Organisation for Economic Co-operation and Development

EDU/EDPC(2018)45/ANN7

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9 October 2018

DIRECTORATE FOR EDUCATION AND SKILLS
EDUCATION POLICY COMMITTEE

Future of Education and Skills 2030: Curriculum Analysis

Connections between Anticipation-Action-Reflection and Continuous Improvement Cycles

8th Informal Working Group (IWG) Meeting
29-31 October 2018
OECD Conference Centre, Paris, France

This draft paper was written by Ariel TICHNOR-WAGNER, Senior Fellow, ASCD. The purpose of this literature review is to compare the Anticipation-Action-Reflection (AAR) cycle to continuous improvement cycles and discuss the implications for how the AAR cycle could be implemented in education and other sectors that utilise similar approaches.

For ACTION participants are invited to SEND their comments before 5th November.

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JT03437004

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1. Introduction

The Anticipation-Action-Reflection (AAR) cycle is the learning spiral through which students develop transformative competencies and student agency. The process of using strategic foresight and planning to feel ready to influence the future (Anticipation), having the will and capacity to take effective action (Action), and critically reassessing one's actions to develop deeper understanding and improve future actions (Reflection) is similar to Plan-Do-Study-Act (PDSA) and Plan-Do-Check-Act (PDCA) cycles used in business, healthcare, and education sectors as part of continuous improvement processes.[1] The purpose of this literature review is to compare the AAR cycle to continuous improvement cycles and discuss the implications for how the AAR cycle could be implemented in education and other sectors that utilise similar approaches.

[1] PDSA and PDCA cycles are not identical. The architect of the PDSA cycle, W. Edwards Deming, frequently noted that these were not the same processes, with the "Check" often referring to evaluating the sale of product and "Study" emphasizing deeper learning (Moen & Norman, 2010). However, because PDSA and PDCA are often used interchangeably today (Taylor, et al., 2014), for purposes of this review both will be referred to as "PDSA."

2. Description of PDSA and PDCA Cycles

2.1. Purpose

PDSA cycles are theoretically grounded tools utilised in continuous improvement approaches, including Improvement Science, Continuous Quality Improvement, and Total Quality Management. These improvement approaches use PDSA cycles to understand and change systems and organisations, not individuals (Berwick, Developing and Testing Changes in Delivery of Care, 1998; Kilo, 1998; Laffel & Blumenthal, 1989; Shortell, Bennett, & Byck, 1998). For example, Improvement Science develops capacity for sustaining systems change through the utilisation of improvement routines, including PDSA cycles (Cohen-Vogel, Cannata, Rutledge, & Socol, 2016; Kilo, 1998). PDSA cycles are the basic method of inquiry to guide rapid learning (Bryk A. , Gomez, Grunow, & LeMahieu, 2015), which help to answer three questions: 1) What are we trying to accomplish? 2) How will we know if a change is an improvement? 3) What change can we make that will result in an improvement? (Langley, Nolan, Norman, & Provost, 2009). Similarly, Continuous Quality Improvement (CQI) is a "philosophy of continual improvement of the processes associated with providing a good or service that meets or exceeds company expectations" (Shortell, Bennett, & Byck, 1998). In this approach, teams of staff and quality improvement experts use PDSA cycles to develop, test, implement, and redesign processes that address symptoms of poor quality (Scoville, Little, Rakover, Luther, & Mate, 2016).

PDSA cycles are small-scale, iterative rapid cycle tests of change that test whether proposed changes – be it to product development, manufacturing, management, or service delivery - lead to improvements in organisational processes and outcomes. These changes are as varied as making morning meetings at a construction company more effective, improving service in a dental office to increase customer satisfaction, eliminating contamination in shipping drums, and reducing energy use in school (Langley, Nolan, Norman, & Provost, 2009). PDSA cycles are meant to be integrated into the daily work of individuals across the system, involving and empowering leadership, managers, and staff at all levels of an organisation to make evidence-based decisions as they engage in improvement efforts (Cohen-Vogel, et al., 2015; Laffel & Blumenthal, 1989; Shortell, Bennett, & Byck, 1998; Scoville, Little, Rakover, Luther, & Mate, 2016).

The small-scale nature of these cyclical tests of change minimises risk, as it 1) allows users to collect evidence and reflect on whether or not a proposed change will work without immediately disrupting the existing systems and structures within an organisation and 2) provides a "safety net" in the event that "the changes should fail to perform as predicted" (Kilo, 1998; Langley, Nolan, Norman, & Provost, 2009; Morris & Hiebert, 2011). The intentionally flexible nature of these cycles allows them to be utilised across varied contexts, develop "fit-for-purpose solutions" rather than force-fitting pre-conceived solutions to problems, and adapt changes to local conditions (Cohen-Vogel, et al., 2015; Langley, Nolan, Norman, & Provost, 2009; Taylor, et al., 2014; Tichnor-Wagner, et al., 2018). Cumulatively over time, these small tests of change combine to produce larger improvements that simultaneously address localised contexts and constraints while building system-wide capacity for ongoing learning (Morris & Hiebert, 2011).

