Rethinking Technology & Creativity in the 21st Century

Transform and Transcend: Synthesis as a Trans-disciplinary Approach to Thinking and Learning

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"Poetry is the achievement of the synthesis of hyacinths and biscuits."
—Carl Sandberg (1928)

"By the word synthesis, in its most general signification, I understand the process of joining different representations to each other, and of comprehending their diversity in one cognition."
—Immanuel Kant (1855)

We have argued that Perceiving, Patterning, Abstracting, Embodied Thinking, Modeling, Play, and Synthesis are seven trans-disciplinary skills, or tools for thinking, that encapsulate the ways in which creative people think. In this article, we focus on the seventh of these tools—synthesizing.

In 2003, a DJ named Brian Burton, also known as Danger Mouse, produced an album that blended music from the Beatles' *White Album* and Jay-Z's *Black Album* – it was appropriately titled the *Grey Album*. By the DJ's own admission, the project was intended as an underground hip-hop experiment, primarily for local club use. However, word of the compilation spread quickly via the Internet, as did downloads of the music. It became a phenomenon unto itself. This, in turn, spurred legal backlash from EMI for the unauthorized remixing of Beatles samples. At the time, many national news outlets reporting on this incident made reference to *mixing* (Danger Mouse's 'Grey Album' spurs dispute, 2004), *remixing* (Pareles, 2004), and *melding* (DJ Mixes Beatles, Jay-Z into "Grey," 2004), while others used a more colloquial term long known in the music world. Danger Mouse had created the quintessential *mash-up*. And the term began its journey toward the mainstream.

Today, mash-ups describe everything from video editing to culinary fusion. The rise of computer networks that allow for easy sharing, as well as the evolution of creative software tools have resulted in a fertile and unprecedented environment for mashing-up just about anything. A YouTube search for the term mash-up nets over seven million results. For fans of both classic literature and zombies, *Pride and Prejudice and Zombies* rose as high as number three on the *New York Times* bestseller list. ,Art historians across the world cringe from mash-ups that include the works of Dali, Escher, and Van Gogh in the context of Disney, Donkey Kong, and The Muppets.

So, what makes a *good* mash-up? We argue that a good mash-up both transforms and transcends the original material. Consider the *Grey Album*. Danger Mouse did not just transition from 20 seconds of *Jay-Z*, to 10 seconds of the *Beatles*, and then back to another clip of *Jay-Z*. Editing in this way would be more of a medley

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than a mash-up. In a mash-up, the music is layered, voices often overlap, accompanied with alterations in tempo and key for one or more of the samples.

However, just combining new tempos and key changes does not necessarily result in a good mash-up. In order to truly understand the impact of a mash-up, one must take into account the listener. Did the mash-up change how the listener experienced the song(s)? Did they dance differently than they would have for the original samples? Did the mash-up change how the listener remembers the song? Did the mash-up create new meaning? Did the message from the song(s) change? Did the mash-up create a new experience, one different from the experience generated by the components that make up the mash-up?

This idea of a mash-up, as being a transformation of the original components, is key to understanding the trans-disciplinary thinking skill of *synthesis*. The skill of synthesis is a complex one, and as such perhaps a bit more challenging to describe than the other six skills that we have covered in previous articles in this series. There are several ways that synthesis can arise, or can be designed, and we will explore several aspects of synthesis in this article. But from whatever angle we examine synthesis, at its core this skill involves the bringing together of elements into some kind of newly constructed knowledge or novel creative work. In a mash-up, multiple elements are brought together to create something relatively new. While the *Black Album* and the *White Album* represent pre-existing work/knowledge, the *Grey Album* arose as something new and different –a mash-up with an identity of its own.

While synthesis might involve bringing together or blending existing work or knowledge into something creative or new, it can also be a form of knowledge or thinking. Synthesis can involve the combination of several (or all) of the other trans-disciplinary thinking skills – into a new combination that represents an original kind of knowing. This lies at the heart of the idea of combinatorial creativity (Ferguson, 2011), where new ideas emerge from the combinations and tweaking of existing ideas in novel ways. As such, we explore the thinking skill of synthesis, and what it can creatively produce, in different ways and at multiple levels.

Thinking Across Disciplines: What is Synthesis in Thinking?

We have noted how a synthesis produces something novel out of different (but often pre-existing) elements. Root-Bernstein & Root-Bernstein (1999) define synthesizing as a skill in which "sensory impressions, feelings, knowledge, and memories come together in a multi-modal, unified way" (p. 296). As Mishra, Koehler, & Henriksen (2011) frame it:

> Synthesizing requires that we put multiple ways-of-knowing together. When we fully understand something, our feelings, senses, knowledge, and experiences come together in a multifaceted and cohesive kind of knowing. A person feels what they know and they know what they feel (p. 26).

