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Composites and Advanced Materials Curriculum Mediation with STAR.Legacy E-Learning Mosaics

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Key Words: pedagogy, learning, change, methodology, ethnography

Target grade level(s): Teachers, adults

Mode of presentation: in class activity, discussion

Prerequisite knowledge: N/A

Objectives: Explore concepts and gain hands-on practice with new teaching methodology that focuses on STAR.Legacy Mosaics. Unpack pedagogical concepts like metacognition, preconceived ideas, expert blind spots, 'fish is fish', and more.

Equipment and Supplies Needed: Computer projector, flip chart and color pens.

Introduction: STAR.Legacy is a relatively new teaching model that goes beyond traditional limitations of classroom captive audiences, which typically result in ubiquitous conveyor-belt outcomes. This is a fundamentally different way of structuring curriculum, where, by immersion in cyclical iterations, learners make preconceptions visible, engage in metacognitive processes for intentionally revising their thinking, and recognize their emergent learning by receiving continuous formative assessments. Recent research attests that this iterative cycle enables a rich pedagogical content layer that enlivens the learning environment and has the potential to enhance deeper understanding of complex subject matter.

Procedure: The students will be introduced to the constituent components of the STAR.Legacy pedagogical model. They will be given a challenge, asked to generate initial thoughts, engage in some multiple perspectives, undergo some formative assessment, revise their thinking, and finally share their ideas with their peers. This will take approximately 45 minutes. There will be a discussion following with a questions and answer session.

Comments: This activity can be duplicated by carefully designing a challenge and following the other stages of the methodology.

Evaluation of the activity: Students will be asked to evaluate their learning experience before the end of class

Abstract

Change has always been endemic and expected in an industry as complex and ambitious as the aerospace manufacturing enterprise. Yet, it is the pace of that change that provides for constant ‘learning’ challenges in today’s competitive workplace. This ongoing fast-past change is creating what some call a never ending “skills gap” between what people know at the moment and what they need to know in order to be successful in their everyday lives and the workplace. Typical aerospace companies are no strangers to either competition or change and continually facilitate millions of man-hours of training per annum. In order to explore efficiencies in delivery and implementation, this paper introduces an archetypical learning intervention—STAR.Legacy Learning Cycle (Legacy)—that investigates continued learning in the evolving aerospace workplace. Situated within the conceptual framework of ‘adaptive expertise’ [1-7], it is argued that this archetypical pedagogy instills a deeper understanding of content and processes associated with courses on composites manufacturing and, in many ways more importantly for the evolving aerospace industry, prepares engineers to become future learners. The approach we helped them implement involved efforts to organize teaching, learning and assessments in ways that went beyond their current training and focused on characteristics of adaptive expertise such as the willingness to take risks and successfully collaborate by asking questions of, and helping, their peers.

Findings from recent empirical and qualitative studies have confirmed the following researchers’ hypotheses with regard to learning and teaching composites and advanced materials to engineers in the workplace; incumbent workers (engineers) indicated that (i) the interactive problem-based instruction methodology was superior to the traditional lecture-based model; (ii) they were more engaged during problem-based methodologies—they interacted more with each other, and with teachers and subject matter experts (SMEs) than in the traditional lecture-based method; and (iii) they learned with understanding during the challenge-based methodology, as demonstrated by adept use of high-order questioning during workgroup sessions [8-11] as opposed to having the knowledge and information flow over them in the lecture-based methodology.

Ethnographic discourse analysis indicated that the legacy learning cycle was paramount in facilitating the type of questioning and the learning outcomes in which participants developed enduring social networks within the workplace, an outcome that is argued, supports preparedness for future learning.

STAR.Legacy—it means Software, Technology, Action and Reflection (Legacy refers to what is produced by the current users and left as legacy for the next generation of learners, either as a new resource or as a new launching off point) goes beyond the traditional limitations of classroom captive audiences that typically result in counter-productive conveyor-belt outcomes. This is a fundamentally different way of structuring curriculum, where, by immersion in cyclical iterations, learners make preconceptions visible, engage in metacognitive processes for intentionally revising their thinking, and recognize their emergent learning by receiving continuous formative assessments. Recent research attests that this iterative cycle enables a rich pedagogical content layer that enlivens the learning environment [12] and has the potential to enhance deeper understanding of complex subject matter [13].

Though intrinsically simple in its conceptual instantiation, STAR.Legacy nevertheless consists of several intricately, interlocked foci of pedagogical exposition. It envisages a flexible framework in which elements of course modules are outlined and presented—a framework which supports rapid dissemination of curriculum design principles, while at the same time facilitating an increase in the quantity of courses that can be developed [14]. Because of its propensity towards interactivity and its incipient penchant for enhancing the conception and growth of social networks, it trends towards an emphasis on “understanding”, a primary characteristic of the learning sciences with its strong focus on processes of knowing [15, 16].

