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RESEARCH ARTICLE

A Makerspace walks into a high-school: a case study of the micropolitics of school reform

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Abstract
Adoption of Maker programs entails deep cultural and structural changes within schools. In this case study, we interviewed a principal and seven faculty members in a high school in the United States, after the first year of implementing making-centered curricula. We report how faculty members responded to the reform, their motivations and beliefs, and the concomitant shifts in power and status. We found that educators are required to make non-trivial adaptations to their skills, instructional approaches, and pedagogical beliefs, and that successful adaptation may lead them to gain status, resources, and support within the school. Those are gained on account of technical expertise and educators' efforts to promote the vision of the reform. The extent to which faculty members adapt to a reform, accommodate and support others in their process of adapting, or resist it, may determine whether the reform is successful or not. As such, school leaders face the challenge of encouraging faculty to buy into such reforms. The case study provides a unique perspective on Maker-centered reforms and outlines important implications for administrators seeking to implement similar programs.

Keywords Maker education · School reform · Reform implementation · School micropolitics · Case study

Introduction

Maker programs have arrived in school settings, often re-configuring previous computer labs, libraries, or wood shops. Before their spread into schools, Maker initiatives were more commonly found in informal learning environments, such as museums and community organizations, where formalized structures and norms—such as staff hierarchies and curricular standards—tend to be fluid or nonexistent (Taylor, 2016). The passage from such informal domains to the highly-structured environment of a K-12 school has not always been seamless.

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Scholars have documented the challenges that arise when schools decide to implement novel, technology-rich pedagogies (Campos et al., 2019; Rouse & Rouse, 2022; Weiner et al., 2021). Maker programs, in particular, make infrastructure demands, such as the larger blocks of time to conduct Maker activities as well as human and capital resources to build and maintain Makerspaces. The human resource need applies both to the *technical expertise* needed to run Maker activities and to *socio-cultural factors* in the organization, such as support for internal and external partnerships and knowledge-sharing (Godhe et al., 2019; Halverson & Sheridan, 2014). Tensions may also arise due to leadership and implementation factors, such as favoring technology-based curricula over other activities at the school (Vossoughi et al., 2016). Finally, differences in *pedagogical beliefs*—such as to the role of the instructor and the amount of supervision—might also give rise to tensions between newly implemented programs and existing structures within a school (Campos et al., 2019; Weiner et al., 2021).

Several benefits have been associated with Maker Education in K-12 settings. For example, it has been argued that students who engage in Making are more likely to develop science self-efficacy, or an inclination towards science-related careers (Chu et al. 2017), and to develop soft skills such as collaboration, creativity, and critical thinking (Bergner et al., 2019; Taylor, 2016). Most of the extant research on Making, however, has focused almost exclusively on practices, activities, and individual outcomes promoted by school-based programs (Litts, 2015; Rouse & Rouse, 2022) without providing robust evidence of how Maker pedagogies affect real-world schools and education systems. In this respect, few empirical studies have ventured beyond optimistic projections for students to include organizational factors such as the role of school leadership, challenges to faculty buy-in, and potential tensions involved in the implementation of Maker programs.

In this study we bring together education reform and Maker education scholarship to investigate (a) how teachers react to the introduction of a Maker program at their school and (b) how the introduction of such a program affects power dynamics in the school. To answer these questions, we conducted an instrumental case study (Stake, 1995) focused on eight high-school educators involved in the launch of a Maker Education program at UCHS, an all-girls school in a northeastern city in the United States. Our interviews depict a complex scenario, in which the launching of the program required educators to undergo profound changes to their roles, practices, pedagogical approach, and perspectives.

Background

Maker Education designates a broad variety of pedagogical approaches, typically centered on collaborative, technology-enhanced activities (Halverson & Sheridan, 2014; Kajamaa & Kumpulainen , 2019). Such activities, although occurring in flexible arrangements, often involve the use of a particular set of digital fabrication tools, such as 3D printers, laser engravers, electronic micro-controllers, and programming blocks (Chu et al., 2017; Martin, 2015), as well as practices, such as project-based learning, open sharing of designs, and collective "debugging" of one's creations. Making is also associated with a set of cultural norms and values, especially learning by doing and learning by having fun (Clapp et al., 2016; Dousay, 2017; Papert, 1999; Taylor, 2016).

Maker pedagogies have been described as a cross between Social Constructivism and Constructionism (Blikstein & Worsley, 2016; Papert & Harel, 1991), implying that knowledge is socially constructed by students and instructors, who create and share physical or

digital artifacts and their creative processes (Halverson & Sheridan, 2014). Papert (1980), often credited as the first proponent of Maker Education, defined such artifacts as "objects-to-think-with" (p. 11), or artifacts that allow one to reflect, develop an interest towards and, ultimately, learn from.[1]

Maker education: from programs to communities

Among the various characteristics of Maker Education, this study pays particular attention to *community building*. Several scholars have examined how building and growing a community within and outside a Maker program is key to achieving its goals (Litts, 2015; Marshall & Harron, 2018; Sheridan et al., 2014). Santo et al. (2015), for example, found that participation in an active network of organizations, educators, and learners played a crucial role in "inspiring, validating and orienting towards maker education" (p.9). Similarly, Sheridan et al. (2014) conducted a comparative case study of three Maker programs, finding that being a "maker"—either on the learner or instructor side—involved not only using tools or devising innovative creations but, perhaps most importantly, "becoming a member of a community; taking on leadership and teaching roles as needed; and sharing creations and skills with a wider world" (p. 529).