2.2. Process

The PDSA cycle follows the basic principles of the scientific method: articulating a hypothesis, testing the hypothesis, and making changes to the hypothesis or seeking to replicate results (Bryk A. , Gomez, Grunow, & LeMahieu, 2015; Moen & Norman, 2010; Taylor, et al., 2014). The cycle consists of four phases: 1) Plan, 2) Do, 3)Study, and 4) Act.

The "Plan" phase answers, "How do we understand the presenting problem and the organisational system in which it is embedded?" (Bryk, Gomez, & Grunow, 2013). During this phase, a change aimed at improvement is identified. Problems of practice are articulated and the root causes and larger system in which the problem is embedded are analysed, allowing for theorisation about alternative mechanisms and brainstorming of numerous possible causes and effects (Bryk, Gomez, & Grunow, 2013). Often, basic tools such as driver diagrams, fishbone diagrams, and Pareto charts are used to better understand the system that is causing the articulated problem to occur (Moen & Norman, 2010). From there, specific objectives are identified in the form of performance measures and goals, predictions are articulated about the expected outcomes, and decisions are made about who will implement the change, when it will happen, where it will happen, and how data on its efficacy will be collected (Langley, Nolan, Norman, & Provost, 2009; Park & Takahashi, 90-day cycle handbook, 2013).

In the "Do" phase, the change is carried out. This typically begins at a small scale. For example, in a school setting, this would entail starting with a handful of teachers or classrooms before spreading to an entire department, grade level, or school in subsequent PDSA cycles (Cohen-Vogel, et al., 2015). During this time, data on what happened during the test is collected using practical measurements, that is, tools that can "feed back information quickly and without disrupting ongoing activity of the system" (Lewis, What is improvement science? Do we need it in education?, 2015) and that can be "embedded naturally into the work life of the organisation" (Bryk, Gomez, & Grunow, 2013). Such "just-in-time" measures are meant to be easily administered by site-level employees, taking the form of, for example, short questionnaires or checklists that collect just enough data to learn from the test and use that new knowledge to plan the next test (Cohen-Vogel, et al., 2015; Insittute for Healthcare Improvement, 2018).

The "Study" phase addresses how we know whether the proposed change actually leads to an improvement (Bryk, Gomez, & Grunow, 2013). During this phase, outcomes are measured and data is analysed to assess the impact of the change. Questions answered during this phase include: What was learned? What went wrong? How do our results compare to our initial predictions? (Taylor, et al., 2014).

The "Act" phase consists of identifying next steps based upon what was learned in the "Study" phase. This phase emphasises revision and refinement of the original change (Bryk, Gomez, & Grunow, 2013). Decisions could range from completely abandoning the change being tested, modifying it, or scaling up the next cycle to include more users (Cohen-Vogel, et al., 2015). From here, the cycle repeats itself, wherein the lessons learned from the "Act" phase are applied to the "Plan" phase of the following cycle (Taylor, et al., 2014). The iterative nature of these cycles is essential. Through multiple iterations of PDSA cycles, the collection and analysis of data over time increases understanding of variations across contexts and allows for deeper understanding of whether changes lead to desired outcomes. Furthermore, multiple cycles are needed to develop a change that will actually work in the context in which it is being implemented (Bryk A. , Gomez, Grunow, & LeMahieu, 2015).

3. Uses of PDSA Cycles across Sectors

PDSA cycles have its roots in industry, have become widely adopted in healthcare, and have just recently been introduced to and implemented in education. This section reviews outcomes, challenges, and case studies associated with the implementation of continuous improvement cycles in these three sectors.

3.1. Industry

W. Edwards Deming is credited for introducing PDSA cycles as a method of improvement for increasing quality and successes while simultaneously reducing costs and failures (Anderson, Rungtusanatham, & Schroeder, 1994). Continuous improvement, defined as "the propensity of the organisation to pursue incremental and innovative improvements of its processes, products, and services", was one of the key concepts underlying Deming's management model, with PDSA cycles a fundamental tool to actualise such improvements (Anderson, Rungtusanatham, & Schroeder, 1994). Deming viewed feedback loops as vital for improvement across all business processes, and adapted the PDSA cycle from statistician Walter Shewhart of Bell Laboratories. The "Shewhart Cycle" consisted of three steps reflective of the scientific method: 1) Specification, which corresponded to making a hypothesis, 2) Production, which corresponded to carrying out an experiment, and 3) Inspection, which corresponded to testing the hypothesis. (In industry, PDSA cycles have also been referred to as the "Shewhart cycle", "Deming wheel," and "Deming cycle"; see (Moen & Norman, 2010).