Examining synthesis as a complete form of knowledge or experience allows us to make a point about trans-disciplinary thinking that we have implicitly touched, but perhaps not emphasized enough, in the previous articles within this series. While we often describe these seven skills in individual terms ("perceiving is this"…or "abstracting involves that"), in actuality, the skills often play out in more unbounded and overlapping ways. While a person might emphasize one skill, such as patterning, to write a poem, they might also just as importantly call upon abstraction to generate metaphors, or perceiving to observe nuances in the poem's structure or rhythm, or embodied thinking to empathize with elements or characters, or play to tinker with the themes, lines, or rhymes. We argue that this holds true for any creative act, whether it be the creation of a painting or developing a proof in mathematics. In other words, while each trans-disciplinary skill may be defined individually for the purposes of discussion, and while each has its own identity and way of acting, in reality they often work together in synergistic ways. Synthesis is where many or all of these skills (perceiving, patterning, abstracting, embodied thinking, modeling, and play) can come together in a complex, rich and nuanced manner. This, we believe, is the root of true understanding.

Educational psychologists often distinguish between knowing and understanding (Watson & Kopnicek, 1990). To *know* is to hold a piece of knowledge or have a basic level of information about something. But to *understand* is to experience something at many levels. Not only to have basic knowledge about it, but also to have multi-sensory and multi-faceted ways of experiencing and applying it. Aldous Huxley wrote that knowledge is passive, while understanding allows for the ability to act on something. This is where we find creativity and synthesis – the ability to act (or to create) rather than just to hold information.

Exemplifying Synthesis

When we consider what it means to understand something rather than just know it, we are looking at a form of knowledge that brings together many elements in multi-dimensional ways. To this point, the Root-Bernsteins (1999) provide the example of Sir James Lighthill, an applied mathematician at University College, London. Lighthill explored over sixty different disciplines in his work on applied mathematics, but the work he was most famous for was his research on aero-acoustics (a branch of physics concerned with sound generation in fluids). Lighthill (1999) credits his creative success in aero-acoustics on not just his knowledge of fluids, but also his deeply personal synthesized understanding of the domain. He writes:

> I have a general pleasurable feeling about fluids,

> and…my hobby is swimming; I have a great deal of interest in the ocean, ocean waves, ocean currents, ocean tides – and I so enjoy observing all when I swim…I do a three mile swim every weekend to keep fit. (p. 297)

In a sense, Lighthill saw this knowledge as a part of who he was. He understood this realm in a thorough and multi-sensory way. Swimming became a way to explore his understanding of aerodynamics and fluid dynamics, or as he puts it:

> I've done a lot of work on ocean waves and tides and currents, and I feel I understand them well enough to be quite prepared to swim in them, because with my theoretical knowledge, supplemented by an immense amount of experience swimming in these conditions, I can swim safely and use my knowledge of waves and tides…I constantly have to add up vectorially my swimming velocity and the current velocity, and the wave rift due to these very powerful waves (p. 297).

For Lighthill, swimming became the experience of equations, and the knowledge of those equations became the sensory and full-body experience of swimming. His physical observations and the sensual experience of an ocean swim coalesced into a *synthesis* of knowledge and experience.

Lightman's synthesis of sensory and mathematical knowledge, in the service of inquiry, illustrates how understanding something transcends merely knowing it as a discrete piece (or a set of discrete pieces) of information. In this example, knowledge becomes integrated into a more fluid (pun intended) way of being and operating. As a scientist, his way of knowing in a more whole, integrated, or *synthesized* way, connected directly to who he was.

Of course Lighthill is just one example of a multitude that can be culled from across the disciplines. Albert Einstein similarly perceived his hobby of sailing to be a sensory experience of knowledge, in which he felt the wind, sails, water, and waves both in a bodily sense, and as an experience of physical equations. In music, the composer Igor Stravinsky once praised Johann Sebastian Bach for the way his compositions blended the experiences of listening and creating – such that "you can smell the resin in his violin parts, taste the reed in the oboes" when listening to his work (Root-Bernstein & Root-Bernstein, 1999, p. 302). Synthesis, as such, becomes a place where mathematicians, artists, musicians, and scientists alike know what they feel, and feel what they know.

Recent research (Henriksen, 2011; Henriksen, 2014; Henriksen & Mishra, in press) has shown that this idea of synthesis applies not just to excellence and creativity in science or art, but to the profession of teaching as well. Henriksen (2011) explored how nationally recognized, accomplished, and effective teachers utilized each of the seven trans-disciplinary skills in their thinking and teaching. While each of the other six skills showed up in varied ways in classroom practice, synthesis emerged as a key theme of how these teachers integrated aspects of their interests, personalities, and lives into their teaching.

