Connecting Students During COVID: A Case Study

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Abstract

This paper describes the process of providing network access and devices to students in Hawai'i during the COVID-19 pandemic, beginning in 2020. Roughly a third of the 165,000 students did not have network access or a device at home at the start of the pandemic lockdown. HIDOE managed significant supply chain issues, organizational issues, and project issues. Despite these challenges, HIDOE was able to dramatically reduce the number of students without access to remote instruction. By using a modeling language ex post facto, this paper identifies key improvements school districts should consider when facing similar disruptions in the future.

CCS Concepts: • **Applied computing** → **Distance learning**; **Enterprise computing infrastructures**; **Enterprise architecture modeling**; • **Software and its engineering** → **System description languages**.

Keywords: Modeling language, COVID-19, digital divide, education, remote learning, digital transformations

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1 Introduction

This paper presents a case study of the distribution of devices and network access to students in public schools from kindergarten to 12th grade in Hawai'i during the COVID-19 pandemic. Public schools in Hawai'i are operated by the Hawai'i State Department of Education (HIDOE). The author was the Chief Information Officer (CIO) of HIDOE at the time. The author's team, the Office of Information Technology Services (OITS) is responsible for ensuring technology stability to all public schools and most charter schools. Thus, the author and his team played a major role during the COVID-19 in supporting the new requirements induced by the crisis.

Like many school districts, HIDOE opted to send students home and provided education via remote learning instead of in-person learning. This created a dramatic shift in network usage, a radical increase in the use of video conferencing, and urgent needs for new devices and network access for students at home.

Hawai'i is a unique state in the United States for many reasons, but two are particularly relevant here. [Conner 2024b] Specifically, there is only one school district covering the entire state, and geographically, the state is an archipelago with plane flights the only public way to move from one island to another.

Unlike other states, Hawai'i does not divide their K12 education system into a state-wide education agency (SEA) and several local education agencies (LEAs) or "school districts". A given state may have dozens or hundreds of districts. Each district usually has statutory authority to fund the district through property taxes. As there is only one district, HIDOE itself, public education is both an SEA and an LEA. HIDOE does not have authority to fund itself through property taxes. Instead, it is funded primarily through general taxes in the state,[1] with funding appropriated by the state legislature.

2 The Problem

Specific details around the change in operation of HIDOE schools at the start of COVID is documented by meeting minutes of the Board of Education, which are public records under Hawai'i Revised Statues Chapter 92 (the so-called "sunshine law") [HRS 2024b]. Below is a section in reference to discussion of a letter sent by the Superintendent at the time, Dr. Christina Kishimoto, to the Hawai'i State Teachers Association (HSTA), the union of which all teachers are members. This is from the April 2, 2020 meeting, shortly after the start of the crisis [of Education 2020b]:

> Kishimoto reviewed the March 19, 2020 letter of commitment regarding COVID-19 preparation and response from her to HSTA Executive Director Wilbert Holck. She detailed that the background of the letter of commitment relates to graduation and standardized test waivers.

Graduation and standardized tests of course required students to gather in large numbers — something contra-indicated by social distancing guidelines during the COVID-19 pandemic. This allowed the Superintendent to move on to more immediate, and potentially contentious, issues, namely whether

[1] HIDOE also receives limited Federal funding, as most SEAs and LEAs do.

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HIDOE employees would remain employed and under what conditions.

> She detailed that the Governor signed his first emergency proclamation regarding the COVID-19 pandemic on March 4, 2020. She noted that the emergency proclamation gave county and state agencies relief from following HRS Chapter 89, entitled "Collective Bargaining in Public Employment," to accomplish emergency management functions.

Here, the Superintendent is referring to the changes in employment conditions induced by remote work. Normally, under Chapter 89 [HRS 2024a], changes in working conditions require consultation with the relevant unions. Superintendent Kishimoto pointing out that she is working with the unions, despite the waiver of that requirement as an emergency proclamation by then-Governor Ige. She went on to further explain some of the specific changes, such as extending spring break for students while requiring teachers to work remotely to develop remote instruction approaches:

> Kishimoto noted that the Department had a one-week scheduled spring break from March 16 through March 20, which it extended to March 27 due to the spread of the coronavirus. Subsequently, the Department added a third week of modified school closures to April 3, 2020.
>
> The Department asked teachers to work from home to prepare modified lesson plans, cleaned schools, and determined social distancing in preparation to open schools on April 7, 2020. At this time, the Department was in discussion with HSTA regarding whether the Department would fully shut down schools for the rest of the year.
>
> The Department articulated its desire to separate the closure of a school building from the fact that the school system would continue to operate and be an important source of support and education to students.

