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Two modes of thinking in knowledge building

Dues maneres de pensar en la construcció del coneixement

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Resum

En el treball productiu basat en el coneixement i les idees, hi tenen un paper vital dos tipus de pensament: el pensament crític i el de disseny. El pensament crític ha dominat l'educació, a partir dels diàlegs socràtics des de l'antiguitat fins als moderns marcs d'argumentació, els programaris i les llistes de competències per al segle XXI, orientacions curriculars i proves d'avaluació. El pensament de disseny, per contra, ha entrat en el discurs educatiu molt més tard i des de fora, des de contextos en els quals el treball creatiu amb el coneixement i les idees és dominant. Com que l'educació per a la innovació esdevé un imperatiu, el pensament de disseny ha començat a captar a l'atenció però encara ha de integrar-se en el corrent principal de treball amb continguts educatius. La construcció del coneixement opera en mode de disseny. En aquesta modalitat, el pensament de disseny té el paper principal en la creació de coneixement i en la millora de les idees, mentre que el pensament crític hi exerceix importants funcions de suport. Moure's de manera flexible entre els dos tipus de pensament és essencial. Per donar suport a la construcció del coneixement és necessari que els mestres estableixin una comunitat que els proporcioni suport mutu per al discurs de la construcció del coneixement i mantenir una norma de responsabilitat col·lectiva pel que fa a la noció de millora. Són necessaris molts anys per desenvolupar un alt nivell tant en el pensament crític com en el pensament de disseny, però els nens poden començar a funcionar en la modalitat de disseny des de molt joves i amb això guanyar la competència en ambdós tipus de pensament i aprendre a usar-los junts en l'avanç del coneixement de la comunitat. Això, en el sentit més ampli, és a dir, en la socialització en la vida i en el treball en una societat del coneixement.

Paraules clau

Construcció del coneixement, pensament crític, pensament de disseny, innovació, comunitat de coneixement, millora de les idees.

Abstract

In productive work with knowledge and ideas, two kinds of thinking play vital roles: critical thinking and design thinking. Critical thinking has dominated education, from Socratic dialogues of ancient times to modern argumentation frameworks, software, and 21st century skill lists, curriculum guidelines, and achievements tests. Design thinking, in contrast, has entered educational discourse much later and from outside– from contexts where creative work with knowledge and ideas is dominant. As education for innovation becomes an imperative, design thinking has begun to gain attention but has yet to become integrated into the mainstream of work with educational content. Knowledge building operates in *design mode*. In this mode, design thinking plays the leading role in knowledge creation and idea improvement, while critical thinking plays important supportive roles. Shifting flexibly between the two kinds of thinking is essential. To support knowledge building teachers need to establish a community that provides mutual support for knowledge building discourse and that maintains a norm of collective responsibility for idea improvement. Both critical thinking and design thinking take many years to develop to a high level, but children can begin functioning in design *mode* from an early age and thereby gain competence in both kinds of thinking and learn to use them together in advancing community knowledge. In the largest sense, this is socialization into life and work in a knowledge society.

Keywords

Knowledge building, critical thinking, design thinking, innovation, community knowledge, improving ideas.

Foreground

A distinction between two modes of dealing with knowledge and ideas – originally labeled "belief mode" and "design mode" (Bereiter & Scardamalia, 2003) – has played an important part in knowledge building theory and pedagogy (e.g., Chen & Hong, 2016; Scardamalia & Bereiter, 2014). Belief mode was seen as comprising the wide variety of ways in which people evaluate knowledge claims – the ways in which they arrive at decisions about what to believe. Design mode was seen as the mode of invention and idea development – the kind of activity through which new knowledge is created. What makes design mode especially important in knowledge building is that it is the mode of *idea improvement* – a core principle of knowledge building (Scardamalia, 2002; Scardamalia & Bereiter, 2006). Design mode and belief mode both deal with ideas in significant ways; in belief mode the focal question is "Is it true?" whereas in design mode the focal question is "How can we make it better?"

