Article

Digital Innovation in Times of Crisis: How Mashups Improve Quality of Education

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Abstract: Innovation is a crucial force underlying the organizational and societal ability to survive and thrive in crisis times, especially in education. However, not all challenges require creating novel solutions; occasionally, combining pre-existing solutions—an approach known as the mashup methodology—can provide equal benefit. Nevertheless, this approach appears to be relatively unknown. In the current case study, we provide an example of using a mashup of technologies to solve the challenge of running a remote virtual hackathon under COVID-19 social distancing regulations. Additionally, we argue that utilizing the mashup is a form of modeling, in which students learn by witnessing its use. Utilizing the Technology Acceptance Model, we show that by modeling the use of the mashup methodology in this hackathon (Study 1—case), we managed to improve students' attitudes towards the method and increase its perceived usefulness and ease of use in their eyes. This, in turn, raised their intention to use it as an innovation tool in the future. Study 2 revealed that this effect on participants' intentions is more significant than what would be achieved by merely teaching people about the methodology. The results of these studies add to the growing literature emphasizing the importance of using digital innovations as means of improving the quality of education, thus increasing the satisfaction and well-being of students.

Keywords: innovation; mashup; technology acceptance model; day-to-day creativity; modeling

1. Introduction

In late 2019, the first cases of a new pandemic were detected [1]. In less than a year, this new pandemic—now known as COVID-19, or Coronavirus—has spread globally, infecting more than 160 million people, killing almost 3.5 million people, and causing trillions of dollars of damages to world economies [2]. Indeed, shortly after detecting the virus, the World Health Organization (WHO) termed it a pandemic and announced a global emergency [3]. Individuals, organizations, and countries worldwide have responded and are still responding (February 2021) to the health and economic threats caused by the COVID-19 pandemic [4].

The COVID-19 pandemic has also had an extensive impact on the education sector [5–7]. By the 1st of April 2020, schools and educational institutions were closed in 185 countries, affecting a total of 1,542,412,000 pupils and students worldwide. A report by the International Association of Universities found that out of 424 Higher education institutions from over 109 countries, two-thirds reported a change to distance learning, citing technical infrastructure as the main challenge when shifting [5]. Further complicating matters are factors, such as the inexperience of teachers working in an online environment [8], the information gap, and the non-conducive home learning environment [9–11].

Innovation is a fundamental approach to confronting severe crisis events, such as the COVID-19 pandemic. While some research suggests that organizations tend to stop investing in ongoing innovation projects in the face of severe crises (e.g., the 2008 global financial crisis [12]), other scholars emphasize the role of innovation in overcoming or

even exploiting such challenges [13,14]. First, significant crises are unexpected, highly uncertain, unknown, and having unusual time pressures [15]. Thus, organizations' mere viability and survivability may be at risk when facing severe crises [16]. In these times, educational institutions cannot act in a routine "business-as-usual manner" but rather find new, innovative ways to maintain their activities and relevance. Second, history shows that in times of crisis, there are also opportunities for new services, products, business models, educational practices, or even new organizations that are more suitable for the new reality (e.g., Airbnb in the 2008 economic crisis [17]).

During the months of the COVID-19 pandemic, the world has seen accelerated innovation of different magnitude and purpose. First and foremost were the efforts to produce a vaccine for the virus or medical devices to cure people or prevent infections, most of which involved innovation. Pfizer and Moderna used the innovative mRNA approach to develop an FDA-approved vaccine in a record time of less than a year [18]. Other organizations converted their operation and manufacturing lines to produce medical devices or products within weeks. Two examples mentioned by Lee and Trimi [19] are Ford switching from automobiles to medical ventilators and True Value Co., which converted from paint to hand sanitizer. But organizational innovation did not stop with medical products and services. There are ample examples in almost all countries and across all industries at the micro, mezzo, and macro levels. Airbnb reinvented itself as a traveling solution for local (rather than international) tourists and was able to survive the crisis and successfully IPO [20], and many restaurants developed takeaway, drive-through services, or self-service kits [21]. In the education sector, e-learning quickly became the best practice, and played an impactful role in the survival of educational institutions [22], when almost all schools, colleges, and universities had to innovate their teaching methods to shift overnight to remote or hybrid methodologies [23]. Besides such internal innovation (or intrapreneurship) endeavors, numerous startups have rapidly evolved, pivoted, or accelerated product development to offer solutions for distant learning. One prominent example is "Class for Zoom" (now simply called: Class), a startup that has emerged during of the COVID-19 pandemic and built an enhanced and improved online class application integrated with the Zoom platform [24].

In the current article, we discuss the role of digital educational innovation in times of crises of this kind. The digitalization of education is an important avenue of innovation, as it is related to higher quality education [25–27] which has been found to positively impact the quality of life [28,29]—an especially important issue in times of crises [30]. We argue that mashups—an approach for innovation that is not widely known and used in organizations or education—may be a suitable solution in such circumstances. We describe the case of running a virtual hackathon using a mashup of several internet-based applications, and show that it is not only a good educational problem-solving tool, but that it is also an efficient pedagogical tool in promoting innovation amongst the students themselves. As detailed below, we relied on the Technological Acceptance Model (TAM; [31,32]) to investigate participants' attitudes and planned behavior [33] towards the mashup approach.

