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Brain-centric Design Reverses Ebbinghaus' Forgetting Curve

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Image

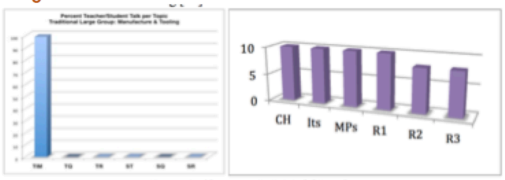

Figure 3. Classic vs. BcD Model Results

Recent Publications (minimum 5)

1. O'Mahony, T. K., Carr, R. (2019 Brain-centric Design: the surprising neuroscience behind learning with deep understanding. Thanet House Publishing, New York, NY.

Brain-centric Design Reverses Ebbinghaus' Forgetting Curve: Transforms a Learning Community Immediately and Forever

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Abstract: A global manufacturing and retail corporate entity compared their traditional learning models with a new method of training for a cohort of North American customer service agents. The questions they were interested in exploring pertained to corporate Return on Investment (ROI) as measured in several meaningful outcomes regarding attrition, retention, and customer impact. The traditional model had been used for the previous ten or more years and involved a subject-matter-expert (SME) whose job it was to transmit company information (including culture) to new employees. This method is structured as a transmission model in a traditional lecture/student setting00students in rows facing forward towards a 'sage on the stage' compiler of pertinent knowledge. The comparison method comprised a break from traditional 'sit-and-git' models by embracing a neuro-based teaching and learning experience that focused on Me-Here-Now enhanced learner identity, and connectedness of conceptual components in a non-linear modality. Trainee agents (N=250) attended courses in face-to-face and tech-enabled learning labs for onboard training content—125 in a traditional 'classic' site and 125 in the new neuro-centric BcD site. Data were collected via online end-of-course instruments, interviews, and self-report surveys. Findings suggest that the neuro-centric methodology compared more than favorably with the traditional method so that trainees (i) learned with deep understanding, (ii) were more likely to retain important information and express contentment in their work, and (iii) were more successful at increasing ROI for the company. We describe the model, implications of these findings, and suggest further research avenues going forward.

Introduction

The capacity to acquire expertise is one of the great and peculiar strengths of the human species [1], yet in our competitive 'white-water' world we know that expertise in and of itself is hardly sufficient [2, 3]. Expertise (coupled with efficiency) is a critical workplace capacity in today's aggressive global marketplace. The challenge is for companies to activate the potential of their workers, but also to be agile [4], competitive [5], and (as of late) socially responsible or what some refer to as 'green' [6]. An employees' healthy connection to job and place of employment is essential in order to sustain a lifelong learning approach where social contribution is tangible, and where personal fulfillment is balanced with corporate interests. Is this attainable? We argue in this paper for an affirmative - Yes. People can achieve their true potential in the place of their employment and make meaningful contributions that give them a sense of belonging purpose and at the same time advance corporate goals. The hypothesis that was tested hinged on a comparison of the two teaching methods. Would the traditional method, which the company has used for decades compare favorably with the new method that some trainers were proposing, since it involves a shift from classic training methods to a blended tech-enabled model and a reversal of teacher roles?

Theoretical Framework

Knowledge and skills feed expertise and form a critical characteristic of professional workforce participants who either thrive or struggle in fast-paced workplace settings. Expertise is often defined as knowledge, efficiencies, and competencies that result from practice over time—approximately 10,000 hours of practice according to Ericsson, an expert in expertise applied to

learning [7]. Ericsson's 'Maximization of Efficiency' model has gained a great deal of attention in academic institutions, workplaces, as well as in research centers where learning is studied.[8] However, this model has been challenged by an alternate brain-aligned approach in recent years as the neuroscience of learning is gaining momentum in schools and workplaces.[9] This approach is described by Coyle [10] in his best-selling work—*The Talent Code*. His approach begins with a conceptual understanding of synaptic myelination and embodies generative discussions about deep and intentional practice. This definition of expertise involves a critical awareness of the field, a process of reflective thought about process, and metacognitive exercises that focuses on worker agency in the learning process. In addition, and equally important for workers who find themselves increasingly in a white-water modern world [3], expertise is typically accompanied by a concept of transfer—defined as ability to perform a task or solve a problem in a different or novel situation [11], so that individuals display a flexibility and agility towards ill-defined and/or wicked problems [12], and, in particular, a tolerance for ambiguity. Expertise is also associated with personal growth, fulfillment and potential, so that workers can lead sane, joyful lives [13].

Participants

In this study, we compare a traditional 'classic' learning and teaching model to a Brain-centric Design (BcD) methodology in areas that are highly consequential to corporate culture, ROI, and market share. Contact centers are outsourced to vendors who specialize in customer care centers (1200-1600 in total). Corporate LEAD Team (Learning and Development) train and certify Trainers on-site to deliver curriculum to newly hired customer service agents. The business operates six contact centers. The following details the essential demographic face of the participants.

Cohort A

- Launched in October 2016.
- Three trainers ages 25-38, 0-16 years of experience training in contact centers
- Agents 54% male, 46% female
    - 68% Black and African American
    - 23% White Non-Hispanic
    - 5% Latino and Hispanic
    - 3% Asian
    - 1% Other

Cohort B

- Launched in October 2018.
- Three trainers, ages 23-29, 2-5 years of experience training in contact centers
- Agents 61% male, 39% female
    - 79% Latino and Hispanic
    - 9% White Non-Hispanic
    - 8% Black and Afro-Caribbean
    - 3% Other
    - 1% Asian

Figure 1. *Agent Age Breakdown* below details the age breakdown for all new trainees.