Of note, PDSA is one of a number of improvement cycles that businesses have embraced. For example, the Six Sigma program for improvement – adopted by a number of large companies such as GE, ABB, Motorola, Honeywell, Sony, Honda, and Ford – uses the DMAIC cycle: Define Opportunities, Measure Performance, Analyse Opportunities, Improve Performance, and Control Performance (Bhuiyan & Baghel, 2005). This methodology focuses on reducing variation in all organisational processes, including manufacturing, design, administration, and service. The DMAIC and PDSA cycle are well-aligned. Akin to the "Plan" phase, the Define, Measure, and Analyse phases determine project scope, quantifiable objectives, key metrics, and the gaps, root causes, and obstacles. As with the "Do" phase, the Improve phase focuses on implementing changes. The Control phase emphasises data measures to sustain gains, similar to the "Study" and "Act" phases (Sokovic, Pavletic, & Pipan, 2010).

The RADAR (Results, Approach, Deploy, Assess, and Refine) Matrix is another improvement cycle that industries have used to measure performance. Like PDSA cycles, the steps of the RADAR Matrix include: "determine the *results* it is aiming to achieve", "plan and develop sound *approaches* to deliver the required results", "*deploy* the approaches systematically for implementation", and "*assess* and *refine*" the approaches deployed via ongoing analysis of the results achieved (Sokovic, Pavletic, & Pipan, 2010). Lean six sigma, and the balanced scorecard also provide continuous feedback loops in process and basic strategy outputs (Bhuiyan & Baghel, 2005).

Outcomes. Originally conceived and utilised as a method for improving quality of manufactured products, over the past seven decades the use of PDSA cycles in industry has expanded to improving management strategies, processes, and systems across an organisation (Bhuiyan & Baghel, 2005). Outcomes of companies who have used PDSA or similar improvement cycles have included: waste reduction in systems and processes, elimination of variation in production across settings, savings in expenses, and increases in growth and revenue (Bhuiyan & Baghel, 2005; Laffel & Blumenthal, 1989). For example, in using the Six Sigma approach, Motorola saved 14 billion U.S. dollars while experiencing a fivefold increase in growth over a ten-year period (Bhuiyan & Baghel, 2005). Anderson and colleagues (1994) similarly noted the correlation between continuous improvement of process, product, and service quality and customer satisfaction. Along with business outcomes related to the quality of products and services, PDSA cycles have also been found to increase ongoing learning and knowledge production across organisation, as the method builds capacity for employees to self-regulate their learning (Anderson, Rungtusanatham, & Schroeder, 1994).

Example of PDSA in Practice: Japan's Post-War Economic Revitalisation. Deming brought the concept of tests of change to Japan in the 1950s, where he is credited with helping to revive the post-World War II Japanese economy through his improvement methodologies (Anderson, Rungtusanatham, & Schroeder, 1994; Berwick, Developing and Testing Changes in Delivery of Care, 1998; Cohen-Vogel, et al., 2015). The Deming wheel that he presented in 1950 to the Japanese Union of Scientists and Engineers included the following four cyclical steps: 1) Design the product with appropriate tests, 2) Make the product and test in the production line and in the laboratory, 3) Sell the product, and 4) Test the product in service and through market research by finding out what users think about it and why nonusers have not bought it (Moen & Norman, 2010). Japanese executives revised the Deming wheel into a Plan-Do-Check-Act cycle, where "Plan" corresponded with designing the product, "Do" corresponded to production, "Check" to sales as a measure of customer satisfaction, and "Act" to testing the product through research. Japanese industry leaders further broke down the "Plan" phase to include the determining goals and targets and determining methods of reaching goals and the "Do" phase to include engage in education and training and implement work (Moen & Norman, 2010).

This methodology, grounded in Deming's work, has remained the foundation for *kaizen*, or continuous improvement, in Japanese industry (Berwick, Developing and Testing Changes in Delivery of Care, 1998; Moen & Norman, 2010). Kaizen breaks down organisational hierarchies by emphasising the importance of learning for continuous growth at all levels of an organisation. Management-oriented *kaizen* focuses on company strategy, group-oriented *kaizen* on employee teams who find and solve problems associated with their daily work, and individual-oriented *kaizen* on workers identifying solutions to problems they face (Bhuiyan & Baghel, 2005).

3.2. Healthcare

Deming's method for continuous improvement was first introduced to the healthcare sector in 1989 by Dr Donald Berwick and other healthcare leaders concerned about the quality of health care delivery in the United States due to too many preventable errors and high variability in treatment (Berwick, Continuous improvement as an ideal in heatl care, 1989; Laffel & Blumenthal, 1989; Morris & Hiebert, 2011; Shortell, Bennett, & Byck, 1998). The uptake was quick. By 1993, 69% of hospitals in the United States were implementing some form of Continuous Quality Improvement utilising rapid tests of change (Shortell, Bennett, & Byck, 1998). In the ensuing decades, PDSA cycles have been applied broadly across healthcare, for administrative and clinical purposes and for inpatient and outpatient care (Shortell, Bennett, & Byck, 1998). Examples range from patient scheduling and billing, operation waiting time before surgery, reducing infections, arterial closure complications, improving the delivery of in-hospital medications, and reducing costs of care, length of stay, and patient charges without adversely affecting surgical outcomes, among many others (Nicolay, et al., 2012; Shortell, Bennett, & Byck, 1998).

