Teaching the Design Process in a HyFlex Environment

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Abstract

This paper addresses how one instructor redesigned a face-to-face design course known for its collaborative and experiential learning focus to accommodate a synchronous hybrid flexible (HyFlex) delivery. In semesters prior to spring 2020, students in the course learned the design process by practicing it using a project supported by clients and customers in the local community. Due to Covid19, however, students during the 2020 spring and fall semesters could not physically meet with traditional clients, which is integral to the experiential aspect of the course. It was also difficult for students to physically meet in teams. These alterations had the ability to negatively affect the learning experience. Thus, the collaborative nature of the class and the client identification and interaction structure was revised. This paper describes the course design process focus, project and client identification, and team collaboration process used in the HyFlex delivery to aid learning of the design process.

Keywords

Freshman Design; Online Design; HyFlex Delivery

Introduction

Traditional face-to-face (f2f) design-based courses most often have a team focus where students participate in many collaborative activities. These activities address problem and user need identification as well as solution generation, selection, build, and test. Traditionally, the supporting activities occur in the classroom in small groups or out of the classroom in team or client meetings. However, the Covid19 environment forced many traditional f2f courses to occur in online and hybrid flexible (HyFlex) modes. This caused those who teach design-based courses to rethink how collaboration and interaction occurs in an environment that requires physical distancing and synchronous and asynchronous online participation.

This paper addresses how one instructor redesigned a f2f freshman introduction to design course known for its project-based, collaborative, and experiential learning focus to accommodate a synchronous HyFlex delivery. In semesters prior to fall 2020, students in the course worked through the design process to build a solution for an individual with a disability to help the individual be independent. The clients for these projects were young people in local schools, adults in local adult-care facilities, and children and adults in a regional Special Olympics chapter. Due to Covid19, students now cannot meet with clients in the community and cannot visit local schools or local adult and child-care facilities. However, students having clients and customers from whom they hear of and observe problem issues is an integral part of the design process and this specific freshman design course.

The move to HyFlex course offerings made in-class small group activities inconvenient and ineffective. In the past, in-class activities may be whiteboard use, small group interactions, and

group presentations. Collaborative activities may include group interaction exercises, group brainstorming, and team problem solving. The HyFlex environment required that these interactions be reevaluated to allow for in-class and on-line synchronous participation with the desired result being successful learning of the design process and successful projects developed through productive team collaboration.

HyFlex Teaching

In a HyFlex teaching and learning environment, students are free to decide how they will participate in class – either f2f, on-line, or a combination of the two.[1] Because of this, the instructor must provide both on-line and f2f experiences that are both effective and equitable for the students. This is challenging. It is particularly challenging because the instructor may not know who is in the f2f class each day. Another challenge is ensuring students are engaged in a single learning community no matter how they are flexing their participation mode.[1]

The structure of a HyFlex course is built around four principles: Learner Choice, Equivalency, Reusability, and Accessibility.[2] *Learner choice* is where students choose how they attend and participate in the course week to week or even day to day.

Equivalency means that the learning activities of each participation mode allow for equivalent learning – reflective learning, interactive learning, and collaborative learning. All modes should allow students to contribute to the course discussion so reflective, interactive, and collaborative learning can occur. Creating an equitable environment where all students can achieve the stated course outcomes, is a major challenge of HyFlex teaching.[3]

Reusability emphasizes that artifacts used for and doing the learning activities for all participation modes be available to all students following those activities.[2] Thus, course sessions and collaborative student activities should be captured and posted to the course management site. If physical handouts are used, they should also be available electronically. All announcements should be shared in f2f and on-line modes. This also means that activities that occur online only (such as online chats, asynchronous discussions, and peer reviews), should be captured so that f2f students can access the material.

Accessibility, which is not necessarily something instructors control*,* must occur for HyFlex teaching to work. Students who desire to flex their participation must have the technology, skills, and physical access to the participation modes. This may require the institution to provide technology or software or the instructor to use on-line available software or tools to increase access.