1.1. Literature Review

1.1.1. Innovation in Times of Crisis

The ever-existing tension between the costs and benefits of organizational innovation [34] is accentuated in times of severe crisis, such as the COVID-19 pandemic. Many organizations and educational institutions struggle to maintain their operation in the turbulent environments caused by the pandemic, which forces them to be extremely cost-effective [19], and consequently cut budgets for innovation [12]. Indeed, innovation is often costly as it requires spending time and resources on exploration without immediate revenues [35], hiring or training employees, or buying new devices and software. On the other hand, for most educational institutions, innovation in times of the COVID-19 crisis was not intended for growth or improvements but rather for their mere survival as they needed to reinvent themselves to face the new circumstances [19,35]. While this may be

possible for large companies, such as Airbnb or Ford, with their strong brands and "deep pockets", many educational institutions may find it harder to allocate the resources needed for innovation even if their survival depends on it [36,37].

Indeed, the cost-benefit tradeoff is especially harsh on educational institutions, which have been forced to reinvent their educational models, while suffering great financial damages due to limited enrolment and lack government support following the outbreak of the pandemic [5]. E-learning tools and techniques (the most adopted solution) are not without their challenges—the most prominent and relevant of which are accessibility, affordability, and flexibility [38]. Educational institutions were required to develop new E-learning tools, train personnel and students to use them, and ensure that the tools fit the vast array of teaching subjects.

1.1.2. Mashup and Their Advantages

One way to overcome this tension is by using mashups—specifically a mashup of available internet applications—instead of buying or developing full technological solutions. Mashups are defined as products (usually software applications) created by combining existing products into new and useful applications or services that often serve a specific or short-term need [39]. Thus, using mashups—instead of buying, renting, or developing new software solutions—may improve an organization's results in terms of time, money, accuracy, and flexibility [40]. First, even when using methodologies designed to hasten and improve development processes (e.g., agile development [41]), software development is often lengthy and complicated as it requires multiple players, stages, and iterations [42]. Mashing up pre-existing software products can save time as it requires no development or testing time. Using mashups may also be faster than buying or even renting software (e.g., through SaaS) as these involve multiple decision-makers and organizational processes (e.g., testing, budgeting, integration with existing organizational software, etc.). To further ease this process for users and make it easier to develop custom mashup products, numerous mashup-specific development tools have emerged, such as Yahoo Pipes, Microsoft Popfly, and Intel Mash Maker [43]. The latter, for example, is a browser plugin which allows user to integrate data from various web sources, displaying them simultaneously in the same interface and allowing them to interact (e.g., mashing up information from a map website with one from a housing website to find a new home).

Second, while research has pointed to the positive contribution of ICT to companies' performance and growth [44], developing, buying, or even renting ICT solutions can be costly [45], and must be complemented with quality management to yield a positive ROI [46]. Using already existing software products in a mashup approach may be a more economical, and especially relevant, factor in times of crisis events, such as the COVID-19 pandemic. In other words, mashups are a form of "digital recycling", due to their emphasis on using existing software rather than developing new ones. Such "digital recycling" may address the problem of software underuse, which was shown to be a prominent characteristic of poor digital sustainability [47]. Third, research has shown that software development [48], and implementation [49] failures occur quite often in organizations. There are multiple reasons for such failures, such as pressing delivery dates that impact the development process, project scope underestimation, or poor risk management processes [50]. Paradoxically, a mashup solution can improve accuracy in all aspects—including time and need-product compatibility—even though it may seem less accurate than software products developed purposefully for a specific need or use-case. This may be due to the tried and tested functioning, features, and capabilities of pre-existing software, reducing uncertainty and increasing accuracy. Finally, while times of crisis may be significant and have long-lasting consequences on individuals and organizations [15], the mere definition of a crisis event implies that it is relatively short-term. When circumstances change for better or worse, organizations may need to adapt; thus, flexibility is crucial [51]. Since mashup solutions are faster and cheaper, they may also be more flexible and better suited for crisis times.

An important distinction needs to be made between mashups and traditional forms of software integration. Mashups focus mainly on opportunistic integration, stemming from the end user's personal use needs, usually for nonbusiness-critical applications. On the other hand, traditional integrations (such as the Business Process Execution Language) focus on systematic and repeatable enterprise processes. These tend to have a wider set of non-functional requirements, such as the security and reliability of the systems, which make the development of these traditional compositions more complex than mashup solutions [39].

Despite its apparent advantages, the mashup approach is not widely used as a means of innovation both routinely and specifically in times of crisis. It is possible to illustrate this lacuna by examining popular and academic publications. For example, consider the following search results funnel in ProQuest (all source types, all documents types, all languages, searching in "Anywhere, except full text"): "COVID-19"—3,350,861 results, "COVID-19" AND "innovation"—14,684 results, "COVID-19" AND "innovation" AND "solution"— 1799 results, but "COVID-19" AND "innovation" AND "solution" AND "mashup" (or mashup)—0 results.

This possible limited usage and research around the mashup approach are also evident when exploring scholarly publications. For example, compare the following search combinations retrieved from ProQuest in peer-reviewed academic journals (in English, searching in "Anywhere, except full text"): "innovation" AND "software"—16,888 results, but "innovation" AND "mashup" (or mashup)—25 results; "crisis" AND "software"—771 results, but "crisis" AND "mashup" (or mashup)—4 results.