But how are Maker communities established and grown? The literature points to three ingredients: identity building, legitimate peripheral participation, and technical expertise. First, identity is described as a bonding element among participants in a Maker program that gives direction, fosters engagement, and shapes practices (Hughes et al., 2022). Writings on Maker Education contain a handful of terms associated with such identity factors, often described as a "maker mindset" (Dougherty, 2013), including: a playful and joyous attitude toward learning (Martin, 2015); eagerness to engage in hands-on activities (Dousay, 2017; Papert, 1999); openness to learning from failure (Martin, 2015); and a "can-do spirit" (Clapp et al., 2016). The process of identity building is often challenging and even destabilizing for teachers and students (Becker & Jacobsen, 2021). That said, Litts (2015) observed that there is a shortage of empirical research examining the common identity elements among those who participate in making and how such elements manifest in a K-12 environment.

The second key element for community building is the idea of legitimate peripheral participation (Lave & Wenger, 1991), which describes the journey of novices from the periphery of a community to its inner circles. This trajectory towards mature practices and full participation is marked by situated learning experiences and involvement in social and cultural practices of the group. When new members join, they are presented with simpler, peripheral assignments that introduce the group's social norms and cultural aspects, such as vocabulary, expectations, and beliefs. With more participation in peripheral practices, novices gradually become acquainted with old-timers' ways of doing, knowing, and learning. Such successive movements towards full membership are the key mechanism through which communities of practice (CoP) grow and evolve (Wenger, 1999). Several scholars have associated this CoP model with Makerspaces. For example, Halverson and Sheridan (2014) maintain that Maker Education programs are communities of practice centered

[1] Constructionism owes a somewhat unacknowledged intellectual debt to Dewey, who, in 1899, drew attention to "the instinct of making–the constructive impulse...shaping materials into tangible forms and permanent embodiment... There is no distinction between experimental science for little children and the work done in the carpenter shop" (Dewey, 1990, p.60).

around "a physical place set aside for a group of people to use as a core part of their practice" (p. 502) Likewise, Rouse and Rouse (2022) argue that several Maker programs are intentionally designed to offer entry-level activities to novices, who are then gradually conducted to inner levels of the community.

A third element of Maker community building is technical expertise, also called *craft* (Marshall & Harron, 2018). While manually operated tools (e.g.; drills and saws) can also be found in them, modern Makerspaces are predominantly characterized by digitally-controlled tools like 3D printers and micro-controllers (Martin, 2015). Crafting with these tools includes learning not only the hardware but also computer-aided design applications, tasks that are not always straightforward and often described as a learning challenge for the whole group to solve (Sheridan et al., 2014).

Where do these three concepts interconnect? First, Jones et al. (2021) posit that activities performed at a Makerspace (both the nature of the processes carried out and the type of products or projects carried out) play a central role in forming and shifting identities in a community of maker educators. In essence, making is what makes a maker in a technology-oriented community of practice. Second, possessing and *brokering* practical knowledge about Maker tools and techniques is a currency that affords a central status in a community. According to Wenger (1999), brokering is carried by individuals who facilitate connections and knowledge exchange between community members. Technology brokers—or "stewards" (Wenger et al., 2009)—have a deep understanding of the community's goals, practices, and values, and play a fundamental role in helping members navigate the community, connect, and develop a shared identity.

Re-making a school

The education reform field has documented numerous cases where buy-in from school faculty could make or break a new school initiative (Cobb & Jackson, 2012; Datnow, 2000; Little, 1995; Malen & Cochran, 2014; Tyack & Cuban, 1995). Principals are typically tasked with envisioning, communicating, and securing the compliance of teachers towards a new program. Datnow (2000) foregrounded how such directives are received by others, including "advancing reform efforts, symbolically displaying reforms, or resisting them overtly or covertly" (p. 358). Differences in viewpoints toward the reform may be related to an individual's ideological stance as well as their position in the social system of the school. Some differences may get resolved through negotiated meaning-making. These negotiations, however, have their limits. When principals are the initiators of a reform, "staff often reported being strongly encouraged to go along with the principal's reform choice" (Datnow, 2000, p. 365). To understand how change is implemented or resisted in a school, it is not enough to look at individual-level buy-in. A reform effort often brings about micropolitical interactions (Datnow & Stringfield, 2000) and programmatic repurposings (Cobb & Jackson, 2012) of existing practices in the school.

Research on schools' micropolitical landscapes has revealed how internal—and sometimes invisible—"micro power" processes can either facilitate or frustrate the implementation of reform (Malen & Cochran, 2014; Kapoor, 2004). Under this view, schools are small yet complex political systems, influenced by broad sociocultural forces, where actors exercise power in various ways over "competing demands, chronic resource outages, unclear technologies,... and divisive allocation choices " (p. 4). This phenomenon has been thoroughly studied by Little (1995), who described schools under extensive reform initiatives and changes in leadership as "contested grounds". In this context, numerous defense

mechanisms may arise to resist or subvert an original reform idea (Papert, 1997; Spillane, 1998; Tyack & Cuban, 1995), and alliances are key for both implementation and resistance. Malen and Cochran (2014) found that principals often deliberately handpick a group of faculty and staff who share similar beliefs to either facilitate implementation or suppress resistance to change. Teachers, on the other hand, tend not to publicly voice their discomforts within a school, often fearing to fall out of favor with leaders and colleagues (Datnow, 2000). But they may still try to resist or override decisions that are not in accordance with their beliefs.

