Going back to the roots of W.A. Shewhart (and further) and introduction of a new CPD cycle

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Abstract

Purpose – Investigating the beginning of project management (app. 30 BC) with a focus on business models similar to the "PDCA" cycle, the purpose of this paper is to find an approach which could be used as a new standard procedure for the eradication of projects in Lean project management.

Design/methodology/approach – Based on literature research of models similar to Walter A. Shehwart's three-step and Edward W. Deming's four-step (PDC(A)) wheel, the investigated models are interconnected to form a new concept which represents an innovative cycle logic proposed to be applied in Lean project management. This new cycle logic is rolled out on three different levels, which are transferred from the Lean management hoshin kanri model to Lean project management. In addition to literature research, semi-structured interviews were performed to get an indication as to the integration of Lean management (with a focus on PDCA) in project management today.

Findings – It was found that the "Check Plan Do" cycle is a Lean variant of the "Plan Do Check Act" model that is already used in consulting projects in practice, partially appears in project management standards, in governance models of ambulance, fire services, human aid and military forces and in quality management models of Six Sigma, design for Six Sigma and an excellence model of the European Foundation for Quality Management. To ensure continuous improvement it was found that the new CPD cycle can be used on different "planning" levels in analogy to the hoshin kanri logic.

Originality/value – To the best of the author's knowledge, a discussion as to how the PDCA cycle can be adapted to Lean project management, considering the implication of business models similar to the PDCA wheel, has not yet been conducted within the field of project management.

Keywords Continuous improvement, Continuous improvement process (CIP), Kaizen, CPD Cycle, Hoshin kanri, PDCA cycle, Project management, Lean management, Quality management, Process management

Paper type Conceptual paper

1. Introduction

A key idea to continuously improve product quality is the application of the Shewhart cycle, more renowned as Deming cycle or Plan Do Check Act (PDCA) cycle (later known as the Plan Do Study Act (PDSA) cycle) (Bushell, 1992; Gupta, 2006; Johnson, 2016).

The PDCA cycle, circle or wheel is a four-step problem-solving process consisting of:

(1) "Plan" (establish a new processes delivering a desired outcome);

(2) "Do" (implement the new process);

(3) "Check" or "Study" (measure the results of a process and observe any differences between that and the desired outcome) and the most important aspect according to Sokovic *et al.* (2010); and

(4) "Act" (analyze the difference between observed and expected outcome) (Nicolay *et al.*, 2011; Poppendieck, 2010; Dennis, 2010; Shook and Dennis, 2007) which is the most important phase (Nicolay *et al.*, 2011; Sokovic *et al.*, 2010) because here the cycle starts again for further improvement. By substituting the word "Act" with the expression of "Adjust," the intention of improvement in this phase becomes much clearer (Poppendieck, 2010; Dennis, 2010; Shook and Dennis, 2007).

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Figure 1 shows that the PDCA cycle builds an incremental part of the continuous improvement process (CIP), which is also considered as the cultural root of Lean management (Medinilla, 2014).

Many experts believe that the PDCA cycle and the combined process of standardization are the core of the Toyota Production System and Lean management (Romberg and Liker, 2010).

Considerable research has been devoted to including the PDCA cycle in:

- risk management (Prachak and Keow, 2012, p. 1302), where the PDCA was used to assess risk management in health care centers in Thailand;
- strategy design (Buglione *et al.*, 2013, p. 17), where the PDCA is adapted to improve and design business process models and strategies; and
- knowledge management (Tyagi *et al.*, 2015, p. 212), where the PDCA method is proposed in order to support and improve the efficiency of the knowledge creation process.

Considerable effort has been made to embed the PDCA/PDSA cycle in areas with social impact, as in the following examples:

- children's education (Dooley, 1997), where the PDCA method was used to stop a child from frequently crying;
- career planning (Brong, 2002), where the PDSA cycle is proposed to be used to improve one's career;
- school systems (Adrian, 2009), where the PDSA was used in almost every plan of one school district in the USA to encourage innovation, which led to winning the Malcolm Baldrige National Quality Award in education in 2008 for North Carolina's Iredell-Statesville Schools;
- training in health care/microsurgery (Jin *et al.*, 2012), where a quality management training curriculum was based on PDCA cycles to control the learning process and the surgical quality of rat liver transplantations;

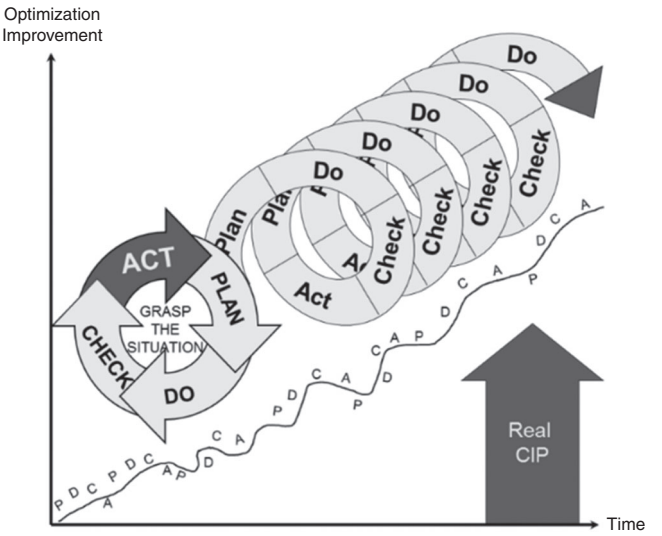


Figure 1.
PDCA and CIP

- vocational education and training (Moldovan, 2012), where the classic Deming cycle was augmented and considered as a basic approach for the quality assurance process of Vocational Education and Training;
- design thinking (Cleary, 2015), where elements of (actual) design thinking (Stanford Design Thinking Model consisting of: empathize, define, ideate, prototype, test) (Stanford Arts Institute 2012) are integrated into an (earlier) seven-step approach of PDSA (developed by Kume, 1985); and
- IT management and other processes (Cleary, 1995), where the seven-step PDSA was used for improving a hot line process for software support, an invoice system process, a crisis intervention process, a food labeling process, a delivery process of prescriptions for a hospital, a manufacturing process (O-ring production) and a retail furniture store reclamation process.