Another way to illustrate the underuse of mashups in times of crisis is by examining Google's "interest over time" in Google Trends (Figure 1). While crisis-related search terms, such as "layoffs", concurrently spikes with the search term "crisis" (for example: during the 2008 crisis or the 2020 COVID-19 crisis), this is not the case with the word "mashup."
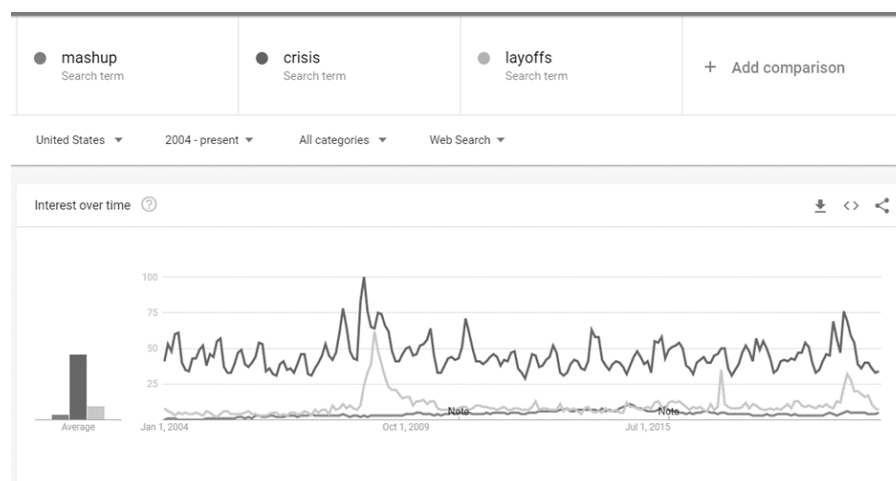

Figure 1. Mashup's 'Interest Over Time' in Google Trends.

In addition, we conducted a pilot study further supporting the above indications of mashup underuse: One-hundred-and-one participants (58.4% female; mean age = 30.33, range = 20–66) from the "Prolific" crowd-working platform were paid to complete a questionnaire. In this questionnaire, we included three items, measuring whether participants: (1) Were familiar; (2) witnessed the use; and (3) used—the mashup methodology. After answering these questions, we taught them about mashups by providing participants a short description of the concept. We also measured the perceived usefulness and ease-of-use of the mashup approach according to participants, followed by a measure of their intention to use it. The results suggest that participants had low familiarity with the mashup concept and had rarely witnessed its use or used it themselves. Additionally, the results indicate that following a short description of the mashup concept, participants judged the mashup

methodology useful and had overall positive attitudes towards it. On the other hand, they did not think of it as easy-to-use, and their intention to use it as a technological solution did not reflect the overall positive attitudes. For a full description of the methods and results of the pilot study, see the Supplementary Materials (S1).

In the current case study, we describe using the mashup approach in an educational context. Specifically, we applied the mashup approach to run a virtual hackathon for educational purposes by practically emulating the critical characteristics of a physical hackathon.

1.1.3. Learning about Mashups through Modeling

Besides the benefits of using mashups from the institutional perspective of educational organizations (i.e., maximizing innovation while minimizing costs and response-time), using this approach may also have pedagogical advantages. In light of the potential importance of mashups as a means of day-to-day innovation in times of crisis and beyond, we argue that future employees and especially managers and innovation leaders, should learn about this approach as part of any entrepreneurship or intrapreneurship training program.

Since entrepreneurship and intrapreneurship are recognized as significant economic drivers of today's economy [52], there has been considerable development of entrepreneurship education and training (EET) programs in academia [53], and organizational settings alike [54]. But not all students, employees, or managers taking part in EET programs will eventually become entrepreneurs or intrapreneurs in the sense of "new venture creation" [55]. That is, not all of them will create new businesses or innovative projects within existing organizations [56]. On the other hand, many of them may still take part in "day-to-day" innovation [57]—a term describing behaviors "aiming at getting things done in an entrepreneurial-innovative and unusual way" [58] (p. 51). "Day-to-day" innovation is a central concept of the "new value creation" [59] approach that focuses on the new value—both big and small—created by individuals, teams, or organizations for other people and themselves. The mashup approach is highly suitable for "day-to-day" innovation [57] as its very definition [39] emphasizes creating new value and getting "things done in an entrepreneurial-innovative and unusual way" [58] (p. 51), without focusing on developing new business.

To this end, using mashups in educational settings may be seen as "teaching by doing", a complementary approach to the well-known "learning by doing" (e.g., [60]) practice in EET. Indeed, one of the main approaches of EET programs is "learning by doing" [61,62], which is part of the broader concept of Experiential education [62]. Experiential education involves "carefully chosen experiences . . . structured to require the learner to take initiative, make decisions and be accountable for results . . . ' [63]. Two examples of "learning by doing" [61,62] are hackathons [62], and internships [64].

Teaching by doing may be seen as a form of modeling, a key element in pedagogy that is lacking in many EET programs. Modeling by teachers, educators or trainers is the process in which they demonstrate different behaviors or skills by behaving accordingly themselves [65]. Research has pointed to the importance of modeling in other domains, such as medical education [66]. When educational institutions' administrations or teachers use mashup solutions to answer educational problems or respond to specific pedagogical needs, they may offer students a model for their own future behavior in organizational settings.

