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How COVID-19 Led to Improvements and Adaptations to Experiential Learning Opportunities for an Increasingly Remote Environment

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Abstract

In the words of Oscar Wilde, "To expect the unexpected shows a thoroughly modern intellect." When the COVID-19 pandemic spread throughout the US in March of 2020, companies in all sectors of the economy learned that it is imperative to quickly respond to the unexpected. Companies needed to leverage their organizations' core values to adapt and implement a crisis strategy that met the needs of the COVID-19 pandemic while evolving the value offered to stakeholders. This paper is a case study on how Argonne National Laboratory, the organizing committee of an advanced vehicle technology competition developed a "contingency thinking" strategy to pivot and address stakeholder's needs despite the uncertain impacts of COVID-19.

Contingency thinking is an adaptive planning strategy based on the principles of design thinking and value assessment. This strategy is an iterative process which includes: assessing the value of activities, developing contingency plans with increasing fidelity, collecting feedback from stakeholders, and incorporating feedback into the next iteration of contingency plans. Competition organizers employed this process because it reinforced the core mission of the competition and delivered minimum viable value irrespective of the ever-changing COVID-19 implications. The contingency thinking process resulted in the collegiate competition's first ever virtual semester – "Career Connected Learning." Career Connected Learning was a five-part virtual initiative providing students with resources to excel in the competition, collaborate with other universities, and meet stakeholders' expectations. This dynamic initiative tailored activities to universities' unique circumstances and was praised by all stakeholders.

This case study reviews the competition organizer's successful implementation of the contingency thinking process. As this was the first time the organizers implemented a highly adaptive process, the organizers faced many challenges including a compressed timeline, ever changing constraints for planning events, and the impacts of COVID-19 on team morale. Throughout this process, the organizers learned the importance of communicating a clear problem statement, collecting structured stakeholder feedback early, keeping an open mind, utilizing low fidelity prototypes, and employing project management tools. Over the past year, organizers gained experience from their successes and failures, and these valuable lessons can be applied to any organization seeking to manage the unexpected.

I. Introduction

This case study focuses on the EcoCAR Mobility Challenge organizers' effort toward implementing contingency thinking to address stakeholder value and organizational stressors in an ever-changing COVID-19 environment.

A. Historical Competition Background

For over 30 years, Argonne National Laboratory has managed multi-year automotive collegiate competitions concentrated on advanced vehicle technologies, from hydrogen fuel cells to hybrid-electric vehicles. The current four-year competition, the EcoCAR Mobility Challenge, centers around electrification, connectivity, and active driver assistance with 11 participating universities throughout North America and over 25 industry sponsors. Figure 1 shows the EcoCAR Mobility Challenge's yearly competition goals and vehicle development process.

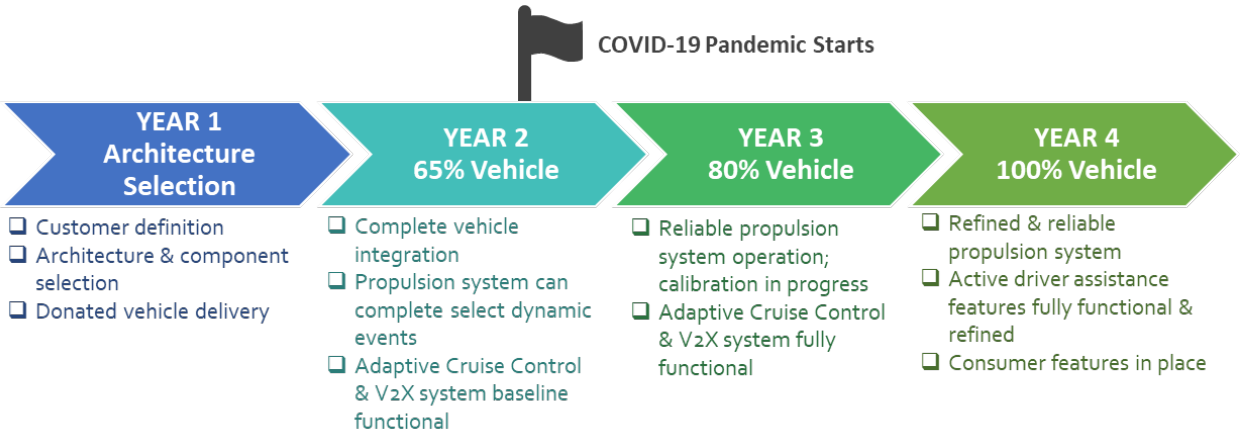

Figure 1. Overview of the yearly competition goals.

In Year 1, students focus on vehicle architecture design, component modeling and selection, and defining their customer. Year 2 and Year 3 focus on vehicle integration, testing, and refinement; universities receive their vehicle and integrate the chosen hybrid-electric propulsion systems, develop initial vehicle controls, and implement basic connected and automated systems. Finally, Year 4 is dedicated to achieving refined functionality for all systems and implementation of team-designed consumer features.

In order to guide universities through the vehicle development process, EcoCAR organizers develop scored deliverables that serve as competition-wide assignments for the universities. These deliverables, in the form of technical reports and vehicle evaluations, allow organizers to assess each universities progress and serve as a primary method for determining university rank each year.

In addition to the scored deliverables, EcoCAR organizers host three in-person events each year to evaluate university progress through the vehicle development process. EcoCAR provides funding for every university to send 10-15 individuals to each in-person event. Two of the in-person events are workshops that take place at the beginning of each academic semester and facilitate product training, professional development, a career fair, university morale, and engagement with EcoCAR sponsors and organizers. The last in-person milestone is the year-end competition, which consists of weeklong dynamic vehicle evaluations at an automotive testing facility and a week of technical presentations to a group of industry professionals. The culmination of the year-end competition is an awards ceremony where the results of the dynamic

vehicle evaluations, technical presentations, and deliverables are calculated and the winners for the year announced.