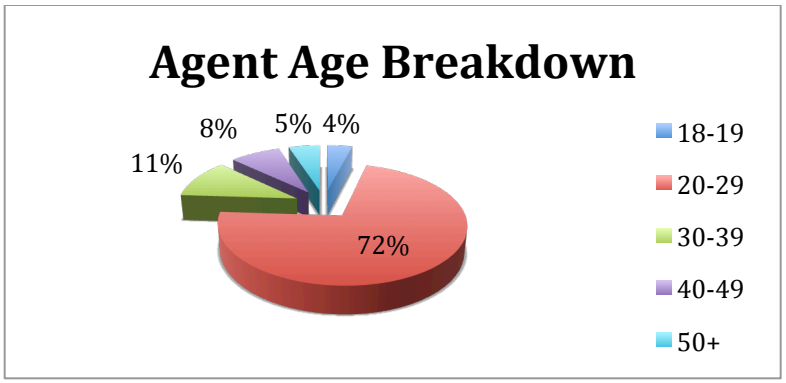

Figure 1. Agent Age breakdown

In the classic model, agents learned that 72% of customer contacts were post-purchase—the mental models that accompanied teaching methods placed the customer/agent relationship in a post-purchase ‘’fix-it’ mentality. Post-purchase means that the reason a customer contacted the agent related to an existing order—typically something has gone wrong. An example might be, “I ordered something last week and it hasn’t shown up yet.” Less than 10% of content curriculum focused on how to serve a pre-purchase consumer. The pre-purchase customer is a whole different mindset from the post-purchase customer. Pre-purchase customers are interested in locating or buying something. From the company view, these customers are the best opportunity to make new sales and improved ROI.

The critical differences between both models (classic vs. BcD) centered on the role of the teacher. In the classic model the teacher fulfilled the role of ‘Sage on the Stage’ where all instruction and information came from the source who stood in front of the learners. In the BcD model, in contrast, the focus was on learner agency—a derived momentum that was achieved through trust in a pedagogical model that was neuro-centric in its inception and which called for a facilitator rather than a teacher.

Assignment to Intervention

Participants in the study were not randomly assigned; it was not possible to assign people to different learning settings because of geography and timing. Instead, researchers were resigned (like a lot of large corporate entities) to work with existing opportunistic cohorts who were receiving training at comparable locations and times, but in different methods.

All trainers derived from the same corporate training and development group. The intervention that we investigated centered on onboarding training that was offered to two cohorts in different North America sites. Demographics were similar in both cases. The two sites were chosen because of their close similarity from a business perspective.

- Same Business Partner Outsourcer
- Both sites supported e-commerce via telephone serving the same customer group
- Similar agent headcount
  - 115 during non-peak month
  - increased to 175 during peak **“Back-to-school”** months: July – Mid-September
  - increased to 225 during peak **“Holiday”** months November – Mid-January

Each site had three local trainers and were supported by Corporate Learning and Development leads. Traditional training utilized traditional teams that created curricular materials, instructional design, and classroom management techniques that were in use for many years. Brain-centric

Design trainers received training in the new model from corporate trainers who had themselves been trained at the source from the inventors of BcD. This model was very different from the traditional method in that it involved a focus not on content but on individual trainee engagement in learning through metacognitive agency.

Data Capture at Contact Centers

Data was captured by internal corporate-approved metric measures that accounted for rigor, quality, and transferability across domains. Objectivity was achieved through adherence to data processes that prevented researcher bias. Conclusions depended on participant responses and deliverables as derived from the study. Findings are reported independent of interpretations or constructs that researchers might place -- opinions or aspirations of the research team were eliminated from the final analysis. Metrics are reported on that focus on the following aspects of the business:

- **Agent Performance** –*Voice of the Consumer* (VOC) is a measure of the customer's overall satisfaction with their Customer Service experience; VOC is only generated when Customers complete a survey
- **Speed to Green** – The length of time for Agents to demonstrate proficiency by performing at KPI goals (data-driven only)
- **Agent Attrition** – Defined as the number of trainees who end employment (voluntarily or involuntary) during Agent training (Days 1-30) (See note below: **Attrition is Expensive**)
- **Conversion Rate / Sales** – Defined as when an agent converts the customer service call into a sales transaction (data driven score only)

Attrition is Expensive: According to research conducted by The Quality Assurance & Training Connection (QATC), the average annual turnover rate for agents in US contact centers ranges between 30-45 percent, which is more than double that of all occupations in the U.S.[14] In fact, in this particular industry, it has been documented that after agents complete training and join the production floor, attrition rates reached as high as 50% by the 90-day mark as agents resigned or were removed from the account. With traditional curriculum attrition during training, days 1-30 of employment, reached as high as 33%. As an example, a class starting with 24 students would have 21 complete classroom training. Another five agents gone by day 30. While this is not acceptable to either the corporate entity or business partner, it is reality. High attrition numbers are an expensive problem in any industry and it is exceptionally high in contact centers. High attrition results in constant recruitment and screening of suitable candidates. It has been shown to accelerate burn-out in trainer stocks who keep churning out trainees from the classroom, and it produces an inexperienced and timid workforce. Attrition rates like this are intensely expensive for any operation. In this industry training costs are calculated as $2874 per agent hired. New Hire Training for e-commerce telephone agents is 96 hours (12 eight-hour classroom sessions) followed by 80 hours (ten 8-hour shifts) working in production with 1:10 supervisor to agent support ratio; after that support ratio is 1:20. Included in the 80 hours is 10 hours (1 hour per shift) of review and micro-lessons.

Traditional Implementation

In this corporate implementation, a traditional learning curriculum consists of 96 hours face-to-face and blended theoretical and hands-on instruction in learning labs that are consistent with transmission models of knowledge acquisition. From that standpoint a traditional curriculum employs typical teaching methods like lecture, projected presentation slides, and formative and summative assessments using quizzes and end of course tests. The e-learning platform housed the same slides being projected, captioned videos of process steps, text-heavy pages, and true-false or multiple-choice question quizzes after every module. Every topic was presented in a single

modality. Activities were limited to simulated role-play. In the interest of time and content delivery schedules, student discussions were brief and infrequent. The overall course (and class) climate was predicated on the idea of 'lots of important content' but very little time.