In the following sections, we delve into the mechanisms by which certain teachers, amidst an all-embracing reform initiative, gained status through enacting a Maker *identity* (i.e., showing a vision aligned with the school's) and developing (or brokering) *crafting* skills.

Methods

Context of investigation

The Urban Catholic High School (UCHS; pseudonym) is a private, all-girls, Catholic high school located in a large metropolitan city in the United States and serving predominantly African-American and Latina students. UCHS leadership led a school-wide effort to promote science, technology, engineering, and math (STEM) education during the two years leading up to this study. This effort, spearheaded by Cecilia, the new principal, included the creation of a school-based Makerspace and the introduction of classes and programs. To support the initiative, Cecilia formed a "Tech Team" of four faculty members acting as the driving force of the reform. Furthermore, she established partnerships with several organizations, such as non-profits, technology companies, and the authors' home institution. Using these connections, especially MakerSchools (pseudonym)—a non-profit that supports schools in implementing maker curricula—she secured equipment, materials, professional development, and access to out-of-school programs.

Study design

This instrumental case study (Stake, 1995) was conducted between March and June of 2018, at the end of the first year of program implementation, and focused on the experiences of educators. Therefore it does not include data from students or faculty not directly engaged with the program. We opted to use instrumental case study as the research methodology to explore the issues that school leaders or faculty may face when adopting a Maker program into the school. Specifically, our study focuses on a) how teachers react to the introduction of a Maker program at their school and (b) how the introduction of such a program affects power dynamics in the school. We use the case of BCHS to shed light on these issues.

Participants

The relevant faculty identified for this study included the school principal and the four members of the Tech Team. We also asked our interviewees who else we should talk to

Table 1 Study participants

Participant	Role	Subject
Cecilia	Principal	–
Amir	Tech team	Makerspace class
Milo	Tech team	Robotics, unity, cyber security
Serena	Tech team	Robotics
Carlos	Tech team	Design, engineering
Jasmine	Teacher	Business
Dylan	Teacher	History
Marie	Librarian	–

(i.e., snowball sampling) which led us to speak with two teachers who incorporated Maker activities into their Business and History classes and with the school librarian (Table 1).

Data collection and analysis

In this study, data collection included conducting semi-structured interviews (Rubin & Rubin, 2011). Since the case involves educators with varying responsibilities and points of view, three interview protocols were used: one for the principal, one for the Tech Team members, and one for other faculty members. Interviews lasted 30 to 75 min, with more time spent with the Tech Team and the principal. All interviews were recorded and transcribed for analysis.

The first two authors of this paper conducted two rounds of coding of all transcriptions, observation and interview notes using qualitative analysis software. In the first round, we engaged in topical coding, in which we organized passages into the topics without using a predetermined coding scheme (Richards, 2014). We compared each individual coding scheme and discussed how the process changed our understanding of the case. We then incorporated the third author to review the outcomes of the initial round. These additional discussions served to reduce potential biases, add the perspective of the third author, and plan the second coding round. Further exploration and grouping of these initial codes led us to decide that the focus of the second round of coding should be on the *actions* that the educators we interviewed described taking in reaction to the Maker initiative and their underlying *motivations* and/or *beliefs*. Motivations were grouped based on whether they were positive or negative (valence) and who gained from them. For example, "motivation–students" was used when interviewees explained they took an action to benefit students and "negative consequences for others" was used when teachers described actions taken to prevent students from being adversely impacted.

In one excerpt, the school principal explained the following:

> We had one room up and running and doing professional development for teachers. And the reason why you have to do P.D. first is anything will fail if you don't have the teachers feel comfortable with the projects and what the capabilities are.

The above excerpt was coded for the action "accommodating others to foster change" and the motivation "to benefit the school or the program". In this round, coders had flexibility to infer intentions and draw connections within the data. To maintain the integrity of the process, we created analytic memos whenever interpretations were involved. We coded

each segment for all motivations and actions it included since actions reported by the interviewees often had more than one motivation. When no clear motivation or belief could be devised, we coded "no motivation/belief". We then compared results and discussed any disagreement until consensus was reached for all excerpts that differed on at least one code.

Researchers' perspective

Two of the authors of this paper had been involved with the school community, providing pedagogical advice to the Tech Team when appropriate. In recognition of the biases such familiarity can introduce, the second author was invited to participate in the analytic process, ensuring that at least one author had only the data to rely on when coding, analyzing, and writing the case. We believe this measure was instrumental in mitigating potential biases brought by our involvement with the school community.

Findings

In our analysis, we identified a spectrum of teachers' reactions to the transition, ranging from extensive efforts, including adoption and active promotion of the reform, to narrower efforts, such as aligning with the Maker vision and making limited accommodations in support of it. Less enthusiastic reactions included (mere) compliance, disregard, and resistance.

We grouped our codes into several themes to support the analytic process. Those included adaptation/growth, accommodating others, advocacy/brand fluency, compliance/towing the line, resistance, and shallow implementation/window dressing. Though these themes supported us in analyzing the interview data, we believe that unfolding the individual stories of the various participants reveals more about the complex set of motivations and constraints those involved needed to navigate.

We unpack the findings by focusing first on the actions and reactions of individual faculty members, starting with the inner circles of the reform and moving outwards, and then moving on to explore broader themes that emerged in the analysis.

