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# Meeting students halfway: Materials in an ideas-centered classroom

Richard Reeve\*

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## Abstract

This design case examines how the intended design for a Knowledge Building Communities (KBC) is altered by the learning spaces created by the students. The case is that of a grade six class as they instantiated the KBC approach while learning about flight. The design is analyzed in terms of Bielaczyc's Social Infrastructure Framework and Law's trials of strength that the design endured and how the trial of model-building challenged the design. The discussion focuses on the challenge of maintaining a discourse-centered design when materials are prevalent in the classroom and how generative pedagogical practices are required to adapt the design.

**Keywords:** Knowledge Building, Design; Materials, Pedagogical Practice, Learning Spaces

“Ideas that make a difference in the world don't fly about free  
of the weightiness of their material instantiation”  
(Barad, 2007, p. 55).

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## **Introduction**

The Knowledge Building Communities (KBC) approach is described as involving “the production and continual improvement of ideas of value to a community” (Leithwood, 2018, p. 107). This places the focus on the human community to locate and define what knowledge will be valuable to the community and in turn how that knowledge will be produced. Typically, KBC’s are undertaken using a technology-supported discourse environment such as Knowledge Forum (KF) (Scardamalia, 2002) which places the burden of how knowledge is to be communicated on written discourse. However, there are other materials that participate in instantiating a KBC many that do not support written discourse. This article explores what happens when a design for a KBC is challenged by students’ need to express ideas using means outside of the written form. This trial reshapes the initial design to the point that it expands what the designers had set out as acceptable practice in this KBC and the materials that make it possible.

## **Theoretical Framework**

Typically, designers have worked to create KBC’s focused on knowledge creation by working from a core set of principles (Scardamalia, 2002). Knowledge Building (KB) and the communities it supports have been described since the early 2000’s via a set of sociotechnical principles that combine social actions with the technology that supports their realization (Scardamalia, 2002). The central technology used in KBC’s is Knowledge Forum (KF) a collaborative databasing program that allows all members of the community to read and build-on to the ideas of other members of the community. Ideas can be risen above using tools built into the KF system and new avenues of inquiry can be supported through the creation of new view spaces within KF. Powerful ideas can be built together but it is also the case that these are ideas disconnected from the material world and in many ways from those that created them. The current version of

KF was constructed on the premise of Popper's three worlds epistemology with world three, or the world of ideas, being that which the KF environment supports (Bereiter, 2002). Holding to this version of the nature of knowledge, representationalist as it were, means that all ideas need to be able to be translated into language to be worked on in KF. Given that most of the tools available in KF are based in language a problem arises for those that have ideas based in the materials at hand but may not know how to represent these ideas using language to express them in KF.

Karen Barad's ontology of matter de-centers humans and argues for matter as intra-acting participants in our reality (Barad, 2007; Pепpler et al., 2020). Agential Realism (AR), as Barad terms it, gives rise to a whole host of new possibilities for capturing and describing what is involved when a KBC comes into being. This paper, like others (Damşa et al., 2019), seeks to shed light on what else, including humans, participates in a KBC and thereby what a particular infrastructure includes and how the entanglements that transpire make space for knowledge building to occur.

Although the KB and AR ontologies are related in that the social or human component is connected to a material or technological participant the AR approach expands what is considered as being material contributors to the practice that is rendered. Where the KBC principles focus on the technology of KF and how knowledge creation is supported using this specific technology the AR approach includes an expansive array of material participants, including both KF and the humans involved, but also including the materials read, experimented with and the discourse practices engaged in by the group.

Barad's (2007) basic argument is that how we come to know the world is through performative intra-actions that instead of being representations of a world of objects are performed into being through the practices we engage in as materials entangle with one another. According to Barad (2007) "performativity is properly understood as a contestation of the unexamined habits of mind that grant language and other forms of representation more power in determining our ontologies than they deserve" (p. 133). For Barad (2007) "a performative understanding of discursive practices challenges the representa-

tionalist belief in the power of words to represent preexisting things” (p. 133). Barad (2007) continues that “Unlike representationalism, which positions us above or outside the world we allegedly merely reflect on, a performative account insists on understanding thinking, observing, and theorizing as practices of engagement with, and as part of, the world in which we have our being” (p. 133) or as Fenwick and colleagues (2011) position it a KBC does “not exist and cannot be identified separately from the networks through which they are themselves enacted” (p. 6).