For example, while skills such as perceiving or patterning might contribute to how creative teachers perceive subtle aspects or sequences of student learning, synthesis arose at a broader level to show how such teachers connect their understanding to teaching practice in a holistic manner. The teachers in Henriksen's study noted how they often strengthened their teaching by incorporating passions and interests from outside of their profession (e.g. music, the arts, dance, other hobbies or subject matters). A science teacher how he brought his interest in the arts into his science teaching to strengthen and enrich his students' experience; a teacher who loved music would often bring music concepts into her math or other subject lessons. It is clear from the research that exceptional teaching requires a synthesis of ideas, experience and personality – in other words, their identity. This is captured best in a quote from Sarah Wessling (a recent National Teacher of the Year winner) who said, "I think that *we teach who we are* (italics ours), and I know that I teach who I am… I think that's true all of the time, that whatever it is that interests you… that energy manifests itself in the fabric of the classroom."

Unpacking Synthesis: From Synthesis for Meaning to Creative Synthesis

We need to distinguish between two forms of synthesis— what we call *synthesis for meaning* vs. *creative synthesis*. We argue that both forms of synthesis are important but there are clear differences between the two.

Synthesis of meaning occurs when a multiplicity of sources are integrated together to find coherence of meaning across these diverse sources (DeSchryver, 2015a; 2015b). It is the act or product of juxtaposing or sequencing of a variety of elements from multiple sources—akin to the idea of medley we described earlier in the article.

This can be best understood by looking at some typical learning activities that students are asked to do in today's digitally mediated learning environments. In such contexts, students are often asked to demonstrate their understanding of a topic through writing or constructing a video, multi-media project, or presentation. In the process, they visit multiple Websites – incorporating text, images, videos, simulations and other media. If they want to *know* about a specific topic, they glean a global coherence of meaning from across those resources. This, we argue, is the pedagogical equivalent of a medley, in that there is minimal change to the original information that has been collected.

Though synthesis for meaning is an important first step in knowledge gathering and development, educators should not be fooled into thinking that the collection, summarization, and/or rearrangement of key ideas

from original resources is necessarily a higher order act. It is an important, and arguably essential step toward higher order thinking, but does not in and of itself constitute synthesis in the way that the Root-Bernsteins (1999) or Mishra et al. (2011) suggest.

In contrast, the idea of *creative synthesis* is a complex one that integrates "senses, knowledge, and experiences" as they come together in a multifaceted and cohesive manner (DeSchryver, 2015a; 2015b). Synthesis, according to this viewpoint, is a creative act, producing something new out of the combination of elements. Identifying it as such distinguishes *creative synthesis* as a generative activity that transcends the information upon which it is based, from the simple combination of sources – the *synthesis of meaning*. In this way, creative synthesis transforms information in new ways, and leads to new knowledge and understanding. From our musical example of DJ Danger Mouse provided at the start of the article, creative synthesis is akin to the mash-up. It leads to new experiences, new insights, and new ideas. It is a quintessential higher-order thinking activity.

To further clarify our distinction between synthesis of meaning and creative synthesis, let us look at some action verbs that can be used to characterize them. Activities that focus on synthesis for meaning are typically characterized by action verbs such as arrange, categorize, collect, and summarize. Activities that seek creative synthesis, on the other hand, are characterized by a different set of verbs: create, develop, design, and generate. There is a substantive difference between these activities as characterized by the action verbs used. We do not mean that synthesis of meaning is not important or that we should focus our attention entirely on activities that seek to develop creative synthesis. We are suggesting, however, that developing a coherence of meaning across multiple sources (synthesis of meaning) is an essential foundational step before we can move on to more generative forms of thinking (creative synthesis).

Digital Tools for Synthesis

Whether exploring synthesis for meaning or creative synthesis in the classroom, there are a variety of digital tools that directly support related teaching and learning activities. For instance, a fully functioning online database system, like Evernote, allows students to annotate, tag, and revisit assemblages of a range of multi-modal resources in ways that enhance the possibility of combinatorial idea play that is often associated with creative synthesis.

When students are using the Web to perform research or explore new ideas, they typically start that process with a search engine. The choice of search engines does not necessarily impact their ability to either synthesize for meaning or creatively synthesize; how they use that search engine, or the keywords they choose, does (DeSchryver, 2015a; 2015b). For instance, using keywords that are closely related to the task or topic at hand (i.e., consistent keywords) may tend to provide resources that are more amenable to synthesis for meaning, while keywords more far afield from the task or topic (i.e., divergent keywords) may provide a diverse set of resources that are more amenable to creative synthesis.