Lean project management is not a new project management methodology. Lean project management is generally recognized as the pursuit of adding value for the customer/client and is about removing (project) waste through continuous improvement (Ballard and Howell, 1999, 2002; Green and May, 2005; Jørgensen and Emmitt, 2009).

In positive terms, "lean" is about adapting the five Lean principles defined by Womack, Jones and Roos (define the value for the customer, identify the value stream, keep the value stream in flow, let the customer define your tact time, and strive for perfection) to project management (Womack and Jones, 1996) (Figure 2).

In negative terms, "lean" is about reducing the seven kinds of waste defined by Taiichi Ohno (Ohno, 1989; Won *et al.*, 2000; Hoyle, 2007; Koolmanojwong and Lane, 2013) (overproduction, high or excess inventory, unnecessary movement, unnecessary transport or conveyance, waiting, overprocessing or incorrect processing, production of defective parts and rework, in Lean project management equaling inexact requirements – management, wrong or aureated products, task switching, superfluous interfaces, waiting times, bureaucracy, and rework (Erne, 2010)).

Lean project management is linked to the method of agile project management, which is often used in the area of ("leagile") (Wang *et al.*, 2012) software development (Highsmith, 2004; Leybourne, 2009; Kupiainen *et al.*, 2015).

Source: Based on Womack and Jones (1996)

Figure 2.
Visualization of the five Lean principles

Few studies (e.g. "From Plan Do Check Action to PIDCAM: the further evolution of the Deming wheel (Platje, 1998) (Plan Implement Do Check Action (or Assess) Management (PIDCAM)), however, have investigated whether the PDCA cycle is also a core element of project management. No studies were found concerning inclusion of the PDCA cycle in Lean project management.

This paper tries to answer the following questions analyzing the applicability of the PDCA cycle to Lean project management:

(1) How was the PDCA cycle developed and which models are similar to a PDCA cycle?

(2) How can the PDCA cycle logic be adapted to Lean project management?

2. Method

In order to answer the questions mentioned above the chosen research method was literature research in addition to approximately 50 semi-structured interviews with a total duration of 60 hours performed over the period January 2013 to June 2015 as a major part of a PhD thesis. One of the main questions in the interviews was which tools of Lean management could be integrated into project management today. The interviews were analyzed using an inductive (bottom-up categories out of the collected material) content analysis approach (Elo and Kyngäs, 2008) which was supported by a qualitative data analysis software tool developed by Professor Philipp Mayring (Larcher, 2010; Ramsenthaler, 2013).

The majority of interview partners were professionals in the area of the automotive industry (the cradle of Lean management) with a consulting background (Figure 3).

3. History, development and structure of the PDCA cycle

In 1256, the first repeating cycle consisting of "examination," "creation of hypotheses," "performance of experiments" (scientia experimentalis) and the necessity of an independent "control" was described by Roger Bacon (1214-1294), who was a forerunner of the Renaissance and empiricism (Lay, 1981, p. 34), (Glick and Livesey, 2005).

On the basis of the following equations:

- examination = check;
- creation of hypotheses = plan;
- performance of experiments = do; and
- control = check.

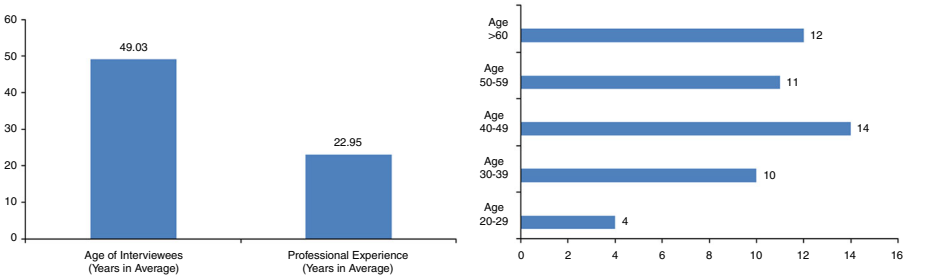


Figure 3.
Interviews performed over the period January 2013 to June 2015 and experience of interviewees (in years)

We observe that Roger Bacon essentially created a "Check Plan Do Check" (CPDC) cycle (NB: starting with the activity "Check").

Filippo Brunelleschi (1377-1446), acknowledged as inventor of the linear perspective, was among the first to clearly separate design (plan) and execution (do) in construction projects (Garel, 2013).

Indeed, long before Brunelleschi, Marcus Vituvius Pollio (circa 80-15 BC), a famous Roman Architect, also split work into "ratiocination" (mental work including design = plan) and "fabrica" (manual craft = do), although he himself made use of earlier Greek sources (Vitruvius, 1511; Vitruvius and Ryff, 1548).

Francis Bacon (1561-1626), known as the father of empiricism and modern scientific method, developed a scientific approach (Novum Organon) in 1620 which was described in 1939 by Walter Andrew Shewhart (1891-1967) as "control using statistical methods for a three-step process consisting of specification (Plan), production (Do) and inspection (Check)" (Bacon, 1858, 1902).

Shewhart published this idea in the book *Statistical Method from the Viewpoint of Quality Control* (Shewhart and Deming, 1939) and expressed that these three linear steps should go into a circle or scientific method consisting of making a hypothesis, carrying out an experiment and testing the hypothesis (Moen and Norman, 2010).

Based on the following equations:

(1) making a hypothesis = plan;

(2) carrying out an experiment and = do; and

(3) testing the hypothesis = check.

A three-step "Plan Do Check" (PDC) cycle can be identified.

William Edward Deming (1900-1993) used Shewhart's cycle in his quality training in Japan in 1950 but made a new version stressing the concept of permanent interaction of design, production, sales and research in the following four steps:

(1) design the product (with appropriate test);

(2) make the product and test it in production line or laboratory;

(3) sell the product; and

(4) test the product in service and through market research (Deming, 1950).

By the 1950s, the Japanese were concerned about their bad reputation of producing poor quality products. Therefore, Deming's trainees in Japan optimized the cycle and developed the famous PDCA cycle in 1951 containing the four steps:

(1) define a problem and hypothesize possible causes and solutions = (plan);

(2) implement a solution = (do);

(3) evaluate the results = (check); and

(4) return to the plan step if the results are unsatisfactory, or standardize the solution if the results are satisfying = (act) (Zollondz, 2006, p. 87).