## Methods

To understand the KBC, that is the focus of this article, the story of its first three-weeks (i.e., nine days) will be told through an edited design case. Design cases are studies that tell how a particular case came to be through the eyes of the designers involved (Boling, 2010). A design case is a type of case study that focuses on the design decisions that were made within the case as it was developing by the designers. In this case the designers were a researcher and a collaborating teacher (Kali et al., 2015). The goal here is to work to see the phenomenon of the KBC as it was being developed – from within the process. Focus is placed on the materials, both human and non-human, which went into the design and the reasons the design decisions were made. It is important to note that the ontological shift from representation to material entanglement had not been made before this design case was enacted. Therefore, analysis of this design case includes a critique of the decisions made by the designers as they appeared to have pressed for a representationalist approach to explaining ideas while the students appear to have had other things in mind.

The design case presented here represents the first of three phases enacted in this grade six classroom as thirty students and their teacher sought to build knowledge about flight. In the analysis portion of this article focus is placed on the nature of how the various heterogeneous components related to one another and how the design dealt with the challenges to it functioning as a successful system. Bielaczyc’s Social



Infrastructure Framework is used to analyze the basic design of this KBC (Bielaczyc, 2006).

Following Law's (1989) process of heterogeneous engineering, I outline the disparate components of the design as presented in the design case and then feature two of the *trials of strength* encountered by the design through the initial nine days. The goal in reporting this design case and the trials it endured are to describe the trials that the design endured as the process unfolded. As such the goal is to describe the evolving KBC from within the process of its own creation.

Trials of strength are like the challenges faced by the design. Challenges that are either overcome or serve to reshape the design in new directions. For Law (1989), it was the design of ships that had to endure long sea voyages and came to be designed in certain ways based on the trials that were encountered at sea. For the design of this KBC there were challenges encountered that seemingly ran counter to the intended design that needed to be overcome.

Where the object of study was the KBC, a public school formed the field of study for this research which was in a mid-sized city in an average Socio-economic Status (SES) neighborhood in Eastern Ontario. One quarter of the thirty students in the class had Individualized Education Programs. The teacher was experienced with over ten years of teaching experience, but he had never taught using the KBC approach before engaging in this study.

Extensive field notes created by the researcher throughout the three-weeks form the central basis for this edited design case. Written in a back view of the KF database the pattern used was one of proposing a plan for each session and then writing a field note in response to what happened during each session. The researcher's notes were readable by the teacher. Student notes in the KF database and photos of classroom activity supplement the field notes.

Focus is placed on the instantiation of several classic components of a KBC to give the reader a description of the spaces that are created between the heterogeneous parts that included: Knowledge Building Circle; Knowledge Forum; Journals; Teacher Launch; Tracking systems; Materials-based Model-building; Experimentation; and Readings.

## Design Case

### Week 1 – Day 1

On the first day we introduced several (heterogeneous) parts including paper-based journals for the students to record their initial wonderings and theories about flight. Prompts included: 1) What don't you understand about flight? 2) Do you have a theory about how things fly? Students wrote and drew their responses to the prompts. The session was preceded by an introduction by the teacher (Figure 1). This teacher launch component became a stable part of the design throughout the unit with the teacher using this time to introduce new materials (e.g., templates for readings), reviewing existing strategies and reminding students about their responsibilities during the period.

**Figure 1.** Teacher doing paper wing demonstration on Day 1 and encouraging students to try it.



A hands-on materials table with an array of (heterogeneous) materials was made available at one end of the classroom (Figure 2). After an hour of researching their questions and building airplanes the group came together in a Knowledge Building (KB) Circle. The teacher stressed that this was a place to talk to each other about the ideas they have and that everyone should be able to see and hear each other in the circle.