Presently there is little research on the effectiveness of HyFlex teaching. However, one study indicates that HyFlex mode student completion rate can be almost as high as that for the f2f mode and can be much higher than that for the traditional online only mode.[3] Other studies state that the HyFlex participation mode shows promise because students like the flexibility it provides.[2,3] It is noted that emphasizing equity in equivalence, reusability, and accessibility, is important in creating a successful HyFlex environment.[2]

Design Process and Thinking

Teaching in a HyFlex environment is challenging. Teaching design in a HyFlex environment adds additional complexity. This is because design itself is complex. It involves working through a process that requires the designer to thoroughly understand a problem, identify and understand needs of a client(s) and customer(s), and identify the range of applications and use environments. It also involves iteration of progress while developing possible solutions, testing ideas, prioritizing client and customer needs, and finalizing the solution. It then requires modeling and documenting to take the proposed solution to a deliverable product. And to top it off, most of this is done in a collaborative team environment.

Working through the design process requires a student to participate in being a design thinker. Design thinking is activity-based and uses many hands-on methods.[5] But what makes design thinking so essential to the engineering design process is its emphasis on developing an understanding of the people for whom the service or product is being designed. It especially emphasizes that the designer should develop empathy with respect to the product user.[5] This emphasis on a system's or process' human core is known to lead to better products, services, and processes.[6] This is one reason user and client interactions are so integral to the design process.

The Freshman Introduction to Engineering Design (IED) Course

The mission of the subject freshman design course - titled *Introduction to Engineering Design (IED)* - is to

> *provide an experience so freshman students are introduced to the design process, gain experience the design process, understand the emphasis of the design curriculum at UTC, and assimilate knowledge to apply the design process in later courses.*

Due to this mission, the primary goal of IED is to

> *expose students to (1) problem definition, (2) customer interaction, (3) attribute generation, (4) function, constraint, and objective identification, (5) idea generation, (6) creative thinking, (7) simple decision-making and (8) idea to reality transformation*

using a real-life application—improving an entity. In most cases the entity is a device that helps persons with a disability become more independent. Project teams have community customers or clients and a budget. Individual and team-based hands-on activities are used to aid the learning.

IED meets 2 times a week for 2 hours each meeting time. Prior to fall 2020, the first 7 weeks of the class were dedicated to the class working together on a virtual project to learn the components of the design process. For the last 7 weeks of the class students broke into small teams of 4 to 5 students to understand, design, build, and deliver a solution for a real customer's problem – thus working from client need to product delivery. Prior to spring 2020, the culmination of the course was an operating and functional device delivered to the client or customer. Student reviews indicate the production of a delivered produced is essential to their learning of the design process.

Changes to IED to Accommodate HyFlex Teaching

The HyFlex mode helps IED respond flexibly to reactions to the Covid19 environment including

- students choosing to not attend f2f courses
- students being isolated or quarantined
- the University moving to 100% online courses
- the University switching between a closed and open campus

However, the Covid19 environment puts restrictions on student interactions. These include an inability to (1) meet with customers at regional schools and service facilities and (2) work closely in teams around a table, sharing technology, paper, and writing implements.

To work within the HyFlex mode and the restrictions of the Covid19 environment the IED curriculum was revised to make it more flexible. Also, on-line tools were introduced for class session interactions and project team collaboration.

Curriculum

The major change for the course was to delete the first 7-week virtual project and move directly to the hands-on customer supported 2nd project. This was done to initiate students working in teams before the campus may close. The underlying goal for this was to provide foundation to help students communicate as a team in a virtual environment.

Because of the change to teach the design process using the single project, the instructor identified which design process components and activities are most essential and applicable for student learning. The components identified are (1) satisfying needs of a real customer, (2) identifying design criteria (functions, objectives, and constraints), (3) generating solution possibilities, (4) determining best solutions options, and (5) testing functional concept effectiveness. Prior to fall 2020, much emphasis was put on the team-based design build, but this component was de-emphasized for the HyFlex course since a build could not be guaranteed.

Also, prior to fall 2020, most project assignments were team related. The HyFlex IED includes the team project but puts more emphasis and responsibility on individual work products - assignments are now 50% individual and 50% team produced. Table 1 summarizes the project assignments.

The goal of the individual assignments is to initiate project understanding, project solution brainstorming, and concept modeling and testing prior to team collaboration so individuals can better contribute to team decision making. The other goal is to ensure project design solution generation and concept prototyping occur even if the course goes 100% on-line.