In order to execute a competition of this magnitude, sponsors provide both in-kind donations (e.g. engineering software applications, hardware, dedicated training sessions) and supplemental monetary donations. In return, sponsors receive opportunities to interface with the student participants and an increased visibility within the EcoCAR program. EcoCAR highlights sponsor contributions to external audiences via social media, blog posts, interviews, and other marketing mediums. Additionally, EcoCAR provides sponsors with roughly 1000 students and future engineers to beta-test their cutting edge technology.

B. COVID-19 Impacts on the EcoCAR Mobility Challenge

In response to the COVID-19 pandemic, EcoCAR organizers began a dynamic and ever-developing process to understand pandemic impacts on universities and sponsors. Stakeholder feedback identified increased concerns for the program moving forward including physical restrictions, the ever-growing "Zoom fatigue," and the ability to sufficiently utilize sponsor contributions. The organizers needed to develop a method to ensure they could meet their stakeholders' desired value regardless of the environment. Over the summer of 2020, organizers began developing and implementing the contingency thinking process.

II. Literature Review

A. Design Thinking

Design thinking is a user-centric, iterative process for developing innovative solutions. The process was coined by Tim Brown, CEO of the world renowned design-firm IDEO [1], and has been promoted by many organizations such as Stanford's d.school, MIT Sloan School of Management, Northwestern Segal Design Institute, and others [2]-[4]. Design thinking consists of five stages: empathize, define, ideate, prototype, and test [5].

During the empathize stage, designers learn about their users; they ask users for their opinions via surveys and interviews, they observe how users interact with products, and they experience the problem themselves to understand how users feel. After seeing a problem through the lens of users, designers move onto the define stage where they establish design goals and define the scope for their problem. Next, designers move onto ideation; during this stage, they use techniques such as brainstorming and brainwriting to generate creative, out-of-the-box solutions. Once the team has an abundance of ideas, they will choose which solutions (or parts of solutions) will go into their prototype. In the prototyping stage, designers bring their solution to life; prototypes can be created in a variety of mediums and early prototypes will be low fidelity. When a prototype is ready, designers move onto the testing stage; at this point, they show the prototype to users and collect feedback on what users like and dislike. This feedback is used to iterate the prototype, and with time, the designer will increase the prototype fidelity [5].

For simplicity, the design thinking process is often presented in a linear, cyclical fashion, but the implementation of this problem solving process can be messy. Designers commonly repeat steps, skip steps, or take the steps in a different order [6]. The key with design thinking is that there are multiple iterations, and each iteration incorporates user feedback to solve the defined problem. Working with users adds more time to the process, so iterations should be executed quickly. When designers "fail fast," they learn more about their users in a short period of time, and this knowledge helps designers rapidly prototype a solution that users love [7].

B. Pivoting

While a commonly used term across industries, "pivoting" has little objective definition or known factors that would cause a business or organization to pivot. A study conducted by Kirtley and O'Mahony found most organizations only seek to pivot "after receiving new information that conflicts with or expands their beliefs … or uncertainties they face"[8]. An organization will rarely make sweeping changes to their company's strategies overnight or as the result of a single decision. More commonly, the resulting pivot is the culmination of consistent strategic reorientations [8].

Pivoting is regularly accompanied by an internal value assessment. This starts with an organization questioning the status quo; they ask themselves "Is there a better way?" and they do not assume a historical process is correct or incorrect [9].A value assessment requires an organization to measure the importance and gain relevance for a given effort to gain an understanding of the user priorities [10].

III. Case Study

In order to navigate the COVID-19 environment and develop plans for the 2020-2021 academic year, EcoCAR organizers incorporated design thinking principles into their contingency planning process; the contingency thinking process is shown in Figure 2.

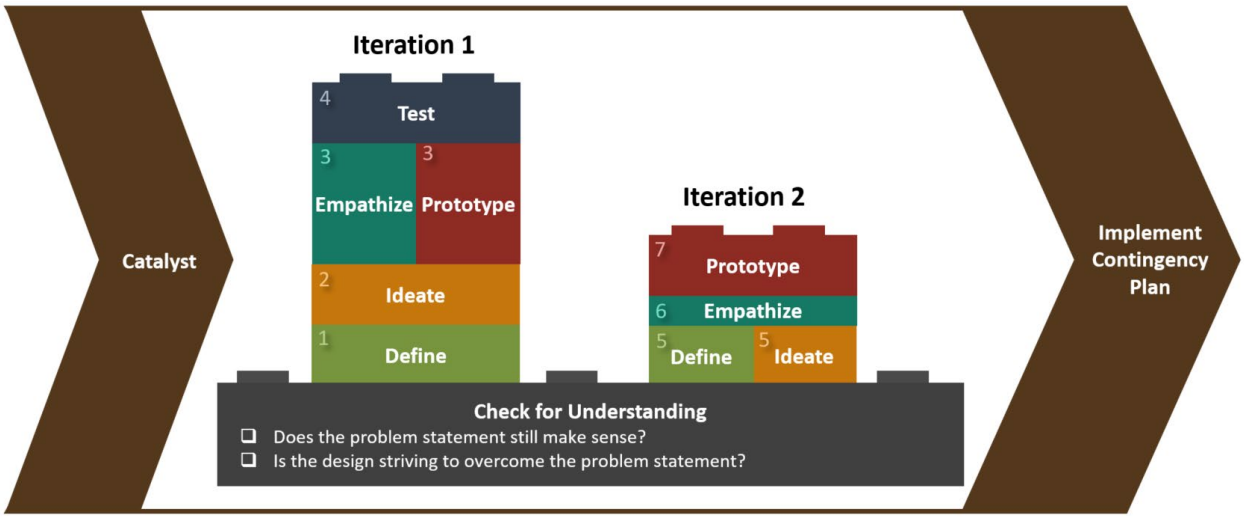

Figure 2. Specific Contingency Thinking Process followed by Organizers.

A. Process

Step 0. Catalyst

For the EcoCAR organizers, the catalyst requiring them to develop and implement the contingency thinking process was the COVID-19 pandemic. In February 2020, the first participating university transitioned to remote learning and others shortly followed. Key EcoCAR events were altered in scope, most notably the cancelation of the year-end competition in May.