Outcomes. A large literature base has shown that the use of PDSA cycles as part of a process for continuous improvement has led to positive results across various healthcare outcomes (e.g., (Nicolay, et al., 2012; Shortell, Bennett, & Byck, 1998; Taylor, et al., 2014). Shortell and colleagues (1998) systematically reviewed the literature on clinical applications of CQI in healthcare from 1991 through 1997. The majority of the 55 studies reviewed showed positive, significant results on the variable of interest. (Notably, only two studies employed randomised clinical trials, the others relied on pre-post observations.) Nicholay and colleagues (2012) conducted a systematic review to identity and evaluate the application and effectiveness of quality improvement in surgery. Of the five studies that used PDSA/PDCA cycles, all found improvements on the variables of interest. An evaluation of the use of PDSA cycles within the United Kingdom National Health Service likewise pointed to positive outcomes when PDSA outcomes were implemented with fidelity (Walley & Gowland, 2004). For example, in one case, multiple iterations of PDSA cycles focused on reducing patient wait times by freeing up bed space for incoming patients found that the discharge lounge reduced patient wait times, and identified additional areas for improvement – mainly that the lounge was used by patients waiting for take-home drugs.

Example of PDSA in Practice: Institute for Healthcare Improvement. Founded by Dr Berwick in 1991, the Institute for Healthcare Improvement (IHI) utilises the science of improvement as a means of improving quality, safety, and value in healthcare around the world (Insittute for Healthcare Improvement, 2018).[2] The Model for Improvement that they apply to their work tests changes on a small scale in clinical environments using PDSA cycles (Kilo, 1998). Their improvement process includes setting a clear, measurable aim, a measurement framework to support reaching that aim, a theory of action of how a proposed change will lead to the desired results, a clear description of how a change will be implemented, and a dedication to PDSA cycles and learning from tests of change. To date, their website houses links to over a thousand publications related to improvement in health care delivery and outcomes (Cohen-Vogel, et al., 2015).

One example of how the IHI has utilised PDSA cycles in clinical settings was through the Institute for Healthcare Improvement Breakthrough Series, which convened a series of collaboratives of 20 to 40 organisations that worked together for 9-12 months focused on a specific health care topic (e.g., reducing delays and waiting times, reducing caesarean section rates, improving asthma care, reducing adverse drug effects, reducing costs and improving outcomes in adult cardiac surgery). Each organisation's team included representatives from system leadership, technical expertise, and day-to-date leadership. The first learning session of the collaborative consisted of each team solidifying aims, establishing real-time measurement systems, and planning the tests of change (the "Plan" phase). This was followed by action periods where the plans were carried out (the "Do" phase) and ongoing communication between organisations within the collaborative took place. During the second learning session, teams assessed progress and shared key findings (the "Study" phase) and planned to scale progress beyond the initial test site (the "Act" phase). The final learning session compiled and disseminated lessons learned across the

[2] For detailed information on IHI's history and current work around improvement science and PDSA cycles, visit http://www.ihi.org/about/pages/ihivisionandvalues.aspx.

collaborative. Overall, the median progress of different collaboratives fell between modest improvement, defined as 30% improvement at a major subsystem level within the organisation, or significant progress, defined as 50% improvement at a systems level (Kilo, 1998).

Challenges. At the same time that research has found PDSA cycles to be an effective process for enacting changes that lead to desired improvements in healthcare settings, research has also uncovered implementation challenges. Due to the fact that PDSA cycles are often different from how healthcare providers have been trained and from traditional standard operating procedures, they require intense capacity-building efforts and time commitment to implement successfully (Berwick, 1989; Nicolay, et al., 2012; Shortell, Bennett, & Byck, 1998). In a study assessing the quality of PDSA cycle application, Taylor and colleagues (2014) found wide variation in how PDSA cycles were implemented and reported on in peer-reviewed literature, suggesting either a lack of understanding of the PDSA process or the capacity of site personnel to implement PDSA cycles with fidelity. This lack of capacity has been attributed to time and money constraints (Berwick, 1998), along with change fatigue (Essain, Williams, Gakhal, Caley, & Cooke, 2012).