Both modes are valuable and work well together, but since ancient times education has been conducted almost exclusively in belief mode. This remains true even in some of the most advanced educational approaches alive today. "Arguing to learn"

(Andriessen, Baker, & Suthers, 2003), which shows up in sophisticated innovations at all educational levels, enshrines belief mode in much the way it was enshrined in the academies of ancient Greece. In knowledge building, design mode is the principal mode of student interaction with academic subject matter. Belief mode is important, of course, but is assigned a supporting rather than the dominant role.

Reviewers of articles and discussants have readily grasped and endorsed the idea of design mode, but the "belief mode" label did not fare so well. Some took it to mean unquestioning acceptance of beliefs: "because the book says so." We allowed that belief mode can work that way but that it can also mean Socratic reasoning, rational argument, and evidence-based judgment. Because the term "belief mode" generated misunderstandings no matter how exhaustively we tried to explain it, we experimented with alternative terms. We have tried "proposition mode," "argument mode," and "justification mode." These avoid some misconceptions but promote others. In some presentations we just talked about design mode and said nothing about the other mode; but this was not adequate either. Education needs to help students function well in both modes and to shift appropriately between modes; and for that, contrasting concepts are needed. For reasons that will be elaborated later, in this article we refer to "critical/analytic mode." This covers only a part of belief mode activity, but it is the part most highly regarded in formal education and it offers the most significant contrast to design mode.

The two modes are associated with two well-recognized kinds of thinking: critical/analytic mode with critical thinking and design mode with design thinking. "Critical thinking," with its millions of web citations, is everywhere in educational discourse. It is common to many 21st century skills lists (Binkley, *et al.*, 2012), curriculum standards and guidelines, and modern achievement tests. "Design thinking" is a rapidly growing meme, found mainly in the business literature (e.g., Kolko, 2015), but now making its way into education. A number of companies, including the famous design group, IDEO, have gotten involved in providing consulting, workshops, and toolkits for design thinking in education. One website lists 45 design thinking resources for educators (www.teachthought.com/?s=design+thinking). In the following sections we first elaborate on the meanings of these two kinds of thinking and then discuss functioning in the two associated modes.

Critical thinking and design thinking

Human beings have probably been doing critical thinking and design thinking ever since they first began arguing about beliefs and building complicated structures. However, the *concept* of critical thinking took shape during historical time in the work of philosophers such as the pre-Socratics. The concept of design thinking came much later. It appears to have had its origins in design schools and design labs and only recently to have spread beyond them. As pressure mounted on businesses to innovate, it began to be recognized that design thinking could be applied to creation of new products, services, and processes – that it is in fact the kind of thinking that produces innovations (Brown, 2009; Martin, 2009). A frequently quoted statement attributed to Roger Martin[1] is "We rely far too exclusively on analytical thinking, which merely refines current knowledge, producing small improvements to the status quo. To innovate and win, companies need design thinking. This form of thinking is rooted in how knowledge advances…" The way knowledge advances, according to Martin, is the same way identified earlier in education by Paavola and Hakkarainen (2005). It is through abduction, defined very loosely as advancing an idea which, if it proves valid, achieves a goal (such as explaining a phenomenon or solving a problem). Thus critical thinking is involved – in determining whether the idea is valid – but in creative knowledge work assessing validity comes *after* a promising idea has been produced.

Sometimes the term "critical thinking" is used to refer to all kinds of rational thought. However, this renders the "critical" part superfluous. The U.S. National Council for Excellence in Critical Thinking (*www.criticalthinking.org/pages/defining-critical-thinking/766*) defines the term more carefully and in a way that makes clear its relation to belief: critical thinking is the "intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, or evaluating

1. The statement actually appears in the publisher's description of Martin.

information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action."

In productive work with knowledge and ideas there is continual interplay between critical thinking and design thinking. That is why it is useful to consider *modes* in which critical and design thinking have roles, but different roles depending on the mode. In what we will call "critical/analytic mode," critical thinking plays the leading role, but design thinking comes into play when attention turns to rhetoric – building a persuasive case. (Plato himself recognized the distinction; in the *Gorgias* he contrasted rhetoric with Socrates' goal of seeking the truth.) In what we call "design mode," design thinking plays the leading role but critical/analytical thinking is brought into play when issues of truth and factuality arise.