The initial recovery plan was to host a Fall Workshop and Vehicle Event (WAVE). WAVE was an attempt to combine sponsor engagement opportunities (software and hardware training, recruiting activities, and professional development) with dynamic vehicle evaluations. However, WAVE was based upon the historic competition development activities of workshops and vehicle testing events, without first identifying changes to stakeholder desired value and priorities as a result of COVID-19.

After weeks of internal discussion, organizers realized it was not possible to predict how COVID-19 would affect stakeholder travel policies and participation in EcoCAR events. The weeks of unused, high fidelity planning led to frustration and cyclical conversations. Organizers needed an approach to EcoCAR planning that enabled the development of contingency plans to meet programmatic goals while addressing stakeholder value in new ways – this led them to the contingency thinking process.

Step 1. Define

With a realized catalyst, EcoCAR organizers entered the defining stage of the contingency thinking process. In this phase, organizers discussed the programmatic impacts of COVID-19, agreed upon a problem statement, and identified the primary goals of contingency planning.

The organizers defined the problem as, "How can the EcoCAR Mobility Challenge maintain the fall 2020 vehicle development milestones in the COVID-19 environment, while preserving student and sponsor engagement with one another and organizers?" Though changes to the fall vehicle development milestones would affect subsequent years, organizers determined during this stage that they needed to limit the scope of their efforts to the upcoming academic year as they were originally planning to host WAVE in September 2020.

Organizers then performed a value assessment on the initial WAVE concept to understand the value propositions for their stakeholder groups. This value assessment was an internal exercise based upon historical data from the stakeholders and did not directly involve any outside organizations. The result of the assessment identified that dynamic vehicle evaluations and sponsor-student engagement opportunities needed to be maintained regardless of the environment.

Step 2. Ideate

After the organizers defined the problem statement, they began the ideation phase. In order to promote productive brainstorm sessions, organizers researched brainstorming strategies and developed a set of guidelines to structure the ideation process [11]. Organizers entered ideation with the intent to create short-term and long-term solutions. When ideating, the organizers wanted to consider potential solutions in isolation; therefore, they decoupled sponsor engagement activities and dynamic vehicle evaluations as presented in Table 1.

Table 1. Template used for structured ideation

Environment	EcoCAR Activity	
	Sponsor Engagement	Dynamic Vehicle Evaluations
In-Person		
Virtual		

Organizers separated into groups to generate ideas for each of the given scenarios: In-Person sponsor engagement, in-person dynamic vehicle evaluations, virtual sponsor engagement, and virtual dynamic vehicle evaluations. The result of this ideation was a multitude of ideas that were, by nature of the process, disjoint from one another. By following this ideation process, organizers were able to understand how individual ideas could translate value between scenarios, addressing one of the organizational concerns surrounding unused plans. To facilitate idea selection, a meeting was held with the majority of the EcoCAR organizers present, and the organizers vetted the ideas based on the estimated effort to execute and the expected value to stakeholders.

Step 3. Empathize

Now with initial solutions from the ideation phase, organizers developed a standardized procedure to discuss the four scenarios with stakeholders. The four scenarios were the result of possible combinations of "environment" and "EcoCAR activities." These procedures relied heavily on protocols, which provided a step-by-step guide for an organizer to follow when conducting interviews or developing a survey. These protocols enabled all organizers to participate in the empathizing phase while ensuring a consistent scope for feedback collection. In order to capture candid feedback, organizers tailored the empathizing medium to each of the stakeholder's preferences.

Sponsor input was collected via video interviews to facilitate an informal environment. This semi-structured conversation allowed sponsors to provide input that may not have been captured in the sponsor interview protocol. The video interviews were conducted to understand sponsor's current travel restrictions and their interests in participating in both in-person and virtual events during the Fall semester. Additionally, the video interviews concluded with the sponsor articulating their primary motivation for being involved in EcoCAR. Unlike many companies, the organizers found themselves in the unique situation where they were not developing a product to sell, nor were they offering a service for contract. Therefore, in order to fulfill stakeholders' desired value, it was critical to determine each sponsors' primary motivation for being involved in EcoCAR. Sponsor feedback showed overwhelming support and understanding of the program challenges due to COVID-19, and sponsors were committed to provide the best experience for EcoCAR students. In order to meet the value desired by sponsors, organizers needed to deliver an opportunity – virtual or in-person – for sponsors to engage with students.

University feedback was captured with an anonymous student survey and a video focus group of faculty advisors. The two mediums were chosen to account for the large number of student participants, while maintaining informal feedback with the faculty. From the faculty focus group, organizers were interested in receiving updates on university travel restrictions and faculty opinions of the solutions presented in the four scenarios. From the anonymous student survey, the organizers wanted to know what portions of traditional EcoCAR events students found valuable. The collective university response emphasized the importance of in-person events as a way to drive vehicle development, maintain student engagement and recruiting activities, facilitate regular interaction with EcoCAR sponsors, and provide a way for teams to see their hard work pay off.

Step 3. Prototype – Initial Fall Plan

EcoCAR organizers chose to rapidly prototype as they received feedback from stakeholders to account for their shrinking timeline. The ability to collect feedback, ideate, and prototype simultaneously is a cornerstone of the contingency thinking process.

After generating disjoint ideas and receiving stakeholder feedback, organizers began joining separate ideas into cohesive prototypes. As organizers met in weekly planning meetings, they identified three fall contingency prototypes for further development, as shown in Table 2. Each prototype would aim to deliver the expected value of the traditional fall workshop and dynamic vehicle evaluation opportunities to universities, sponsors, and organizers. The organizers decided not to pursue a fourth option consisting of both in-person sponsor activities and virtual dynamic vehicle evaluations; this decision was driven by COVID-19 social distancing guidelines and the sheer number of individuals who attend sponsor activities.