That the legacy cycle should be more accessible for learning in this environment is no trivial matter; it is no secret that engineering students (like students in many other disciplines) have been heavily encumbered with a traditional lecture method throughout their educational lives, since high school, persisting through college, and even in the workplace. In fact, survey results from this group of engineering students indicated that their preference for learning methodology remained solidly with what they had become familiar over time—the lecture mode. Such embedded preference belied the learning outcome where clearly, engineers in the *Introduction to Composites* course learned more from the legacy methodology [17] than from the lecture methodology (where as many as six participants had already fallen asleep before the first hour had elapsed—including outsiders whose roles were merely to observe the ongoing intervention). The embedded nature of this setting regarding cultural events and ideas could have far-reaching repercussions for all concerned; learners, subject matter experts, and teachers (who also were encountering for the first time a new model of exposition). It is worth exploring, if in this embedded culture, people would feel free to trust, to get out of their silos, and to openly interact and ask questions, and thus embody the model that is implied by the legacy cycle. Or, would engineers subvert Legacy’s intrinsic pedagogy in favor of the local culture?

In the next section, I will describe a number of interconnected pedagogical implementations that were used to transform the learning experience of incumbent engineers at the Boeing Company for this pilot study. These include a description of the STAR.Legacy pedagogic archetype, an overview of Bransford’s *How People Learn* conceptual framework [2], an outline of a backward design process based on Wiggins & McTighe’s curricular transformation [18], and an overview of intentional transformative processes that shift the pedagogic environment from sequestered problem solving towards a preparation for future learning.

STAR.Legacy. This pedagogic archetype is an iterative challenge-based cycle for learning and exposition (see: Figure 1.) It evolved out of research carried out by the Cognition Group at Vanderbilt [19]. STAR.Legacy—it means Software, Technology, Action and Reflection (Legacy refers to what is produced and left for the next generation of learners) goes beyond the traditional limitations of classroom captive audiences that typically result in ubiquitous conveyor-belt outcomes. This is a fundamentally different way of structuring curriculum, where, by immersion in cyclical iterations, learners make preconceptions visible, engage in metacognitive processes for intentionally revising their thinking, and recognize their emergent learning by receiving continuous formative assessments. Recent research attests that this iterative cycle enables a rich pedagogical

content layer that enlivens the learning environment [1] and has the potential to enhance deeper understanding of complex subject matter [12].



Figure 1. STAR.Legacy Learning Cycle

Though intrinsically simple in its conceptual instantiation, STAR.Legacy nevertheless consists of several intricately, interlocked foci of pedagogical exposition. It envisages a flexible framework in which elements of course modules are outlined and presented—a framework which supports rapid dissemination of curriculum design principles, and facilitates an increase in the quantity of courses that can be developed [14]. Because of its interactive, social network focus, it trends towards an emphasis on “understanding”, a primary characteristic of the learning sciences with a strong focus on processes of knowing [15, 16].

In STAR.Legacy, students are first presented with a real-life and relevant problem—Challenge. The challenge elevates the central issues pertaining to the primary focus of the coursework to an intelligible narrative that is compelling and realistic for individual audiences. Selecting a good challenge is critical and has positive effects on motivation, similar effects on memory and situates the learning in a real world setting. Participants are then asked to make a neural commitment to addressing this challenge, a first generative process that begins to expose approaches and solutions. By writing their initial ideas, learners are essentially ‘making visible’ their preconceived ideas and any potential mis-information. It is important to allow the student the freedom to ‘jump in’ as it were, to even make mistakes here. Empirical findings regarding ‘scaffolded’ initial thoughts, where facilitators assist the student and structure their initial thoughts (with worksheets, hints and other aids), show that such interventions hurt the learning process down the road. Typically there is a desire to structure the initial thoughts so that a person is “right” in the way we have been taught to give the “right” answer in sequestered classrooms

where grades take precedence. There is evidence to suggest [20], that students will produce “righter” initial thoughts if the facilitator structures their thinking, but down the line it can hurt their creativity.

Returning to these written initial thoughts later in the cycle, serves as a comparison metacognitive marker that illuminates the learning journey. This opportunity to compare, in writing, ‘early’ and ‘later’ thoughts forces the learner to confront elements of reconstructive memory where the tendency is to think to oneself—“I knew that all along”. Metacognitive tasks oblige us to admit that we didn’t in fact “always know that” and force us to engage with changes in our thinking. An inclination towards metacognitive habituation is closely related with the concept of adaptive expertise—particularly the capacity to admit that we might have been wrong and/or that we learned something new.