**Figure 2.** Flight materials table at front of room covered with heterogeneous materials.

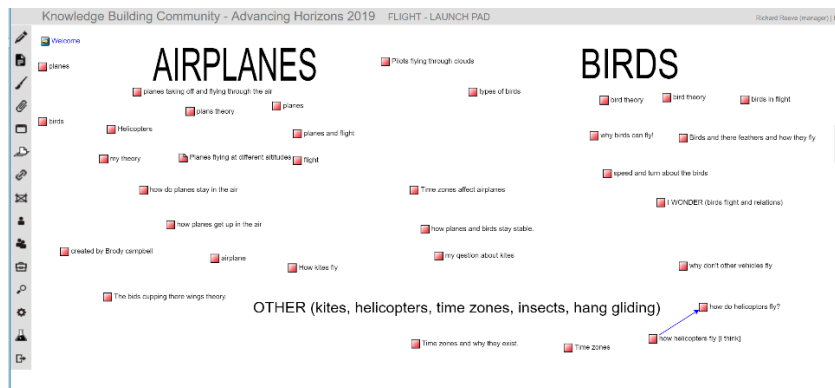


## Week 1 – Day 2

Knowledge Forum (KF) was introduced on the second day. Note creation and the placement of notes by the computer was covered. Students were instructed not to move other students' notes, but this was still an issue for a few students (Figure 3). During the KB Circle

discussion about the KF environment and the issue of the moving of notes was further discussed. Being respectful of the ideas of other students was discussed at some length.

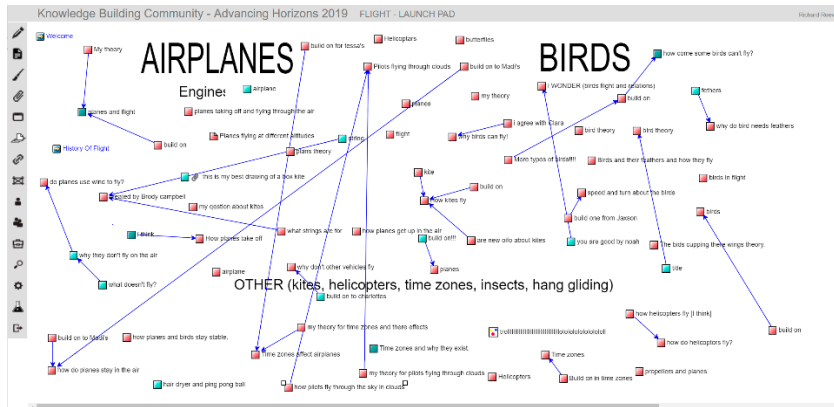
**Figure 3.** Knowledge Forum database on Day 2 of study. Flight LaunchPad view.



## Week 1 – Day 3

A note representing the array of areas of focus being worked on was presented and it was pointed out that everyone was accounted for in the range of topics being looked at by the class. Several readings were selected for various groups including the flight and kite groups. Students who did not have a reading went onto the KF database and worked there. A few read notes but many created new notes. A student asked about how to build-on when she had an idea to add (Figure 4). The whole group was instructed on how to build-on. In the group discussion at the end of the 100-minute period it was discussed that those that had done the readings had not spoken during the KB Circle while those that had done experiments and created hands-on models had shared their work.

**Figure 4.** Flight LaunchPad view on Day 4 of study with build-ons indicated by lines between notes.



## Week 1 – Summary

Many heterogeneous parts were added to the design including KF, KB Circle, readings, journal template and model-building. The teacher mentioned that he felt something more needed to be done to ensure the students knew they were accountable for their time during these elongated periods of one hundred minutes and that they needed to be committed to their inquiry work. It was discussed that the idea that writing reflections and plans for the use of their time in their journals was something that should be encouraged to be done daily using the template introduced on the first day. This structure for the writing seemed to help the teacher in alleviating his concern about students being accountable for the time they were spending during class using the materials in the room.

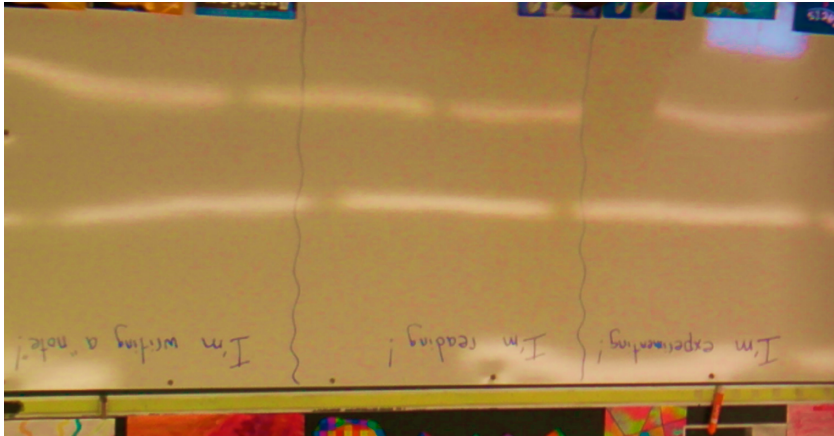
## **Week 2 – Day 4**

Students were encouraged to log onto the KF system and read the notes they had not yet got a chance to read. A student suggested that a new area of focus could be the History of Flight as it was not being captured in what was listed on the Launch Pad view (Figures 3 and 4). A new History of Flight view was created, and a few notes were copied over to it.