The subtext here is the threat of furloughs of government workers. Had the schools not been providing instruction, as a separate issue from whether the *building* was open to students, it was apparent that the Legislature or the Governor would have induced mandatory furloughs to save money, as most of the budget for HIDOE is provided by general tax income. In Hawai'i, the leading sector of the economy is tourism, which of course disappeared during the pandemic.

Instead, as many school districts did, HIDOE chose to focus on providing remote learning. Instruction would still be provided (consistent with state law in many states, including Hawai'i), and school staff would still be employed, albeit in a modified role:

- Teachers would be providing instruction online, including synchronous video classes as well as asynchronous interactive lessons.
- Administrative staff would continue to run the school, ensuring students are getting the services they needed.
- Cafeteria staff would still prepare meals, albeit distributed for pick-up rather than consumption in the cafeteria.
- Custodial staff would continue to maintain the buildings of the schools, both to support staff required to work physically on campus, and to ensure schools were ready when students (eventually) returned.

In short, the school system would still fully employ their substantial employee base (the largest single employer in the state), though shifting how the work was done. As noted, normally, that would require extensive negotiations with numerous unions. While the governor's emergency proclamation meant no negotiation was required, and furthermore, state law provides that all state employees are considered "emergency workers" [HRS 2022], the Superintendent still worked to ensure that the unions were supportive. But transforming this from a concept agreed by leadership to something implementable by the people doing the work faced many challenges.

3 Challenges

The support of remote learning during the COVID-19 pandemic can be described as a socio-technical system [Lee et al. 2014], incorporating many aspects of the complex situation. However, Lee's approach, categorizing systems into one of three categories, social, informational, and technical, does not fully capture the complexity of the situation of deploying technology access during COVID-19. This drives the motivation of using a broader, more inclusive approach of a more descriptive modeling language.

HIDOE's organization is complex, spread across eight islands, supporting twenty thousand full-time employees, twenty thousand more part-time employees, at 257 schools, in locations ranging from extremely rural to extremely urban. Some students reside in locations completely off grid. Some students have special needs, such as learning English as a second language, or requiring additional supports to access education. Much of the technology itself was new to HIDOE, and teachers themselves requested specific and additional tools to support remote learning. And of course, all aspects of this socio-technical system were changing as new technologies and capacities were brought online, as the nature of the pandemic shifted, and as skills in remote learning grew.

The key challenge was that roughly a third of the 165,000 students did not have network access or a device at home at the start of the pandemic lockdown. Some of the challenges

faced by HIDOE were similar to ones faced by other school districts, but some were unique to Hawai'i. These challenges can be grouped in three categories:

- Supply chain issues,
- Organizational issues, and
- Project issues.

3.1 Supply Chain Issues

HIDOE managed significant supply chain issues, as most school districts were going through similar challenges. As Federal and state emergency relief money became available, HIDOE would place orders for more devices to provide to students. Following procurement rules, a quote was obtained, ideally from multiple vendors. In the time in which the quote(s) were reviewed, the devices were often purchased by another school district. Thus, when HIDOE presented a purchase order, perhaps only one day later, the devices were no longer available to order.

This affected a school's choice in devices. For example, a school may have preferred ChromeBooks over iPads. When ChromeBooks were available to quote but not available to purchase, schools were faced with a difficult decision: iPads or nothing. HIDOE of course was not unique in facing these challenges, but due to HIDOE's particular organization, specifically its focus on school empowerment, schools found this situation frustrating.

3.2 Organizational Issues

On paper, HIDOE's reporting structure is a strict hierarchy, starting from the top at the Superintendent. At the time of COVID, the Superintendent had seven direct reports who were Assistant Superintendents covering functional areas, such as curriculum, finance, and technology (the author held one of these roles). In addition, a Deputy Superintendent reported to the Superintendent, and managed a collection of fifteen Complex Area Superintendents (or CASs). Each CAS is responsible for two to four complexes. A complex consists of a high school and all the middle schools and elementary schools whose students would be zoned for that high school. The principal of each school in the complex reports directly to the CAS.