Specific on-the-ground challenges have included difficulties of those in higher-up positions, such as senior management and clinicians, sharing ownership with staff (Walley & Gowland, 2004). As Kilo (1998) noted, "healthcare professionals have not been trained to, and therefore do not work well across, professional boundaries" (p. 3). However, successful PDSA implementation requires an organisational culture that fosters openness, collaboration, and learning across all levels of the organisation (Essain, Williams, Gakhal, Caley, & Cooke, 2012; Laffel & Blumenthal, 1989; Shortell, Bennett, & Byck, 1998). A study of quality improvement among healthcare groups in the UK found that PDSA cycle users tended to force-fit predetermined solutions to problem identification in the "Plan" phase rather than users seeking to understand the system that was at the root cause of the issues identified (Essain, Williams, Gakhal, Caley, & Cooke, 2012). Finally, the frequency, relevance, and reliability of data collected to inform the "Study" and "Act" phases have been an issue when it comes to using PDSA cycles to effectively measure whether improvements have been made (Taylor, et al., 2014).

3.3. Education

The use of continuous improvement cycles is relatively new to the education sector (Cohen-Vogel, et al., 2015; Lewis, 2015; Park, Hironaka, Carver, & Nordstrum, 2013). Advocates and early adopters of continuous improvement within education have viewed PDSA cycles as a driver for systemic change to improve student outcomes as PDSA cycles a) address organisational and structural factors that impact student learning and b) by allowing for local adaptions, hold promise for scaling up effective educational innovations across diverse school and district boundaries (Lewis, What is improvement science? Do we need it in education?, 2015). For example, Morris and Hiebert (2011) explicated that small tests of change are best utilised for testing and revising "knowledge products" (e.g., lesson plans) that improve teaching, as testing a lesson plan in multiple classrooms and accumulating the results over multiple iterations allows for learning from small mistakes to occur in the design and revision of optimal curricular and instructional materials. Bryk and colleagues (2015) argued that applying continuous improvement methods education would reduce variation in student outcomes, therefore "more consistently producing positive outcomes for diverse students being educated by different teachers in varied contexts" (p. 13).

As in healthcare, PDSA cycles have been applied to find solutions for an array of problems of practice. These include slowly scaling up school-based innovations that lead to sustained improvement in high school students' academic, social, and emotional outcomes (Cohen-Vogel, et al., 2015; Tichnor-Wagner, et al., 2018) student completion of community college developmental math courses (Bryk A. , Gomez, Grunow, & LeMahieu, 2015; Lewis, What is improvement science? Do we need it in education?, 2015), the retention of new teachers (Bryk et al., 2015), and teaching the Common Core State Standards (Park, Hironaka, Carver, & Nordstrum, 2013).

Of note, PDSA cycles are closely related to other approaches used to improve curriculum and instruction in education (Tichnor-Wagner, Wachen, Cannata, & Cohen-Vogel, 2017). Action research entails ongoing cycles wherein teachers 1) identify an area for improvement within their classroom practice, 2) plan a change to address that area, 3) act and observe the change process and results, 4) reflect on the process and results, and 5) re-plan based on their reflection (Kemmis & McTaggart, 2005). Design-based research builds on the tradition of action research, wherein researcher and practitioners work together to design and implement an intervention to overcome a local problem or improve a local practice using multiple iterations of creating and testing prototypes in the setting in which they are to be implemented (Anderson & Shattuck, 2012).

Outcomes. Early research on PDSA cycles in the education sector point to positive outcomes regarding building capacity for system-wide learning and change. First, the introduction of PDSA cycles helps build capacity to implement improvement processes and generate knowledge within the education system at the classroom, district, and community-wide level (Park, Hironaka, Carver, & Nordstrum, 2013). As one example, the School District of Menomonee Falls trained teachers in using PDSA cycles on implementing the Common Core State Standards. Teachers worked with students on setting measurable aims on what the class should achieve for that standard. With input and feedback from students, teachers identified and tested different instructional approaches to support students in achieving that aim. During the seven to ten day learning cycle, teachers collected student data to track progress and collected student feedback on the instructional strategies utilised (e.g., what worked, what needed to be tweaked, what should be abandoned), thus contributing to students' metacognitive development of understanding their own learning (Park, Hironaka, Carver, & Nordstrum, 2013).

The Carnegie Foundation for the Advancement of Teaching, a leader in advancing continuous improvement in PK-20 education (Cohen-Vogel, et al., 2015), has convened Network Improvement Communities targeting specific problems of practice with evidence of success (Bryk A. , Gomez, Grunow, & LeMahieu, 2015). Carnegie Math Pathways, an improvement network of 19 community colleges, utilised PDSA cycles as an effective method for improving the success rates of students completing developmental math classes. In the first three years of implementing two new courses that network members developed, about half of students enrolled in the courses successfully completed them, a marked increase from previous completion rates of students in traditional developmental math sequences (Sowers & Yamada, 2015). Carnegie's Building a Teacher Effectiveness Network focused on retaining beginning teachers in urban school districts by addressing teachers' feelings of burnout and increasing confidence. For example, one district in the network developed a protocol for principals to have conversations with beginning teachers guided by six prompts, which they predicted would lead to teachers' feeling supported. They went through four iterations of PDSA cycles, first tweaking the conversation protocol in one school before moving to test the protocol across five additional schools in the district. During these PDSA cycles, the principals testing the protocol identified the need for developing a delivery standard for how often these conversations should occur and - for schools with larger numbers of new teachers - the need to bring additional people into the process beyond the principal. Through iterative testing cycles, what began as a series of PDSA testing by one principal in one school scaled into system-wide change in how school and district administrators interacted with new teachers (Bryk A. , Gomez, Grunow, & LeMahieu, 2015).