Below, we argue and provide evidence that learning about mashups in innovation and entrepreneurship programs via modeling might increase students' acceptance and willingness to use this approach. To do so, we rely on the Technological Acceptance Model [31,32].

1.1.4. Technological Acceptance Model

The 1970s saw multiple technological advancements in operation systems that would improve organizational effectiveness, yet they were rarely adopted at the time. Most efforts by psychologists at the time failed to produce reliable measures to explain system acceptance or rejection [31]. The Technological Acceptance Model (TAM; [31,32]) was

designed to investigate whether using a specific technological solution affects participants' knowledge and willingness to use it. TAM is an intention-based model for predicting and explaining the use of technology, which is grounded in Fishbein and Ajzen's seminal Theory of Reasoned Action (TRA; [67]). According to TRA, beliefs influence attitudes, which generate behavioral intentions, finally culminating in actual behavior. The theory was then modified and updated to include subjective beliefs regarding the amount of control an individual has in executing an action (Theory of Planned Behavior; [33]). TAM adapts this framework to the use (behavior) of technology, with the ultimate goal of explaining the determinants of technology acceptance.

TAM's innovation—above and beyond the theory of reasoned action—incorporates two direct behavioral intention measures: Attitudes towards the technology and its perceived usefulness. The effect of perceived usefulness on behavioral intention has received various empirical and theoretical justifications [68–70]. Perceived usefulness also indirectly affects intention by affecting the attitudes themselves. An additional indirect factor in TAM affecting behavioral intention is the perceived ease-of-use of the technology, which affects both the perceived usefulness and the attitude towards the technology. In this manner, perceived usefulness can be seen as the cognitive element affecting behavioral intention, while attitude is the affective element [32]. Mathieson compared TAM and the theory of planned behavior as theoretical models for predicting the use of information systems and found that TAM fits the data to a slightly greater degree [71]. Many studies (e.g., [31,72–76]) have affirmed this finding and have shown that TAM offers a reliable prediction of technology acceptance across populations (e.g., students, administrative employees, computer scientists) and technologies (e.g., office-suite applications, safety compliance technologies, software development programs). Of relevance to the current article is a study that found that TAM accurately modeled 131 users' acceptance of a mashup technology [77]. Specifically, the study found that perceived usefulness was the best predictor of user acceptance of a tool that allowed users to integrate multiple different iGoogle widgets (with different functions) into the Google calendar. Even more relevant to this article's focus on mashups for educational purposes, is a different study that utilized TAM to explain students' intention to use a mashup search engine, that allowed students to effectively search for learning materials, while integrating their learning style scores with teaching material category [78].

In the context of using the mashup as a "teaching by doing" solution, we use the TAM as the basis for claiming that the mashup approach itself (as opposed to a complete mashup product) not only functions as a resource-efficient solution to some of the educational problems created by crises, such as the COVID-19 pandemic, but also provides students with the knowledge, tools, and motivation to use it themselves in the future.

2. Study 1—The Case of Running a Virtual Hackathon

2.1. Context

Hackathons, in their traditional sense, are intensive computer-programming events in which groups of programmers and relevant professionals work together over a short period of time to create software prototypes or solve specific challenges [79]. A recent survey showed that the most prominent reason people participate in hackathons is for the purpose of learning, followed by networking and contributing to social change [79]. Interestingly, and of relevance to the current study, hackathons were recently used as experiential education tools. For example, hackathons were used to teach research methodologies [80], and teaching consulting [81], by taking advantage of the real-life simulation aspects of the hackathon method (i.e., intensity, teamwork, and tangible consequences or products). In the following section, we describe using a mashup to run an educational hackathon during the COVID-19 pandemic.

The "Mutual Responsibility" hackathon detailed below was orchestrated as part of the "orientation week" at a private university in central Israel. As such, the 234 participants were all prospective students of a B.A. program in entrepreneurship. Besides the

234 participants, 34 additional people participated in the hackathon as mentors, facilitators, and judges.

The hackathon's stated mission was to explore possible solutions to the challenges brought upon by the emergence of the COVID-19 pandemic, namely: (1) The economic challenge—helping those in need of vital funds, due to either the loss of their own/their spouses' workplace or a pre-existing risk factor (e.g., are holocaust survivors, are disabled, etc.); (2) the community challenge—at-risk populations who suffer from loneliness, due to social distancing; and (3) the business challenge—the many business owners forced to suspend their activity or close down, due to pandemic safety regulations.

The event was set for five hours (15:30–20:30), including the final presentation phase. The schedule was as follows: (1) 15:30–16:00—Opening statements, an explanation as to the various technologies used throughout the hackathon, description of the COVID-19 challenges, overview of the timetable, and instructions for team "ice-breaker"; (2) 16:00–16:30—team "ice-breaker"; (3) 16:30–16:45—instructions on ideation phase and the selection of the leading idea; (4) 16:45–17:30—ideation phase and selection of a leading idea (with help from mentors); (5) 17:30–17:45—instructions as to the proper format for the final presentation; (6) 17:45–19:00—preparation of the final presentation (with help from mentors); (7) 19:00–19:15—short break; (8) 19:15–20:30—the finale of the hackathon, including the preliminary and final judgment of the different presentations and selection of winners.

Due to COVID-19 government regulations, the hackathon did not take place in one physical vicinity. Instead, organizers used a mashup of the various technologies mentioned above to run the hackathon remotely. During the event, participants "moved" between the general meeting room (phases: 1, 3, 5, and 8) to their team rooms (phases: 2, 4, 6).