At each school, the principal has full authority to structure reporting as she or he sees fit. A principal may have all teachers of a certain grade level report to a common person below the principal, or perhaps a similar organization by subject area. A principal has authority not only over hiring but also over most of their budget. A CAS may oversee the performance of the school, in terms of student outcomes. But if those outcomes meet or exceed expectations, the principal can take whatever approach they wish. Similarly, union agreements between the teachers' union and the principals' union provide teachers with substantial authority in how they teach and with substantial limits on principals' actions within a teacher's classroom.

While this approach empowers teachers substantially, it created tensions when teachers were (rightly) looking for direct guidance for how to teach safely during COVID. Everyone both wanted the security of clear direction, but also wanted the ability to take a different approach if they felt it warranted. This was further complicated by pragmatic considerations. For example, most teachers had all teaching materials at school, not at home.

Even getting agreement to close buildings but still offer education required a very balanced engagement of all stakeholders, as noted in this further quote from the April 2, 2020 BOE meeting [of Education 2020b]:

> Kishimoto noted that the Department worked in partnership with HSTA during the week of March 16, 2020 to develop actions that were necessary to ensure that teachers were able to provide a continuity of education in the event of extended school closures.
>
> HSTA agreed that any closure would be of school buildings rather than school systems, and education in other areas, such as food programs, would continue in modified formats.

This speaks to the modified work roles described above in Section 2. The teachers' union agreed that its members would accept modified working conditions with the implicit avoidance of the cessation of work.

> The Department met with HSTA on March 19 to document procedures and agreements so that teachers clearly understood their roles and responsibilities.
>
> She stated that the letter of commitment was drafted to document key functions and processes to ensure the continuity of education throughout the COVID-19 crisis.

Again, this speaks to avoiding the cessation of work, i.e., unpaid furloughs for teachers. But it also addresses the question of whether children in school were continuing to be educated. This remained a significant issue for parents, as evidenced in the voluminous testimony of parents, who were concerned about multiple issues:

- The safety of their children if required to physically attend school;
- The education of their children however that education was offered; and
- The timeline and requirements on either of these approaches.

> The Department and HSTA agreed on the terms of the letter of commitment and shared it with the Department of Human Resources

> Development, the Office of the Governor, the Department's deputy attorney general, the Office of the Attorney General, Employment Law Division, and Kishimoto signed the letter as the Superintendent of Education.
>
> Kishimoto stated that having the signed letter of commitment allows the Department and HSTA to work quickly to develop guidelines to provide instruction for all students for the duration of the COVID-19 health crisis.

Here, the subtext of the minutes is that the Superintendent has engaged all major stakeholders and come to an approach that allows flexibility and responsiveness for all parties.

3.3 Project Issues

During the time period of the COVID-19 pandemic, HIDOE was also implementing major technological changes as part of a multi-year digital transformation [Conner 2024b], a major technology modernization effort undertaken at HIDOE over the time period from September 2017 to July 2021. This effort was led by this author and implemented by a team of technologists reporting into the author, as well as numerous other stakeholders across HIDOE.

The author first presented a specific plan $\mathfrak{p}$ as a proposed implementation of the high level plan $\mathbb{P}$ describing the transformation of $\mathbb{T}$ from the start year of y_0, over the next five years, y_1, y_2, y_3, y_4, y_5. At a very high level, then, if the implementation of $\mathbb{T}$ is represented by the as-is state t_n for some year y_n:

$$\square\mathbb{P} \rightharpoonup \Diamond\mathfrak{p} = \{\mathbb{T} \quad \rightarrow \quad ((y_5, t_5), \quad \cdots, \quad (y_0, t_0))\}$$

Of course, by considering the date ranges, it is apparent that it spanned the COVID-19 period discussed here.

As noted in Conner [2024b], the core financial system for HIDOE was replaced during this time period:

> During the summer of 2019, bids for replacement were submitted by vendors. The selection process continued into the fall, and a contract was signed in January 2020 for a vendor to implement Oracle Financials in the Cloud as quickly as possible. Implementation was completed in time for the new financial system to be used at the start of the following fiscal new year, July 1, 2021. In eighteen months, a multi-billion dollar organization had replaced its core accounting system. The cutover to the new system proceeded smoothly, and a month after the start of the new year, the legacy accounting system was de-activated and the substantial mainframe capacity was returned to ETS.

ETS is the state-wide technology organization, and the mainframe capacity was crucial, as the state's unemployment system ran on that same mainframe.