The vast majority of Japanese public schools have successfully adopted lesson plan studies (Lewis, What is improvement science? Do we need it in education?, 2015), which follow a similar cycle of planning, acting, and reflecting. Working together for several months, a small team of teachers study and improve on an existing lesson, following the process of 1) specifying learning goals for the lesson, conducting research to determine the best approaches to reach the lesson goals, and using the resources to develop a detailed lesson plan, 2) teaching the lesson while the rest of the team observes, 3) debriefing on the lesson's success, and 4) revising the lesson based upon what was learned during the debrief (Morris & Hiebert, 2011). This approach has largely been credited for improving high quality teaching in primary school Japanese classrooms (Lewis & Tsuchida, 1997; Shimahara & Sakai, 1995; Morris & Hiebert, 2011) and for spreading instructional innovations focused on teaching for understanding mathematics and science across Japan's national education system (Lewis, 2015).

Example of PDSA in Practice: The National Center for Scaling Up Effective Schools. The National Center for Scaling Up Effective Schools, a research and development centre seeking to scale up practices proven to improve high school student achievement in two diverse urban school districts, utilised a model of improvement with rapid-cycle testing as one of its three core principles (Cohen-Vogel, Cannata, Rutledge, & Socol, 2016).[3] District leaders, school administrators, and school staff in collaboration with researchers used PDSA cycles to adapt prototypes addressing social-emotional and academic learning to specific school contexts.

After teams in both districts designed prototypes based upon research of highly effective schools in their local district, three school sites conducted PDSA cycles to test the prototype. One district began with four teachers in each of the schools testing out Rapid Check In (RCI) forms as a way of reaching each of their students and flagging any academic, social, or emotional concerns. They found that RCI's increased student-teacher interaction and that students were excited that teachers showed that they cared for them. The tests also revealed a need to revise the protocol so that there was a clear process in place to refer students who needed additional academic or social-emotional support. The second district conducted a PDSA cycle in each school to test and revise two lessons: one on growth mindset and one on problem-solving. Then, the three schools branched off to conduct PDSA cycles around different ideas spawned out of those initial lessons. Across the school and district sites, practitioners saw the value of implementing PDSA cycles as an improvement approach that gave teachers' voice, customised innovations to local contexts, and ultimately helped students succeed (Tichnor-Wagner, Wachen, Cannata, & Cohen-Vogel, 2017). In addition, PDSA cycles allowed prototypes to be implemented across school sites in ways that allowed for local adaptations. However, schools varied in the extent to which practices were implemented with integrity to the prototype design and

[3] For more information and list of publications on the National Center for Scaling Up Effective Schools, visit https://my.vanderbilt.edu/scalingupcenter/.

the extent to which the new practice was ultimately scaled across the school (Tichnor-Wagner, et al., 2018).

Challenges. Challenges associated with implementing PDSA cycles in education have predominately coalesced around capacity constraints associated with time and data collection. School and district practitioners complained that documenting the PDSA process was too laborious or entailed too much paperwork; opposed measuring outcomes; or felt that they did not have time to fully engage in the design of practical measures, data collection, and data analysis due to curriculum requirements, standardised tests, or overcrowded schedules (Tichnor-Wagner, Wachen, Cannata, & Cohen-Vogel, 2017; Park, Hironaka, Carver, & Nordstrum, 2013). Furthermore, in education systems with high-stakes accountability measures, practitioners found it hard to disentangle the collection of data for improvement purposes from accountability and distal outcomes (Tichnor-Wagner, Wachen, Cannata, & Cohen-Vogel, 2017). As in healthcare (e.g., (Berwick, 1989; Walley & Gowland, 2004), elements that helped to overcome such challenges include leadership support and strategy, communication and stakeholder engagement across silos, setting up organisational infrastructure to organise the work, and building understanding around the PDSA methodology, data collection and analysis (Park, Hironaka, Carver, & Nordstrum, 2013).

4. Comparison of AAR and PDSA Cycles

4.1. Similarities

The processes of the AAR and PDSA cycles have many commonalities. The Anticipation phase of the AAR cycle mirrors the "Plan" phase of PDSA, as both emphasise planning for future events through considering a variety of perspectives. For example, the "Plan" phase includes making predictions because "as you build your knowledge, you will need to be able to predict whether a change will result in improvement under the different conditions you will face in the future" (Moen & Norman, 2010). The "Do" phase of PDSA is aligned with the "Action" phase of PDSA, which is about taking carefully planned ideas and acting upon them. Finally, the "Study" and "Act" phases mirror "Reflection" in that both concepts emphasise learning from making meaning of the consequences of the actions that one took.