A principal-driven reform

To launch her reform vision, one of principal Cecilia's first steps was to form the Tech Team, which included four teachers: Milo, Carlos, Serena, and Amir. At the same time, Cecilia also recruited several external partners. First, support was provided through pedagogical consultation by two of the authors of this paper, working mainly with Carlos. Second, MakerSchools provided curricula, materials, and coaching for teachers, going as far as joining the Tech Team's weekly meetings and one-on-one mentoring. Other external supports included fundraising, receiving equipment and materials, having students and teachers participate in out-of-school workshops and summer programs, and bringing content experts on technology-related topics. Cecilia emphasized the importance of these support structures, including professional development (PD) opportunities, time to self-teach a skill or a subject matter, and weekly Tech Team meetings to discuss the curriculum and its implementation. (Though most of these support structure were directed towards the Tech Team, the broader faculty also had access to at least a portion of these resources.)

According to her: "The reason why you have to do PD is that anything will fail if you don't have the teachers feel comfortable with the projects and what their capabilities are. "

In our study, Cecilia's efforts to secure alignment with new beliefs were at least partially successful. The vision she put forward was often echoed by interviewees, specifically: making and showcasing tangible products lead to more effective learning; schools should prepare students for the job market and for a digital future; and early exposure to STEAM subjects leads to long-lasting interest in STEAM careers. Another belief championed by Cecilia was the idea of Making as a service to others. When first introducing the program to the faculty, she screened a heartfelt video of a child receiving a 3D printed prosthetic arm and said: "Let's be of service to the world. Let's use technology for social good... in a productive way that helps others ". She recounts: "I think the buy-in was pretty simple and the enthusiasm of some of the teachers was contagious because they were so excited about it. "

The tech team

The Tech Team was the first group to adopt and/or accommodate the new Maker initiative. Some also went beyond to actively promote the vision of the reform within the school.

Amir was coaching the school's track team when the principal approached him about becoming the school's first Makerspace manager and teaching a Maker class. He was at first "kind of taken aback by [the changes]. " Grasping the opportunity to grow his responsibilities in the school and to learn skills that might help his career in the future, however, he "sooner or later began to realize why [Cecilia] chose [him]. " Amir understood that his previous experience as a sports coach provided him with tools to support student collaboration in the Makerspace, an important ingredient in the Maker education playbook. For Amir, the skills for operating 3D printers had to be learned simultaneously with those of teaching. Fortunately for him, he was given time and resources to learn. Amir shared that initially he ran a pilot class where "It was mostly me learning about machinery and software and then barely introducing it to the girls and the faculty... I would kind of do a mock class just for myself and I would take notes on how to correct myself ". He added: "you're sitting here for eight hours a day. You do a lot of learning about it yourself and how to teach the students properly. " To provide him with additional guidance and support, Amir would regularly meet with the rest of the Tech Team and with external partners to discuss the pedagogy and technology he implemented in class.

Serena holds a degree in engineering and had worked as UCHS's information technologist. During the reform, she became the Robotics teacher and joined the newly formed Tech Team. She shared: "I was asked if I would go into teaching when I was leaving college and I said no. " Nonetheless, Serena had high hopes for the program and spoke with conviction:

> We have to be lifelong learners, right? You don't want to stay stagnant, not in this technological society, because things go obsolete real quick. Being in this environment is an opportunity to learn and grow. Not only for me to learn and grow but to share what I know and what I'm learning with the kids as well and prepare them for the future because they are tomorrow's innovators.

Serena's sentiment about growth opportunities and technology is a common refrain of Maker enthusiasts and hints at an adaptation of beliefs, alignment of identity, and the development a certain fluency in concepts and ideas that are on brand with avid Maker educators.

In comments surrounding the above quote, Serena managed to cover a wide range of beliefs, including the role of schooling, the future of the job market, of technology, and the ability to leverage Maker education principles to transform students into entrepreneurs and innovators. While Amir's perspective did not point as clearly to the development of a Maker identity, he clearly saw the value in the creation process, saying "you see the change in [the students] because they see how fun and rewarding it can be. Because you're getting something out of nothing. It's being created by your ideas and your imagination and now it's in your hand. "

Amir and Serena reported building their skill sets not only in digital fabrication but also as classroom teachers employing Maker pedagogy. Their motivations appeared to include both how beneficial the new program would be for students and how they would benefit themselves from growing in these directions. In their newly minted roles teachers, both Amir and Serena saw that honing their craft and developing their identities as Maker educators would improve their status within the school.

Milo, another Tech Team member, did not have to reorient as much as Serena and Amir. Prior to the reform, he taught Introduction to Computers and was in charge of the schools technological infrastructure. After the start of the program, Milo started teaching Programming and became involved in Serena's Robotics class as well. Matthew is likely the most tech-savvy faculty member in UCBS and as such he was given a central role in the reform right from the start. He described how he "made a floor plan of how the [Makerspace] might look and presented it to Cecilia. "

Carlos, a math teacher and former cabinet maker, was also significantly and favorably impacted by the reform. Within the new program, Carlos was given domain over his own in-school wood shop and the mandate to design two new classes (Fundamentals of Design and Fundamentals of Engineering), along with the role of Technology Integration Specialist. He recounted: "I spent my life making things. The opportunity to share that knowledge with [my students] is an incredible gift to me at this point in my life. " He contrasted teaching the new classes to his recent experience teaching Geometry:

> It got to a stage last year... when no matter what I was doing I wasn't seeing the results that show that I was effective. [Students] weren't buying into what I was doing. Over here they're buying into it. And when they're buying into it, then they're enthusiastic, they don't want to leave the class is what it's coming down to. I tell them "Ladies, you have to go to your real classes now."