According to Masaaki Imai, the Japanese executives who were taught the cycle in the seminar sponsored by the Japanese Union of Scientist and Engineers made the following adaptions:

(1) plan = design (product design corresponding to a planning phase of management);

(2) do = production (of the product);

(3) check = sales (do sales figures confirm customers' satisfaction?); and

(4) act = research (If a complaint is filed, it must be incorporated into the planning phase and action taken in the next cycle) (Masaaki, 1986; Moen and Norman, 2010).

A comparison of the two four-step cycles described above shows that the second cycle (regarding the production of goods) is on a higher level than the first cycle (regarding the solving of problems). This finding is referred to as the application of the PDCA cycle on a micro and a medium level.

As documented by S. Mizuno of the Tokyo Institute of Technology in 1959 and published in 1985, Kaoru Ishikawa wanted to enhance and revise Deming's PDCA cycle and added the actions "Determine goals and targets" and "Determine methods of reaching goals" to the action "Plan" and included "training and education" in the "Do" or implementation phase, while the concept of "control" or "kanri," meaning to revise standards constantly, which is a strong impetus from the Lean philosophy (Ishikawa, 1985).

Toyota adapted the Deming cycle and called it the "GTS cycle" (grasp the situation): GTS stands for the Lean management philosophy of genchi genbutsu, a Japanese term meaning "go and see" and make up your mind for improvements at the place where added value is generated (Japanese gemba).

Noriaki Kano discussed the so-called three-step "Plan Do See" cycle with Dr Deming in the period 1977-1980 and learned that "See" and reviewing the data should be followed by "take action" (Moen and Norman, 2010).

In 1982, more than 30 years after first delivering quality training in Japan, the four-step PDCA cycle was first officially published in Deming's (1982) book *Out of the Crisis* (p. 88) describing each step of the cycle as follows:

(1) plan a change or test! (Plan) (answering the question as to what accomplishments of the team, changes, data and observations are desired or needed);

(2) carry out the test or change on a small scale! (do);

(3) observe the effects of the change or test! (check); and

(4) study the results! (act) (what can be learned or predicted?).

While Deming's quality optimizing theories did not find acceptance in the USA, the first Deming Prize was awarded in 1951 in Japan (Gorecki and Pautsch, 2010, p. 17).

Only much later was Deming's work recognized in the USA, and in 1987 he was awarded the National Medal of Technology and he became one of the most wanted Consultants in the USA.

Ford and GM were some of the first companies which engaged Deming after he became famous in America and Deming's theories helped GM to return to the path of success (Zollondz, 2006, p. 94).

By this time, Deming, who worked at the Massachusetts Institute of Technology (MIT), had already developed the PDCA cycle further and changed its name from PDCA to PDSA, because he thought this connotation was closer to Shewhart's basic ideas (Moen and Norman, 2010).

The PDSA cycle was first published in Deming's (1993) book *The New Economics* in 1993 (p. 132). The PDSA cycle was documented as the "Product Quality Planning Cycle" in the "GM Reference Manual for Advanced Product Quality Planning (APQP) and Control Plan" (Chrysler *et al.*, 1995).

In 1992 De Jonge added the component "Management" to the PDCA cycle which was completed by Platje *et al.* (1994), who created the PDCAM cycle (pp. 100-106) and further developed the cycle into the PIDCAM six-step cycle in 1998 (Platje, 1998, p. 204), adding the activity "Implementation" to the modified Deming wheel.

Figure 4 shows the most important development steps in the evolution of the PDCA cycle.

4. Models similar to PDCA

As described in the management manuals of the organizations listed below, the investigated governance models are similar in structure to the PDCA cycle in that they provide a continuous improvement structure:

- German Red Cross (2016) (The International Red Cross and Red Crescent Movement is an international humanitarian movement with approximately 97 million volunteers, members and staff worldwide which was founded to protect human life and health, to ensure respect for all human beings, and to prevent and alleviate human suffering (Pesch, 2008).
- German Fire Services (The German Fire Services consisting mainly of voluntary-, municipal- and plant-fire brigades has 25,000 bases with approximately 1,35 million employees (Verband Deutscher Feuerwehr, 2012; Feuerwehr, 1999; Katastrophenschutz und zivile Verteidigung (AFKzV), 2004).
- German Federal Agency for Technical Relief (Technisches Hilfswerk (THW) is a civil protection organization controlled by the German federal government) (Scheibe *et al.*, 2004).

For all of the above models, each cycle starts with the process of "Situation Assessment," which is equated with the activity "Check."

After "Check," the "Plan" phase follows, succeeded by a "Command" phase which is directly connected to the "Do" phase but not explicitly mentioned. The models listed can therefore be designated as "Check Plan Command (Do)" circles.

The governance model of the German (and also Austrian) army is similar, but contains another monitoring phase (Check) after the "Command" action (Figure 5).

Also consulting projects usually start with an analysis phase similar to that of the models mentioned above, as shown in Figure 6.

Table I shows:

(1) How the PDCA logic is integrated into the project management standards of:

   (a) Verband der Automobilindustrie (VDA) – the German Association of the Automotive Industry with its members BMW, Bosch, Daimler-Benz, Johnson Controls, Steyr-Daimler-Puch, Volkswagen, etc.);

   (b) the German project management standard DIN 69.901;

   (c) Project Management Institute's (PMI's) *Project Management Body of Knowledge*, 5th edition, American National Standard BSR/PMI 99-001-2013; and

   (d) the British de facto project management standard PRINCE2.