The hackathon's general format was as follows: Each team chose a challenge to tackle, after which team members began an ideation phase for possible solutions to the challenge. After selecting a leading solution, participants developed it further by focusing on the problem, solution, innovation level, and feasibility. All proposed solutions were then judged first by senior students who led the orientation week. Judgment criteria were: (1) Predicted effectiveness; (2) Feasibility; (3) Uniqueness; and (4) Quality of presentation. The top eight teams pitched again as finalists before a panel of external experts from the Israeli innovation and startup industry. The winning team received a prize of 2000 ILS (approximately 350 USD) to donate to a social organization of their choosing.

The entire event was run remotely using a mashup solution, which integrated the following software applications:

(1) Zoom: A "freemium" video conferencing tool that allows users to host and join video chats (via invitation link) using their browsers, a designated P.C. application, or a mobile application [82]. It allows for screen sharing capabilities, private rooms, and live polling options. Due to its ease-of-use and low network bandwidth requirements, it has become one of the most popular video-conferencing tools throughout the COVID-19 pandemic [83]. As for the relaying of instructions to all participants, the Zoom video-conferencing software was used as a virtual location for the general assembly, in stages (1), (3), (5), and (8).

(2) Google Meet: A free video-conferencing platform provided by Google [84]. Like Zoom, it allows users to invite and join meetings using a designated link and offers screen sharing capabilities. It can be used on a web browser or via a dedicated mobile application. The most important aspect of the hackathon—the face-to-face virtual team communication (for ideation and designing the presentation)—was executed using the Google Meet video-conferencing software. Each team was required to create their unique conference room for their and their mentors' use during stages (2), (4), and (6).

(3) Airtable: A "freemium" (most basic functions are free, while advanced functions require paid subscriptions) cloud-based online platform for creating and sharing relational databases. It allows for the insertion, collection, and organization of numeric, image, and string data in the form of spreadsheet hybrids [85]. Building up to the

hackathon (stage 0), Airtable was used as the primary database for all the relevant information, including participant and mentor lists, descriptions of the COVID-19 related challenges, and the hackathon schedule and timeline. Airtable remained the primary database used by the hackathon organizers, mentors, judges, and participants, which they used to upload presentations, download resources, view the schedule, and display Google Meet conferencing links for each team.

(4) Linktree: A "freemium" social media reference web platform that allows its users to build a landing page for their product/service [86]. This landing page (accessed via a link) contains an easy-to-navigate menu of additional links relevant to the user's product/service. For example, an Instagram influencer looking to give their audience all their relevant links (e.g., Facebook page, merchandise shop, etc.) would represent those links in a single Linktree landing page. Finally, all-important links to the various resources in Airtable—the schedule, the presentation format, team information, mentor information, participant information, description of the three COVID-19 challenges, and submission boxes—were all available on the designated hackathon Linktree landing page.

(5) Whatsapp Messenger: The most popular free-to-use mobile text messaging program in Israel, used by many to communicate with their family, friends, peers, and co-workers. It allows for the instant transfer of text messages and photos, videos, and voice messages, for not only one-on-one conversations, but also group chats [87]. The participants were split up into groups of four, where each group had one mentor, and each mentor had multiple groups. Each mentor was provided with a Whatsapp group that included himself and his mentees to facilitate communication, transfer relevant files and links, and build up ideas before and during the hackathon. Likewise, the hackathon organizers had a designated Whatsapp group with the mentors to relay crucial information before and throughout the hackathon.

In summary and as can be seen in Figure 2, all the technologies mentioned above were utilized as a mashup for the proper execution of the hackathon, including administrative preparation, resource management, information transfer, and horizontal (between participants) and vertical (between participants and organizers/mentors) communication.

2.2. Sample and Data Collection

Three weeks after taking part in the "Mutual Responsibility" hackathon, participants were approached via email and requested to fill out a questionnaire that included the TAM measures and other items meant to measure their general attitudes toward the hackathon. Out of the 234 students that participated in the hackathon, 124 (80 males, 44 females; mean age = 23.77) completed the questionnaire in its entirety (53%). All participants were undergraduate students who participated in the hackathon as part of their "orientation week," preparing them for their first year in the university.

2.3. Measures

Perceived Success: We included four items measuring students' perception of the success of the hackathon and their satisfaction with it. Four additional items were used to measure students' perception of the success of the mashup approach itself and their satisfaction with it.

"Teaching by doing": As aforementioned, the TAM constituted the theoretical basis for testing whether the mashup approach is a good "learning by experiencing" tool. The items used to measure TAM constructs were adapted from previous studies [31,32,71].

All items were rated on a seven-point Likert type scale, ranging from strongly disagree (1) to strongly agree (7). For a detailed list of the measurement items, see Appendix A.