Milo and Carlos are experienced teachers and advanced in their respective crafts—Milo in computing and technology, Carlos in design, engineering, and woodworking—and the opportunities brought up by the new program were well within their comfort zones. Their knowledge and experience were potentially the reason they were given freedom to design their own classes while Amir used a curriculum provided by MakerSchools.

Aside from adapting to meet the needs of the reform and adopting maker pedagogy into their classrooms, several members of the Tech Team also became active promoters of the reform. However, getting other teachers on board was not as simple. The Tech Team reported prompting other faculty to familiarize themselves to the new capabilities and opportunities afforded by the Makerspace, explaining how those can be incorporated in their classes, providing technical support, and sharing the promises of the Maker education. When referring to these promotion efforts, Amir described it "like ramming it down their throat. So that's what we were doing but they've gotten more involved with what we're doing ".

Beyond the inner circle

Members of the Tech Team—motivated both by belief in the reform vision and the personal benefits that came with it—demonstrated a firm commitment to adopt the new program in a meaningful way. Teachers outside of this group, however, were not as well-supported in acquiring the skills to fully adopt the program, and those who wanted to engage with it had limited ways to do so. The main types of engagement included touting the potential benefits of the program and sharing class time with the Tech Team in an attempt to integrate Maker activities into different subjects.

Dylan, the History teacher, saw the Maker program as an opportunity to show support to the new principal in creating a new school culture. After the initiative was announced, Dylan recalled he was "definitely encouraged by the principal. [Not] a declaration saying "this is what we're going to do " but rather a school culture instead of something that is formally mandated or written. " He added that:

> It's the attitude of the new principal. She's initiating all these programs, and as a new teacher I'm kind of just going along with it. I don't know what was before this because this is my first year [at the school]... You know, everything is tech, and it just seems appropriate.

Jasmine, the Business teacher, also embraced Cecilia's vision. She saw the reform as an "opportunity to get a different skill set... it allows our students to be better prepared for college and hopefully their first internship or part time position ". Both Dylan and Jasmine were well-versed in the promises of the Maker program. They also went beyond words and worked with the Tech Team to integrate Maker activities into their classrooms.

Touting the benefits of the reform and opening their classroom doors to integrate Maker activities into their classes are actions that can be viewed as forms of legitimate peripheral participation within the nascent UCHS Maker CoP. While Dylan and Jasmine don't go as far as learning the skills required to operate the digital fabrication tools in the Makerspace or to assume a Maker identity, they accommodate the reform and model ways in which other faculty could be part of it. Though creating meaningful Maker experiences was a goal pursued by all teachers involved with the program, technical expertise, pedagogical knowledge, and depth of activities were major challenges. This was especially evident when considering how Making was integrated by Dylan and Jasmine. The next subsection expands on those experiences.

Tensions and challenges in meaningful curricular integration

One critique of Maker programs is that the mere appearance of excitement on students' faces is touted as evidence of the initiative's success. In Serena's words, "the fact that I see the girls are excited is a success in my view. ". While excitement about learning is better than the alternative, it does not prove that meaningful learning goals are being met. In the Maker education literature, Blikstein (2013) coined the term *keychain syndrome* to describe over-reliance on exciting-but-not-educational activities where students are more enthralled by the final product and less focused on learning about the fabrication process. At UCHS, the first attempts Jasmine made to incorporate Making into her Business class were developing bracelets, stickers, and keychains—projects that are quick to execute and have a high probability of success, but require little input from learners. Jasmine seemed to

recognize a short-coming in the student experience: "We were given a design of the bracelet, so the only thing for the students to decide was really the color. So there wasn't a lot of input for them to give. " With respect to other lessons, Jasmine explained, "Milo generally would present the topic and then give step-by-step instructions ". Jasmine's tone reinforced the view that students experienced a lack of agency in some activities.

Concerns with the limited agency of students became more prominent when a time-sensitive project was launched to design a gift for the school's alumni. A decision was made to engrave the school logo on wooden coasters. According to Amir, the students didn't choose what they would be working on but instead "[Jasmine]'s the one that came up with the idea for the coasters and that's having a huge impact on the kids ". Jasmine acknowledged that "The girls felt that they were left out of the decision making process. " To make matters worse, the production of the coasters themselves was another missed opportunity to engage the students in learning by doing. In fact, there were several technical challenges to making the coasters. However, concerned about the time pressure of the upcoming alumni event, teachers experimented themselves until arriving at a solution without involving students in the debugging processes, a central activity in Maker pedagogy (Peppler, 2022). From Carlos's perspective, the project was an "interruption " where faculty and students "were cranking out the coasters [in] a production setup ".

Another tension arose from the gap in knowledge teachers outside of the Tech Team had in Making practices and pedagogy. Consider how Jasmine described her role in the program: "When we're in there [the Makerspace], Milo is the teacher... I took no leadership role in it. " When asked about her level of comfort teaching in the Makerspace, she reiterated: "I was fortunate that I didn't have to teach it... So I sat in like a student... The girls picked it up one, two, three and then they helped me bridge the gap, so that I was at their level. " Jasmine placed herself in the same position as her students. This perceived lack of agency may have affected her ability to meaningfully integrate Maker activities in the business class.

Perhaps it is not surprising the the more prominent examples of shallow implementation originate from classrooms in which teacher were not as experienced, lacked technological knowledge, or felt the need to 'play along' with the plan of the new principal as Dylan shared.