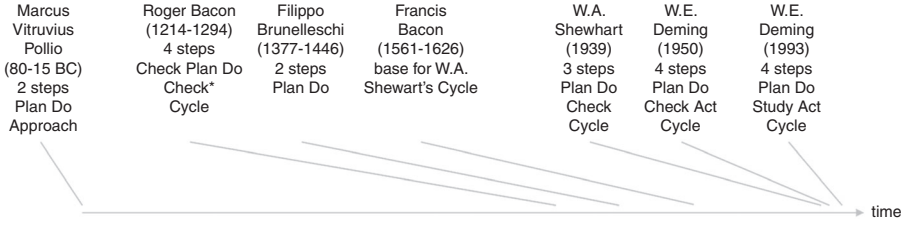
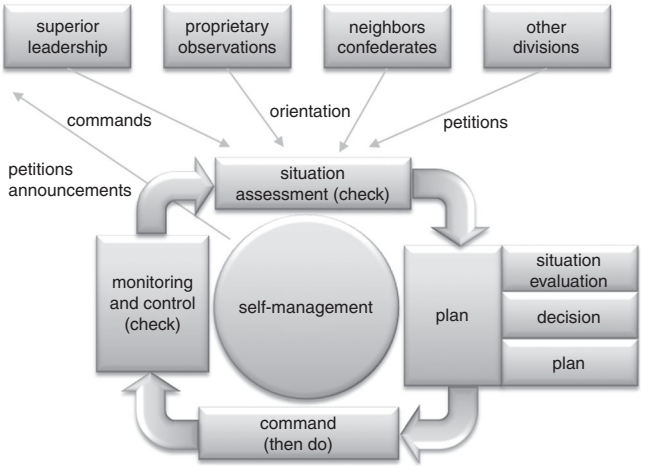


Figure 4.
Plan Do Check Act Cycle evolution on timeline

Note: *First check for examination last check for control



Note: Copyright granted for all without restrictions
Source: Vocator (1998)

Figure 5.
Check Plan Command (Do) cycles in the German Army

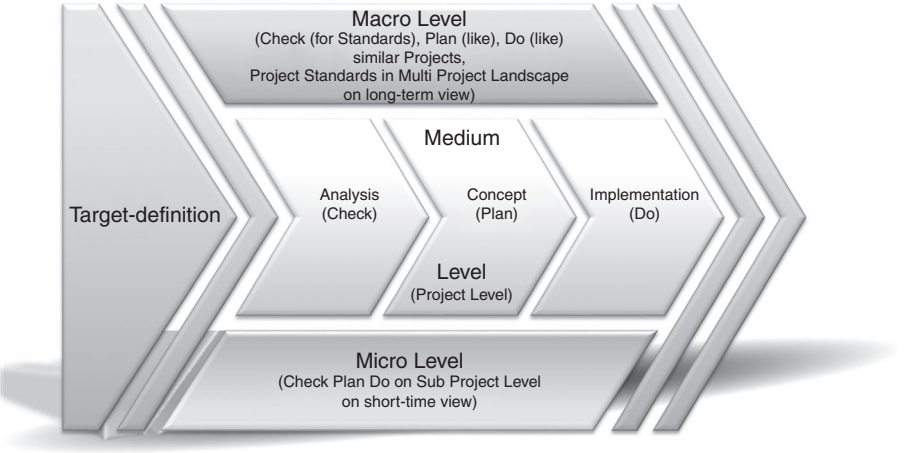


Figure 6.
Check Plan Do cycle in consulting projects

(2) which parts of the PDCA cycle are integrated into the governance cycles of:

(e) the German Ambulance, Fire Services, Human Aid and Military Forces;

(f) the "Orient Observe Decide Act" (OODA) loop developed by John Boyd for use in military operations, and the subsequent Lean software enterprise research and development cycles, which owes much in its development to Boyd's OODA loop;

(g) Learn model build measure loop; and

(h) Build measure learn loop (developed by Eric Ries).

(3) a comparison of the PDCA with the quality approaches of:

(i) Define measure analyze improve control from Six Sigma.

Standard	P (Plan)	D (Delegate)	D (Do)	C (Check)	A (Act)	PDCA in total
a) Automotive Industry VDA 4.3 (PM Level 1)	existing in variation (Concept)	not existing	existing in variation (Production)	existing in variation (CIP)	existing in variation (CIP)	existing in variation
a) Automotive Industry VDA 4.3 PDCA cycle (Level 2)	existing (Plan)	not existing	existing (Do)	existing (Check)	existing (Act)	existing (PDCA)
b) DIN 69.901 (PM Level 1)	existing (Planning)	not existing	not existing	existing in variation (Control)	existing in variation (Control)	not existing (Do is missing)
c) PMBoK (PM Level 1)	existing (Planning)	not existing	existing (Execution)	existing in variation (Monitor & Control)	existing in variation (Monitor & Control)	existing in variation
c) PMBoK (PD Cycle)	existing (Plan)	not existing	existing (Do)	existing in variation (Monitor & Control)	existing in variation (Monitor & Control)	existing in variation
d) PRINCE2 (PM Level 1)	not existing	not existing	not existing	not existing	not existing	not existing
d) PRINCE2 (PM Level 2)	not existing (only before PRINCE2:2009)	not existing	not existing	existing in variation (Control Stage)	existing in variation (Control Stage)	not existing (Plan, Do not existing)
d) PRINCE2 (PM Level 3)	existing (Project Plan, Plan Next Stage)	existing in variation (giving ad hoc directions)	existing in variation (Executing Work Package)	existing in variation (Capture Previous Lessons, Reviewing the Stage Status)	existing (Taking Corrective Actions)	existing in variation (but not on level 1 and 2, therefore not comparable)
d) PRINCE2 PDMC cycle (Meta level)	existing (Plan)	existing (Delegate)	not existing	existing in variation (Monitor & Control)	existing in variation (Monitor & Control)	not existing (Do is missing)
e) Military Command Cycle	existing (Plan)	existing (Command)	not existing	existing in variation (Situation/Position/Location Determination/ Assessment, Monitoring)	not existing	not existing (Do, Act is missing)
e) Firebrigade, Public Aid Forces Command Cycle	existing (Plan)	existing (Command)	not existing	existing in variation (Situation/Position/Location Determination/ Assessment)	not existing	not existing (Do, Act is missing)
f) OODA Cycle (Observe, Orient, Decide, Act)	existing in variation (Orient)	not existing	existing in variation (Act)	existing in variation (Observe)	existing (Act)	existing in variation
g) LMBM (Learn Model Build Measure)	existing in variation (Model)	not existing	existing in variation (Build)	existing in variation (Measure)	existing in variation (Learn)	existing in variation
h) BML (Build Measure Learn)	existing in variation (Build (Plan))	not existing	existing in variation (Build)	existing in variation (Measure)	existing in variation (Learn)	existing in variation

(*continued*)

Table I.
PDCA integration into project management and other management cycles similar to PDCA

i) DMAIC Cycle (Define, Measure, Analyze, Improve, Control)	existing in variation (Define)	not existing	existing in variation (Improve)	existing in variation (Measure, Analyze, Control)	existing in variation (Measure, Analyze, Control)	existing in variation
j) DMADV Cycle (Define, Measure, Analyze, Design, Verify)	existing in variation (Define)	not existing		existing in variation (Measure, Analyze, Verify)		existing in variation
k) RADAR (Results, Approach, Deploy, Assess, Refine)	existing in variation (Approach)	not existing	existing in variation (Deploy)	existing in variation (Assess)	existing in variation (Results, Refine)	existing in variation