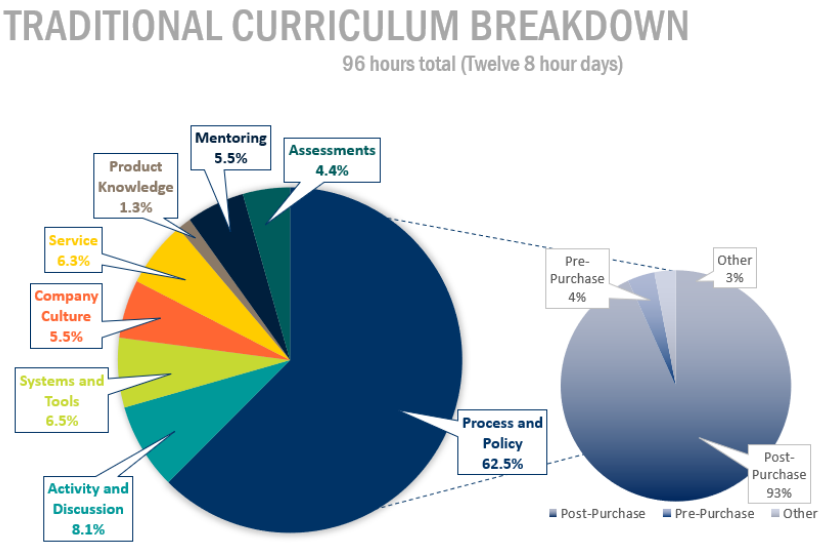

Figure 2. Breakdown by percentage of training time dedicated to topics and skills

Cohort A was launched with a traditional "Rookie Camp"- 12 days (96 hours)

- Learning Roadmap organized by volume of Contact drivers, from highest to lowest.
  - Heavy focus on policies and process
- Traditional classroom experience:
  - Trainer reading aloud text heavy slides
  - eLearning for viewing videos and taking quizzes
  - Listening to or reading aloud agent and customer interactions
  - Quizzes are pass/fail
  - Minimal interaction with other learners and/or teammates
- Daily agenda different each day:
  - Modules forced to fit into days organized by Contact Driver
  - Some processes or topics trained in lengthy multiple-hour modules, often with only one modality and no breaks, immediately followed by multiple choice quiz
  - Other processes or topics would be covered in minutes with no quiz or discussion
- Tools and systems mainly trained through lecture and slides or viewing videos of the system being used
  - Hands-on is only available in "Live" production environments making for limitations of what can be practiced with very little hands-on experiential training
- Mentoring is 5.25 hours (5.4%) with a tenured agent, or whoever else was available
  - Learners are brought to mentors scattered throughout the contact center production floor
  - Most agents only allow the learner to observe
- Empathy trained on day 11

Cohort B was launched with a BcD neuro method - 12 days (96 hours). The resulting Curriculum yielded a stronger focus on activities and discussion, more time dedicated to hands-on learning with systems and tools, decreasing time focused on process and policy. The agent-centered focus

introduced a new emphasis on understanding the job through increased social and experiential learning.

- Daily Agenda is consistent:
  - Each day broken into quarters with a scheduled break between
  - Each quarter in the Challenge Mosaic format
  - Brain breaks and physical activity incorporated into each quarter
  - Content experienced through multiple modalities
- Facilitator engages learners in:
  - Large and small group Discussions, Large and small group Activities, Creating Process Maps, Gamification, Study and teach back, Scripted Role Play, Experimenting with System training environments, Self-reflection, Music, and Movement
- Mentoring with pre-chosen mentors
  - Identified mentors who demonstrated desired skills and behavior
  - Conducted in a designated area of production floor
  - Mentors are brought to learners; learners are hands-on with mentor guidance
- Empathy training repositioned at beginning of roadmap on Day 2
  - Incorporated into all role-plays
- Significantly increased number of small and large group activities

Previous results from similar implementations had indicated that findings would indicate a rather significant shift in learning outcomes and cost savings for choice of method. For instance, a typical result from traditional transmission models have been reported in many learning sciences studies. Figure 3, *Classic vs. BcD Model Results,* gives a picture of what to expect. As shown in the left panel of the graphic 99% of observable verbiage is accounted for by the trainer (sometimes referred to as the 'sage on the stage' since the sage voice is the only voice heard). These data were culled from a classic adult training setting where incumbent engineers were presented with 8 hours of critical mission information for their daily work needs. Results indicated that the fire hose of information flow caused cognitive overload and lead to poor retention and lack of understanding.[15]

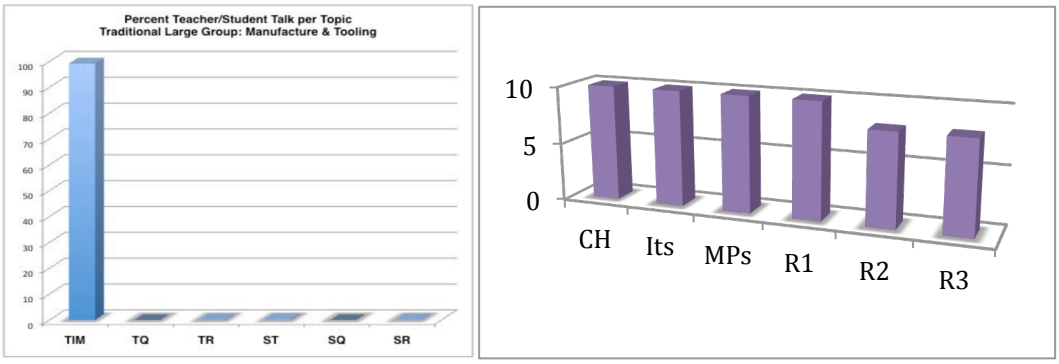

Figure 3. Classic vs. BcD Model Results

In contrast, the right-side panel in the graphic below shows a typical interactive engagement in the BcD model. Data for this graph were culled from a 2019 learning lab where adult learners used the pedagogical model (see appendix 1 for more details) with the measures as described and engagement patterns shown. In this instance, learners were able to retain the new information, enjoy a proficiency and level of deep understanding that resulted from the increased engagement and social interaction.[9]

Findings

We describe findings here that relate to the essential questions that we investigated with regard to using a classic or BcD teaching method for training adult learners in different contact sites.

The first question had to do with agent performance—would agent performance be improved as a result of BcD training methods or would the classic method retain its position as leader in the field? VOC scores were collected from customers who interacted with agents on the floor. Survey rating choices are Extremely Dissatisfied, Dissatisfied, Neutral, Satisfied, or Extremely Satisfied. VOC is calculated by dividing sum of surveys rated Satisfied and Extremely Satisfied by sum of all surveys completed. "Dissat" is calculated by dividing sum of surveys rated Dissatisfied and Extremely Dissatisfied by sum of all surveys completed.