Carlos, who demonstrated the deepest Maker pedagogy knowledge among our interviewees, directly criticized the way Maker activities were incorporated in some classes:

> I could see obvious applications for sciences... I don't see the obvious applications in the Humanities, in English and in Social Studies. Most of the stuff we come up with are gadgets or gee whiz sort of things that don't really pertain... It's like *window dressing* rather than substance... And now there's this push to use it... I'm still waiting for somebody to come along with something that shows a genuine integration into a curriculum.

Our observations corroborated Carlos's argument that aspects of implementation were mere *window dressing*, in which simple and often shallow activities were showcased as genuine curriculum integration. One example is how 3D printing was incorporated into the Global History class. Students were directed to choose a castle or a cathedral that Amir printed for them to take home. As pointed out by Dylan, the goal of the activity was to use printed objects to discuss their architecture more concretely and to create a more a memorable learning experience. From Carlos's perspective, however, this experience came nowhere near meeting that goal: "It's almost like a Christmas ornament... What did they learn about the construction of cathedrals? "

Several participants mentioned these concerns and listed them as one of the reasons some faculty members were hesitant to engage with or even resisted the reform. Before we move on to discuss further the reactions that were unsupportive of the reform, we report on one belief that seemed to pervade many of our conversations and undergird several teachers' motivations to adopt and implement the reform.

A unifying ideal: technology as the great equalizer

For teachers who could not easily adopt Maker practices, one way to accommodate the new program was to embrace the discourse around its benefits to the school and the students. We noticed one particular narrative emerge from many educators: that early exposure to Maker technologies would support socioeconomic and gender equity. Students at UCHS were predominantly Black or Latina girls from a low- to mid-income families. Cecilia stressed that STEM careers were not typically on their radar: "[Some students] would never know to think about engineering schools. If you want to be an engineer you're not just going to plop down when you're 23 and say "I'm going to be an engineer now. " You could, but it will be so much better if you have the exposure early on ". Cecilia mentioned that programs that include content such as 3D printing "would help bring digital equity " and gender equity in subjects like math, and added that:

> The idea is that, whether you like it or not, it's something that's going to be really important as a tool for you throughout your lifetime. So not to feel as though that this is a barrier to you. The same would be true for any STEAM topic that it's available to you... you know how to use it.

Other interviewees also pointed to exposure and access as possible solutions to matters of equity. Milo voiced a concerned with "how you change the culture [in computer science or robotics classes] so that girls are welcome, " and Dylan added that he believed that, thanks to the changes in the school, "the students are now receiving an education that is on par with other great schools in the city. You know, technology is the great equalizer. "

Resistance and marginalization

Though most reports about the new Maker program were positive, almost all interviewees mentioned some measure of resistance to it. When we first interviewed Cecilia about her faculty's reaction to the reform, she said that there were "no teacher barriers at all ". However, when asked how teachers felt about the changes, she acknowledged some discomfort:

> I don't think all teachers feel comfortable, but I think they work through that. I think experiencing it themselves gave them a greater sense that you don't have to be an expert at something. The kids will probably surpass you in a couple of weeks and you just have to get used to that.

Accounts from other interviewees conflicted with the principal's description that there was "complete buy-in " from faculty. This resistance became more evident when Amir shared that the Tech Team "had to do a lot of pushing. " But how did resistance to the new program manifest in the school? Our interviews showed that teachers may resist change silently, ignoring new directives, or openly, by questioning whether their current practices, motivations, and pedagogical beliefs fit those proposed by the new program.

Silent resistance and distrust in the reform

Milo, a central member of the Tech Team, brought some light into how change was silently resisted by the general faculty: "Change can be difficult if you don't know what to expect. A lot of the teachers were doing things one way and then all of a sudden now they're expected to do things a different way. " A similar description was given by Dylan, the History teacher:

> Using technology in the classroom is something that veteran teachers may not be ready to incorporate. I partially don't blame them. Seasoned teachers have found a way that works. Stuff like a Makerspace and iPads might seem an overload.

Beyond resisting new pedagogies brought by the Maker program, teachers also lacked confidence in the capacity of the school to sustain such change in the long run. Consider how Carlos, an experienced teacher and part of the Tech Team, describes his own ambivalence:

> Having come from the public school system, whenever talk was about this new thing, it was never followed up properly... [Teachers ask] "Is this going to be for real? Am I going to get gung-ho on this and all of a sudden they're going to stop it? And then everything I did is wasted..." That has happened before.

According to Carlos, the lack of confidence in follow-through leads teachers to passively resist new programs and as such they "simply ignore [the initiative] until it becomes a critical mass of one sort or another and either they are forced to deal with it or the thing dies under its own weight. " Other reasons mentioned for resisting change, mostly by ignoring it, were that incorporating new technologies, content, or pedagogical approach into a functioning classroom can become too big of a disruption, especially in classes preparing for standardized assessments. For Jasmine, the new program is not used enough by the faculty because "we are very focused on [State exam's] curriculum and there is a timeline to that ". The inception of the Maker program also led to adverse effects to some members of the school staff. This was the case for **Marie**, the librarian, who was 71 years old at the time of the interview and had been working in the school for over 35 years. Marie's role mostly included handling the borrowing and returning of books, validating printing requests made by students and faculty, and "monitoring the girls " while in the library to make sure they are using the library computers or their personal iPads for studying. Marie saw her physical space and professional practices directly affected by the new program, which ultimately led her to feel excluded from the reform and to even fear for her job.