Table 2. Initial Fall 2020 Concepts

Prototype	Environment	
	Sponsor Engagement Activities	Dynamic Vehicle Evaluations
#1 - Fall WAVE	In-Person	In-Person
#2 - Hybrid WAVE	Virtual	In-Person
#3 - Virtual Semester	Virtual	Virtual

Once the prototypes were populated with lower-level activities, organizers identified it would be impractical for them to further develop the activities for all three prototypes in parallel. This realization led organizers to take two actions. First, they must develop a contingency plan to connect the three prototypes, which would identify the pivot points in the development timeline and communicate which activities will be initiated as a result of a pivot. Secondly, in an effort to provide time for activity development before execution, organizers needed to determine which ideas provided value while being able to translate between the three prototypes. Identifying the translatable ideas allowed organizers to begin development on the activities that were independent of the fall environment. This contingency plan documented the required modifications to the vehicle development milestones while allowing timeline flexibility for questions that still needed answers.

Step 4. Test – Initial Fall Plan

Now with a single contingency plan outlining three prototypes, organizers went back to stakeholders for a second round of empathizing. This round of empathizing was even more time-constrained with the fall approaching; therefore, the feedback pool was limited to prominent sponsors and the faculty focus group. Organizers selected sponsors based upon their level of monetary and in-kind contributions to the EcoCAR program. For both the sponsors and faculty, video interviews were the chosen medium to guide stakeholders through the contingency plan and explain the nuances of individual activities. During these interviews, organizers communicated how the initial stakeholder feedback shaped the prototypes and organizers inquired whether the stakeholder felt the prototypes met their value targets.

Throughout the interviews, sponsors and faculty commonly gave feedback that contradicted their previous points of view. These contradictions stemmed from increasing doubt in stakeholder ability to participate in any in-person activities for the remainder of 2020. While maintaining the

dynamic vehicle evaluations had been a primary feedback point from universities, it was no longer realistic given their own travel restrictions and social distancing requirements. By design, the comprehensive contingency plan included a prototype that accounted for the possibility of this change in stakeholder perspective.

Step 5 and 6. Iterate – Final Fall Plan

After receiving feedback on the initial prototypes in the contingency plan, organizers were guided by stakeholder responses and COVID-19 environmental developments to redefine their problem statement as shown in Figure 3.

Refined Problem Statement: How can the organizers maintain the Fall 2020 vehicle development milestones ~~in the COVID-19 environment~~ with an entirely virtual Fall, while ~~preserving~~ developing new strategies to encourage student and sponsor engagement with one another and organizers?

Figure 3. Modified problem statement.

Now with a redefined problem statement, EcoCAR organizers began another round of ideation focused solely on a virtual environment for the fall. Using additional stakeholder feedback, organizers iterated on Prototype #3 and combined refined ideas to address their problem statement; organizers knew from stakeholder feedback that these ideas must be presented as a single initiative and not a consolation caused by the COVID-19 environment.

Step 7. Prototype – Final Fall Plan

The contingency thinking process resulted in organizers developing EcoCAR's first-ever semester-long platform to facilitate student progress in a virtual environment – "Career Connected Learning" (CCL). CCL is a five-part virtual initiative that provided students with resources to excel in the competition, collaborate with other universities, and meet the expectations of stakeholders. Figure 4 provides an overview of the five virtual activities as well as the value they provided to students, sponsors, and EcoCAR organizers.