Results were significantly better than in the classic model.

In Figure 4, *Classic vs. BcD Model Results for VOC & Dissat*, cluster data compares customer satisfaction scores for each model—Classic vs. BcD. Results indicate that Cluster A and B showed increases (A = VOC of 90% and above; Dissat of 7.25% and below; B = VOC of 84% to < 90%; Dissat of 7.25% to 9.25%), and Cluster C and D showed decreases (C = VOC of 80% to < 84%; Dissat of 9.25% to 15%; D = VOC below 80%; Dissat 15% and above). The goal is to have dissatisfaction scores as low as possible – below 9%. In this report, by shifting to a BcD model, top producers with happy customers (clusters A and B) increased; while poor producers with dissatisfied customers (clusters C and D) decreased. The company was able to impact their bottom line: Satisfied customers are loyal and more likely to recommend the Brand to others, they purchase more often and spend more when they do.

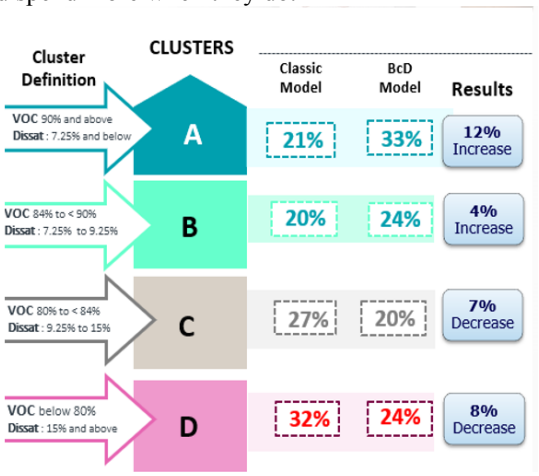

Figure 4. Classic vs. BcD Model Results for VOC & Dissat

The second place that we detected improvement was the shortened duration of time it took for agents to perform at goals. In the classic model, it typically took an agent between six and nine months to demonstrate proficiency by performing at KPI goals referred to as 'Speed to Green'. As shown in Figure 5, *Fastest Speed to Green at Contact Center*, agents who were in the BcD model achieved the fastest in the history of the customer service division (more than 15 years) Speed to Green achieving the goal in just three months.

VOC	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Cohort A (Traditional)	78%	81%	82%	80%	80%	**84%**
Cohort B (BcD™)	73%	80%	**84%**	82%	83%	86%
Goal	84%	84%	84%	84%	84%	84%

Figure 5. Fastest Speed to Green at Contact Center

The third question focused on attrition. As reported earlier, attrition is typically very high in contact centers with resulting high costs for the corporate entity. In this study, we show that by using a BcD neuro-centric model in training, the company was able to save large sums of money in areas that are usually incredibly predictable and wasteful. Figure 6, *The Price of Attrition in Typical Contact Centers*, offers a view into the world of agent attrition and exorbitant costs.
In Cohort A, attrition was 17% during classroom training. During the first two weeks of production 7% more, for a total of 23% attrition in the first 30-days.
In Cohort B, which utilized BcD certified trainers and curricular improvements; attrition was less than 2% during classroom training. During the first two weeks of production attrition was 5%, making the total 7% in the first 30-days.

Attrition in Contact Centers	Agents: Day 1	Training Expense:	Agents: Day 15	Agents: Day 30	Hiring Target	Hiring Target Variance	Additional Training Expense:
Cohort A (Traditional)	125	$359,250	103 (-16%)	96 (-7%)	110	-18	$51,732
Cohort B (BcD™)	125	$359,250	122 (-2%)	116 (-5%)	110	+6	$0

Figure 6. The Price of Attrition in typical Contact Centers

The price of attrition is more than just the training wages and other expenses associated with hiring. With the traditional model, accelerated trainer burn-out from the constant need for training classes due to agent turnover meant $12,000 spent to interview, hire, train, and certify an additional trainer. The inexperienced and timid workforce resulted in 26,000 repeat customer contacts and supervisor escalations, which equates to a $147,000 increase in operating cost. The BcD™ Learning Model's 7% attrition meant no additional agents were needed and there were six additional agents to offset future attrition; this saved $17, 244 in training expenses. No additional trainers were needed saving $12,000 by comparison. The most significant difference is that repeat customer contacts dropped by 18,000, saving $102,000 in operating costs.
BcD methodology saved $183,000 in Training and Operating expenses.

The fourth question focused on sales and conversion rates. Once more, we report that the BcD model increased significantly the dollar amount value of sales as a result of conversions on the floor from new agents who were speed to green and proficient in a timely manner.

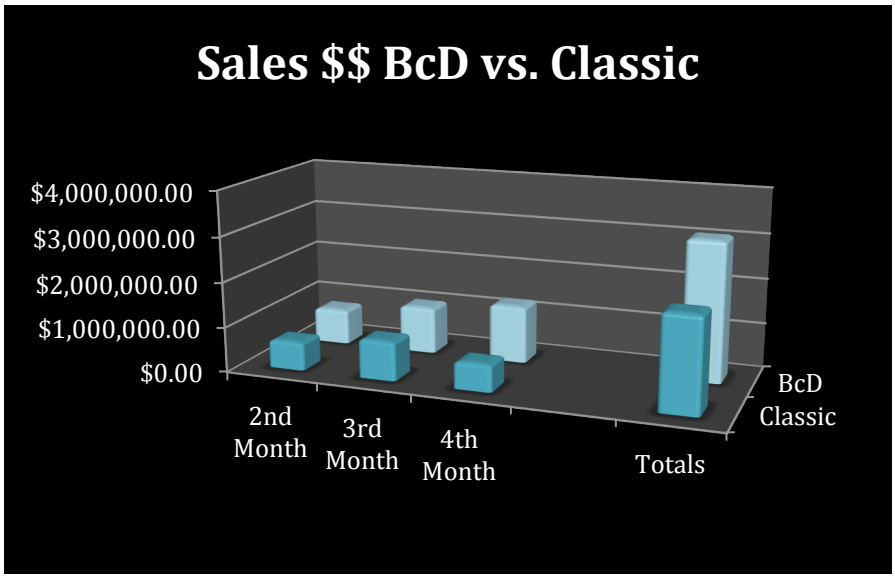

Figure 7. Sales $$ Classic vs. BcD

Conversion is the percentage of customers who visited your site or store and make a purchase. This has a significant impact on a company's bottom line and anything that can improve or positively impact the conversion rate is seen as a boon for the salesperson or the manager. In this study, researchers compared conversion rate and actual sales for the three months following completion of training for both classic and BcD methodology. Results are shown in the bimodal graph Figure 7, *Conversion $$ Classic vs. BcD*. In the classic implementation, sales started out at$627,937.92, and increased the following month to $865,542.98. Then in the next month, it was as if Ebbinghaus' infamous forgetting curve kicked in and $$ fell to $599,772.16. This is not unheard of in the classic model where distance from the learning event can be accompanied with forgetting, inefficiency, and a need for refresher interventions.[16]