The meaning of modes

Design mode and critical/analytic mode are not the only modes of classroom interaction, nor do we argue that they should be. There is "negotiation mode," when the object is to reach a mutually satisfactory resolution of competing desires. There is "play mode," when activity takes on a game-like or recreational character. An idea like environmental protection may find students responding to it in "social action mode," leading to efforts to "do something about it." But the predominant mode in some classrooms is what we may call "schoolwork mode," where the object is the successful carrying out of assigned tasks. There is value in all these modes, but design mode and critical/analytic mode have special significance in formal education, as modes of dealing directly with intellectual content. There are classrooms where neither of these modes of activity is evident, where all the serious work that goes on is in schoolwork mode. This is rightly criticized as low-quality education, conducive to rote learning and mindless "projects." But efforts to upgrade it usually focus on moving toward critical/analytic mode, with critical thinking and critical mode of classroom activity (e.g., argumentation) so tightly bound that there is no room for design thinking. Thus, for example, the possibility that the argument itself is focused on the wrong issues, requiring a design-mode effort to formulate the key issue, is unlikely to find a place in the discussion. Upgrading schoolwork mode to design mode means turning it into knowledge building, where idea improvement becomes the norm. In design mode, formulating and deepening the problem is an important part of knowledge building discourse (Bereiter & Scardamalia, 2016).

Modes are complex kinds of activity that have both cognitive and non-cognitive, observable and unobservable characteristics. Within a few minutes in a classroom, an observer can generally recognize what mode or modes are active. Associated with each mode are different postures and physical actions, routine practices, types of dialogue, kinds of social interaction. These are the observable parts. Not observable, but equally definitive are mindsets, values, and conceptions of what is going on. Teachers can directly influence the observable parts but have much less influence over the unobservable.

There is a natural affinity between work in design mode and critical/analytic mode; thus we see very young children in quick succession saying: “My theory is that leaves turn colour in the fall because they are cold” (a design mode statement) and “Let’s put some leaves in the freezer and see if they change colour” (an experiment born out of design mode thinking while incorporating an evidence-seeking shift into critical/analytic mode). As suggested in this example, design mode calls rather naturally for phases of critical analysis; it is integral to knowledge creation. In contrast, critical analysis within education typically stands alone. It has been a way to bring students around to true and warranted knowledge claims without concern about where the knowledge claims come from, about unresolved problems with them, or about possible paths of further development. The result is a timeless view of knowledge. What is accepted as true may change tomorrow, but the students’ concern is with what is judged to be true today. That is a realistic view when the objective is mastery of testable knowledge. We cannot test students’ understanding of knowledge that has not been created yet. But critical/analytic understanding of existing knowledge is not sufficient for education for knowledge creation. For that, students need to work with ideas in design mode.

Seeking truth or improving ideas?

In critical/analytic mode, getting to "the truth of the matter" – that is, to justified belief – is usually an end in itself. In design mode, facts have an instrumental role. This does not imply a disregard for truth or validity. It implies, rather, that facts are considered within a wider framework of information quality, importance, and action in the face of uncertainty.

What this means can be illustrated with a practical example. If you are an architect or builder planning the laying of floor joists in a house, you naturally seek valid information about maximum span for joists of different sizes and materials. However, this is not simply a matter of determining what is true. Instead, you face three kinds of problems:

1. Information quality. How trustworthy are the different information sources? Information quality becomes especially problematic if you are seeking answers on the web or relying on hearsay. But you do not expect to find perfect information. What you need is information that is *good enough* for the situation you are dealing with.
2. Information importance. How much does it matter what the maximum span is? If the span you are contemplating is within the most conservative limit, then it does not matter what the "truth" is with respect to the immediate problem. If you aim for an unsupported span that exceeds the conservative limit, then the issue of what information you can trust becomes crucial. If, however, local building codes specify the maximum span, then the truth of the matter is irrelevant to your immediate purpose. (Clearly, much more information of high quality would be needed if the task were to improve the building code.)
3. Action in the face of uncertainty. If the conflicting information confronts you with a dilemma, you might decide to play it safe by building a supporting wall under the floor; you might consider other sizes of joist or other kinds of wood; or you might come up with some "creative" solution.