Table 1: HyFlex Course Assignment Distribution

Assignment		Responsibility	
#	Description	Individual	Team
1	Student problem selection proposal and user identification	X	
2	Student problem research to identify history, present designs, and client/customer needs.	X	
3	Project definition that formalizes project purpose and design		X
4	Individual solution generation	X	
5	Team-based solution generation		X
6	Initial design solution selection decision		X
7	Concept prototype/model design	X	
8	Concept prototype/model test process	X	
9	Concept prototype/model test results	X	
10	Final solution prototype status report		X
11	Final solution prototype presentation		X
12	Final solution design report		X

Finally, prior to fall 2020, the instructor identified projects and project clients and customers. However, after fall 2020, the instructor identified only problems for the students to address. Students then identified two project preferences as well as possible users or clients they could contact if the course were to go 100% on-line. The students were instructed to ensure they can interact with the contacts in the Covid19 environment. The instructor then placed the students in teams based on the preferences. Most projects involved solving issues for persons with physical disabilities or conditions such as severe arthritis. Student teams of 3 to 5 students were assembled. This resulted in at least 3 possible users or clients per project.

Teaching Tools

Another course change was to replace all in-class collaborative and interactive activities with ones that could be completed and shared in an on-line collaborative environment. This required using software that makes material and activities accessible to all students such as Zoom, Canvas, Microsoft Teams and Forms, and Aww App.

Zoom is used for connecting on-line students to the in-class sessions. Zoom breakout rooms are used for small group in-class activities. However, Microsoft Teams is preferred for team-based activities and communication. Microsoft Teams provides a platform for project teams to meet visually and verbally. A benefit of Teams is that it provides a location for maintaining and sharing project documentation. Recordings of meetings can also occur and communication in the on-line chat space is preserved.

Canvas is used as the learning management system (LMS) for IED. Since not all students participate in the f2f class session, it is necessary to provide class session activity access, instructions, and materials electronically. For example, one brainstorming activity requests teams to expand their collection of brainstorm solutions by using at least three Design Heuristics[12]. In the past students would blindly choose three Design Heuristic cards from a

physical stack. Now the heuristics are provided using the quiz function on Canvas. This quiz houses 23 Design Heuristics. When a member of the team opens the quiz, the team is provided 5 randomly selected heuristics from the 23. The team is directed to use 3 of these heuristics to expand their collection of brainstormed solutions by at least 3. Teams then may use collaboration tools such as Aww App to complete the activity. Samples of heuristics are shown in Figures 1 and 2.

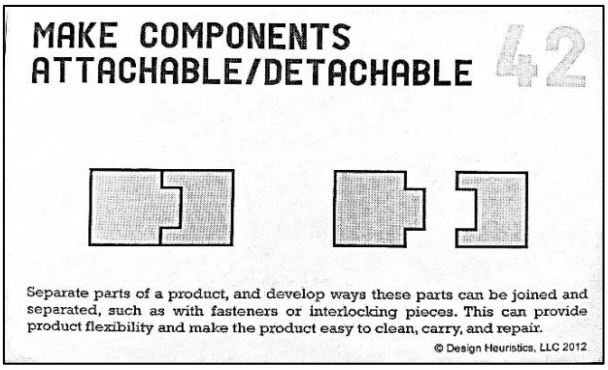

Figure 1: Design Heuristic 42 [12]

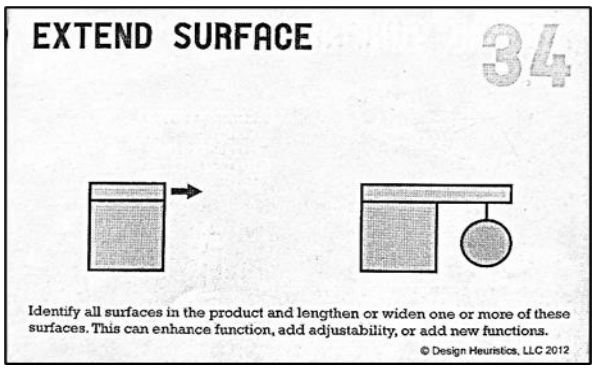

Figure 2: Design Heuristic 34 [12]

Aww App is a virtual whiteboard with selections for freehand sketching, post it notes, block diagramming, and document and figure insertion. [7] It can be used privately or shared with others for collaborative sessions. For IED, Aww App allows in-class and on-line students to collaborate during course and team meetings to communicate research findings and criteria identification and to participate in brainstorming activities. Figure 3 is a download of an Aww App result for a class activity where students identify project research findings and convert the findings into design objectives. All students contribute to the research comments and objective identification by opening the Aww App link on the course Canvas class session page and typing their response. There is some delay when watching the contributions, but it does not negatively affect the results of the activity.