In contrast, BcD agents demonstrated two very significant improvements as described here and made visible in Figure 7. Beginning at a modest $786,421.90, it was significantly more than the classic kick-off. Similarly, sales increased in the following month but in this case, a very robust increase to $1,039,516.50. The next month continued to improve with sales soaring to $1,269,528.70. This demonstrating clearly that the new agent had learned with deep understanding. Finally, the totals for both methodologies clearly show that the sales ability of the BcD agent was significantly better for the bottom line.

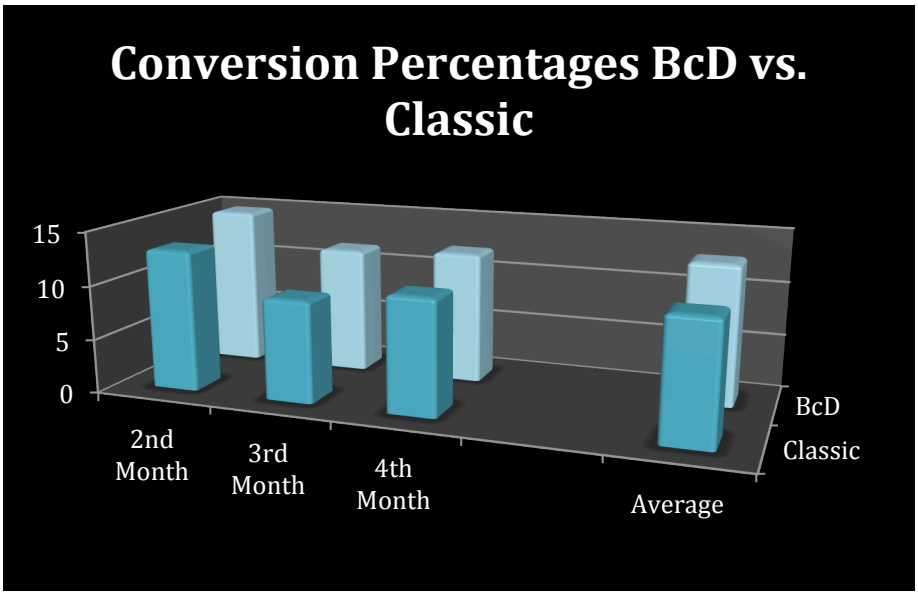

Figure 8. Conversion % Classic vs. BcD

A similar story emerged with regard to conversion rates over the same time frame. The neuro method outperformed the classic method as shown in Figure 8, Conversion % Classic vs. Bcd. Once more, the athletes who were trained with BcD methods delivered higher averages for conversion percentages in the first three months after training.

Limitations

As mentioned earlier, participants were assigned not in a random basis but as a result of opportunistic cadence relating to time and place. Fidelity of generalizability to wider audiences is cautioned at this stage until further validation of the approach is attained. We are however, satisfied that the BcD methodology is agnostic of geographic location, age, gender, and race.

Discussion

In this study we report on learning outcomes and significant bottom line savings, which emerge when two competing methodologies for training adult learners are compared. The first method was a classic 'sit and git' model where the 'sage on the stage' held court and dominated all learning intercourse. The innovative comparison model was a brain centric methodology where the learner took center stage and learning sciences areas like agency, metacognition, and cognitive rehearsal were the dominant features of the learning intercourse. Several issues surfaced which helped make sense of the findings and which now seem to add value to future studies.
The first had to do with the shift from teaching into facilitating and the sense of vulnerability that that process unfolded for the incumbent trainers. People who had spent a lifetime as sage on the stage did not find it easy to 'let go' entrenched thinking about how learning happens. However, it became clear quite soon that the impact on the learning environment and learners was immense once the teacher trusted the model and stepped back to allow the learner agency take hold.

The second centered on emergent ideas and agency. Unexpected unplanned for innovations and suggestions came from the floor. When agents were afforded the time and space for processing the new information and making sense of it in the 3R process, new and welcome additions surfaced that will be incorporated into future classroom settings. In other words, the learner was co-creating the space with the facilitator. This was a joy to witness and it was evident that the learners were more engaged when their voices were heard, and their innovations were accepted. The brain was apparent in every classroom. We describe the classroom transformation as a synaptic synthesis that is measurable, replicable, and sustainable.
Finally, the most surprising effect of the new method was one that we had not anticipated since it applied to the trainers rather than to the agents. Trainers had never witnessed this kind of high energy (often bordering chaotic) setting for teaching before and they were impressed by how much information the students could retain and how quickly and deeply they gained understanding of difficult concepts.

In conclusion, both trainers and students agreed that the BcD method was fun, innovative and easy to learn with. Facilitators are increasing their skills with the method and reading up on more areas about learning and the brain, which is also helping cement the intuitiveness of the learning space with science that corroborates and reinforces. They understand why novices who are engaged and invested in the method are able to retain, understand, and articulate information that is brand new, and conceptually difficult, while maintaining a positive and energetic disposition towards their job, their fellow learners and their workplace.

Future

Future research in this area will look more deeply at some of the variables that were difficult to isolate in this study. For instance, we will examine the difference a group perspective might have on the learning outcomes since it suggests even more agency and more engagement if the participant is involved in creating the material. We are committed to the neuro-centric method so much that we are excited about discovering nuances and corridors that might increase learning effects.