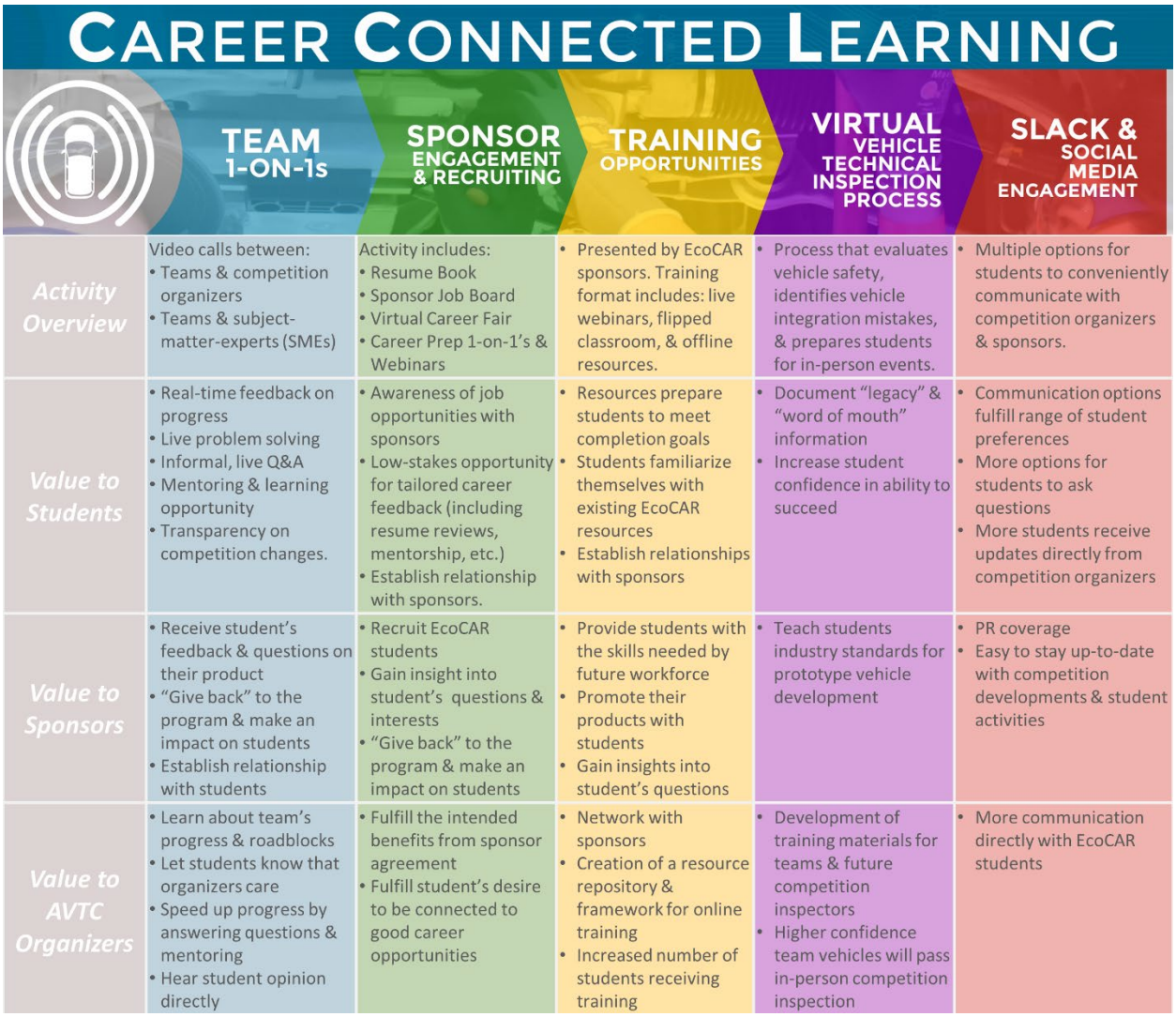

Figure 4. Overview of the Career Connected Learning Initiative.

The organizers wanted to ensure that CCL was perceived positively by students; they wanted the activities to be seen as supportive of student's future careers and different than virtual college classes. As such, the organizers packaged activities into the Career Connected Learning initiative and developed supporting strategic messaging that was used in written documentation, emails, and social media.

Step 8. Test – Final Fall Plan

At the end of the Fall 2020 semester, EcoCAR organizers evaluated the success of the CCL initiative by collecting feedback from sponsors and students through the use of informal surveys, interviews, and focus groups. As shown in Table 3, the primary goals of the data collection activities were to learn how each CCL activity was perceived by stakeholders and how the activities could be improved. Additionally, the organizers used the data collection activities to foster stronger relationships with stakeholders. Given the stress and uncertainty caused by the

COVID-19 pandemic, organizers wanted to ensure that sponsors felt valued and that students knew the organizers supported them.

Table 3. Primary Goals of CCL Evaluation Activities.

	INFORMATION WANTED	HOW ORGANIZERS WILL USE THE INFORMATION
PRIMARY GOAL OF SPONSOR FEEDBACK	How well did each CCL activity contribute to fulfilling sponsorship agreements?	Learn if sponsors thought the CCL activities were worthwhile. Determine which CCL activities to keep, cancel, or modify.
	How can CCL activities be improved?	Make changes to CCL activities to make them more sponsor-friendly.
PRIMARY GOAL OF STUDENT FEEDBACK	How valuable was each CCL activity to students in meeting the Year 3 goals and preparing them for their future careers?	Learn if students thought the CCL activities were worthwhile. Determine which CCL activities to keep, cancel, or modify.
	Did the CCL activities work well in a virtual format?	Prioritize which EcoCAR activities need to happen in-person vs. virtually
	How can CCL activities be improved?	Make changes to CCL activities to make them more student-friendly.

To collect sponsor feedback, organizers set up 45 minute interviews with 13 of the most prominent sponsors. Sponsors were overwhelmingly pleased with the organizers' adaptability to the ever-changing COVID-19 constraints and willingness to be transparent about possible changes to the EcoCAR program. Many sponsors took advantage of the new sponsor engagement and recruiting activities, and wanted to see these continue in the future.

Student feedback was collected via informal interview focus groups and anonymous surveys. The focus group interviews were concentrated on learning "why" students thought CCL activities were valuable whereas the survey was used to collect quantitative data. The organizers hosted 26 focus group interviews that were 15-25 minutes long; the focus groups were set up to ensure that all universities and EcoCAR technical focus areas were represented. The anonymous survey was designed to be completed in 5-10 minutes and was sent to a student list serve to ensure that every student had the opportunity to provide feedback. All survey questions were listed as optional to let students decide which aspects of CCL they wanted to provide feedback on. Of the 519 students on the Fall 2020 EcoCAR roster, 86 students (16%) participated in a focus group and 84 students (16%) completed the survey. Given the anonymity of the survey, an unknown number of students participated in both a focus group and the survey; as the focus group and survey asked different questions, having students participate in both activities resulted in minimal duplicate feedback.

Students were excited about the breadth of new EcoCAR activities, and they appreciated that many of the activities were tailored to their university's unique situation and interests. Figure 5 captures detailed student feedback including key quantitative data from the survey, trends on what students liked, and recommendations for improvement.

Figure 5. Student feedback on Fall CCL.

Given the positive feedback from stakeholders, EcoCAR organizers extended all five CCL activities into the Spring 2021 semester and modified the activities to address sponsor, student, and faculty feedback.

B. Impacts to the Program

Organizers

Defining the relationships between organizers, sponsors, students, and other stakeholders was a key aspect of the contingency thinking process. Understanding these relationships allowed organizers to change their communication tactics to be more transparent and targeted. These streamlined communication methods have encouraged all parties to have important conversations more frequently, thus minimizing the organizers development of unused plans.

Additionally, the contingency thinking process encouraged organizers to modify their meeting structure to be more agile. Organizers replaced lengthy, weeklong planning sessions with more frequent touchpoints, structured brainstorm sessions, and formal meetings to decide on the path forward. As organizers hosted CCL "Team 1-on-1s," they disseminated student feedback internally and used the feedback to continually update their contingency plan.

Sponsors

Organizers created a "Sponsor Protocol" to standardize informal conversations with sponsors, and the development of this protocol strengthened relationships and ensured consistent communication between sponsors and organizers. Additionally, this protocol increased overall sponsor engagement and allowed organizers to work directly with sponsors to create new, customizable opportunities for sponsors to interact with students.

Students

Contingency thinking resulted in the development of a feedback process that collected direct, organized, and actionable feedback from the full spectrum of students in the EcoCAR program. This feedback allowed organizers to tailor CCL towards each teams' unique situation and provide students with numerous benefits as described in Figure 5. Additionally, this feedback process improved the relationship between organizers and students.

Year 3 Spring

As the COVID-19 pandemic continued to escalate through the Fall of 2020, organizers relied on contingency thinking to develop a plan for the Spring semester. As shown in Figure 6, the possible scenarios for the Spring semester were similar to the Fall, but there was an increased desire to provide students and sponsors with the value of an in-person vehicle testing event.