	Platform				
Software:	**Airtable**	**ZOOM**	**Google meet**	**Whatsapp**	**Linktree**
Stage:					
(0) Preparation	Primary database for information in preparation for the hackathon	-	-	Pre-hackathon communication channel within groups and between mentors	-
(1) Opening	Database containing relevant links and hackathon schedule	General assembly: opening statements and explanation of mashup	-	Communication channel between mentors and hackathon directors	Landing page containing relevant links to all information and resources
(2) Ice-Breakers	-		Meeting place for team "ice-breaker"	-	-
(3) Ideation Prep.	-	General assembly: ideation phase instructions	-	-	-
(4) Ideation	Database for uploading of ideas and final selection		Meeting place for team ideation and subsequent selection	-	-
(5) Final Instructions	-	General assembly: final presentation instructions	-	-	-
(6) Presentation Prep.	Database for uploading of final presentation		Meeting place for team preparation of the final presentation	-	-
(7) Break	-		-	-	-
(8) Final	-	General assembly: judging of presentations and winner announcement	-	-	-

TIME (downward arrow along left side of table)

Figure 2. Technologies that comprise the mashup, their use, and a stage-by-stage timeline.

2.4. Results and Discussion

Table 1 depicts the mean scores and standard deviations for each factor, along with the reliability test in the form of Cronbach's alpha. As can be seen, all values are above

the widely accepted 0.7 alpha score. Therefore, in testing our model, we used an index for each factor.

Table 1. Descriptive statistics and reliability test for TAM factors.

Factor	Mean	S.D	Cronbach's Alpha
Satisfaction			
Hackathon	5.59	1.24	0.85
Mashup	5.26	1.23	0.80
TAM			
Perceived Usefulness (PU)	5.64	0.99	0.84
Perceived ease-of-use (PEOU)	5.26	0.96	0.74
Attitude (ATT)	5.50	0.98	0.71
Intention to use (ITU)	5.17	1.13	0.87

As can be seen in Table 1, students' satisfaction and perception of success regarding both the hackathon itself and the mashup approach to it were high. A one-sample *t*-test with 4 (the middle of the Likert scale) as the criterion showed that satisfaction and perception of success w were significantly larger than the criterion for both the hackathon and the mashup, *t* (123) = 14.26, *p* < 0.001 and *t* (123) = 11.41, *p* < 0.001, respectively. In other words, the students perceived the hackathon to be an enjoyable and successful educational experience, coupled with a general feeling of satisfaction and success regarding the mashup approach.

To examine the virtual hackathon's effect on participants' intention to use the mashup methodology, we ran a path analysis using AMOS (for SPSS; [88]), with TAM as our explanatory model. The model was examined in terms of explanatory power (R2) and the theorized individual causal links.

The explanatory power of the model for each construct was examined using the R2 for each dependent construct (i.e., attitude and intention to use). Perceived usefulness and perceived ease of use explained 70% of the variance in participants' attitudes towards the mashup methodology (see Figure 3), with perceived usefulness being the prime contributor to this explanatory power. Perceived usefulness and attitude towards the mashup methodology explained 71% of the variance observed in participants' intention to use the mashup methodology.
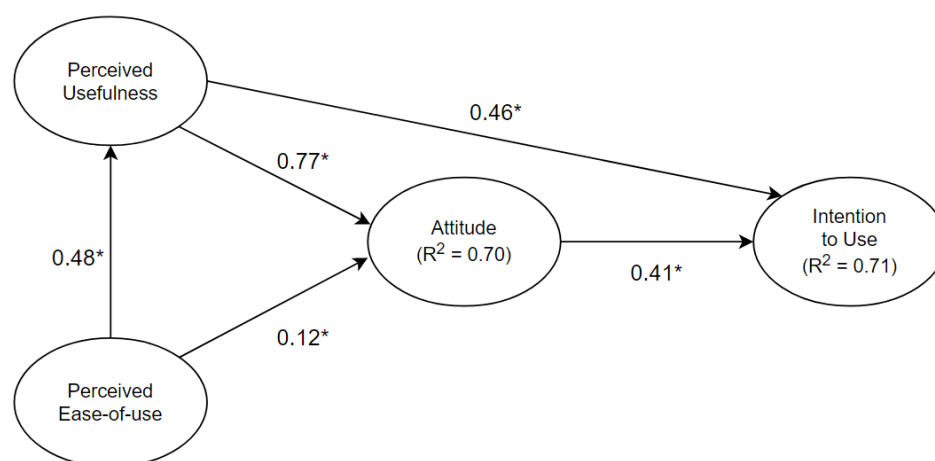

Figure 3. Technology acceptance model—Hackathon case study. * *p* < 0.05.

The path analysis results also supported the theorized causal links between independent constructs (see Figure 3). Perceived ease-of-use had a significant positive effect on perceived usefulness, with a standardized path coefficient of 0.48. Both perceived ease-of-use and perceived usefulness had a significant positive effect on attitude towards

the mashup methodology, with standardized path coefficients of 0.13 and 0.77, respectively. Finally, perceived usefulness and attitude towards the mashup methodology had a significant positive effect on using the mashup methodology, with standardized path coefficients of 0.46 and 0.41, respectively.

All in all, our results show that using the mashup approach to run a virtual hackathon is a successful and enjoyable educational experience, as evidenced by the participants. Furthermore, using the mashup may serve as a model for students, as evidenced by participants' high intention to use it to solve technical problems of their own in the future.

A possible limitation of our study and what restricts our second claim (i.e., using mashups as modeling or "teaching by doing" means) is the lack of a group consisting of individuals who learned about, but did not experience the mashup approach. Another limitation is that the TAM items focused on the mashup methodology, which might have led to a "demand characteristics effect" [89]. That is, participants might have understood the research's purpose and consequently answered accordingly.