The plans for the library were mentioned several times during our interviews with other faculty. Carlos revealed that the principal was "very interested in trying to get grant money to redesign the library, " while Amir postulated that "that library is probably not going to exist next year, it's going be a multimedia room. " Marie, who described herself as being "very protective of what I'm responsible for, " was initially optimistic about her ability to fit in with the changes around her, saying "I like gadgets... I like working with my hands. I like this idea of virtual reality but as long as I know my place with it. " However, it became clear that Marie felt she was being ignored or kept out of the loop in the planning and implementation process. She recalled: "I didn't find out until they were already into it, because I wasn't included. I basically saw it and had to figure out where is this going?... Nobody asked me, would you like it? " Marie later expressed fear and anxiety when thinking about the effects of the reform on her. In one illuminating moment she asked:

> Am I a librarian then? Do I sit and take care of books and monitor the girls? Or am I going to be part of this Tech Team? What is my part? My concern is "do they still need me? What would my job be then? How do I get involved? "

In summary, though our interviewees reported several cases of resistance, the majority of reactions were positive, citing opportunities for growth, excitement from a revitalized curriculum, and a feeling that the school is "stepping into the 21st century " (Dylan). We also encountered some signals of identity alignment and forms of legitimate peripheral participation, both can be interpreted as efforts to become more central members of the new CoP. The next section will discuss how educators' reactions led to fundamental shifts in power, and why the Maker program might have benefited some teachers and not others.

Discussion: power shifts in the school community

The Maker reform at UCHS rippled through the school's micropolitical landscape, with wide-ranging changes in resource allocation, roles, status, and pedagogical focus. In this section, we discuss our findings in light of both school reform and Maker education literatures. We delve into the micropolitical interactions and the shifts that resulted from the introduction of a new program using the notion of reform as "contested ground" and "a means for illuminating dilemmas of role ambiguity and conflict that mark the evolution of teacher leadership" (Little, 1995, p. 48). From the literature on Maker education, we focus on three elements of community formation: identity, legitimate peripheral participation, and technical expertise (or craft). As we shall discuss, identity alignment and technical expertise are factors that can result in both status and movement during a technological reform period in a school community of practice.

In the present case, the Tech Team members were appointed as *insiders* and given both flexibility and resources to implement the leadership's vision. Their central role in the reform program afforded Tech Team members opportunities for pedagogical reflection and professional development. Conversely, *outsiders*, or those beyond this inner circle, typically had little influence to determine how their own curriculum would be affected by the new program and ethos proposed by the principal. However, these centrality positions were not necessarily fixed. Although inner circle status was initially granted by appointment to the Tech Team, there was also evidence of movement once the wheels of reform were set in motion. Educators' shifting positions towards or away from central participation within the community can be understood in terms of *craft* (i.e., technical expertise) and *identity* (i.e., alignment with the Maker vision).

Craft and identity: currencies of virtue and success

A school's faculty is a small society, and, as in all societies, status is an asset that is not uniformly distributed. The introduction of the Makerspace at UCHS was an event with the power to instantly change the status distribution. Storr (2021) relates how status can be earned through virtue, dominance, and success. Dominance (by strength or force) tends not to be a significant status factor in professional communities like offices or schools. At UCHS, however, belief in the power of Makerspaces—manifested through faculty discourse—and the technical and pedagogical expertise to implement Makerspace lessons became, respectively, new currencies of virtue and success. Teachers who were singled out

to be leaders in the new initiative gained status by virtue of the appointment and shored it up by actively praising and promoting the transformative potential of the Makerspace. Our interviews also revealed instances in which reform was met with indifference, or even active resistance from teachers who did not subscribe to the promise of Making or had less to gain from the initiative—a phenomenon also observed by Tyack and Cuban (1995).

When the principal decided to transform UCHS into a "STEAM school", those who already possessed technological skills or knowledge about Making (i.e., what is Making, how a lab works, particular techniques, etc.) moved closer to the heart of the community. In our case study, this mobility became evident when Amir, a former athletic coach far from the core of the school's decision-making center, rose in status and influence by receiving technological training. In his words, "suddenly teachers were coming to me with questions and problems. " This story of status through success-in-craft was also true for Carlos, who was quoted earlier as describing the reform as "gift at this point in [his] life ".

The role of technical expertise in the reform is clear when teachers outside of the Tech Team attempt to implement the new curriculum. Dylan, the History teacher, explained his reliance on their technical knowledge: "If I didn't receive help and there were complications, that would turn me off to trying again. " Dylan also lamented the lack of PD opportunities offered to him: "If I could understand the technicalities... I would give teachers a way to do that. " It was clear to Dylan that partaking in curriculum redesign required that he "understands the technicalities ".

Conversely, not possessing technical skills—or lacking the knowledge or will to acquire them—defined most of the outward trajectories observed at the school. Consider Marie: having limited knowledge about making, engineering, or computer programming, the school's librarian was not only denied decision power about upcoming transformations in the library but also became dependent on others to minimally influence such changes. Marie described herself as "inflexible" when it comes to learning new pedagogies or acquiring new maker-related skills. Her story shows the replacement and displacement dynamics that rapidly took place once the new program started.

Carlos presents perhaps the most nuanced case of movement in response to the reform. As a former cabinet maker, his identity as a maker and his craftsmanship were well developed, which naturally made him a central figure in the reform. However, Carlos did not fully align with the vision of incorporating Maker activities across the school, especially when those were applied to humanities subjects, revolved around "gadgets or gee whiz sort of things " or activities which he classified as "window dressing ". When his beliefs were aligned with the reform, he fully embraced it; when they were not aligned, he chose to accommodate them grudgingly, as in the case of the alumni luncheon coasters project. For these reason, and despite being part of the Tech Team, we saw Carlos as possibly moving away from the center of the community to its periphery should the Maker program continue challenging his beliefs.