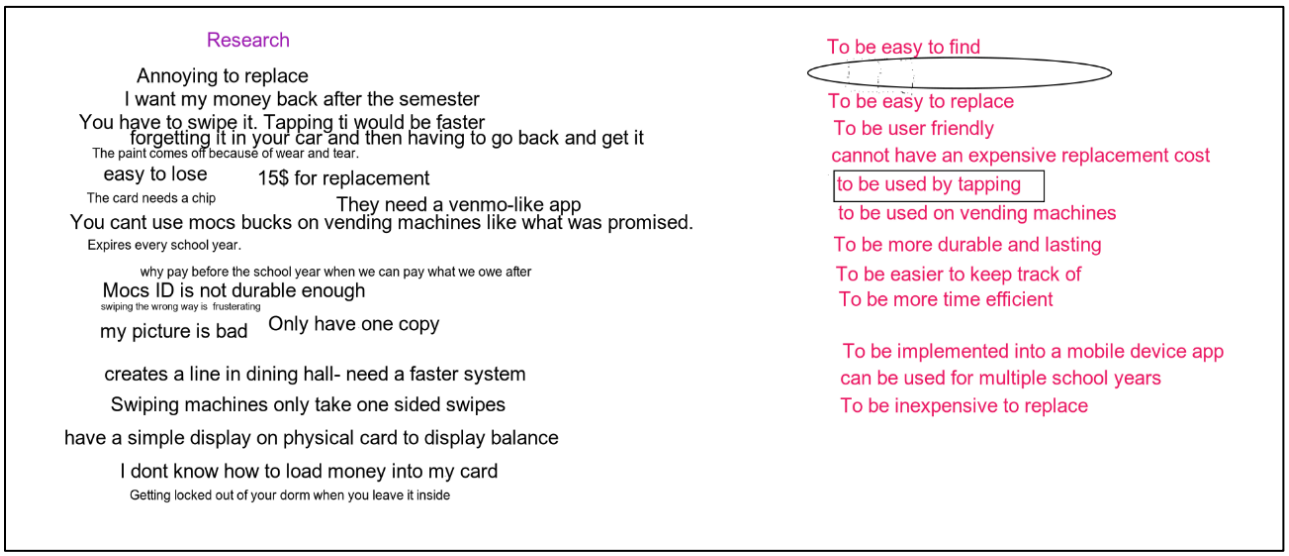

Figure 3: Aww App Example – Objective Identification for Improving Student Access Card

Aww App also has embedded templates useful for collaborations. One example is the Empathy Map template. Figure 4 is a result of a team assignment to create an Empathy Map to aid in identifying user needs related to user feelings, tasks, influences, pain points, and use goal. The application of this map is a COVID19 mask for individuals who do not have full use of their hands or arm. Aww App allows team members to participate synchronously by creating sticky notes and placing them in the appropriate location on the map. Sticky notes can be color coded to indicate which student provided which comment.