4 Success of Deployment

Despite all the challenges describe above, within six months, the rate of students without access was reduced to less than 2%, including families that refused remote learning. Despite an increase of video conferencing from a handful of meetings per week on a single platform to tens of thousands per day on three different platforms, HIDOE's network suffered no capacity-related outages (there was one physical outage where a rat broke a cable on a military base where the military had not yet provided HIDOE approval for a redundant physical connection).

So at the time, operationally, deployment of devices and access was broadly successful. Despite that, stakeholders across the board were frustrated. In the end, the Superintendent chose not to pursue renewal of her employment contract. As the saying goes, the wonder of the dancing bear isn't how well it dances but that it dances at all. But stakeholders appeared to want the bear to compete with Fred Astaire or Gene Kelly as a dancer. Could the bear have danced better? Of course, but simply demanding the bear do better is insufficient. We must analyze what happened and determine how to do better next time.

5 Analysis

In this section, a specific analytical tool designed for large, time-varying systems [Conner 2024a] is used to understand more about how HIDOE provided access, reacted to COVID, and dealt with the specific challenges described in Section 3. We will summarize this tool here before proceeding to using this tool to analyze HIDOE's COVID response.

5.1 The Analytical Tool

The analytical tool is a modeling language, as it is designed to describe systems that change over time. Every value can potentially represent a time-varying value, as is used in some interactive graphics systems [Elliott et al. 1994]. Any value $\mathbb{V}$ can be a simple or time-varying value $\mathfrak{v}$. Note that we are distinguishing between the *signified*, the actual value $\mathfrak{v}$, and its *signifier* or the name $\mathbb{V}$, in order to keep clear which aspect of semiotic intent is meant [Barthes 1970]. Visually, the language uses the Fraktur font to represent the signified, the actual values, and uses Blackboard Bold when representing the signifier, the name or reference to the thing. During the COVID crisis, the distinction between a signifier such as the intent to educate and the signified such as the actual instruction became quite sharp.

The modeling language is also designed to describe large and complex systems, so values are organized into actors, in the sense of Agha's Actors approach [Agha 1986] but also in the sense of an object in the simple object model of the Self programming language [Ungar and Smith 1987].

An actor $\mathbb{A}$ has a unique identity $\mathfrak{I}$. As with simple values, we distinguish between the signified, $\mathfrak{I}$ and the signifier, $\mathbb{A}$, noting this signifier/signified relationship as $\mathbb{A} \rightharpoonup \mathfrak{I}$. In addition, actors in this model have three critical descriptive components:

Characteristics An actor $\mathbb{A}$ has a set of characteristics $\mathbb{S}$. Each characteristic has a name and a reference to another actor, comparable to a slot in Self. In a mathematic symbology, we can define $\mathbb{S}$ using set notation, with characteristics given by a name and a right arrow to an actor identified elsewhere, e.g., $\mathbb{S} = \{a \rightarrow \mathfrak{i}\}$.

Sharing An actor $\mathbb{A}$ can share characteristics with another actor. A specific characteristic c can be marked as sharing. The actor to which c refers provides all of its characteristics to $\mathbb{A}$ unless $\mathbb{A}$ specifically defines that characteristic instead. In a mathematic symbology, we can continue with the definition of $\mathbb{S}$ using set notation, with characteristics that identify an actor providing shared characteristics given by a name and a doubled right arrow $\Rightarrow$ (i.e., suggesting more characteristics than what is here) to an actor identified elsewhere, e.g., $\mathbb{S} = \{a \Rightarrow \mathfrak{i}\}$.

Existence An actor **A**, whether signifier **S** or signified $\mathfrak{S}$, can be marked as either definitely existing, or possibly existing. In the symbology of modal logics, an object that definitely exists s denoted $\Box\mathbf{A}$, while one that possibly exists is $\Diamond\mathbf{A}$. The third existence state, of definite non-existence we denote with $\triangledown$.

There are more aspects to the modeling language, but these basics will suffice to analyze HIDOE's COVID response.

5.2 A Partial Digital Transformation

Because of the different levels of authority represented by HIDOE's organizational structure described in Section 3, the actual technology of the enterprise $\mathfrak{T}_e$ has only limited connections to the actual technology of a specific school $\mathfrak{T}_s$. For instance, each school $\mathbb{S}_i$ independently implemented a mail system $\mathfrak{M}_i$ using an instance of Google for Education $\mathfrak{G}_i$.