The purposes of AAR and PDSA cycles hold commonalities as well. Both are processes for continuous or lifelong learning, emphasising iterative cycles to aid in deeper understanding. As seen in education and healthcare case studies, PDSA cycles have been introduced to practitioners with the dual purpose of developing, refining, implementing and scaling specific innovations (e.g., protocols for increasing positive student-teacher interactions) *and* to build capacity of site-level employees to engage in continuous improvement cycles for any future protocol or process they may seek to implement (Kilo, 1998; Tichnor-Wagner, Wachen, Cannata, & Cohen-Vogel, 2017)).

Both cycles are also designed to lead to agency. AAR equips students to become change agents who influence the future. PDSA cycles provide a framework for employees to become change agents within their organizations. As Langley and colleagues (2009) wrote in *The Improvement Guide*, in which PDSA cycles are the core mechanism that drives their model of improvement, "The theme of this book is making changes that 1) will not happen unless someone takes the initiative and 2) will have a significant long-term positive impact...Change is going to happen. The choice you have is to let the change happen to you, or be more proactive and make the changes" (p. 4). As part of a broader method for improvement, PDSA cycles call for a democratisation of enacting systems-change, wherein decisions aren't made from the top-down but rather involve all members of the organisation, from shop floor workers to high-level management, all sitting around the table together (Bhuiyan & Baghel, 2005; Laffel & Blumenthal, 1989; Morris & Hiebert, 2011).

4.2. Differences

Despite similarities, AAR and PDSA cycles differ in other intended specific outcomes. Along with agency, AAR cycles help students develop the transformative competencies of taking responsibility, reconciling tensions, and creating new value. These, in essence, lead to personal improvements that help individuals transform the world in which they live. For PDSA cycles, the locus of change is not in individuals but in organisations and systems, that is, interdependent structures, people, and processes (Deming, 1986). Here, the focus is on organisation-specific goals (Bryk, Gomez, & Grunow, 2013) and on changing an organisation's culture to embrace learning for improvement with "everyone working together to make improvements without necessarily making huge capital investments" (Bhuiyan & Baghel, 2005; Sokovic, Pavletic, & Pipan, 2010).

Therefore, much of research on continuous improvement emphasises teamwork, and advises that a large number of people within the organisation should be familiar with and utilise PDSA cycles. This focus on the “human side of change” acknowledges that most improvement efforts involve a formal or informal team, and that cooperation is essential for effective change to take place (Langley, Nolan, Norman, & Provost, 2009). For example, Scoville and colleagues (2016) recommended that healthcare improvement teams should consist of frontline staff, unit managers, and quality improvement specialists, which represent those with system leadership expertise, technical expertise, and day-to-day leaders (Insittute for Healthcare Improvement, 2018). In education, the National Center for Scaling Up Effective Schools created District Innovation Design Teams and School Innovation Design Teams consisting of a mixture of district administrators, school administrators, teachers, school counsellors, development specialists, and researchers, to lead the development and implementation of academic and social-emotional innovations using PDSA cycles (Cohen-Vogel, et al., 2015; Tichnor-Wagner, Wachen, Cannata, & Cohen-Vogel, 2017). Morris and Hiebert (2011) likewise argued for the joint creation of products from participants across the education system who hold different types of knowledge, which they deemed vital for increasing ownership and commitment to improve products over time. Improvement science has further embraced collaboration across organisations as well, as seen in the Carnegie Foundation’s development of Network Improvement Communities (Bryk, Gomez, & Grunow, 2013; Bryk A. , Gomez, Grunow, & LeMahieu, 2015) and the Institute for Healthcare Improvement’s Breakthrough Series (Kilo, 1998).

A second major difference between the cycles is PDSA’s emphasis on setting goals with quantifiable aims and precise measurable targets (Bryk, Gomez, & Grunow, 2013), and throughout the process learning from data to understand whether improvements have been made (Langley, Nolan, Norman, & Provost, 2009). Having a way to get feedback so that you know an improvement is happening is a central principle of improvement (Langley, Nolan, Norman, & Provost, 2009). As continuous improvement advocates across sectors have explicated: “We cannot improve at scale what we cannot measure” (Bryk A. , Gomez, Grunow, & LeMahieu, 2015) and “If you cannot measure your process, you cannot define its level of performance and you cannot improve it” (Sokovic, Pavletic, & Pipan, 2010). As such, regular documentation and reporting of targeted outcomes is key to the PDSA process. Data use is fundamental to the cycle to understand “what is working and what is not in any particular setting, allowing site personnel to efficiently alter the program or practice in ways that will [make it more likely to spread] and achieve the desired ends” (Cohen-Vogel, et al., 2015). In sum, without data on outcomes, it is difficult to make decisions on future actions regarding the change being implemented and to know whether PDSA cycles are resulting in actual improvements.