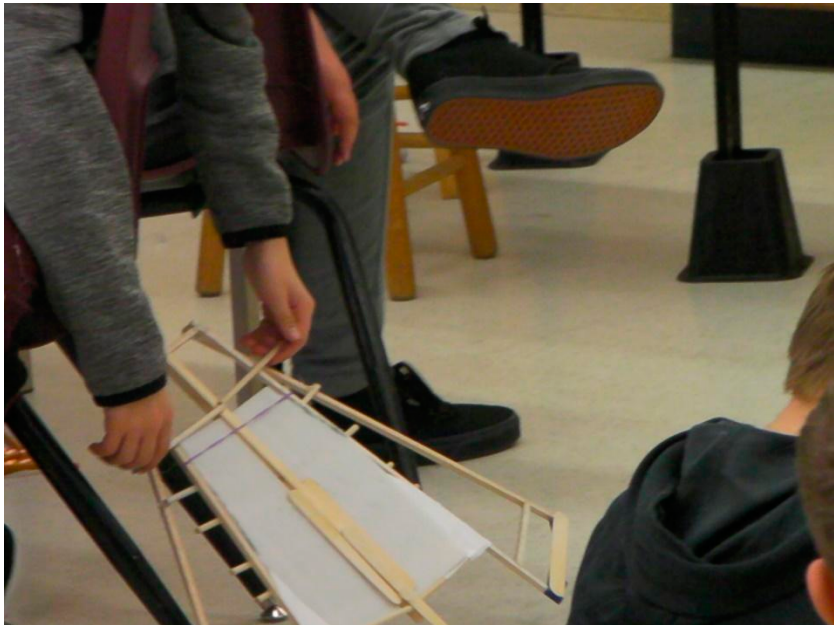
## **Week 2 – Day 5**

A KB Circle was held to discuss what the students were doing and how they were doing it. Focus was on the knowledge of flight that was being developed but also how this knowledge was being conveyed across the classroom to other students. It was noted that many students had different goals (e.g., history of flight, mechanics of flight). Students noted that the ability to collaborate on the experiments was unique as was their need to share their advances. It was also pointed out that they had more opportunity to study different areas than in other units not undertaken through a KBC. Finally, students also noted that there were more materials available to do experiments. Students noted that the KB Circle was a way to share understandings but every time they came together in a circle there should be sharing and summaries of how they were progressing. Some noted that the KF database and the views were another way this sharing and building-on could take place. Finally, one student noted that model-building was another way of helping them to understand flight and to show others about their understanding. The teacher reminded students about their responsibility to be productive during the period and that self-regulation and agency over their activities was important.

**Figure 5.** Board to indicate type of work being done by students.



**Figure 6.** Stealth wing model being built.

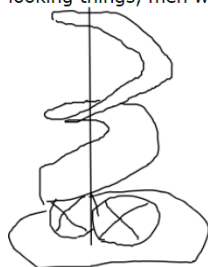


## Week 2 – Day 6

The class started off with a new teacher-generated monitoring structure that had the students take their names on magnetic cards and assign them to task labels that went up on the chalkboards around the room. These included: I will be experimenting; I will be reading; and I will be on KF (Figure 5). Not everyone put their names up on the board. The most names that did go up were concentrated in the experimenting/constructing section. During the work time the groups worked diligently on their various activities. The plane builders worked on a stealth plane wing (Figure 6). A lot of journal-based sketches were made about these theories. During the KB Circle time, the teacher encouraged the class to talk about the ideas on which they were working. It was noted that almost no one worked on KF this day. That they gravitated to doing the same thing at the same time was interesting and was noted by the group. Two students did an experiment to approximate Leonardo da Vinci's flying screw (Figure 7). They noted that it did not work.

**Figure 7.** Arial Screw/Da Vinci's arial screw as a model for helicopter flight.

**New Information** - leonardo da vinci had a very similer idea to melissa's and my expirement. he made a arial screw, i made a diagram to show what it looks like.the wheel looking things, men would go in and spin it then it would lift of the patform.



arial screw.