Digital images are also finding mainstream adoption in K-12 environments. Whether teacher or student created, they provide a powerful medium for synthesis activities. For instance, collages serve as a natural avenue for synthesis of meaning. The act of curating images from the Web into a digital collage based on, for example, the main themes of a novel can demonstrate a coherent meaning of those themes. This act of translating meaning from textual to representative visual artifacts often provides evidence of that meaning beyond written language. When properly structured, assignments that require a more artistic representation of images with the intention of a more Deweyian (1938) "experience" can transcend a synthesis of meaning to support the creative synthesis of knowledge. For example, in courses in our Master's in Educational Technology program, we have designed both iImage and iCinemagraph assignments to require that students not just summarize meaning, but explore a "strong provocative idea," that "awakens feelings and imagination," "moves the audience to a new way of seeing," and "creates a strong experience" both during and subsequent to viewing. This is regularly accomplished in the context of individual subject matter topics, including physics, mathematics, and literature.

Similarly, digital video tools allow for both levels of synthesis. On the Web, Mozilla Popcorn Maker is a simple online video aggregator and editor that is primarily designed to support collecting and rearranging snippets of existing Web videos (e.g. from YouTube). Users can easily import Web videos, clip out short segments, and order them as they see fit. This commonly results in a synthesis of meaning across multiple videos, but does not substantively change the experience of each individual clip. More sophisticated video editors, like iMovie, include advanced features that facilitate intricate layering of voice, music, audio, video, and text, as well as control over speed, coloring, perspective, and other features. These powerful tools are easy to use, and while they directly support creative syntheses of knowledge, they also afford opportunities to explore how aesthetic creativity plays a role in the successful production and dissemination of that knowledge.

When considering the choice of digital tools for teaching and learning, it is important to be aware that some are more predisposed to supporting one form of synthesis over another. For instance, Popcorn Maker is well suited to syntheses of video meaning, while iMovie is better for creative syntheses of video. This is often the case when comparing App or Web based versions of software to fully functioning computer based installs. In this way, the more advanced digital tools are often worth the initial extra effort to acquire and learn given their potential to support higher-order forms of thinking. At the same time, specific digital affordances may also accom-

modate synthesis in meaningful ways. For instance, tagging, an inherently Web-based phenomenon, can be used to indicate a synthesis of meaning (e.g., the application of tags across resources may represent a coherent meaning of those resources), while using tags to explore various combinations and re-combinations of archived information may support idea play that leads to creative synthesis.

There are two key takeaways here for users and educators interested in educational technology and creativity. First, the selection of tool(s) is quite important. Tools that allow for the creation of meaning, i.e. the equivalent of the medley, are limited in what they can do for student creativity and developing synthesizing skills. Thus sometimes investing time and effort to learn the more powerful tools that allow for complexity and layering is important. Second, somewhat conversely, even though the tools make a difference, the structure of the activities and the goals set up for the students may be far more important. Clearly this has consequences for how we plan teacher education or teacher professional development—by emphasizing activities that speak to the higher order skills that constitute creative synthesis—while understanding that it may need to be built on a foundation of synthesis of meaning. We hope that the examples provided in the past six articles, and in this one as well, demonstrate the range of such potential creative activities.

Conclusion

Our discussion here has described synthesis as an overarching trans-disciplinary thinking tool, and also elaborated on two key types of synthesis (synthesis for meaning and creative synthesis), which have implications and both theoretical and practical value for teaching and learning with technology.

In our most recent articles in this series on creativity, technology and education, our work has covered each of the seven trans-disciplinary skills for thinking (Mishra, Koehler & Henriksen, 2011), including perceiving, patterning, abstracting, embodied thinking, modeling, and play – concluding with this current piece on the skill of synthesis. Among these meta-level thinking skills for creativity, synthesis is unique in being yet a further meta-level of the other six skills. As our examples have demonstrated, synthesis is the place where multiple aspects of thinking, and the other trans-disciplinary skills, come together to combine and rework existing elements to form something new – something creative. In this way, synthesis speaks to the core of creativity, even approaching the very way that we define it. Synthesis draws upon existing elements to put the pieces together in ways that are – or that feel – novel, effective, and whole (Mishra, Henriksen, & the Deep-Play Research Group, 2013). The range of applications, contexts, and disciplines in which this plays out are wide-ranging and perhaps unlimited. In some ways this is what makes us human. As chess grandmaster Kasparov (2007) wrote:

> Having spent a lifetime analyzing the game of chess and comparing the capacity of computers to the capacity of the human brain, I've often wondered, where does our success come from? *The answer is synthesis, the ability to combine creativity and calculation, art and science, into a whole that is much greater than the sum of its parts* (italics ours). (p. 4)

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