. Won't miss papers that I'd like to read.

I would love to see a blogging-panel where the CDHub users can post questions / responses / raise issues, then a panel of experts can weigh in.

I think it will be a great resource in particular for new faculty.

Although the CDHub 2.0 site is still an evolving site, it already fully or partially meets all of the initial design requirements and has user interest in future development. With respect to navigation, the current CDHub 2.0 exceeds the initial design requirements, meeting all or part of the future requirements as well. Table 5 summarizes initial verification, listing the status and supporting explanation for each of the initial design requirements.

Future Work

CDHub 2.0 is an ongoing initiative that depends on user input and feedback for further development. The CDHub 2.0 team is in the midst of minor site revisions and has plans for more major modifications in the future. Some of these modifications will enable the site to meet the partially met initial design requirements in Table 5, whereas others will be informed by the set of future design requirements discussed in the Problem Framing section and listed in Table 6. Additional revisions will address specific comments and suggestions from initial users during pilot testing.

Table 5 - Verification of the Initial CDHub 2.0 Site

	Initial Design Requirement	Status	Notes
Access	Website access is restricted to registered users; registration requires users to submit basic directory information.	Met	Unregistered users may access part of the site; additional access is available to registered users who are logged in.
	Website requires login to download, upload, and/or edit resources.	Partially Met	Unregistered users may browse resources, but only logged in members may upload or download resources. No edit capability is available yet.
Content	Resources (e.g. assessments, templates, etc.) are accompanied by a predetermined set of metadata to enable indexing and comparisons within similar resources.	Met	Users input metadata when registering and/or uploading resources.
	Resources are useful to others (e.g. downloadable, editable, identified with suggested use).	Met	Test users were positive regarding the categories of resources, their affiliated metadata, and the ability to access them.
	Resources contributed are identified with their original author by default.	Met	Resources are identified by their uploader, who can specify a primary author/contact, if different.
	Website includes user-posted content in addition to links to already existing web resources.	Met	Links page includes selected journals, conferences, and organizations relevant to capstone design.
	Copyright of resources is attributed to original author.	Partially Met	Copyright of resources may be stated by individual authors/uploaders, but CDHub 2.0 currently includes no overarching statement about copyright.
Navigation	Website complies with common navigation/usability protocols used by computers of various platforms.	Exceeded	Website is built on a responsive WordPress platform, which functions across browsers and mobile devices.
	Website includes a basic search function.	Exceeded	Users can search across the site or within resource types or capstone programs.
Sustainability	Website access is initially free of charge to all users.	Met	CDHub 2.0 does not currently include any mechanism to charge users.
	Initial website features provide immediate value to a broad set of users with small investment.	Met	Test users were positive regarding site navigation, functionality, content, and likelihood of future use.
	Website includes date stamps when resources are posted.	Met	Date stamps are a built-in feature of WordPress.
	Website requires minimal maintenance to add new categories or resources.	Partially Met	Resources are currently limited to assessments and sponsor agreements; adding new categories of resources (e.g. syllabi) will require development of new metadata and additional database coding.

Table 6 - Future Design Requirements for CDHub 2.0 Site

Category	Future Design Requirement
Access	Website enables multiple levels of access privileges for users in different roles (e.g., editor, registered user/contributor, guest)
	Website benefits (e.g., points, stars, virtual currency) accrue to contributors.
Content	Website provides mechanism for copyright protection (e.g. Creative Commons) of posted resources while still enabling sharing.
	Website enables specific functions/initiatives (facilitated discussions, surveys, pilot testing, benchmarking, etc.) to stimulate use and improve quality of resources.
	Website includes review capability for posted content: users can add comments/ reviews to posted material.
Sustainability	Website funding sources are determined to make the site sustainable financially.
	Subsequent website features provide sustained value to a large set of users.
	Website remains current with the (regular) addition of new resources.
	Website content is primarily user-generated.
	Website is developed to serve the full spectrum of engineering, within and across disciplines.

One substantial component of future work includes expanding the types of resources within teaching and administration; such expansion requires the development of new metadata prompts and additional coding of the supporting database and user interface. Additional work will be driven by feedback from site users and the capstone design community in general, for the intent of the overall CDHub initiative is to provide a useful online resource to support the capstone design community. As one test user commented, "*I can see this becoming THE go-to resource.*" CDHub 2.0 is the next step in the realization of such a community resource; true validation of the site will come from its users.

Acknowledgements

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