## Week 2 – Summary

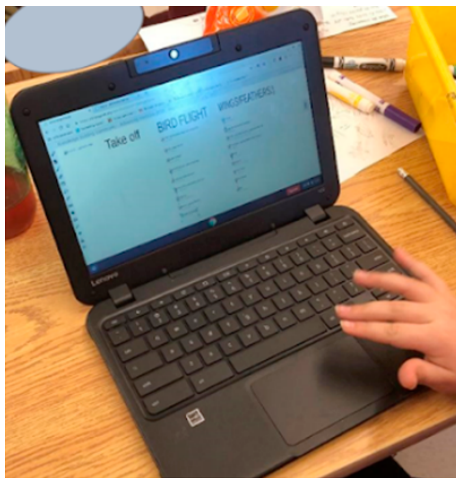
The group continued to make progress both on the conceptual and on the logistical front in terms of setting norms for how the classroom would operate as a KBC. Heterogeneous parts that were added in week two included new views in KF and the many models that had been created to show how flight works. For the teacher key amongst these were: (1) establishing of a system for students to be able to indicate what they were going to work on during each class – board sections for *I will be experimenting*; *I will be reading*; *I will be on KF*; and (2) establishment of a system for students to document their activities (journal entries at the end of each session). It was interesting to see that their experimentation moved to include model-building. The group that started with a flap theory began building and worked well past the end of the class periods to build a wing that was like a stealth fighter plane (Figure 5) to show how lift worked. When holding the plane wing they would use their hands to show how they thought the air might move over the wing to cause the changes in pressure and result in controlled flight. The class discussed that more model-building perhaps should be encouraged explicitly. It was noted that each student's theory about flight could be *built* and that whatever is constructed could help them to explain their idea.

## Week 3 – Day 7

The group took this session to reflect on where they were at in terms of the breadth of problems and theories they were working on. Sheets of 8.5" x 14" paper were distributed, and all the students were asked to complete the task. As the gallery walk progressed several students took up doing some of the experiments to illustrate their conceptions about the phenomena in question. In the debrief the teacher highlighted that model building seemed to be a way of working with an idea that in the case of this topic – flight – could help others to understand their theories and help them to work

with the ideas. Despite the positive discussion about the value of model-building the teacher and the researcher felt a need to discuss the fine line between play and experimentation. The researcher and two students created a new birds view and helped to move notes there from the Flight Launchpad view. Two students organized the birds view – one student saying under their breath “this is ours...” to indicate they saw themselves as custodians of the view. They were shown how to create labels and quickly noted that there were no notes about take-off even though they thought that was a topic of interest in the group (Figure 8).

**Figure 8.** Birds View – Birds view with labels and no take off notes.



### **Week 3 – Day 8**

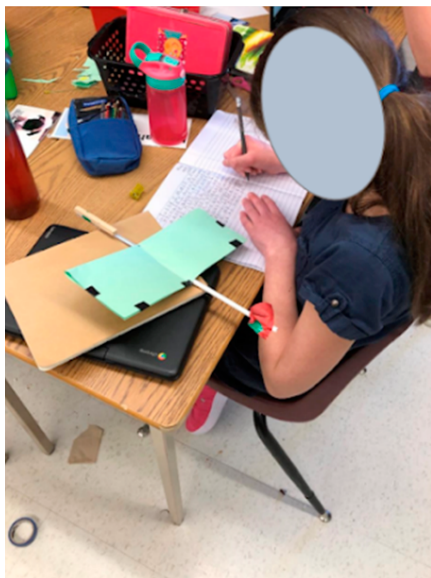
This session was interrupted by an internet outage in the school system. As such the participants were not able to use the KF database as planned. There was a discussion at the beginning of the class about other activities that could be done instead. The teacher noted that the participants could read the books that were now flanking the classroom. Some students picked this, but most chose

to continue with hands-on building activities (e.g., kites, wings, experiments). Also, part of the introductory discussion was a period where one student promoted that the group should get to do projects on Bristol board. There was general support for this idea. The teacher reminded the class that the KF database was a way of presenting ideas to each other. Another student noted that people did not seem to bother with the ideas and could just read a KF note and move on without dealing with it deeply. The teacher noted that this could happen with a Bristol board presentation as well – including that those projects are not changeable so they can stay with old information being displayed where KF could be improved. During this session there was a lot of activity going on with new wing/plane models being built (Figures 9 and 10). The group moved to hold a group talk with the KF database displayed up on the screen. The teacher took the group through the new views (e.g., Birds) and the students involved were asked to talk about what they had done.