It is clear that participants learn new information in ways that (i) facilitates agency, (ii) generates metacognitive processes, and (iii) results in learning with deep understanding. We are interested in investigating the processes by which intentional neuro-centric approaches cause incremental and cumulative understanding of information so that creativity and efficiency are accomplished in which adaptive expertise is promoted. It appears that the Ebbinghaus dilemma of diminishing content retention over time is reversed so that learning is enhanced and learners engage in agentic activities that transform the learning space.

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Appendices

Appendix 1 The learning Model: Iterative Challenge Mosaic

In this paper, we describe a pedagogic model and communication tool, which has been used successfully in many diverse environments and across age groups that range from K-12 education through to adult professional development and industrial training. Learning models have been used for centuries (e.g., Plato, Aristotle, Rousseau, Pestalozzi, Froebel, Locke, Jefferson, Mann, Dewey, Piaget, Pavlov, Skinner, Simon, Montessori, Vygotsky)[17] to enhance teachers' roles in the classroom. A great deal of empirical research has emerged so that learning scientists are very familiar with what makes for a desirable learning environment and, indeed, for a good teaching model. This model – the Challenge Cycle – is quite unique in many ways. It emerged from "anchored instruction" learning experiments conducted at Vanderbilt in the 1990's,[18] and was widely used across the U.S. Later, concepts of this model were incorporated into the 1999 National Academies Press publication: ***How People Learn***,[19] and it is widely used around the world today. Here, we describe the components of the model and offer empirical evidence for why it is so successful in classrooms and why students engage with it.

The Challenge Cycle approach embraces a constructive theory of learning by actively engaging students in the process itself.[20] Students focus on explicit challenges and work to find meaningful solutions. The model 'makes visible' what students already know (prior knowledge) and ties existing knowledge with new information in a comprehensive way that promotes deep understanding.

The philosophy behind using a Challenge Cycle for teaching and learning is rooted in the concept of Adaptive Expertise (AE),[21] with the stated intention of preparing students for future learning (PFL).[22] Traditional learning models tend to focus on Sequestered Problem Solving (SPS) where the teacher prescribes curriculum, students memorize content, the teacher tests students' retention and recall of the content based on summative tests, and students pass or fail based on their responses.[23] There are no learning measures that purport to deep understanding from this method, and such situations contribute to a "mile wide, inch deep" situation where inert scraps of knowledge remain disconnected in the students' mind.[24]

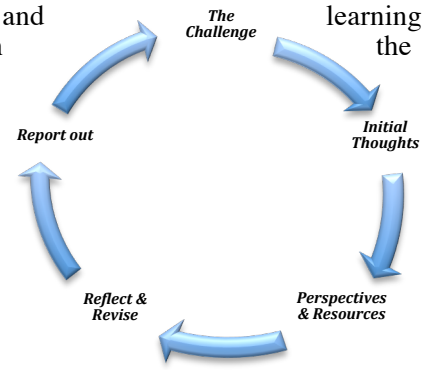

Fig 1: The Challenge Cycle

Challenge Cycles turn this model on its head. Students are allowed, even *encouraged*, to make mistakes and are given the opportunity to reflect on and learn from their mistakes in a cyclical iterative process that rewards decision making, risk-taking, and discourse.[25] Furthermore, students engage the problem-solving nature of the challenge by working collaboratively in groups to achieve sense-making and understanding as a result of discussions with peers and experts relating to information presented through short powerful perspectives.[26] Finally, endemic to the challenge cycle are elements of impending pedagogical enunciation where metacognitive presences are instantiated in a reflective and inclusive manner.[1] The resulting corpus of understanding after students have moved successfully through a challenge is progressively incorporated into the iterative cycle (in the perspectives & resources section). This way, students do not perceive their effort as "busy work" or routinized scripts to "turn in" for a grade, but have instead developed deep meaning in the learning process and uncovered new information relevant to a meaningful project in their lives.[9]

In a Challenge environment, learners are engaged in a collaborative task that seeks to find a solution to a problem that is well described and meaningful to them. Motivation is intrinsically set up from the perspective of Me Here Now.[27] The challenge is often presented via a short video, less than three minutes, which clearly states the issues and invites the learner to help solve it.

There are many reasons for engaging the student in this manner, most importantly to support learners' intrinsic motivation and interest.[28] Research has amply shown that key to learning is student interest.

Fig 2. The Challenge begins the cycle

> While we understand the importance of educational objectives in any course, they often blind us to the benefits of learning, which can't be measured. We appreciate that "the means through which imaginative curriculums can be built is as open-ended as the means through which scientific and artistic inventions occur."[28]

Thus, we present a meaningful challenge in order to create a structured yet flexible framework on which to enhance continued learning.[29] Evidence confirms that learners engaged through Challenge-Based Instruction have shown evidence of increased levels of performance on assessments that require higher order thinking and use of analytical and synthesis acumen.[15, 30] Researchers advise when building a challenge, that it is important to keep in mind the contextual setting – who is the audience (middle school students or teachers) and the setting. Is it a one-hour session or an eight-hour session or a unit that lasts three months? Either way – when designing a challenge that works, it is helpful to be mindful of what can be accomplished in a meaningful way within the time allowed and with the audience you have. For instance, in a class of middle school science students for one hour, the challenge should focus on a single question that can be accomplished in the time allowed. (Example Challenge: Help the students understand how sleep impacts attention)

Having reviewed the Challenge, students are asked to engage in the solution – to make a commitment to solve it by writing their Initial Thoughts on paper (even if they are online). By writing their *Initial Thoughts*, learners are invited to be 'generative' with regard to prior knowledge in a predictive stance. From a neurobiological standpoint, the act of leaning-in, picking up a pen and writing something on paper predisposes the learner to be in a much better position to learn than if this didn't happen.[9] As instructional designer will attest, teachers are constantly worried about the learner's attitude and whether they are in a position that enhances information acquisition or in contrast in a place (mentally) that causes the brain to reject the new information. By engaging with intentionality a learner's higher order processing skills associated with the prefrontal cortex through a simple exercise of writing Initial Thoughts, the instructor can predict that the learner is not in an amygdala hijack. [31]