These three issues are likely to figure in any design work, whether it is designing or improving a physical artifact, a process, a theory, or a history. In the case of designing a theory or a history, improving it may be expected to bring it closer to truth. But in the process of developing the theory or similar conceptual artifact, the same considerations apply as in laying floor joists. Is the information good enough for our theory development to progress? How important are certain pieces of information? And how can we improve our theory, given the inevitable uncertainties with respect to the facts and methods we have to work with? Even when truth of some kind is the ultimate objective, as it is in much of the student questioning that sustains knowledge building in education, students have much to gain by involvement in the actual complexities of idea development and improvement rather than simply being presented with knowledge claims and seeking evidence or reasons to accept or reject them.

Design thinking by students: Theory building

Much of the treatment of design thinking in education has to do with design thinking by teachers and administrators – who of course have been doing design thinking long before it became a buzzword. It often takes the form of designing lessons and activities to meet curriculum goals. Design thinking by educators does not necessarily have anything to do with design thinking by students, however. In “Why ‘design thinking’ doesn’t work in education,” Debbie Morrison (2013) argues that design thinking is great for teachers planning courses but is not suitable for teaching to students in grades K-12. The reason? Because they do not know enough. Morrison quotes from Stanford’s design school website (*dschool.stanford.edu*) a statement according to which the process of design thinking “draws on methods from engineering and design, and combines them with ideas from the arts, tools from the social sciences, and insights from the business world.” Lacking such wide-ranging knowledge, school students are unable, for instance, to come up with breakthrough analogies, which have a major role in design thinking.

If Morrison's argument were applied broadly, it would eliminate from schooling all creative work with disciplinary knowledge and ideas, including (especially) knowledge building. Furthermore, the same argument could be made against critical thinking. It too depends on diverse kinds of knowledge; yet we have never found an educator to declare that critical thinking should be deferred until the later years of schooling.

Design thinking, like critical/analytic thinking, takes years to develop to a high level, and even then it is likely to be perfected within a particular domain or type of work rather than as a general competence. Design thinking and critical/analytic thinking depend not only on a reservoir of relevant knowledge, as Morrison indicates, but also on the development of habits of mind – a design mindset or a critical mindset – and, for collaborative work, social skills and forms of discourse appropriate to each (*cf.* Bereiter & Scardamalia, 2016). However, young students can begin functioning in design *mode* and critical/analytic *mode* when their thinking in these modes still has a long way to mature. Children at the primary level can begin producing theories – if by theories we mean explanations that are vulnerable to evidence. They will not be elaborated and integrated theories but rather will tend to be single-cause explanations. But, interestingly, children show an understanding of theory that is in a fundamental way more advanced than what they are likely to be taught later as "the scientific method" (Bereiter, 2016). They understand that the job of a theory is to explain, that it is not just a guess at the truth. As more information is acquired, they revise and elaborate their theories. They are growing as knowledge builders, and they do this by practicing knowledge building from the beginning. They do not start somewhere else and work up to knowledge building gradually.

If design mode is to play a central rather than an incidental role in the core curriculum, we need a developmental path leading to mature competence in knowledge creation – for design thinking in the context of sciences and scholarly disciplines has to be aimed at creating knowledge products such as theories, histories, proofs, and problem analyses. Scientists and scholars also write books and articles, collect data, argue among themselves, sometimes reach consensus on matters of substance; but it is possible to do these without doing any knowledge creation. So engaging students in these kinds of activities may completely miss the design part.