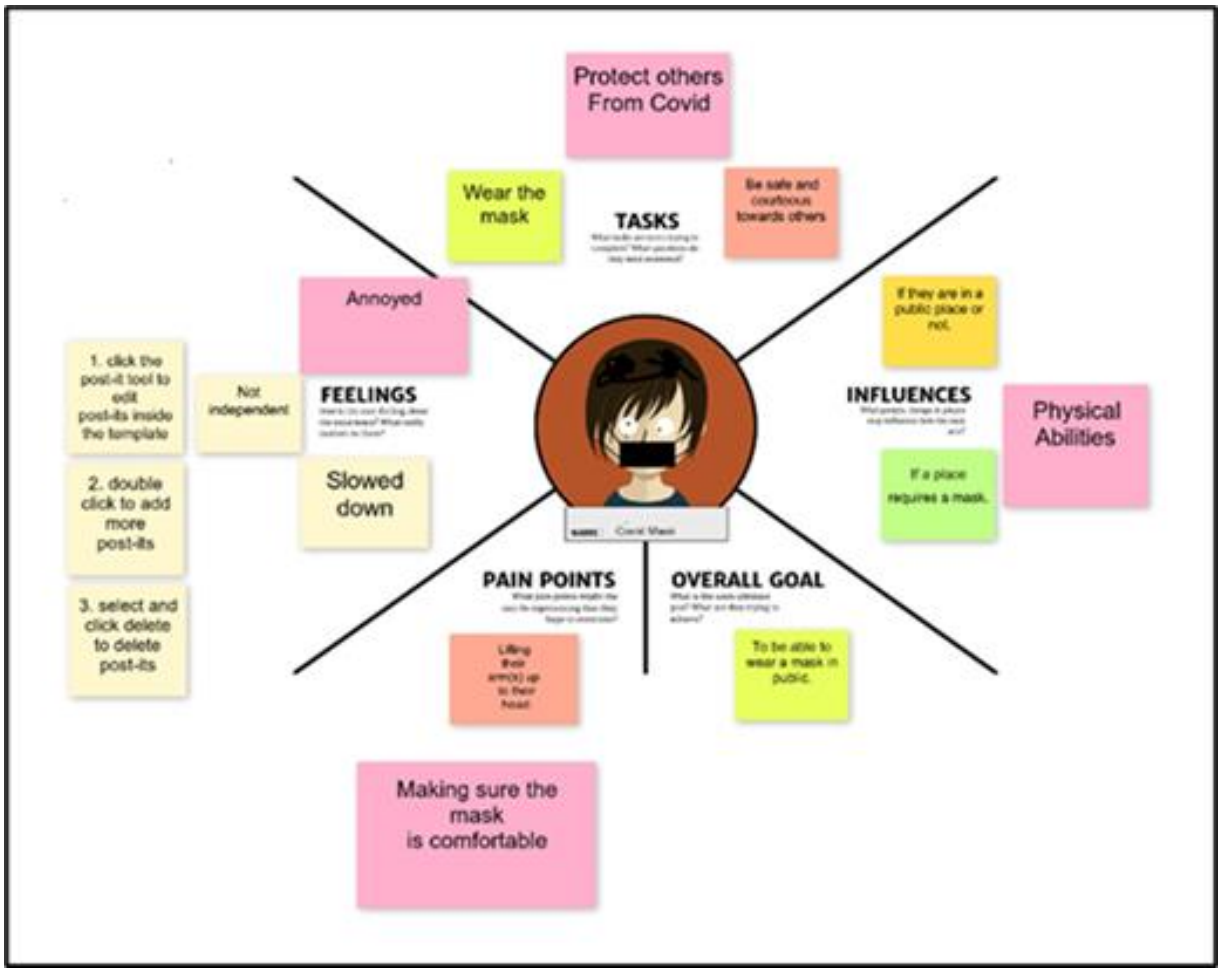

Figure 4: Example of Student Generated Empathy Map using Aww App.

Canvas is used to initiate asynchronous student responses to individual and team contributions such as the examples shown previously. The Canvas Discussion and Peer Review applications are two means to solicit student feedback. For example, the Peer Review application is used when students assess specifically assigned individual project research contributions submitted as assignments. Canvas Discussion is used to solicit feedback from a large group or the entire class. Prior to 2020 this activity occurred in small group f2f discussions within the classroom.

Microsoft Forms also provides a means to solicit student feedback. In IED, Forms is used by students to submit peer reviews of individual and team presentations. The instructor developed a simple form using a 5-point rating scale. A link to the form is made available to students on the

course Canvas site. Students can easily access the link using a desktop computer, tablet, or phone. The link can also be made available using the Zoom Chat function, so students do not have to access the class Canvas site.

A large change for the instructor is the loss of the whiteboard for class lessons. A Surface Pro, a Smart Pen, and Microsoft (MS) Onenote substitutes for the traditional whiteboard. The MS Onenote screen is shared in Zoom for the on-line students and the Zoom screen is projected in the class for the in-class students.