The third stage involves short multimedia resource materials. Each individual is offered multiple viewpoints on particular aspects of the challenge. This is the—Multiple Perspectives phase. It consists of a collection of factual and informative stances regarding the particular module relating to the challenge. In a complex world, there are seldom clear-cut, black-and-white solutions. Gaining perspectives from relevant points of view is critical so that we engender a feeling for authenticity and truthfulness.

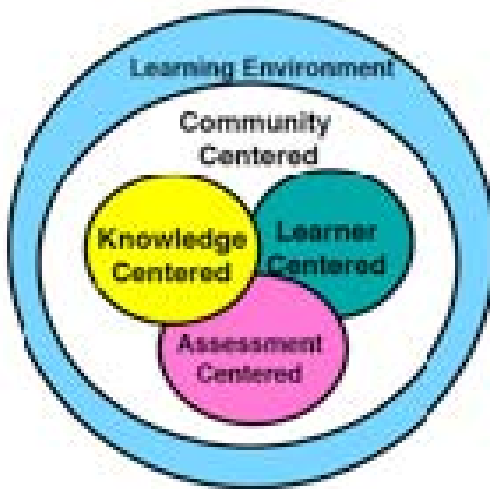
The next phase—Research and Revise—is implemented in small groups of four, five or six individuals. This is where participants revise their nascent ideas and, in particular, look back at their initial thoughts to view and begin to make visible their cognitive advancement towards the solution. Assessment is an important function in this stage of the learning and discovery process. The feedback and timing of feedback is a critical factor in formative assessment. Judgmental feedback—something that is “right or wrong” has its obvious drawbacks, but equally hurtful to a learning situation is a type of “stealth” assessment that occurs when the facilitator knows that the students are doing right, but the students don’t know themselves. The ideal type of assessment would be a form of self-assessment when the facilitator helps the student become more metacognitive so that they not only see right and wrong, but also attain a deep understanding of what’s going on. This becomes a critical metacognitive marker as mentioned earlier, usually an ‘aha’ moment where learners come to realize that their preconceived ideas have shifted and a new understanding has emerged. In what has become a clear marker of individuals who portray adaptive expertise attributes, they often feel they have to step outside their comfort zone and admit they were incorrect in their preconceived ideas [6]. Developing a sense of adaptive expertise often involves people saying to themselves, “I can see it now, change is good, and I am not always right the first time.”

Participants engage in self-imposed formative assessments where they make corrections, fine-tune their design(s) and edit the corpus of their ideas in the following (fifth) phase—Test Your Mettle. This is a vital chance to compare earlier and recent thoughts concerning the challenge—an opportunity to derive deeper knowledge and understanding from metacognitive processes.

Finally, when participants have fully explored pertinent issues and criss-crossed the learning tapestry a number of times in the process of honing their findings, they are provided a platform to air and share their views; to present their learning and their

solutions—Go Public. This is a critical exponent of the learning cycle, a chance for the student to play the role of advocate and spokesperson. This is where the student has the opportunity to leave a legacy for others. Students learn readily from each other and when they assume the role of teacher with materials that they have created and from which others can learn, it dramatically changes the teaching and learning dynamic. When students are in a role of contributing to the learning of others rather than sitting back allowing knowledge to wash over them, it is borne out by an energetic enthusiasm and commitment to knowing.

How People Learn. Bransford’s conceptual framework for how people learn [2] was a central design principle for the learning environment during this Boeing Company pilot project. According to Bransford, design of learning environments in workplace settings, as well as in schools, is linked to issues that are especially important in the processes of learning, transfer, and competent performance. Those processes, in turn, are affected by the degree to which learning environments are “learner centered, knowledge centered, assessment centered, and community centered.”



John Bransford, et al. | 1999 *How People Learn*, National Academy Press.

Figure 2. How People Learn Conceptual Framework

In focusing on learners, it is important to pay close attention to the knowledge, skills and attitudes that individuals bring to the learning situation. It is important to note that cultural differences can affect the learning outcome, as can students’ theories of what it means to be intelligent. A learning environment that is knowledge-centered, takes into account the idea that many curricula fail to support learning with understanding because they present too many disconnected facts in too short a time—the ubiquitous “mile wide, inch deep” problem. In an assessment-centered learning environment, formative rather than punitive or summative assessments are recommended. In the Boeing Company learning environment the idea of testing for knowledge retention or for knowing with

deep understanding was nonexistent, and learners were regularly tested for competence based on how they liked a course or not. Formative assessments help both teachers and students monitor progress. Learner-centered, knowledge-centered and assessment-centered activities come into focus within a community-centered approach to learning. This latter requirement for a healthy teaching/learning environment is particularly desirable for workplace settings in which people's jobs and salaries are linked to performance. Ideally, the learning environment would encourage the development of norms for the workplace settings, as well as connections to the real world, that support core learning values, including fairness, trust, honesty and ethics.