Explanation of color code:

orange: investigated element does not appear in the model compared to the PDCA cycle
blue: a variation of the investigated element appears in the model compared to the PDCA cycle
green: investigated element appears in the model compared to the PDCA cycle

Notes: (a) VDA (1998, p. 13 ff); (b) DIN (2009, p. 9); (c) Project Management Institute (2013, p. 36); (d) TSO and OGC (2009, p. 23), Murray (2011, p. 5), TSO and OGC (2009, p. 5); (e) Vocator (1998), Scheibe *et al*. (2004), Pesch (2008), Feuerwehr (1999); (f) Boyd (2002); (g) Pekka and Oza (2010), Ries and Hickman (2011); (h) Poppendieck (2012); (i); (j); (k) Sokovic *et al*. (2010)

Table I.

(j) Define measure analyze design verify cycle from Design for Six Sigma.

(k) Results approach deploy assess refine (RADAR) logic of the European Foundation for Quality Management (EFQM) excellence model.

Based on the results of the comparison summarized in Table I, it appears that in comparison to the American National Standard BSR/PMI 99-001-2013, the activity "Do" is not integrated into the German project management standard. Several interview partners mentioned that this could be due to cultural differences.

Another finding from this comparison is that military models start with a scout or pioneer activity to assess the actual situation. After this, the planning and decision activity follows.

5. Expert interview results about the integration of PDCA in (Lean-) project management

To answer the question as to which Lean management tools can be adapted for and used in Lean project management expert interviews were performed and the data analyzed using the qualitative content analysis approach developed by Professor Philipp Mayring (2010) and the software QCAMap.

Within this analysis, the following four categories were identified and evaluated:

(1) Cluster 1: an application of the PDCA cycle was proposed for direct integration into Lean project management.

(2) Cluster 2: an application of a variation of PDCA in Lean project management was recommended by the interview partner.

(3) Cluster 3: An application of a planning logic in different temporal dimensions (short-term micro, mid-term medium or long-term macro cycle) was discussed and proposed.

(4) Cluster 4: Cultural influences on PDCA were mentioned.

Figure 7 shows approximately 100 pages of interviews were analyzed and clustered inductively into the four categories relating to the use of the PDCA tool in project management listed above. Seven interviewees mentioned that there is a cultural impact on the PDCA cycle, that a German PDCA may be different to PDCA use in another culture; for example, it was suggested that the difference between "Do" and "Act" is hard for Germans to differentiate. Nine interview partners mentioned that the application of PDCA in project management would be a contribution to make project management leaner. Eight interviewees expressed their wish to change the PDCA for application in the field of project management. Ten interviewees outlined the application of a project management planning method on a long-, mid- or short-term view.

In total, 18 of 51 interview partners mentioned the PDCA in terms of getting Lean in project management.

6. Introduction of a new (three-step) CPD cycle

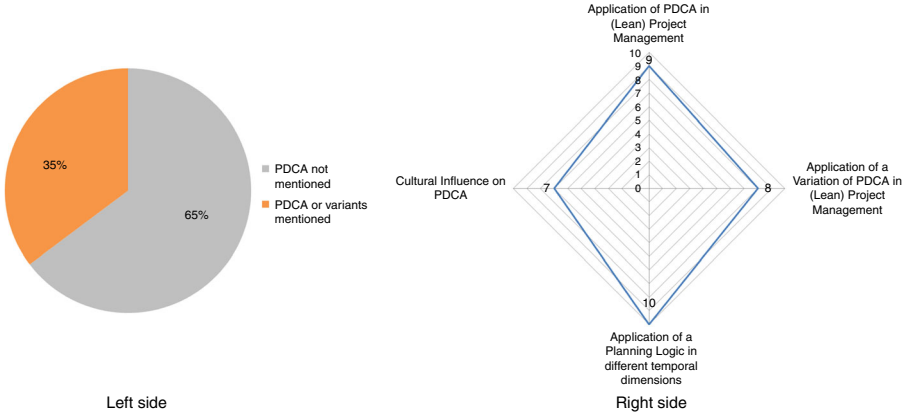
The above mentioned models of ambulance, fire services, human aid forces and military forces, the OODA cycle and the RADAR component of the quality excellence model by EFQM imply starting the PDCA cycle with the activity "Check."

The value added by starting the PDCA cycle with the "Check" activity is that, according to Lean principles standards (e.g. using standard process development plans) and the current status are analyzed and give an optimized basis for the following "Plan" stage.

By equating the "Do" and "Act" activities, as another result of the Lean project management interviews, a Check Plan Do (CPD) or Check Plan Act (CPA) cycle is created.

The value added is that another sequence differing from the PDCA cycle is created and that the "Act" phase starts after a "Check" and a "Re-Planning" phase and not directly after "Check," which adds more precision and a higher degree of maturity to the corrective actions taken.

Figure 8 shows the initial and second loop of a CPD (CPA) cycle.



Notes: Left side: percentage of interviews (out of 51) where the integration of PDCA in lean project management was mentioned (in total 18); right side: number of interviews performed in each cluster

Figure 7.
Interview results

Another finding from the literature research is that the PDCA cycle working as a stamp would produce footprints in a false order along it's trajectory (see upper part of Figures 9 and 10).

This is why the new CPD cycle is displayed with a counterclockwise sequence of the PDC activities within the wheel.

In analogy to the commanding procedures of ambulance, public aid, fire services and military management, the milestone "Command" (NB: a milestone and not a phase because of its short duration) between the phases "Plan" and "Do" is integrated into this model.

At this point the loop of this paper is closing by going back to the roots of the three-step procedure invented by Walter A. Shewhart in 1939.

7. Further evolution of the CPD cycle by using a micro, medium and macro cycle logic (adapted from hoshin kanri)

The Japanese word hoshin consists of the two words "ho" meaning "method" and "shin" meaning "shiny needle" or "compass." Kanri consists of "kan" meaning "management or control" and "ri" meaning "logic" (Witcher and Butterworth, 2001; Shook and Dennis, 2007). Hoshin kanri can therefore be translated as "method for managing and controlling the right (project compass) direction."