Table 2 summarizes the collaborative and interactive activities and software and technology used in HyFlex IED. All class activities and class sessions are captured and posted on the course management system (Canvas). Class sessions are recorded and links to the recordings are posted.

Table 2: Software and Technology Support for Class Activities

Activity	Software and Technology
Research summary and criteria identification	Aww App (online white board)[7]
Empathy mapping	Aww App (online white board)[7]
Brainstorming using Heuristics	Canvas Quiz
Objective and function wording and diagramming	Zoom White Board and Surface Pro
Presentations	Zoom Screen Sharing
Team meetings and document sharing	Microsoft Teams
Individual findings and brainstorming sharing	Canvas Assignment Peer Review
Student assessment of peer presentations	Microsoft Forms
Class lectures and learning sessions	Surface Pro, Smart Pen, MS Onenote

Reactions to Collaborations and Interactions

Students took to using the Aww App whiteboard quickly, though at times they strayed from the assigned task. Some found it fun to "play" with the provided functions, especially using another team's page on the whiteboard. To alleviate opportunities for these occurrences, the instructor limited the whiteboard to one page and provided each team a unique Aww App link and thus a unique whiteboard. This stopped students from playing on another team's page.

The most successful use of the Aww App was the empathy mapping. In their review of the experience many students mentioned this activity being beneficial to their solution generation. Fall 2020 was the first semester for this activity. It was a substitute for a similar f2f activity completed in previous semesters which did not adapt well to HyFlex. The ability to use the template aided in the success of this activity.

The other successful activity was the use of the Design Heuristics to increase the solution generation space. Prior to fall 2020 the heuristics were used as a suggestion to aid solution generation. Beginning fall 2020 it became a specific assignment. The students took ownership of this assignment – receiving randomly selected 5 heuristics and choosing 3 they wanted to apply. Students also commented in their experience review that this assignment was beneficial to

The most beneficial and possibly most important change to IED for the HyFlex format was the strong emphasis on the individual assignments associated with the team project. This allowed

the teams to view their project solutions as a system with subsystems that required modeling and testing prior to system prototype creation. It also ensured each student had practice testing and improving a physical model they created from an abstract solution. Students commented in their experience review that the opportunity to build and test and rebuild illustrated the iterative nature of the design process.

Although there are positive outcomes with respect to course activities, students did not enjoy working in teams using the virtual format. This is mostly due to on-line students not being visually present in class or team meetings. Specifically, it was observed that on-line students did not use their camera function to be present in class sessions and team meetings. This caused on-line students to feel disconnected from on-line team members. It was suggested that teams use Microsoft Teams to enhance communication; however, only a few teams took advantage of it. Also, on-line students often would leave the class session once it broke into a team meeting format. This left only the in-class team members working on deliverables.

Conclusion and Course Improvements

Fall 2020 HyFlex IED was successful. The learning that occurred during the individual model building and testing was much increased from what occurred in previous semesters. The structure forced students to be more individually accountable to the project because they were assessed on their ability to model and test their assigned subsystems. In addition, students participated in class sessions using the collaborative whiteboards. In addition, progression of lessons was successfully presented using the Surface Pro, Smart Pen, and MS Onenote.

However, in HyFlex, team interactions suffered. Previously, teams spent class time working together in a physical space sharing ideas, building in the shop, and composing assignment responses. But, in HyFlex, some on-line students chose to maintain not only physical distance, but also communication distance. This negatively affected team outcomes as well as their own learning. To help improve interactions the spring 2021 policy is for on-line students to use cameras in class sessions and team meetings. The spring 2021 students also used Zoom and google slides to introduce themselves and share one aspect of themselves they believe important. Current use of this policy and the introductions already indicate interactions are enhanced - open conversation is occurring before, during, and after class. This did not occur in fall 2020.

Students did have one complaint about HyFlex IED. They did not appreciate having the responsibility to find their own users/clients/customers for the provided projects. The instructor acknowledges this is not optimal. Due to this, most of the projects for the spring 2021 course are introduced with suggestions for users/clients/customers. A few have specifically identified customers where physical distancing and outdoor meetings are guaranteed.

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