3. Study 2

In Study 2, we dealt with the limitations mentioned above by (1) presenting participants with a concrete scenario and more detailed information about the mashup concept; (2) dividing the participants into two groups. Both read about an organizational dilemma in which they were to choose between a mashup or a designated technological solution. Still, while the first focused on the mashup approach (e.g., "Using the mashup methodology can help me complete my project more quickly"), the latter (control group) answered about a designated software solution (e.g., "Using a designated software solution methodology can help me complete my project more quickly").

3.1. Sample and Procedure

Ninety-nine participants (32 male, 66 female, one other; mean age = 26.16, range = 21–52) from the "Prolific" crowd working platform were paid to complete a questionnaire. They read a description of the hackathon concept and its widespread use as an idea generation technique. They were then asked to imagine that their organization was interested in running a hackathon to solve a specific problem. They read that, due to the Coronavirus, running a hackathon in which all the participants are in the same physical vicinity would be impossible. They were then offered two possible solutions to this limitation:

(1)   Use a designated software solution: Buy, rent, or create a single "virtual hackathon" software program that would allow their organization to run the hackathon.
(2)   Use a "mashup" solution: Use a combination of pre-existing software solutions, which are usually used for other non-hackathon-related purposes, to fulfill each of the hackathon steps and adequately run a virtual hackathon.

Following this information and scenario, half of the participants completed a questionnaire based on the TAM items used in Study 1 with the designated solution (1) as the target technology, and the other half completed the same questionnaire with the mashup solution (2) as the target technology.

3.2. Results and Discussion

Table 2 depicts the mean scores and standard deviations for each TAM factor, along with the reliability test in the form of Cronbach's alpha. As can be seen, all values are above the widely accepted 0.7 alpha score. Therefore, we used an index for each factor.

Then, we conducted independent sample *t*-tests to compare the TAM scores of both groups. In general, the scores for all TAM factors were significantly greater for the group judging the designated solution compared to the group considering the mashup solution (see Table 2). It seems that the designated solution is the preferable solution and the one which most people would intend to use. Furthermore, the lowest TAM factor average score was intended to use the mashup solution (3.86). This is interesting because, in the case of our hackathon (Study 1—case), the average intention-to-use score was 5.17. In other words,

it seems that merely learning about the mashup approach did not translate to a high degree of intention to use it, and that utilizing the approach does indeed confer a unique "teaching by doing" pedagogical advantage.

Table 2. Descriptive Statistics, Reliability Test, and *t*-test Between Groups for TAM Factors.

TAM Factor	Designated Solution Mean (S.D) [Cronbach's α]	Mashup Solution Mean (S.D) [Cronbach's α]	*t*-Test
Perceived Usefulness (PU)	5.62 (0.95) [0.88]	4.25 (1.18) [0.87]	6.33 *
Perceived ease-of-use (PEOU)	5.07 (1.08) [0.85]	4.37 (1.18) [0.89]	3.04 *
Attitude (ATT)	5.68 (0.99) [0.85]	4.19 (1.21) [0.80]	6.66 *
Intention to use (ITU)	5.14 (1.07) [0.90]	3.86 (1.42) [0.95]	5.03 *

Note: Degrees of freedom for all *t*-tests = 97. * $p < 0.05$.

4. General Discussion

As aforementioned, crises, such as the current COVID-19 pandemic, accentuate organizations' "innovate or die" imperative [90], often attributed to Peter Drucker. But not all challenges require creating novel solutions, as combining several pre-existing solutions using the mashup approach may be sufficiently and efficiently innovative. In the current article, we used a mashup of different technological solutions to run a remote hackathon under COVID-19 social regulations. In doing so, we aimed to offer students a similar experience to traditional "physical-space" hackathons, a long-used means of experiential learning. Our results showed that the virtual hackathon was indeed perceived as a successful and positive educational experience, thus echoing previous studies on the digitalization of education [25–27]. The students also showed the same appreciation of the mashup methodology used to execute the hackathon itself.

Additionally, we argued that using the mashup approach would provide pedagogical value in itself, as a form of modeling or "teaching by doing". We reasoned that merely witnessing the use of the mashup would increase students' appreciation and intention to use it to solve their own problems. To test whether witnessing the mashup methodology was indeed related to high intentions of using it in the future, we adopted the TAM as our theoretical model. TAM states that technology's perceived ease-of-use and usefulness predict individuals' attitudes towards the said technology, which is related to individuals' intention to use it. Perceived usefulness is affected by perceived ease-of-use and provides a unique contribution in influencing the technology's ultimate use-intention. Our results were significant and consistent with the TAM. They showed that participants' intentions to use the mashup methodology in the future were high and predicted by their attitudes and perceptions of its ease-of-use and usefulness.

An additional study provided further support for this claim, by allowing us to assess participants' intention to use the mashup approach after being offered a thorough description of it. Our results showed that not only are people less likely to use the mashup approach after only learning about it through a written description, but they were also more likely to prefer a dedicated software solution, with all its expenses and heavy use of resources.

In sum, the current article describes running a virtual hackathon at the height of the COVID-19 crisis using a mashup solution. Faculty members used a mashup of five different internet software solutions to create an innovative remote hackathon system, a solution of greater digital sustainability than buying, renting, or developing a designated technological solution [47]. Thus, students learned about mashups by witnessing their faculty using this approach themselves. Our results indicate that this teaching by doing or modeling was far superior to mere instruction about mashups as an innovative approach to deal with crisis-related challenges.