Hoshin kanri is a seven-step strategic planning process in Lean management directed at eliminating the waste that comes from inconsistent direction and poor communication (Tennant and Roberts, 2001; Witcher and Butterworth, 2001; Witcher *et al.*, 2008; Ćwiklicki and Obora, 2011).

Hoshin kanri comes from total quality management which, according to several authors (Shingeo, 1981; Ohno, 1989; Womack *et al.*, 1990) and as with Lean management in general, is about reduction of waste and a consequent reduction of lead time (Chiarini and Vagnoni, 2014, p. 592).

The hoshin kanri process starts with a long-term phase lasting three to five years, where the company's vision and mission is deployed (macro PDCA cycle). Subsequently yearly targets and goals are defined for every division and part of the enterprise (medium PDCA cycle), which are then controlled over short-time periods (micro PDCA cycle) (Kondo, 1998; Jochum, 1999, 2002; Dennis, 2002). The idea of using the PDCA in several iterations is also part of agile project management (Augustine *et al.*, 2005a; Conforto and Amaral, 2016).

Hoshin kanri translates (long-time) strategies into (short-time) working levels using long- (macro-level), middle- (medium-level) and short-term (micro-level) planning horizons in

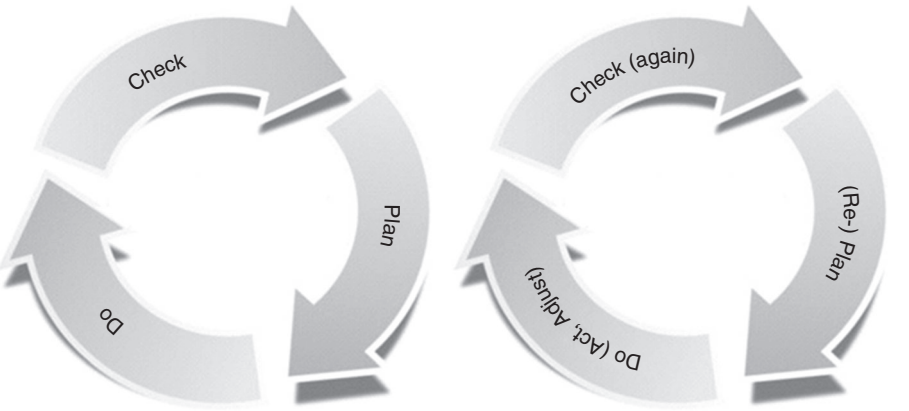


Figure 8.
The new CPD cycle Lean project management PDCA cycle

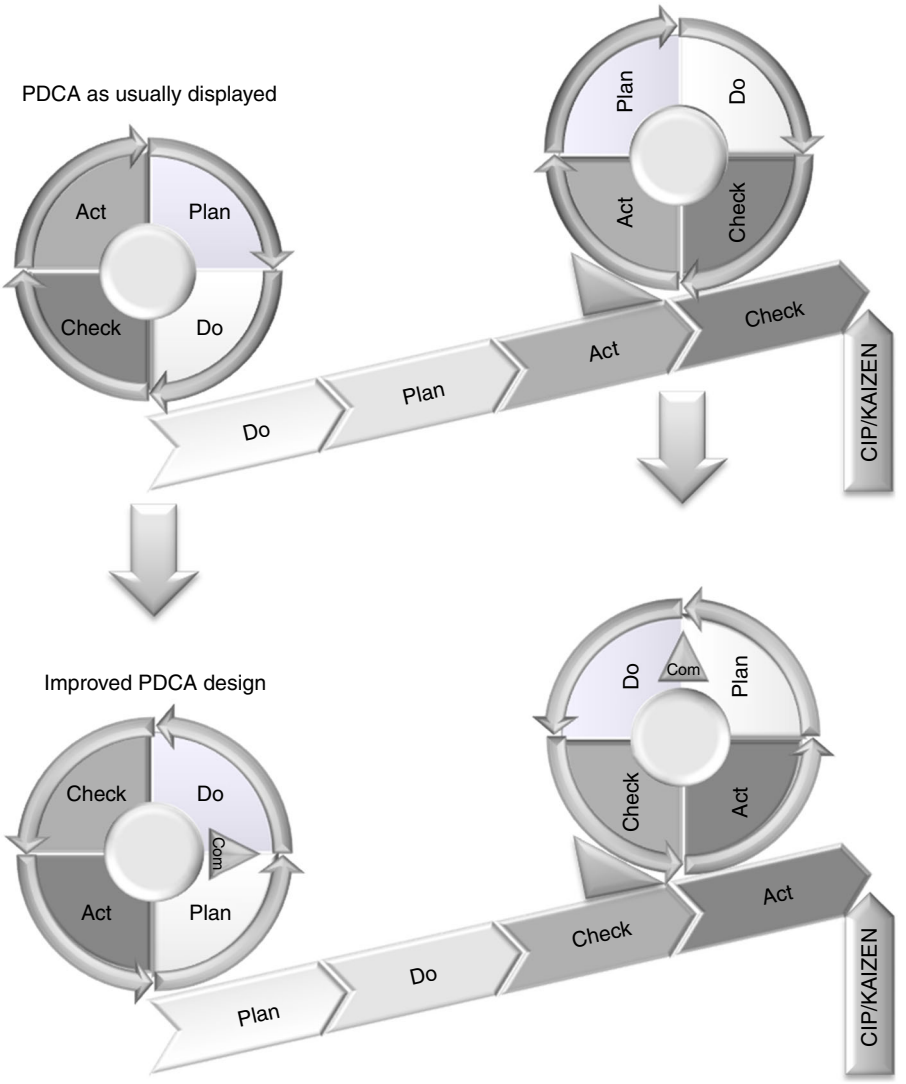


Figure 9.
PDCA sequence as usually displayed vs improved design

which the CPD cycle is applied (Sisson and Eshennawy, 2015; Tsung-Ming and Chao-Ton, 2007; Witcher and Vinh, 2007).