Early progress toward disciplinary design thinking is seen in the invention of explanatory hypotheses, which we suggest should be recognized as theories. This is something even kindergarteners can not only do but thoroughly enjoy doing. Modern teachers encourage this and often marvel at the ingenuity of children's explanations. However, argumentation is so dominant in educational thought that the tendency is to move directly from students' invention of explanatory hypotheses to assessing their truth value. Through gesture, glance, redirection to a more "on course" idea or requirement to gather evidence and debate differing ideas, teachers signal to students that the priority is true and warranted beliefs, not exploration and discovery. That is a way to kill off design thinking. Another practice that tends to defeat design thinking is grouping students' ideas into clusters and treating each cluster as one idea. The result is a kind of averaging out of ideas, so that the most original and distinctive elements are removed. A more design-friendly way is to engage the students in discussing ideas they judge most promising for further collaborative work (Chen, Scardamalia, & Bereiter, 2015). Further development of promising ideas may then follow a variety of paths, which can occur in any order and may be pursued by different groups: (1) evaluating plausibility – often involving the invention of experiments, (2) identifying what has been explained and what is still unexplained, (3) gathering information that seems relevant to the explanatory problem, and (4) inventing new second-order ideas that resolve conflicts among first-order ideas.

Although gathering information through reading and experimentation is part of idea development, using information as *evidence* is a further step that should normally occur only after ideas have been developed to the point where evidence can play a productive role in abductive reasoning (Paavola, 2004). This means having an explanatory hypothesis or theory, *P*, for which it can be claimed that if *P* is true the phenomenon is explained. The hypothesis that change in distance from the sun is what causes seasonal change does not meet this criterion. Evidence that the earth is closer to the sun in July than in January (which incidentally is not the case) would not validate the distance explanation, because that explanation should already have been dismissed because of its failure to comport with known facts, such as the fact that when it is summer in Catalonia it is winter in Patagonia and vice-versa. If, however, students begin putting together a coherent explanation that explains not only seasonal temperature change but also changes in the length of days and the apparent elevation of the sun, they will reach a point where it becomes crucial to establish whether the earth is tilted in relation to the sun. This is when students should start looking for evidence, information that is not only relevant to their project but pivotal. The fault is not in the overuse of critical/analytic mode per se; it is in moving into that mode too soon. After students have generated a number of explanatory ideas, the next step should be putting effort into developing promising ideas into more powerful ones, which usually means constructing a more complete theory. Interest in their ideas and encouragement to go deeper are all to the good, but in design mode facts serve as building blocks in theory building – along with experimentation, reading authoritative sources, considering diverse ideas. When a case is being assembled to uphold or reject a theory, that is when judging the quality of evidence and exercising care in drawing inferences from it become essential parts of the scientist’s tool kit. Introducing those concerns too early can have a deadening effect on imaginative idea development, and killing off imaginative idea development can kill off interest in further work in science for the active thinking student.

Theory building has a developmental course that can be roughly sketched. Children’s initial explanatory ideas are likely to be of the single-factor kind: species endangerment is caused by hunting, birds fly because they flap their wings, and so forth. Single-cause thinking is common among adults as well; how many times have we heard “the teacher” or “the home environment” singled out as the sole determinant of some result? The next step up is multi-variable thinking, which is what we commonly get in popular treatments of complex phenomena. The number seven is especially popular: seven habits of successful, creative, or happily married people; seven signs that you have some dread disease; and so on. In some cases all the factors need to be present, in other cases any one factor will suffice, and in still others the factors are thought to have a cumulative effect. The factors may be said to interact, but usually all that means is that they combine additively (which means there is no interaction). Actually, dealing with interaction, where the effect of one thing depends on the effects of others, takes us to a level of theorizing that leaves many people behind.