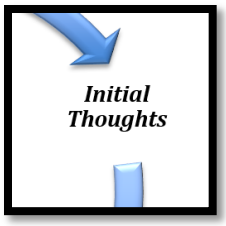

Figure 3. *Initial Thoughts* invite the learner to engage

Two phenomena are set in motion at this stage that have impact on cognitive processes and self-regulation: (i) the pedagogic phenomenon of metacognition is initiated – where the learner is 'making visible' what he/she knows at this stage (thus anticipating a measurable 'shift in thinking' over time as the cycle progresses, and (ii) the learner is taking responsibility for his/her own knowledge by working as an individual before getting into small collaborative groups. The learner then comes to the group with some preparation (even if he/she had little knowledge relating to the challenge in question).[32]

Learning scientists suggest not limiting the learner's innovative and generative capacity by scaffolding the learner with priming questions.[33] They suggest instead, leaving room for him/her to be free to understand the present level of knowledge relating to the challenge (e.g., what are my initial thoughts about how to solve this challenge?)[34] Very often learners begin by stating "I know nothing about this challenge," but they very quickly figure out that there are indeed quite a few things that they know or think they know. This kind of free expressive thinking is exactly what this stage is designed to inspire.[33] Many preconceptions/misconceptions are made visible at this stage, but the learner is not graded, labeled or punished for his/her opinions.[35] Thoughts remain private, written only for the

student to understand their own level of knowing at the outset of the challenge. As Bransford noted in ***How People Learn***:[19]

> "…students come to the classroom with preconceptions about how the world works. If their initial understanding is not engaged, they may fail to grasp the new concepts and information that are taught, or they may learn them for purposes of a test but revert to their preconceptions outside the classroom."

When learners write out their *Initial Thoughts* after being presented with a challenge there is evidence of active engagement. Research has shown that "self-monitoring prompts which encourage planning for and reflection on activities help students to demonstrate an integrated understanding of the relevant science."[36] Further work has found that, in particular, the process of generating ideas helped "students develop two important aspects of adaptive expertise: multiple perspectives and metacognition"[37] where moving from open idea generation to more directed idea generation further facilitated an adaptive approach to learning.[38]

Initial thoughts are just that… what the student knows before being exposed to any new content. Typically, the instructor assigns each individual a prescribed amount of time (Usually one minute) to write down (doesn't matter if it is on paper or online) what they know about the challenge that is presented. These thoughts are not to be graded; they are for the individual to understand how his/her thinking has shifted after an iteration of the cycle and an understanding of metacognition in action.[39]

After the self-insight associated with *Initial Thoughts*, learners are presented with 'Multiple Perspectives' that pertain to the challenge in hand. These are resources that have been especially culled from experts in the field who may differ from one another as to the solution for this challenge. (Depending on the amount and complexity of the content exposition, this process usually takes about 20 minutes.)

Figure 4. Multiple Perspectives chunked in short videos

Research has shown that it is important to introduce a varied voice for many perspectives so that learners get a feeling for the complexity of a particular discipline and understand that information has to be assessed and processed in order to make decisions relating to solutions.[40] Many experts recommend short video clips,[41] but acknowledge that there are no hard and fast rules about how much or how to surface this material (perspectives can be in the form of lectures, video clips, audio clips, readings, guided activities, and so on). Each challenge should dictate the amount and method. Learners are encouraged to take notes during this section as they interact with new information. The interaction will help structure revised thinking later in the cycle. Short video snippets are recommended to take advantage of entertainment and novelty value to learners, and so that new information does not cause cognitive overload.[42]

Multiple Perspectives are essentially the voices of experts. They are referred to as resources because the student sees them as a resource for helping get a different perspective on the challenge. Typically, content (relating directly to Big Ideas in the challenge) resides in the resources. Research shows that it is important to chunk new content into bite-sized units.[43] This is accomplished by aligning new content with big ideas in a backward design process as espoused by the learning theorists[44] who penned the tome *Understanding by Design* (Wiggins & McTighe, 1999). The advantage of having content in short video snippets is manifold; (i) It allows learners to work at their own pace and to iterate through the cycle as many times as is needed; (ii) Short snippets are useful to mitigate cognitive overload; (iii) Connecting the content to enduring "big ideas" helps the learner encode the material into long-term memory for fast and dependable retrieval when needed.[45]

This next portion of the Challenge Cycle has two distinct, but tightly connected, elements that enhance metacognition and learning with deep understanding. In addition, the interactive discussions facilitate a continued 'making visible' of the designed shift-in-thinking that is

anticipated in the model. Recall that in the Initial Thoughts section, learners were asked to make visible their thinking, which could include preconceptions and misconceptions as well as prior knowledge—all of which aided in the comprehending and acceptance of any new material.[46]

While the perspectives and resources are still fresh in the learners' minds, they are asked to 'Reflect' on the new knowledge with particular recall to what they wrote down for their *Initial Thoughts*. Learners are scaffolded[47] through this portion of the cycle with the following questions:

- **What was surprising?**
- **What I already knew, but now see in a new light?**
- **What still needs to be explained?**

Reflection usually takes 3 to 4 minutes and is meant for the individual working alone.[48] In the process of articulating their shift in thinking, students and learners usually arm their voice with information that can be shared in the next portion of the model.[49]

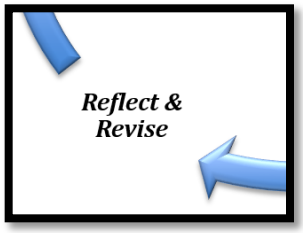

Figure 5. Reflect and Revise supports Metacognition

Research has shown that these sorts of "metacognitive experiences" greatly improve learning and increase positive affect in the process.[50] Meanwhile, cognitive psychologists describe positive affect, which is highly correlated with both insight and analytical problem solving.[51] Brain regions correlated with both decision-making and emotion have increased activation that promotes insight and "Aha!" moments by detecting multiple competing associations. These regions are better "prepared" by being in a positive mood.[52]

> "Teaching practices congruent with a metacognitive approach to learning include those that focus on sense-making, self-assessment, and reflection on what worked and what needs improving. These practices have been shown to increase the degree to which students transfer their learning to new settings and events." (Bransford, 2000)

The Challenge Cycle is designed to allow for individual reflection (typically two minutes). This is then quickly followed by focused discussion in small groups that facilitate a revision of thinking in what is referred to by cognitive neuroscientists as cognitive rehearsal.[53] The same three scaffolding questions (mentioned earlier) are anchors[54] for facilitating any conceptual changes[55] that occur during this phase of the model.