Understanding by design. The third model that contributes to this research approach is a process of developing curricula using inherent backward design. Establishing, or isolating, the “big idea” is based on the proposition that knowledge can usefully be compartmentalized into connected chunks that align with cognitive processes, various memory constraints, and accede to accepted pedagogical practice.

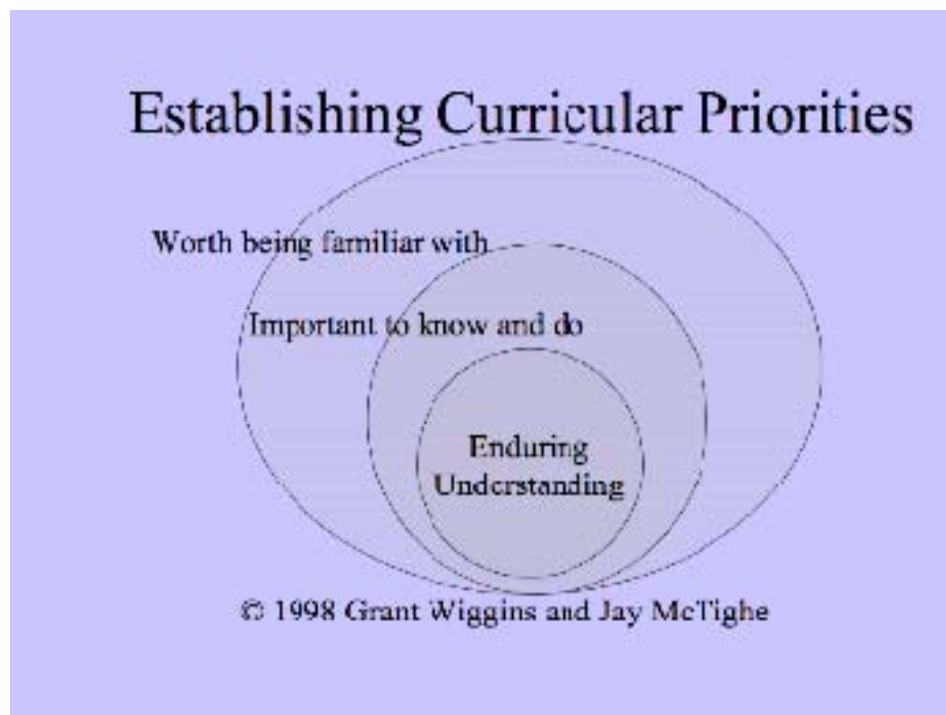


Figure 3. Theory of Backward Design

In this approach, knowledge is conceptualized into meaningful and pragmatic chunks of exposition as follows: first there is a core element, which Wiggins & McTighe refer to as ‘enduring understanding’. It addresses the information that is the essential core product of a reasonable teaching session. Given constraints of short-term memory, cognitive overload, valid reasons why large amounts of disconnected knowledge are difficult or

impossible to process all at once, the underlying design was for the acquisition of core ideas which were envisioned to foster enduring understanding. Next is a category of scaffolding knowledge that assists the participant understand the enduring idea because of its intrinsic relevance to the central 'core' issue and is 'important to know and do'. Finally, there is a body of useful knowledge, which is peripheral to the core ideas but is good to know, or is 'worth being familiar with' in order to address future contingencies.

The structure of the knowledge base that had been traditionally presented to Boeing engineers could, with some effort, be realigned to fit neatly within the principles of Wiggins & McTighe's backward design model for enduring understanding.

Future

Future work will focus on the emergence and development of social networks within the learning environment. Challenge-based discussions prompted by STAR.Legacy designs generate numerous questions that appeared to create opportunities for further discussions (e.g. by phone or computers) that have the potential to help everyone continue to learn once they leave the workshop or classroom. Knowledge of 'whom in one's group knew what' seemed particularly useful to sustaining and accelerating new learning once employees left the workshop and returned to their jobs. The development of robust "social networks" is an important aspect of "preparation for future learning" views of transfer ---views that are often not emphasized in more traditional work on transfer effects [21, 22].

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