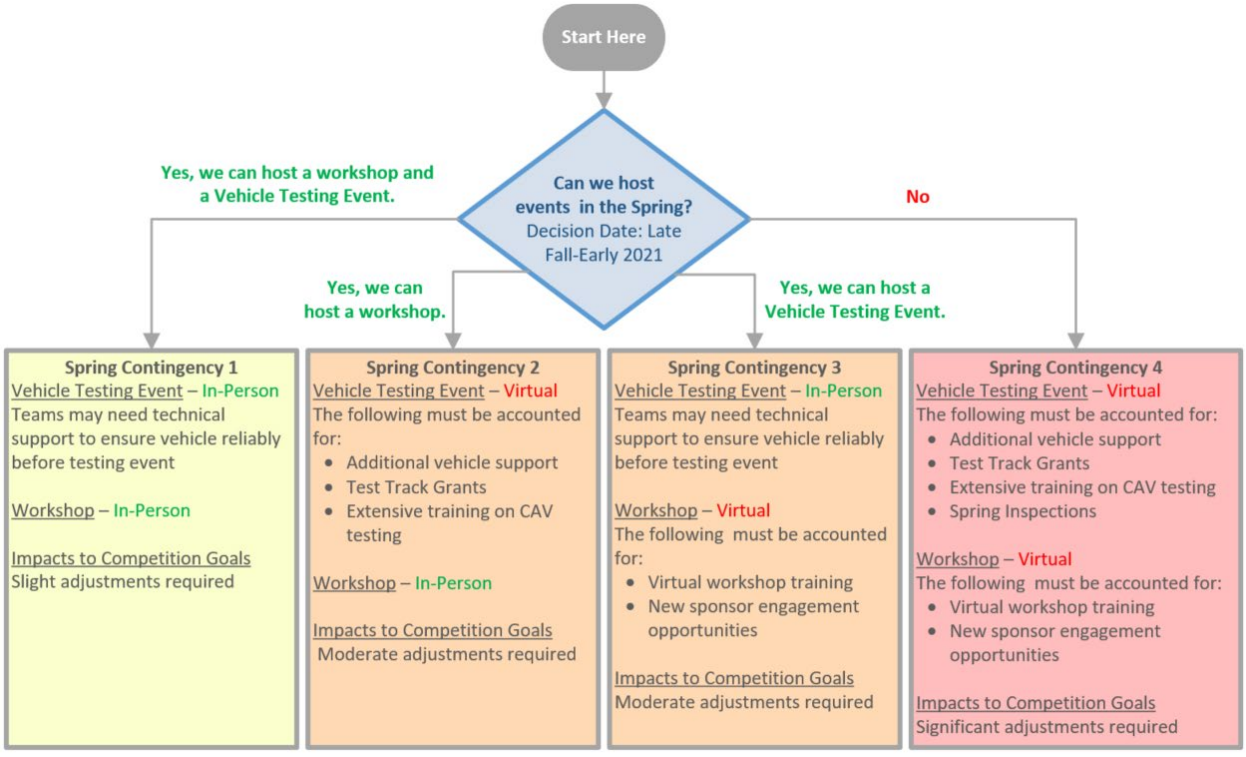

Figure 6. Spring Contingency Plan Flowchart.

Ultimately, organizers enacted spring contingency four. To replace the value of an in-person workshop, organizers extended the CCL initiative into the spring and made modifications to CCL based on stakeholder feedback. In an effort to increase virtual engagement and student morale, the Spring CCL initiative was rebranded as "newly enhanced" and "exclusive." Prior to COVID-19, EcoCAR events were limited to a small subset of student participants, and universities expressed the desired to expand student involvement. The virtual nature of CCL allowed organizers to fulfil this longtime university request, but it came with unexpected feedback – the breadth and flexibility of the virtual CCL initiative made EcoCAR feel less "special." Organizers worked with a focus group of students and faculty to develop tactics for promoting the "uniqueness" factor of CCL activities and to rebrand CCL as an initiative "exclusively designed for students, based on student feedback." At the beginning of the Spring semester, organizers hosted a webinar that announced the new branding and showed stakeholders how the organizers incorporated feedback to modify the CCL program.

The contingency thinking process also allowed organizers improve aspects of EcoCAR that were unrelated to contingency planning. When empathizing with students, organizers learned about pre-existing student pain points that were agnostic of COVID-19. During the ideation phase, organizers inherently generated à la carte ideas that addressed some of the student pain points. The most notable improvement to the EcoCAR program was the creation of a Student Leadership Council – a collection of four students who work with organizers and university leadership to make long-term program improvements.

C. Lessons Learned

Contingency thinking helped the organizers successfully navigate the COVID-19 pandemic and acquire new skills in managing complex situations. In the define phase of contingency thinking, the implementation of value assessment put the organizers on the right track. The value assessment provided organizers with encouragement that even during an unprecedented time, the program could still deliver maximum value to sponsors, universities, and students. The define stage could have been improved if the team continually referred back to the original value assessment results after the first prototype was developed; instead, they relied solely on the feedback from stakeholders. As a result, the organizers lost sight of their originally defined goal, and they needed to iterate the prototype to refocus on the goal. This departure from the original goal could have been avoided if the organizers formally captured the problem statement and communicated it internally and externally.

In the ideation phase of contingency thinking, organizers created an environment that fostered creativity. They brought "outsiders" into brainstorm sessions, established rules that created judgement free zones, and learned how to keep an open mind. During brainstorm sessions, organizers chose constraints that helped them understand the problem and encouraged atypical solutions. While the constraints were valuable, it would have been helpful if the organizers consistently reevaluated them throughout the design process. Given the ever-changing

complexity of the COVID-19 pandemic, reevaluating constraints would have helped the organizers better tailor their prototype to the evolving situation.