This group discussion allows each individual to make public their ideas with regard to the challenge and the perspectives that they think will offer a credible solution. This process invests in deliberate discussion, argumentation, and articulation so that inclusivity and collaboration invite agency and metacognition.[56] The questions occupy a common space with regard to the opinions about the multiple perspectives and resources that they were presented with earlier:

This forum makes space for individual thought and evaluation. At the same time, it highlights and has the potential to clarify any lingering misconceptions, and is inclusive and supportive to connecting new knowledge to prior understanding in a meaningful way.[57] With this kind of dialogue, learners get the opportunity to discover commonalities with peers and practice tolerance for ambiguity—a mainstay construct of adaptive expertise.[46] Participants are also given the prospect (by sharing their opinions) of possibly helping their peers gain new insights as they each learn with and alongside their fellows. The social aspects[58] of this learning platform are tangible in these many if small nuanced elements of group collaborative discussions.

> "…teacher's scaffolding of students' learning or peers' cognitive and metacognitive support can alleviate feelings of difficulty through the instructions or hints that make students aware of critical cues regarding the required information or procedures for the solution of the problem."[50]

Cognitive rehearsal is not quite the same as repetition even if there is a semblance of doing the same thing over and over. There is a difference between rote (where I repeat the same thing many times until I memorize it for recall later) and getting a new perspective (through a different voice, different modality, and different sensory experience), in relation to the concept being learned. Research has shown that by using the iterative challenge cycle, knowledge is reinforced as students restate what they have learned verbally (as well as writing) since most students need many opportunities to reflect in order to build cohesive, coherent accounts of new material.[47]

Reflect is an individual activity. Research has verified that in this singular moment of comparison between initial thoughts and multiple perspectives, learners begin to understand how their thinking has shifted. The shift in thinking is equated to conceptual change. Furthermore, the ability to revise one's thinking in front of peers allows learners to consolidate their information acquisition and bring closure to the cognitive event. The final interaction of the cycle solidifies the process by producing more cognitive rehearsal, more opportunities to revise one's thinking, and more time for processing new information and assimilating it to prior knowledge.

The Report Out occurs in a facilitated large-group discussion—each small group is represented by a spokesperson who reports out to the larger cohort. Naturally, the structure for this outcome is adjusted if the group is online, but the underlying philosophical framework stays the same. Ideally, an expert is present to facilitate a discussion that begins with each small group sharing out what they discovered by answering the same three questions listed above for Reflect and Revise above. (Report Out usually takes roughly 30 minutes.)

Figure 6. Report Out for Cognitive Rehearsal

In support of the learning process promulgated by the iterative cyclical approach, Report Out reinforces reflection, revised thinking and sharing. Once more, each individual is given an opportunity to contribute ideas or solutions, is part of a discussion that includes the distributed expertise of the entire group and is able to reflect on how his/her thinking has or is shifting. Together, the group co-creates a safe learning ecosystem where risk-taking, idea-generation, feedback, collaborative learning, and even argumentation are all highlighted and protected.[59] Report out usually takes 20 minutes. In this exercise, each small group represents the individual. When the spokesperson stands and announces that "We… were surprised …", the individual is represented; the individual has voice; has an opinion that counts and is able to be present without fear of reprisal. These learning measures have been shown to be an important part of identity, sense of belonging, and feeling of contribution that is vital for engage behavior I learning systems.[60]

Learning is a lifelong process. One of the persistent issues in traditional educational methodologies is the treatment of knowledge as discrete packets of information that one gathers in a static nature.[24, 61] Bransford and others have shown that challenge cycles are most effective when they are in the context of a mosaic of interconnected cycles, which "share resources across courses so that student learning can be propelled."[62] For many teachers, this final synthesizing step of the cycle is perhaps the most critical as instructors seek out the most effective way to promote continued learning by engaging with higher order mental processing.[63]

Once learners have taken part in the full cycle by relating what they learned to a new challenge that was seemingly unrelated before, they are being prepared for future learning. The research team of Roselli and Brophy who pioneered early work in the challenge mosaic, stated that when learners can contribute new mosaic elements back into the iterative cycle by creating new usable knowledge chunks in *Multiple Perspectives*, the drudgery disappears. Motivation, interest and commitment are the engaging facets of learning that spring from repeated use of challenge cycles as a method for instruction and new learning. This is how they describe it:

> "…familiarity with a [challenge] cycle and the ability to locate relevant information should better prepare students to become life-long learners capable of solving novel problems and adapting to new expectations defined in the workplace and the growing global climate."[30]

Teachers report that learners readily connect to the learning elements of the challenge cycle.[64] The opportunities for reflective thinking, the clear understanding of how their own thinking has shifted, and the co-creation of safe learning ecosystems have deep implications for learner agency in the classroom and beyond.[65] To wrap up the challenge cycle, learners often get drawn into deeper questions and discussions that advance their thinking and allow them to connect concepts and ideas across challenges, showing true learning transfer. In general, they come to expect teaching that promotes this transfer and gives them opportunities for meaningful learning.[66]

Appendix 2 (a) A Cyclical learning Model

Appendix 2 (b) Visualization of interactivity with a Cyclical learning Model

Appendix 3 Cyclical Learning Model: A Pedagogical Description

SUPPORTING PRINCIPLES IN COGNITIVE NEUROSCIENCE	
The Challenge	-Intrinsic Motivation -Big Picture -Connections
Initial Thoughts	-Safe Environment -Metacognition -Attention -Neural Commitment -Me, Here, Now
Perspectives & Resources	-Content Delivery -Chunking -Schemas -Biases -Primacy effects
Reflect & Revise	-Collaboration -Active vs. Passive Learning -Metacognition -Affect -Cognitive Rehearsal
Report Out	-Productive failure -Feedback mechanisms - Cognitive Rehearsal
Continue the Cycle	-Long-term encoding -Consolidation -Learning Transfer