5. Implications

The review of the literature on PDSA cycles and its comparison to the AAR cycle suggests the efficacy of using a learning spiral that emphasises anticipating (or planning for) future actions, taking action, and reflecting on one's actions in developing agency and fostering transformative competencies. Across industry, healthcare, and education, these types of cycles have led to continuous learning by individuals across an organisation or system and to desired outcomes specific to those contexts. Therefore, one might expect AAR cycles to achieve similar ends as well.

Common challenges that researchers have found to be associated with practitioners implementing PDSA cycles in clinical and educational settings point to precautions and tips that might be beneficial to those introducing AAR cycles to schools. Because of time and resource constraints that school practitioners often face, it is important to embed AAR cycles into teaching and learning already taking place in school, rather than having it be seen as something extra. For example, early adopters of the AAR cycle might consider ways this cycle can teach existing curricular standards while simultaneously fostering transformative competencies.

A second challenge that practitioners identified in implementing PDSA cycles was data collection, and analysis. Though documenting and learning from data is key to all phases of the PDSA cycle, practitioners often lacked the capacity or the time to fully do so. While the AAR cycle does not rely on rigorous data collection and analysis that takes additional time and training, it is still important to build in time into the school schedule to train all administrators, faculty, staff on what the AAR cycle is and how to best embed it into students' everyday learning. As many studies of PDSA cycles have noted, the training of all staff across an organisation is vital for successful implementation (Berwick, 1989; Laffel & Blumenthal, 1989; Shortell, Bennett, & Byck, 1998; Park, Hironaka, Carver, & Nordstrum, 2013). For PDSA cycles, such training has included specific forms and templates to fill out (see, for example, (Langley, Nolan, Norman, & Provost, 2009; Park & Takahashi, 90-day cycle handbook, 2013). While guiding questions and protocols can help with fidelity of implementation, too much paperwork can be overly cumbersome and kill practitioners' will to actually engage with the cycle (Tichnor-Wagner, Wachen, Cannata, & Cohen-Vogel, 2017). This suggests the importance of finding a delicate balance of providing guidance on how to implement AAR cycles without being too prescriptive.

Third are the potential benefits of conducting AAR cycles collaboratively across levels of the education system, extending teaching the process to students and including teachers and administrators in using AAR cycles to develop co-agency as well. The idea of agency can be threatening to those in the higher echelons of an organisational hierarchy. The health care literature in particular highlighted the challenges associated with having senior level administrators and clinicians empowering frontline staff with the capacity to identify problems and find solutions using PDSA cycles as a methodology (e.g., (Berwick, 1989; Walley & Gowland, 2004). As with the health care system, traditional education systems have built-in power differentials, with teachers wielding power over students, school administrators wielding power over teachers, and district and/or government officials wielding power over school administrators (Datnow, Hubbard, & Mehan, 2002; Wirt & Kirst, 2001). This suggests a need to build the will of education administrators and teachers by espousing the benefits of the AAR cycle to aid in students' lifelong learning and collective well-being.

Fourth, in industry, healthcare, and education, an outside group or institution provided technical support to companies, employees, and practitioners engaging in PDSA cycles for the first time. W. Edward Deming provided the initial training in improvement cycles to Japanese industry leaders. The Institute for Healthcare Improvement is a prime example of a hub providing advocacy, training, research, and implementation support on PDSA cycles in the health care sector, as is the Carnegie Foundation for the Advancement of Teaching in the education sector. As such, an organisation external to a country's education system may need to step in to provide schools and education systems technical support as they begin to use the AAR cycle in classrooms and beyond.

Finally, the existing research shows promise for applying the AAR cycle to other sectors. A value of PDSA is that it is flexible enough to be applied to a diverse range of contexts: both across and within sectors. Therefore, the same might be said for AAR cycles. In addition, the individual nature of the "user" of AAR cycles (e.g., a student) may complement the systems-facing approach of PDSA cycles. The AAR cycle could foster in users the mindset of continuous learning through thoughtful planning and predicting, acting, and reflecting, which is foundational to engaging in systems-wide change efforts.

At the same time, the sectors highlighted in this review used PDSA cycles as a way to measure and achieve context-specific outcomes. Furthermore, these sectors are outcomes-oriented, often with a focus on quantitative measures of success. For example, business relies on sales numbers and reaching a bottom-line and many education systems are "graded" based on student achievement, attendance, and graduation data. For AAR cycles to be adopted across these different sectors, the process of going through these cycles may need to include a) documenting evidence for the desired outcomes of agency and transformative competences and b) making explicit connections between the AAR cycle and concrete problems of practice that organisations are facing and concrete goals that organisations are striving to achieve.

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