Limitations and Future Research

Although our study does provide a clear example of the relevance of teaching tools for innovation by using alternative teaching methods, a few limitations must be discussed. First, we limited the measurement of how well the participants internalized the mashup methodology to their intentions to use it, but not their actual usage (behavior). This was mainly because the hackathon did not offer participants any conditions to apply the mashup methodology. Although theoretically speaking, studies have shown a robust and reliable relationship between intentions and actual behavior [71,91], future studies should measure actual behavior.

Second, we used the TAM in a rather novel fashion, as we required participants to rate their attitudes not towards one technology, but rather towards a technological approach comprising multiple technologies. While having been validated many times across distinct domains, the TAM has yet to be significantly validated when used in this manner. Thus, although our study does add to the TAM's validity as an intention-to-use technology measurement tool, we suggest future TAM studies explore the domain of multiple technological solutions in more depth.

Third, our hackathon participants were primarily Israeli students between the ages of 20 and 28, all starting a dual bachelor's degree in Entrepreneurship and business management or computer science. Limiting ourselves to Israeli culture restricts our ability to extrapolate to other cultures and peoples. Furthermore, students studying towards a B.A. in Entrepreneurship do not represent other student populations or employees because they may be uniquely predisposed to adopting innovative methodologies and accepting unorthodox educational methods. Therefore, future studies should vary the population used in terms of nationality, culture, age, work experience, and education.

Finally, out of the 234 participants who participated in the "Mutual Responsibility" hackathon, only 124 volunteered to participate in the research. This pattern could cause a self-selection bias [92]. Therefore, future studies should control this bias by either requiring all participants to participate in the research or comparing their samples with general population data on any possible variables of significance.

5. Conclusions

The need for and benefit of innovation in crisis times has given rise to a myriad of tools and techniques aimed at promoting and facilitating innovation. While many innovations require the creation of novel products or services, others are less wasteful of resources. One such tool, the mashup approach, has been regularly used as an innovative, resourceful, and digitally sustainable solution, yet is relatively unknown to the public. This public anonymity is especially salient in times of crisis, such as the COVID-19 pandemic, which requires societies and organizations to be efficient with their resources. Entrepreneurship education and training programs have shown us that the mashup approach's anonymity can be dealt with by actively teaching students about it. Our case study, by examining the attitudes and intentions of students, offers empirical evidence supporting this claim, in addition to showing the benefits of using sustainable digital solutions as opposed to digitally "wasteful" ones as evidenced by students' satisfaction. Finally, it adds to the entrepreneurship education literature by showing that modeling is not only an innovative educational problem-solving tool, but also an advantageous teaching methodology (compared to only "teaching about") to increase people's likelihood of adopting innovation tools and techniques. Digitally sustainable solutions, it seems, are becoming paramount not only in the realms of sustainability, but also in innovation and education.

Appendix A. Measurement Items

Perceived Success

(1) I enjoyed the hackathon event.
(2) All in all, I'm not satisfied with the hackathon event.
(3) All in all, I feel that I've learned a lot throughout the hackathon event.
(4) I do not think the hackathon was executed in a proper fashion.
(5) I thoroughly enjoyed the use of the mashup approach throughout the event.
(6) All in all, I'm not satisfied with the use of the mashup approach throughout the event.
(7) All in all, I feel that I've learned a lot by using the mashup approach throughout the event.
(8) I do not think the mashup was executed in a proper fashion.

TAM

Perceived Usefulness (P.U.)

(1) PU1: Using the mashup methodology can help me complete my project more quickly.
(2) PU2: Using the mashup methodology CAN NOT improve my ability to complete my project.
(3) PU3: Using the mashup methodology can raise my productivity when completing my project.
(4) PU4: Using the mashup methodology CAN NOT improve my efficiency when completing my project.
(5) PU5: Using the mashup methodology can make the completion of my project easier.
(6) PU6: Using the mashup methodology IS NOT useful for the completion of my project.

Perceived Ease of Use (PEOU)

(1) PEOU1: Learning how to use the mashup will NOT be easy for me.
(2) PEOU2: It is easy to use the mashup for the completion of my project.
(3) PEOU3: My interaction with the software programs comprising the mashup will be clear and understandable.
(4) PEOU4: I find the mashup INFLEXIBLE to interact with.
(5) PEOU5: It is NOT easy for me to become skillful in using the mashup methodology.
(6) PEOU6: I would find the mashup methodology easy to use.

Attitude (ATT)

(1) ATT1: Using the mashup methodology to complete my project is a good idea.
(2) ATT2: Using the mashup methodology to complete my project is UNPLEASANT.

(3) ATT3: Using the mashup methodology is beneficial to the completion of my project.

Intention to Use (ITU)

(1) ITU1: I intend to use the mashup methodology in order to complete my project as soon as I can.
(2) ITU2: I intend to use the mashup methodology in order to complete my projects as often as needed.
(3) ITU3: I intend NOT to use the mashup methodology in order to complete my projects routinely.
(4) ITU4: Whenever possible, I intend NOT to use the mashup methodology in order to complete my projects.
(5) ITU5: To the extent possible, I would use the mashup methodology to do things differently in my project.
(6) ITU6: To the extent possible, I would use the mashup methodology frequently in order to complete my projects.

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