A tool for continuous improvement is the "Toyota Kata" developed by Mike Rother consisting of the four parts: vision, challenge, the improvement Kata and the coaching Kata (Toivonen, 2014). Casten *et al.* (2013) transformed the "Toyota Kata" into a "Lean Construction Kata" by adapting and adopting the concept for a Lean construction production system. The word Kata is taken from Japanese martial arts (Schmidt, 2010) where the fighter absolves a sequence of choreographed movements, e.g., in Karate. In the case of a fight, the fighter must grasp the situation (check) then make a plan (to defend or attack) and then act (do), increasing his chances of winning if he can use trained standards.

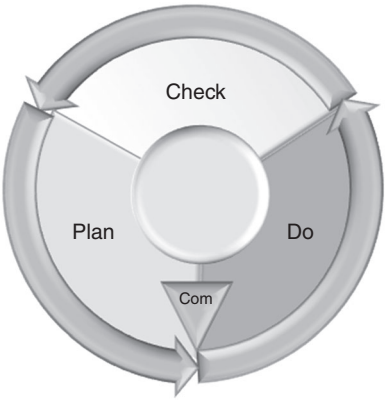


Figure 10.
New CPD cycle

In analogy to the above mentioned Katas, the CPD management routine can be called a (Lean-) project management Kata which is used on three different integration levels as visualized in Figure 11 (Rother, 2009):

(1) The macro CPD cycle level represents the standardization loop between the actual project and other similar successful projects. Starting with the investigation of the initial project situation and other similar project plan standards such as the product development process (PDP) in the automotive industry (check), different standard plans are compared (plan) and a best of bench standard is defined (do) as a basis for the existing project. The application of the CPD cycle on the macro level gives a project the right direction as the word shin (= compass) implies. Each finished project pushes the standard a little higher and delivers new input to optimize the project standard for similar future projects. The macro PDCA cycle has a long-term view as it takes into account similar projects in previous years or decades and represents the highest level of quality assurance in projects.

(2) The medium CPD cycle comprises the project lifecycle and would appear only once in a perfect project. In the "Check" phase, the existing project situation is analyzed and the chosen project standard plan is reviewed for the existing project, adapted to the actual situation (plan) and subsequently implemented (do). According to the fifth Lean principle, "to strive for perfection," the CPD cycle appears more than once (in imperfect projects) such as when a project is divided into a prototype phase (CPD medium cycle one) and a serial production phase (CPD medium cycle two).

(3) The Micro CPD cycle in Lean project management represents the lowest but most frequent level of quality assurance and optimization in projects. In the "Check" activity, the actual project situation and progress are analyzed for each subproject. The project plan is adapted to the specific prevailing circumstances (plan) and processed in the next step (do). The micro cycle consists of daily, biweekly or weekly project meetings or scrummings, giving projects a so-called tact time.

Combining the logic with the CIP, also called Kaizen (Kaizen or Kyzen consists of the two words "Kai" or "Ky," meaning "change" and "Zen," which means "for the better" (Medinilla, 2014; Fujifilm, 2013), the following model shows how projects are continuously optimized by using CPDs in micro, medium and macro CPD levels. Due to the size of the wheels, it becomes obvious that micro CPD cycles are performed most frequently, rolling along the trajectory while the macro cycle is only applied once in a project. In the example displayed, the medium cycle is performed twice in the project (Figure 12).