**Figure 9.** Glider Model Building.



**Figure 10.** Glider Model Writing.



### **Week 3 – Day 9**

During the group meeting the teacher encouraged the students to think in terms of which ideas needed to be addressed immediately because of their importance. One student raised the question of “what is flight?” to the group. Given that this was Day 9 of the unit, this was viewed as an important and elemental question. But the student formulated it with respect to something other than the flight of planes or birds. They asked, “is a ball being thrown flying?” The group vigorously took up this question, applying the four forces (e.g., lift, drag, gravity and thrust) to the flying ball question. The relevant concern seemed to be how long the ball remained in the air (i.e., how much thrust was applied), but the group agreed that it could only be considered flight in some limited ways that fit with the balancing of the four forces of flight but that it was not *controlled* flight.

### Week 3 – Summary

Overall, the group was receptive to the elements that had been added to the class and the way the class was being asked to work as a community of knowledge creators. However, there were challenges. As several students noted there was a tendency to skim across other students' conceptions and, although being tolerated, there was not really a broad appreciation that the topics of focus being pursued by other students were important to everyone (e.g., history of flight). The interest expressed about doing projects suggested that they were missing the opportunity to present their advances to others. We wondered if they might be setting their sights too locally in terms of with whom they were going to be sharing their knowledge advances. If they were thinking of sharing beyond the walls of their own classroom, then they might see the work of other students as being part of the class *project*. A project that needed to be shared and in turn would give them a reason to work to make their knowledge advances as good and well described as possible for those inside and outside the classroom.

### Results

Bielaczyc's Social Infrastructure Framework is used to analyze the design of this KBC (Bielaczyc, 2006) and to expose the design tensions. Briefly, the Social Infrastructure Framework consists of four dimensions including the: (1) Cultural Dimension; (2) Practice Dimension; (3) Socio-Techno-Spatial Dimension; and (4) Outside World Dimension. The cultural beliefs expressed by the teacher and researcher were representationalist in nature. They focused on the need for students to express their ideas in written form (e.g., journals and KF) which was repeatedly raised throughout the three-week period. This was even present in the requirement to document the ideas being worked on while experimenting was occurring. Yet the students' belief that they could convey their ideas using the materials at hand in the form of models pushed back on the teacher's and researcher's cultural be-

liefs. This manifested in a shift in practice away from writing to one of demonstration and explanation for many members of the class with the KB Circle becoming the forum for sharing of ideas. From a belief standpoint the teacher and researcher positioned some of the work done by students as verging on play however for many of the students this was seen as serious play (Rieber et al., 1998). Also, in the practice dimension the practice of having students work in interest-driven groups was a stable design element. However, the pedagogical practice of learning across the groups was challenging during these initial nine days for this group as appreciation for what others were researching was not always forthcoming and they tended to build knowledge for their own sake and not that of the group.

With respect to the socio-techno-spatial dimension (Bielaczyc, 2006), the students had access to computers on a one-to-one basis, but this did not result in universally consistent use. The materials available for model-building often were more appealing to students in terms of where to focus their attention during these initial nine days. Finally, about the outside world dimension (Bielaczyc, 2006) the students initially did not see the outside world as being involved in their study other than for resourcing their inquiries (i.e., readings). When it came time to think about sharing their work, they only viewed themselves as the clients for such presentations. The teacher and researcher had to council the students on how their work could be of value to the outside world. But even then, the students viewed this as a reified poster presentation and not as a dynamic presentation that could be done through KF.

With regards to the trials of strength, Sorensen (2009) describes Law's analytic strategy as being "to treat the environment within which a design is created as hostile and the environment's parts as opponents to the design" (p. 39). In this design case there were several trials that challenged and changed the design and, thereby, worked to shape the resulting KBC away from the initial design.