Between the simple listing of contributing factors and the abstractly structured theories of leading-edge science lie a number of forms of what may be called theorizing, insofar as they achieve some kind of explanatory coherence and are vulnerable to disconfirming facts. Of particular interest at the school level is the “how it works” narrative. A process or phenomenon is explained by a series of events, with one causing the next. The progress of a plant from seed to fruition lends itself to an event sequence narrative, but often the narrative is complicated by the fact that things happen concurrently. A story about how an electric bell works must recognize that the same movement of the striker that sounds the bell also breaks the circuit that drew it to the bell, thus resulting in its springing back from the bell in readiness for a new cycle. Sophisticated theories in the sciences usually do not have a story-like structure. They are what is called “constraint-based,” which means that, like Newton’s laws, they specify relations that hold perpetually and determine observable events such as the orbiting of planets, the recoil of a cannon, and the period of a pendulum. The kinds of theories school students are able to produce, however, can seldom go beyond the “how it works” narrative. They can understand constraint-based theories within the limits of their mathematics, but usually cannot theorize in that mode. This means they can understand Newton but can get only a superficial grasp of the physics that succeeded him and cannot be expected to extend Newtonian theory on their own. In biology, however, “how it works” narratives play a larger role and represent an explanatory game school students can play. Nutrition, respiration, and circulation are all processes that can be given explanations in narrative form, with the stories gaining complexity and undergoing correction as students’ knowledge advances. Evolutionary explanations of the emergence of wings, legs, sexual reproduction, and so on, all have a story-like structure that students can grasp, elaborate, and criticize. One of the worst things about evolution avoidance in American schools (and there is a lot of avoidance, even when the main ideas of

Darwinism are taught) is that students miss out on one of the most productive and rewarding opportunities to exercise design thinking with ideas.

Knowledge building discourse

Discourse is absolutely vital for collaborative work in both design mode and critical/analytic mode, but the discourse takes different forms in each. Since ancient times critical/analytic discourse has taken some form of argument – from the progressive questioning form of Socratic dialogue, through the *sic et non* of medieval scholasticism, to the conventional forms of modern research journal articles. Design mode discourse lacks established forms. Certain kinds of “good moves” in design discourse may be identified (Bereiter & Scardamalia, 2016; Conklin, 2005), but they have no fixed order or manner of representation. In knowledge building, as in knowledge creation more generally, one way to look at discourse is as a gauge of the knowledge building/knowledge creation process. If the discourse isn’t progressing, something is wrong; but the way to fix it is not necessarily to work directly on the discourse. What has gone wrong may lie more deeply in the way ideas are being treated. But discourse is more than a reflection of an underlying process. Knowledge building has been defined as an effort to advance the frontiers of knowledge in a community (Scardamalia & Bereiter, 2003). But where is this mysterious “frontier of knowledge” that a group is supposed to be advancing? It is not to be found in the individual minds of the participants. The frontier is an abstraction drawn from the discourse, representing its leading edge. Ideally, that abstraction is itself brought into the discourse as something that is explicitly examined and refined. Thus a successful knowledge building discourse becomes multi-layered. There is a layer in which, for example, ideas about how germs cause illness are developed. Then there is a layer in which the group’s progress in explaining illness is considered, knowledge gaps and barriers to progress are identified, and plans for inquiry are drafted. A third layer may be concerned with improving the second layer, and so on. But these are not separate discourses. They go on in concert.

Educators who are strong advocates of “hands-on” approaches, experimentation, and first-hand experience often perceive an over-emphasis on discourse in the classroom. There is too much talking, not enough doing. Students throw around terms they don't understand, when they should be working directly with the things and phenomena those terms represent. Those objections often have merit. Classroom talk can easily lapse into verbalism. The question raised is what causes boats to float and the answer given is "buoyancy." "Buoyancy" is no answer; it is just a word that means a tendency to float. A real "hands-on" answer ought to arise from experiments in which different conjectures about buoyancy are tested. But where does this "answer" arise? Where are the different experimental findings brought together and applied to constructing a theory of flotation? In the classroom discourse, of course. Without a successful knowledge building discourse, you just have a lot of students trying out different notions and observing the results. Those observations acquire significance when they are brought into the discourse.

Making knowledge building discourse happen

If discussion is carried out online, thus preserving a record of it, you can easily spot when knowledge building is failing to occur. Some telltale signs are:

- The discussion is boring to read. If you find it boring, the students probably find it boring as well and are not finding the work rewarding.
- There are many entries that say essentially the same thing – raise the same question, make the same observation.
- Facts are presented without suggesting how they contribute to solving a knowledge problem.
- There are many opinions stated without support and most of them are either ignored by others or responded to with simple agreement or disagreement.
- Students may respond to an immediately preceding contribution, but they seldom refer to more than one contribution at a time or to contributions made at an earlier time. In other words, there is little relating of ideas.