One mistake that jeopardized the success of brainstorming sessions is that in the beginning of this process the team did not formalize the transition from idea generation to idea selection. By design, idea selection is not a judgement free zone; when it gets combined with idea generation, brainstorming rules are broken and creativity is limited. Additionally, combining idea generation and selection into a single meeting significantly increased meeting length, and at the end of three hour virtual meetings, participants were drained of energy. During idea selection, organizers struggled to balance the opinions of optimists and pessimists. Everyone wanted to remain hopeful that the COVID-19 pandemic would subside, but this hope made it difficult to acknowledge that out-of-the-box, virtual solutions may need to be implemented. In hindsight, hosting meetings for idea generation and selection on different days would have helped the team be more productive by giving participants a mental break to refresh.

As the team moved from ideation to prototyping, the organizers struggled to keep their prototypes low fidelity. Prior to contingency thinking, organizers were accustomed to developing high fidelity prototypes and presenting the prototypes to stakeholders for buy-in. When the team did develop a high fidelity contingency prototype, COVID-19 forced significant changes to the plans, which resulted in unused plans and low team morale. As the organizers began the contingency thinking process, they transitioned to developing a low fidelity, minimum viable product that was adaptable to the changing COVID-19 situation. When the minimum viable product was presented to stakeholders, the organizers were asked to increase the fidelity of the prototype so that the stakeholders would have more information before choosing a plan. The fidelity of a contingency plan prototype is uniquely complicated, because the desired fidelity changes based on the problem complexity, the breadth of possible pivot points, and where the organization is in the contingency planning process. At any time in the process, certain aspects of a prototype may be low fidelity, while other aspects may need extensive details to help with the decision making process. The organizers are still working to determine what contingency plan fidelity provides enough information to make a decision while minimizing future rework.

Another aspect of the prototyping phase that organizers found difficult was determining a list of scenarios that would force organizers to pivot to a different contingency plan. The organizers struggled to wrap their heads around the possible pivot points because while some of the points are easy to identify, many of them may be unexpected. These pivot points could encompass a variety of internal and external factors, such as COVID-19 protocols, staffing changes, or differences in stakeholder engagement. Furthermore, pivot points are not exclusive, and the contingency plan needs to change depending on the severity and number of pivot points encountered. When the organizers determined specific pivot points, they ran into complications explaining them to others, which lead to confusion during prototyping. The execution of the contingency plans would have been more streamlined if organizers used project management tools to clearly document and communicate project risk factors and pivot points.

After developing a prototype, the organizers moved into the testing phase where they asked sponsors, students, and faculty for feedback on the prototype plans. It took months for organizers to collect all of the feedback, and they did not have the time nor the workforce to process some of the survey data. By the time all of the feedback was collected, the COVID-19 situation had evolved; significant portions of the prototype needed to be adapted and some of the feedback was no longer relevant. Going forward, the organizers plan to allocate more resources to empathizing and testing with users so that the activity can be completed over a shorter time span. Furthermore, the organizers are adapting the "Sponsor Protocol" to work for other stakeholder groups; this protocol streamlined the sponsor feedback process, and the organizers hope it can be used to expedite data collection from other stakeholder groups.

When the organizers moved to prototype implementation, they faced many growing pains. Before the fall semester began, the CCL prototype was low fidelity; the organizers knew what CCL would look like to students and sponsors, but there were no extensive details on how to execute a virtual semester. Given that CCL required the organizers to develop five new activities, the organizers decided to rollout the activities at different points in the semester. The staged rollout gave organizers more time to develop an execution plan for CCL, but it strained the organizer's resources. Throughout the fall, organizers were balancing tasks related to launching new CCL activities, executing CCL activities, and empathizing with stakeholders to learn how CCL was perceived. During the entire contingency thinking process, the organizers would have benefited from supplemental project management documentation that captured resources required, task dependencies, and a timeline analysis.

IV. General Application

Contingency thinking is an adaptable process that any organization can use during a time of uncertainty to develop a resilient contingency plan that ensures stakeholder expectations are met. As contingency thinking is iterative, the process may initially take more time than more traditional, linear planning processes; however, the iterative process ensures that stakeholders are at the center of development activities, organizations maximize time by developing connected and translatable minimal viable products, and contingency plans are adaptable to changing circumstances. The process generates innovative contingency plans by stimulating out-of-the-box thinking and encouraging calculated failure. Additionally, contingency thinking charts a path forward and provides an organization with flexibility to restart the planning process without severe consequences, thus supporting positive team morale during a time of uncertainty.

The idealized contingency thinking process is shown in Figure 7. The first step to enacting the contingency thinking process is to identify if a catalyst has occurred. In some situations, such as a worldwide pandemic, the catalyst will be easily identifiable. In other situations, organizations may need to look for the symptoms of a catalyst; these symptoms may include, but are not limited to: an increase in the amount of internal plans being left unused, redundant internal conversations, frequent scope change, noticeable frustration among team members, or a current organizational direction of "wait and see."

Once a catalyst has been identified, the organization can move into the iterative cycle of: empathize, define, ideate, prototype, and test. While the stages are presented in a linear fashion, organizations are encouraged to view each stage as interchangeable building blocks, with the output of a given piece becoming the input of another. Organizations have the freedom to repeat, skip, and reorder the stages as long as they "check for understanding" before transitioning. This check is the foundation of contingency thinking. Organizations should not view this check as a momentary phase; organizations should continually focus on verifying that the problems and proposed solutions align with the organization's goals. The building blocks of contingency thinking are common with design thinking; however, contingency thinking is equally focused on internal organizational alignment and involving stakeholders in the process.