Repeatedly throughout the design case the teacher added into the design, procedures designed to help track the progress of the students and to remind students of their responsibilities while engaged in the inquiry. These materials included requirements to pub-

licly acknowledge their intentions by placing their names in categories on the board and by requiring journal entries at the end of each KB session. Several avoided the requirement to write a journal entry by working, often diligently, past the end of the class when the entries were to be made. Although seemingly in opposition to the KBC design, these efforts to model their ideas through materials consistently were raised by students as important ways for them to share their work with the rest of the class. The KB Circle was the dominant means of dealing with this trial of strength, but the result was not satisfying for the teacher and most likely not for the students as well, as they continued to be asked to account for in writing the activities they were engaged in during class.

The key trial for this design case was representing ideas through model building. The stealth wing group used their hands to show how air moved around their wing to cause lift but seemingly avoided writing their ideas down in either their journals or in the KF database. The only sharing of these ideas came during the KB Circle when they were allowed to share their model-building work verbally. Likewise, there were other moments where the building of prototypes of kites and helicopters that did not fly but modeled flight (e.g., Da Vinci's flying screw) were engaged in by other groups of students. These opportunities to demonstrate flight through model-building pushed back against an overall expectation for the students to be able to represent in language their understandings of how flight operates in whichever realm they were exploring. Again, the KB Circle served as a key component of the design that allowed for this trial of strength to be adapted into the design of this KBC. Students were able to engage in model-building and then use these models to explain their understandings outside of the formal writing strategies that the teacher was requiring (e.g., journals).

The performative means by which the teacher wanted students to account for their time was predominantly in written form (i.e., journals). However, the students pushed back on this requirement by using the materials available in the classroom to make space for their learning about flight through the building of models to illustrate their understandings. The design feature of the KB Circle made this altera-

tion possible as it provided a means for models to be shared verbally with the rest of the class.

## **Discussion**

As Damşa and colleagues (2019) suggest, the materials represented “wider pools of resources and infrastructures that learners (could) draw upon to construct their own learning spaces” (p. 2078). Learning spaces that were materials-based and intertwined with their thinking about flight. The learning spaces created by the students through their use of the materials to model their ideas of flight led to an expansion of the material spatial environment. Likewise, the trial of strength encountered by the model-making efforts of the students challenged the discourse-centered approach promoted by the teacher and researcher thus yielding a change in the design.

The challenge of maintaining a discourse-centered design when materials are prevalent in the classroom was met by the intended design and alterations were necessary because of the learning spaces created by the students. The trials of strength that were encountered in this KBC design case were significant but successfully handled by the design through the employment of generative pedagogical practices (Mor & Abdu, 2018). In particular, the trial of physical models in place of written representations presented the greatest challenge to the design. The teacher added elements to the design to raise the level of responsibility students had for their KB work. Resistance came in the form of those working with materials to explain their ideas favoring this approach over written explanations. The KB Circle and teacher launch were used to negotiate how these components fit within the design. Students used a host of materials to illustrate their understandings, and these were able to be used during KB Circle time to explain evolving understandings about flight. As Damşa et al. (2019) position it, “learning spaces are enacted by learners but not (necessarily) in the way envisioned by the teacher or outlined by the learning design” (p. 2080). As such the ecology of resources goes beyond just humans and their intentions to build knowledge together through



writing to include the materials, they used to explain their ideas and the material discursive practices they employed to share these with one another. Or as Säljö (2010) suggests the materials and people's thinking were intertwined in a process of meaning-making. Following the 4E approach to cognition (Newen et al., 2018) what the students were engaged in with the materials was like extended cognition with the materials being extrabodily extensions of their minds. The materials pushed back and intra-acted with the humans and the other materials (e.g., journal writing) and as such created new learning spaces for KB to occur.

## **Conclusion**

In the end it is the case that if we are to meet the problems of the physical world through knowledge building practices these practices may need to evolve to include the material world itself. As such, our KBC approach and our conception of it must evolve to include all that takes part in the instantiation of the approach when groups come together to solve knowledge problems with the materials at hand. How students come to understand their part in making a shift from a more traditional classroom to that of a knowledge building community requires more research (Bielaczyc, 2023). Infrastructuring represents a way of accommodating the needs of the community to incorporate infrastructure to make KB function successfully (Kashi et al., 2023). If materials are to be part of a KBC then there needs to be a change in the practices that the teacher applies to how materials participate in the KBC, utilizing generative pedagogical practices that map onto how best to bring materials into the KBC (Mor & Abdu, 2018). In doing so this design was adapted to meet the students halfway in terms of using materials in an ideas-centered classroom.

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