— There is no "rising above" to higher-level ideas that resolve inconsistencies among separate ideas and that have greater "explanatory coherence" (Thagard, 2000).

These shortcomings characterize not only online but teacher-led and other forms of classroom discourse as well. Rising-above requires that teachers and students alike commit to advancing *community knowledge*. If they are bored, if redundant information is taking too much real estate on their communal space or too much time in classroom conversation, if they are reporting facts with no identified purpose, if ideas lack connectedness, if opinions are expressed without support, these are *community* problems that need to be raised as issues for the whole community to deal with.

Collective responsibility for advancing community knowledge is a principle of Knowledge building. Teachers need to provide support for it, which they can do in various ways. When students are contributing ideas to an online space such as Knowledge Forum (Scardamalia & Bereiter, 2006), the teacher conveys to them the importance of reading the notes of community members. This is important for reducing redundancy and for building on each other's notes and also for addressing issues regarding group progress. Correspondingly, the teacher ensures that students are given time to read each other's notes. The teacher devotes class time to discussing the importance of using meaningful note titles so that community members can see at a glance the gist of each note without needing to continually re-open notes. There is also plenty of class time devoted to metadiscourse – discourse about their discourse. Projecting online notes and views can play an important part in metadiscourse, serving as a basis for discussing which ideas to develop further and how best to proceed. Research has shown even grade 2 students engaging in effective metadiscourse when assisted by software tools that provide an overview of domain specific words in their notes and relate these to words used by experts in the domain. These young students were able to interpret these overviews of their work and create effective plans for expanding their knowledge building with more advanced concepts and operations (Resendes, Scardamalia, Bereiter, Chen, & Halewood, 2015).

Contrast this collective responsibility for community knowledge with typical classroom discourse that treats each idea as the personal property of an individual, with response in the form of praise or critical evaluation directed to the individual. This goes beyond the kind of individual recognition that group members of any age deserve and becomes a sort of *hyper-individualization*. In contrast, in an effective knowledge building community, the teacher helps students understand the importance of idea diversity and responsibility not simply to demonstrate personal advances but to help advance the ideas of their peers and to transform diverse ideas into a coherent whole. They create something new and exciting out of the separate facts and ideas they have individually contributed. Focusing on the state-of-understanding reflected in collective contributions can boost morale and self-concept for all, as each person is party to the larger enterprise. We are reminded of one child who could barely speak English and could not write. His contribution to a Knowledge Forum view was a scribble contributed with a title made up of randomly selected letters. The class went on to explore issues of endangered species. When later asked what he was working on he said "endangered species" – his "scribble" was an endangered animal. Perhaps that was a reconstruction; more importantly, it reflected his sense of belonging. It is the opportunity to situate one's contributions within the community's work that generates early identification with a knowledge-creating enterprise.

In elementary mathematics, Paul Cobb and his colleagues (Cobb, Gravmeijer, Jackel, McClain, & Whitenack, 1997) have found metadiscussion to be very helpful in working out what they call "socio-mathematical norms" – norms for what count in mathematics as different ideas as compared to the same ideas expressed in different ways. If individual ideas are treated as separate entities, not only are the contributors short-changed; *hyper-individualization* treats every child's idea as unique, even if it is indistinguishable from some other child's idea. Although intended as support for children's identity development and well-being, it can often create needless problems. If an idea is set out as "Laura's idea" and then changed substantially, is it still Laura's idea or is it now the idea of the student who proposed the change – and how is Laura going to feel about this? In authentic knowledge building the idea, as an improbable entity, is given a descriptive name, perhaps suggested by its author or authors or by the class – something like the “light rays slow down” idea. The idea would then become what in a knowledge building classroom it is intended to be: public property, available to the community for evaluation, use, and improvement. In our experience students’ well-being is associated with their feeling of belonging to the community through contributing ideas that grow.