Implications

We thus offer three implications for new Maker initiatives in K-12 settings:

Maker education is not (just) about technology Our case showed how focusing on technical aspects of Making, or privileging educators more equipped to acquire them, pushed back and even marginalized others involved with the initiative. This phenomenon, viewed against the larger backdrop of school reform, is not particularly new. Three decades ago, Little (1995) described how "new leadership roles arise outside the traditional

departmental structure" (p.52), and how such new forms of leadership were dependent on domain expertise. In STEM-focused reform, a simplistic focus on technology may lead to a decrease in students' and teachers' interest in Making, which is a fundamental departure from the basic tenets of Maker pedagogy (Rouse & Rouse, 2022). Although practical knowledge is needed to run a Maker program, scholars have argued that Maker pedagogies should be privileged above and beyond technical knowledge (Blikstein, 2008; Bower et al., 2020; Vossoughi et al., 2016) and that Maker educators can benefit from Maker-centered professional development for successful implementation (Jones et al., 2020, 2021). Moving beyond technical aspects of Making means acting to create bridges—not walls—between the community and technologies, and stewarding groups of individuals towards shared values and meaning (Wenger et al., 2009). That brings us to the second implication.

Maker education requires shared meaning Although the very definition of Making is fluid, championing initiatives within any school requires stakeholders to understand and share a vision that goes beyond their own job descriptions. In this cultural process of change implementation, having a set of widely shared goals is critical. Cobb and Jackson (2012) have suggested that, given the constant re-purposing and renegotiation of meaning, new programs need to be conceived with clear and aligned "goals for the learning of members of a target group, supports for that learning, and an often implicit rationale for why the supports might prove effective" (p. 487). However, attaining shared meaning in a process of program implementation cannot be induced by power relations nor "subjected to technocratic and institutional demands" (Kapoor, 2004, p. 2).

Finally, *Maker education is not the great equalizer* Several educators at UCHS were eager to embrace the student-focused vision that "technology in the great equalizer." This belief, in fact, helped to align them ideologically with the principal-led reform effort. Looking at the micropolitical shifts among the community of educators—including both centralization and marginalization—and tensions that arose with respect to student agency, this case study presents a more complicated story. Equity is not a passive byproduct of technology, and Maker reforms are not universally inclusive. Indeed, implementing change demands a careful look into the status games played by individuals exerting influence over each other (Papert, 1997; Tan, 2018). The key brokers of both *craft* and *identity* within UCHS were the members of the Tech Team, which confirms a common reform tactic where principals handpick a group of educators to facilitate implementation or suppress any potential resistance (Kapoor, 2004; Malen & Cochran, 2014). While designating an appointed group to lead transformation is not a bad practice per se (Wenger et al., 2009), allocating or withholding support to obtain faculty buy-in may result in resistance, shallow implementation ("window dressing"), and marginalization of part of the faculty. Not without irony, our findings also point to how integrating technology into a school can serve to promote inequality among faculty members that manifests in differences in opportunities, support, and resources received. We also find that top-down pressures from a strong school leader like Cecilia may have led teachers to engage in 'window dressing' to receive additional resources and support or to successfully survive the reform.

Conclusion

In this instrumental case study, we have delved into a single instance of school reform to gain insight into power dynamics and discursive practices in a school. Our focus has been on depth and discovery, not on external validity. And our results were not expected to

generalize, but rather to spur reflection about the human factors in school Maker programs. In addition, due to study design and sampling method, our interviews were limited to faculty members who engaged directly with the program. We therefore mainly received second hand reports of acts of disregard and resistance. That said, we believe that some of the dynamics we observed in this case do have wider implications for Maker reform efforts. In our study, we found that teachers were required to make non-trivial adaptations to their practices, content knowledge, and pedagogical beliefs. Successful adaptation led educators to gain influence, resources, and support within the school. Those were gained on account of their expertise of technological aspects of digital fabrication and on their alignment with (and promotion of) the reform vision. The extent to which faculty members adapt to a reform, accommodate and support others, or resist it, may determine whether the reform is successful or not. Like other school innovations, Maker reforms stir up new dynamics and, potentially, winners and losers. No community is without internal tensions, and reformers should prepare to mitigate student and educator marginalization as much as possible.

Implications of this study included the following: Focusing solely on technical aspects can marginalize stakeholders and deviate from the core principles of Maker pedagogy. Successful implementation requires shared meaning, clear goals, and support for all members of the community. Maker education is not a guaranteed equalizer; the introduction of technology can create inequalities among faculty in terms of opportunities, support, and resources. The process of implementing change involves navigating complex dynamics and power relations, and should prioritize mitigating student and educator marginalization.

With that in mind, it is worth considering how the maker movement can shed light on alternative ways to promote school reform. Indeed, in linking Makerspace innovations with the broader issue of technology-oriented school reform, it is crucial to appreciate their unique characteristics. Makerspaces exemplify a student-centered and collaborative setting where expertise takes on various forms. Leadership often emerges organically and in a decentralized manner. This departure from the common themes observed in principal-led reform initiatives can be viewed as an invitation to think differently. In the dynamic learning environment of the Makerspace, students have the opportunity to teach their teachers, allowing educators to embrace a space where they can be non-experts in technology. Both teachers and students can explore issues of equity and access together, ultimately fostering a more inclusive and innovative educational experience.

Data Availability The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to their containing information that could compromise the privacy of research participants.

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