By the time of the beginning of the COVID crisis, HIDOE had completed one phase of a digital transformation that provided enterprise-wide collaboration $\mathbb{C}$ including email, video conferencing and more. Engineering meetings with Google showed that Azure ActiveDirectory not only could serve as the authenticator for Google for Education but could also be used to provision accounts. Given the existing Azure ActiveDirectory instance was already connected to eHR, this meant that HIDOE could automatically create a Google for Education account for every single person receiving a paycheck, within a single enterprise tenant $\mathfrak{G}_e$ which was made broadly available to HIDOE in 2019, or y_2 here. To avoid disruption, Lotus Notes was left in place for a year, and school Google tenants $\mathfrak{G}_i$ were also left in place.

$$\mathfrak{S}_i = \left\{ \begin{array}{lcl} \mathbb{M}_i & \rightarrow & \Box\mathfrak{M}_i \left\{ \begin{array}{lcl} g & \rightarrow & \big((y_2, \mathfrak{G}_e) \quad (y_1, \triangledown)\big) \\ m & \rightarrow & \mathfrak{G}_i \\ n & \rightarrow & \big((y_3, \triangledown\mathfrak{N}) \quad (\bot, \mathfrak{N})\big) \end{array} \right. \\ \mathbb{F} & \rightarrow & \mathfrak{F} \end{array} \right\}$$

Having this kind of enterprise-wide support was crucial to have in place at the start of the COVID crisis, and provided essential resilience, increasing the overall security of HIDOE. [Conner 2024b]. Configuration of the enterprise environment $\mathfrak{G}_e$ allowed easy sharing with individual school environments $\mathfrak{G}_i$. This also provided two forms of video conferencing, both Google Meet and Webex.[2]

The need for digital facilities was recognized broadly at the time, e.g., internationally by the Indian Institute of Medicine [De' et al. 2020]. Software vendors also noticed dramatic upticks in usage [noa 2020]. This issue was recognized and documented as a continuing concern in 2021 by the US Department of Education's National Center for Education Statistics [Editor 2021]. Finally, researchers have continued to document the impact of the digital divide (the class divide between those with access to the Internet and those without it) [Li 2022]. The issue of the digital divide being increased by COVID was journalistically reported in Hawai'i as well in 2021 [Kanai 2021].

As the COVID pandemic continued in 2020, HIDOE extended $\mathfrak{G}_e$ to create identities $\mathbb{I}$ for students (often called"learners") $\mathfrak{L}$ as well as employees $\mathfrak{E}$.

$$\mathbb{I} = \Box \left\{ \begin{array}{lcl} \mathbb{E} & \Rightarrow & \Box\mathfrak{E} \\ \mathbb{L} & \Rightarrow & \Box\mathfrak{L} \end{array} \right\}$$

This enabled teachers to access students online in a single comprehensive environment $\mathfrak{G}_e$, but that word *online* is key. Neither students nor faculty were guaranteed to have sufficient network access at home, or in many cases, any access at all. Thus, this addressed only the software aspect of the digital divide, not the need for a device to access the network or permission to access the network (i.e., a paid contract with an Internet service provider).

5.3 Providing Access

As a public school system, HIDOE is obligated to serve all students that show up. Students may be from economically challenged homes — some may not have a stable housing situation at all. Other students may have health issues that can interfere with accessing education. Remote learning made these kinds of situations more challenging.

It took substantial time to measure how the gap in access should be measured, with debates by the Board occuring

[2]HIDOE's network is largely Cisco-based, so Webex was already available.

on October 15, 2020 [of Education 2020c]. The following approach was agreed upon for devices:

> 11. Device Gap Formula: (Total student population) – (How many how many students currently have a device, personal or school issued, that can be used to effectively engage in synchronous or asynchronous distance learning) = Device gap
>
> Data Source: Infinite Campus Reporting: Quarterly reporting by school, complex, complex area, and statewide.