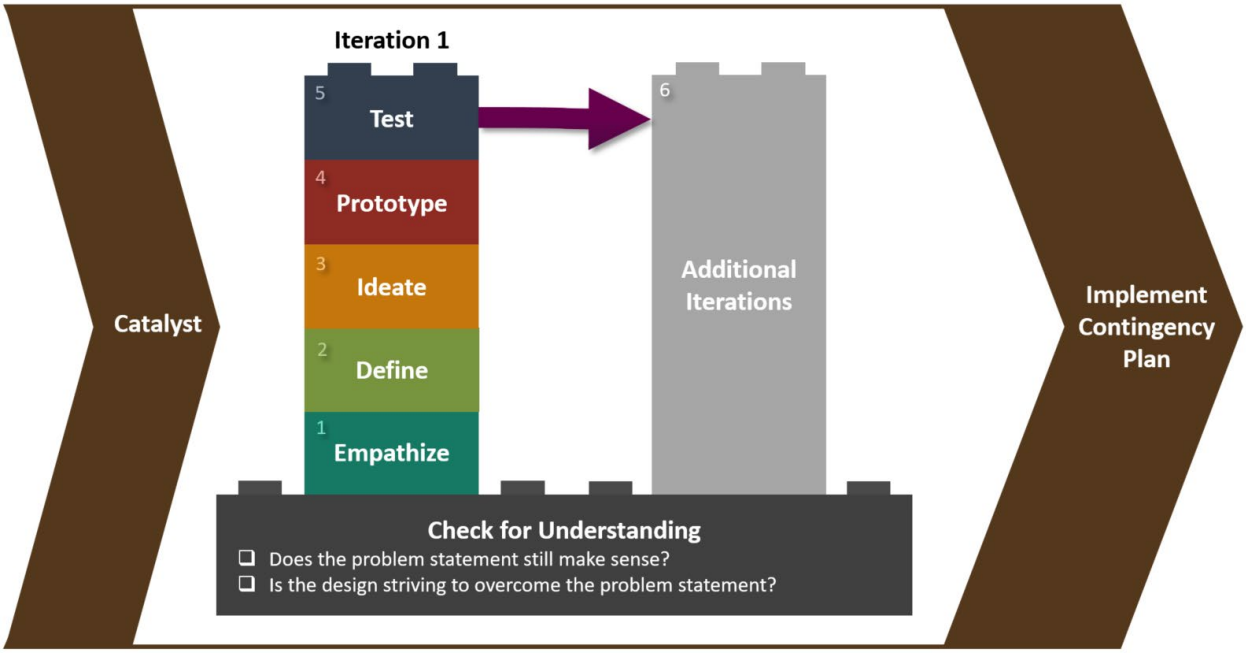

Figure 7. Contingency Thinking Process Overview.

V. Conclusion

In the beginning of 2020, the COVID-19 virus took the world by storm. The information about COVID-19 was changing on a daily basis, and organizations were forced to adapt without understanding the full picture. Like many organizations, the EcoCAR Mobility Challenge struggled to develop a contingency plan that accounted for the breadth of possible scenarios while maintaining stakeholder value. The organizers needed a new way to approach the complexities of the pandemic, so they developed contingency thinking – a temporary, iterative process enacted during a period of uncertainty to provide an organization a contingency plan that meets stakeholder value.

Throughout the summer of 2020, EcoCAR organizers followed the contingency thinking process by: empathizing with stakeholders to understand how COVID-19 impacted their organizations, using stakeholder opinions to define a specific problem that needed to be solved, ideating out-of-the-box solutions, developing low fidelity prototype contingency plans, and testing the prototype plans with stakeholders. The organizers repeated these steps until they developed a concrete plan for the fall semester that met stakeholder expectations in an entirely virtual work environment. The result was "Career Connected Learning" – a five-part virtual initiative which provided students with resources to excel in the competition and encouraged collaboration with other universities and sponsors. At the end of the fall semester, organizers collected stakeholder feedback on Career Connected Learning, and the feedback was overwhelmingly positive. Sponsors appreciated the organizers' transparency and willingness to develop innovative opportunities for them to interact with students; students reported that the initiative helped them meet competition goals and prepare for their future careers. The success of EcoCAR's first ever, virtual semester can be contributed to the development and implementation of the contingency thinking process.

Given the continuation of the COVID-19 pandemic into 2021, the EcoCAR organizers elected to continue using the contingency thinking process to develop their plans for the spring semester. While this case study primarily focuses on one organization's experience with contingency thinking, this process is uniquely adaptable to any complex, changing situation. Any organization can use contingency thinking to develop a plan to manage the unexpected.

VI. Acknowledgements

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References

[1] IDEO. “Hello, I’m Tim Brown.” IDEO, www.ideo.com/people/tim-brown. Accessed 19 Mar. 2021.

[2] Stanford d.school, “Design Thinking Bootleg,” Stanford d.school, Jun. 07, 2018. https://dschool.stanford.edu/resources/design-thinking-bootleg (accessed Feb. 24, 2021).

[3] Rebecca Linke. “Design Thinking, Explained.” MIT Sloan School of Management, 14 Sept. 2017, mitsloan.mit.edu/ideas-made-to-matter/design-thinking-explained. Accessed 19 Mar. 2021.

[4] Northwestern University Segal Design Institute. “Design Innovation.” Design Innovation, design.northwestern.edu/. Accessed 19 Mar. 2021.

[5] Brown, Tim. “Design Thinking.” Harvard Business Review, 28 Aug. 2015, hbr.org/2008/06/design-thinking.

[6] Bowman, Jordan. “What No One Explains about the Design Process.” *UX Tools*, 17 Mar. 2021, uxtools.co/blog/what-no-one-explains-about-the-design-process/. Accessed 17 Mar. 2021.

[7] IDEO. “Design Thinking.” IDEO | Design Thinking, designthinking.ideo.com/. Accessed 19 Mar. 2021.

[8] J. Kirtley and S. Omahony, “What is a pivot? Explaining when and how entrepreneurial firms decide to make strategic change and pivot,” Strategic Management Journal, Jan. 2020.

[9] R. Arteaga and J. Hyland, “Pivot: How Top Entrepreneurs Adapt and Change Course to Find Ultimate Success” Wiley, Sept. 2013.

[10] A. Osterwalder et al., “Value Proposition Design: How to Create Products and Services Customers Want. Wiley, Oct. 2014

[11] Britt, Jessica. “10 Tips to Maximize Your Team’s Brainstorming Sessions.” *LinkedIn*, 24 Sept. 2020, www.linkedin.com/pulse/10-tips-maximize-your-teams-brainstorming-sessions-jessica-britt/. Accessed 19 Mar. 2021.