The managers of any kind of team – sports team, sales team, design team, or research team – have to balance individual needs for recognition and reward with team spirit, with dedication to collective effort. Teachers deal with this tension already, in the course of ordinary school activities. All we are suggesting is that in collaborative knowledge building the balance needs to tip toward shared goals, pride in team accomplishments, and the sense of having contributed to those accomplishments. There seems to be a tendency, however, to tip the balance the other way, leading to no sustained growth of ideas. The result is likely to be the conditions we noted at the beginning of this section – the redundancy, the irrelevant information, the disconnectedness, the stagnation that indicate knowledge building is not taking place. Unfortunately, when this occurs there is a tendency to blame it on the students. As we have suggested, there are things teachers can do to make classroom discourse more dynamic and productive of new knowledge and there are things they can avoid doing that tend to stifle or deflect knowledge building discourse. We have never seen reason to believe that some classroom group of young students is intrinsically resistant to or incapable of working in design mode to advance their understanding of the world.

A skillful teacher can transform a group of students, who may have been accustomed to “schoolwork mode” in their previous years, into an effective and self-sustaining knowledge building community. This takes time, but during this time the students will have been working with knowledge in design mode while becoming increasingly capable and comfortable with it. If students then move on to another knowledge building community, rather than each teacher needing to start anew each year, the cumulative effect is to enable the forms of metadiscourse identified above and collective responsibility for knowledge advancement. As one teacher expressed it, the more agency I turn over to my students the more they assume.

Balancing versus integrating the two modes

Much of formal education is conducted in critical/analytic mode without any recognition of design mode. This is especially the case in approaches to science education based on the belief that argumentation is the basic mode of scientific thought (e.g., Bell, 2002; Kuhn, 1993). There are also mixed modes, where the students tackle concrete design challenges – for instance, designing a miniature boat propelled by air expelled from a balloon – while the underlying principles (for instance, Newton’s third law) are treated in critical/analytic mode. Knowledge building in its purest form represents a third way, in which design mode is the encompassing mode of work with ideas while critical/analytic mode is incorporated into it as a way of dealing with questions about the validity of knowledge and belief claims that arise in the course of idea improvement. Critical analysis thus becomes one kind of “good move” that has a place in knowledge-creating discourse (Bereiter & Scardamalia, 2016).

This is not to say that all of education should be conducted in design mode. Emotional and aesthetic experience, for example, are important parts of education as well. They may well need to take precedence over both design and critical/analytic thinking – with those playing subordinate roles – when the primary concerns are the enrichment of experience, as in literature and the arts, or moral engagement, as in work on values and social action. But if one wants to connect feelings and values to work with conceptual subject matter, education must bring to it the emotional joy of creating coherence, with elegant simplicity holding aesthetic appeal, and with a historically-grounded sense that knowledge can have moral value as a public and not just a personal good. Working with ideas across the curriculum is what most formal education is concerned with; knowledge building represents a way to bring the power of design thinking to it. If it is true that the survival of civilizations depends on creating new knowledge for solving problems (Homer-Dixon, 2000, 2006), then education from early childhood on up ought to be socializing students into a knowledge-creating culture that works – passionately! – in design mode.

There is more to knowledge building than design mode, as we hope this article suggests. Of the 12 frequently stated knowledge building principles (Scardamalia, 2002; Chen & Hong, 2016), some bear directly on thinking in design mode: for instance, “improvable ideas,” “constructive uses of authoritative sources,” “knowledge building discourse,” and “rise above.” Others speak more to social norms and values essential in developing a community where knowledge building can thrive. These include “democratizing knowledge,” “epistemic agency,” “real ideas, authentic problems,” and “community knowledge, collective responsibility.” Ultimately design mode is essential; if students are not working with ideas in design mode they are not doing knowledge building. Much of the successful teacher’s effort goes into community development – building a community that is not only just and mutually supportive of its members but that is devoted to advancing the frontiers of the community’s knowledge.

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