In the modeling language, the device gap $\mathfrak{D}^g$ is the difference between the student population $\mathfrak{P}$ and the population with a device $\mathfrak{D}$. This varies over time, here using s as the start of COVID, i as an intermediate time, and l as a later time, so the student population at the start would be $\mathfrak{P}_s$:

$$\mathbb{D}^g = \square \left\{ \mathfrak{D}^g = \left((s, \mathfrak{P}_s - \mathfrak{D}_s), \quad (i, \mathfrak{P}_i - \mathfrak{D}_i), \quad (l, \mathfrak{P}_l - \mathfrak{D}_l) \right) \right\}$$

For network connectivity, the Board agreed to the following approach:

> 12. Connectivity Gap Formula: (Total student population) – (How many students currently have internet connectivity sufficient for synchronous or asynchronous distance learning) = Connectivity gap
>
> Data Source: Infinite Campus Reporting: Quarterly reporting by school, complex, complex area, and statewide.

This can be modeled similarly to the device gap $\mathfrak{D}^g$ as the connectivity gap $\mathfrak{C}^g$, with similar time markers:

$$\mathbb{C}^g = \square \left\{ \mathfrak{C}^g = \left((s, \mathfrak{P}_s - \mathfrak{C}_s), \quad (i, \mathfrak{P}_i - \mathfrak{C}_i), \quad (l, \mathfrak{P}_l - \mathfrak{C}_l) \right) \right\}$$

Both the device gap $\mathfrak{D}^g$ and the connectivity gap $\mathfrak{C}^g$ were affected by the supply chain issues discussed in Section 3.1.

Finally, the Board agreed on an approach to monitor which schools were not individually ready to fully support distance learning:

> 13. Distance Learning for Vulnerable Students Gap Formula: (Total number of schools) – (number of schools that can support distance learning for their entire vulnerable student population) = Distance Learning for vulnerable student gap
>
> Data Source: Infinite Campus Reporting: Quarterly reporting by school, complex, complex area, and statewide.

While initially this appears similar, it is based on schools, rather than student population. Thus here we use $\mathfrak{S}$ for the school total rather than $\mathfrak{P}$ for the student population. The schools able to support the entire population are labeled $\mathfrak{E}$. The gap itself is the vulnerable students gap $\mathfrak{V}^g$, noting again this is measured in schools, not students:

$$\mathbb{V}^g = \square \left\{ \mathfrak{V}^g = \left((s, \mathfrak{S}_s - \mathfrak{E}_s), \quad (i, \mathfrak{S}_i - \mathfrak{E}_i), \quad (l, \mathfrak{S}_l - \mathfrak{E}_l) \right) \right\}$$

Current data following this standard was formally presented as part of the Superintendent's evaluation at the Board Meeting of December 17, 2020. [of Education 2020a]

> the focus will be on accelerating the Department's digital transformation by decreasing the access gaps from 4.7 percent for the device gap and 13.8 percent for the connectivity gap.

This demonstrates that, while not completely closed, substantial progress had been made in providing devices and network access.

Two aspects modeled here bear on the question of how access could have been handled better. The first is the identity question:

$$\mathbb{I} = \square \begin{Bmatrix} \mathbb{E} & \Rightarrow & \square\mathfrak{E} \\ \mathbb{L} & \Rightarrow & \square\mathfrak{L} \end{Bmatrix}$$

Using the identities $\mathbb{I}$ required training for the schools $\mathfrak{S}$. In the interest of expediency, the technology team focused on enabling the capability first, i.e., solving the engineering problem, knowing that many schools were already familiar with a Google environment. In hindsight, and when elaborated in this modeling language it became apparent that new identities at an intermediate time $\mathfrak{I}_i$ combined with the device gap $\mathfrak{D}^g$ and the connectivity gap $\mathfrak{C}^g$ produced challenges for the overall vulnerability gap $\mathfrak{V}^g$.

Specifically, schools able to address identifies $\mathfrak{S}_\mathfrak{i}$ correlated closely with schools able to support the entire population of vulnerable students, i.e. it appeared that the two were equivalent:

$$\mathfrak{E} \equiv \mathfrak{S}_\mathfrak{I}$$

6 Conclusions

This case study went through the process of HIDOE providing devices and network connectivity to students across the state of Hawai'i. While numerically, HIDOE was broadly successful in addressing the challenges of remote learning presented by COVID-19, stakeholders still had concerns. By analyzing the situation with a modeling language, we were able to identify places where improvements could be made, should such a situation re-occur. Specifically, supply chain issues can be addressed by exercising the relaxation of procurement rules in an emergency situation more aggressively; more training can address changes in the technology landscape; and identity management is a critical factor.

Other responses to extreme situations may similarly benefit from a more detailed and analytical analysis of what was done and how it could be improved. Future work will continue to develop both the analytical tools and to analyze other complex systems.

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