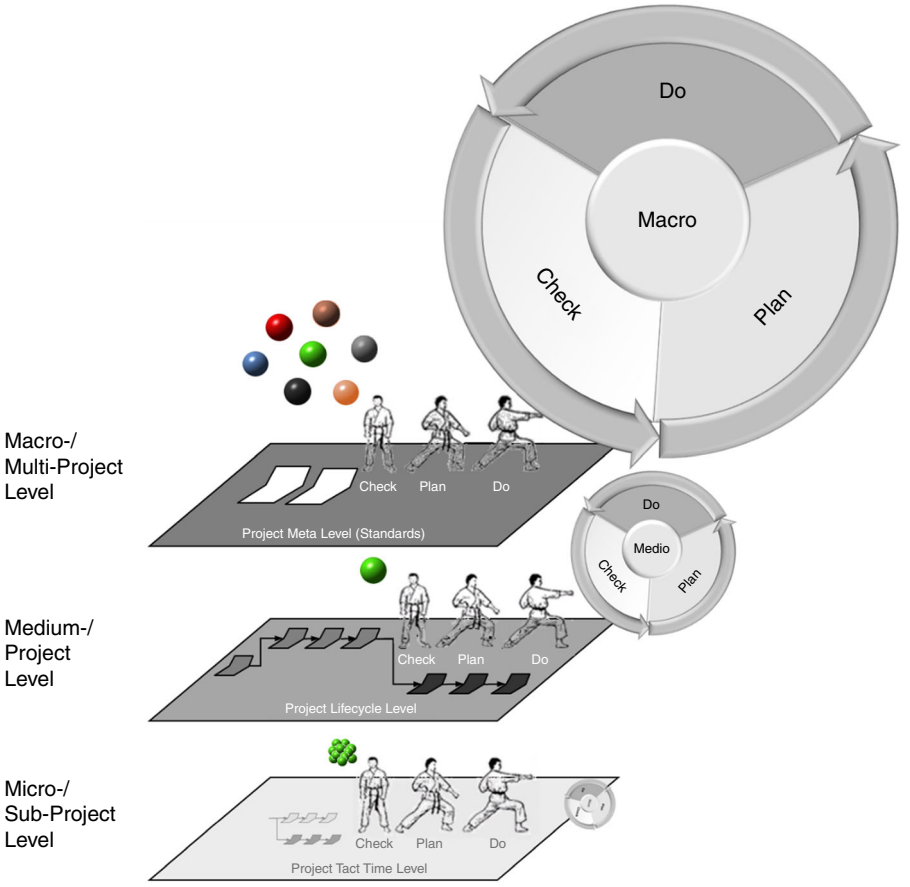


Figure 11.
Micro-, medium- and macro- CPD cycles in Lean project management

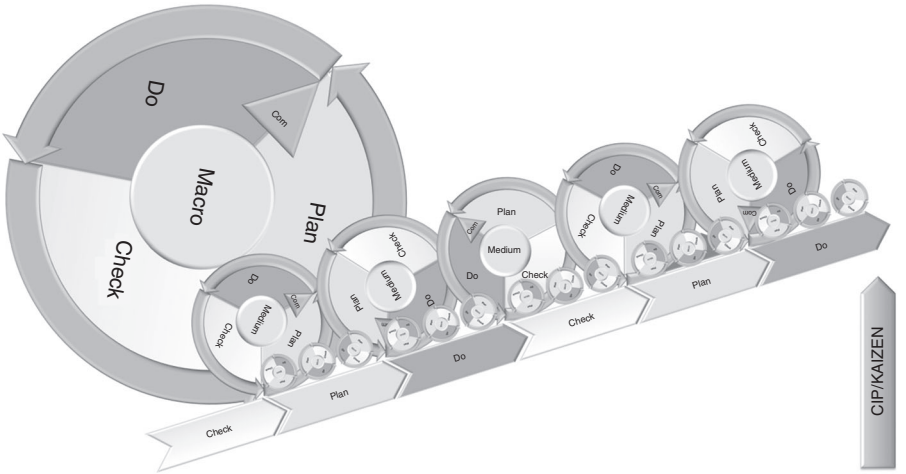


Figure 12.
Micro-, medium- and macro- CPD Kaizen model for Lean project management

Regarding the Lean principle to "Strive for Perfection" (Womack and Jones, 1996) and the fifth principle of Bredillet's Code of Ethics (Bredillet, 2014), projects never stop at a plateau when finished. The knowledge gained by terminated projects lingers on and finished projects and the lessons learned influence the optimization of the project standard created within the macro CPD cycle.

8. Pilot project and evidence that the CPD cycle is a useful adaptation of the PDCA cycle

The concept of the new CPD cycle involves starting a project with a detailed assessment of the actual situation, circumstances, lessons learned and standards valid for the project ("Check"). The "Check" activity gives the project manager a broader view of a project, rather than going into the detail (of "Planning") too soon.

This concept therefore seeks breadth before depth, which is also proposed by Mary and Tom Poppendieck in the field of software project management (Poppendieck and Poppendieck, 2003).

Similarly, it is also essential for survival in the area of ambulance, fire services, public aid and military forces to know the exact details of the current situation (check) of the enemy (disease, fire, floods, hostile troops, competitors) before planning a project in detail.

To improve the development and manufacturing process of a new truck platform of an international premium car and truck manufacturer, the above mentioned method of "hoshin kanri CPD project management" was executed in the automotive practice.

The project started on the macro level, beginning with an analysis of project development process plans of other national and international car and truck manufacturers ("Check" activity on macro level). Following this comparison and benchmarking activity based on an international multi-project view, a new best of bench standard PDP plan valid for new truck development projects was created ("Plan" activity on macro level). In the third phase ("Do" activity on macro level), the new company standard was documented within a new project handbook available as handout and in the intranet and approx. 100 employees were trained. The macro-level loop was planned to be run through again within the next eight years, which is the usual cycle time for new truck platform developments in the automotive industry.

On the medium (project) level, a new (truck development) project (from now on called "pilot project") was selected and analyzed for the application of the new project management standard (first "Check" activity on medium level). In this "Check" phase, company internal standards were analyzed and benchmarked. Subsequently, the project plan which was created on the macro level was adapted to the special pilot project ("Plan" activity on medium level) giving each project activity an exact date. In the third phase ("Do" activity on medium level), the project plan was put into reality by the project actors. The degree of realization of the whole project was checked when a so-called quality gate was reached using a traffic light system and the circle started again from the beginning (check, plan, do).

On the micro level, each subproject leader checked relevant standards and actual circumstances for his subproject, e.g., in the subproject "Risk management" (First "Check" activity on micro level). After this, the project plan was adapted and planned in detail ("Plan" activity on micro level) and the content of the plan was transferred into reality ("Do" activity on micro level). In a two-day rhythm, shopfloor meetings (lasting no longer than 15 minutes) were held to check the degree to which the project had delivered the defined key performance indicators and the micro cycle turned within this project tact time.

For the visualization of the project, an Obeya room (the Japanese word "obeya" means "big room" (Morgan *et al.*, 2006)) was installed showing all three levels of the PDP: on the macro level the PDP standard was displayed, with a general timing in weeks before SOP (e.g. 54 weeks before the start of production); on the medium level a project plan for the pilot

project illustrated the actual dates; and on the micro level a biweekly plan as big as a school blackboard showed the details for the next two weeks.

The check activities on macro, medium and micro levels represent the fifth Lean principle. This principle expresses the state of being constantly uncomfortable with the actual situation and of striving for perfection, which is expressed in the Japanese ideograms of Kaizen with the left side symbolizing a man whipping himself and the right side representing an altar with a lamb on top (Medinilla, 2014) (Figure 13).

The automotive project described above did not start with the "Plan" activity after the project definition phase. First, the project leader tried to fulfill the customer needs with the highest possible level of project skills and project standards. The project team did not immediately start to work in-depth but opened its mind and view, researching for an optimum, state of the art, best of bench way of work under the special project conditions before starting the planning phase. Corrective actions were taken after a re-planning phase and not immediately after the "Check" phase (CPA sequence instead of a "Check and then immediately Act" sequence in the PDCA), which was called a more German way of working, reflecting some of the observations made by interviewees outlined in Section 5.

In summary, the approach used in the pilot project outlined above involved more effort at the beginning as may have been the case using other models. However, in total the project led to significant reductions in project lead times, an increase in process and product quality and, consequently, a significant reduction in cost.

9. Results and findings

Based on the results of the investigated models (ambulance, fire services, public aid and military forces, quality management theories of Six Sigma and the EFQM) and the expert interviews, the PDCA cycle has been diversified and a new PDCA cycle beginning with the "Check" activity is found.

Checking the project environment first and another "Plan" activity prior to the "Act" or "Adjust" activity is a step in the direction of the fifth Lean principle "to strive for perfection."

The new CPD cycle may appear to be shorter than the PDCA. However, this is not the case because another "Plan" activity is included between "Checking or Analyzing the Results" and the "Do" or "Make improvements" or "Act" phase). The cycle revolves at a higher frequency than the PDCA and therefore generates higher process stability.

Figure 14 shows that this paper goes back to the roots of W.A. Shewhart's PDC cycle but altered into a CPD sequence on three different levels to guarantee continuous improvement in projects. The application of the new CPD cycle in a long-term (macro, mid-term (medium-) and a short-term (micro-) planning level borrowed from the Lean management method of hoshin kanri represents the next level in the further evolution of the PDCA wheel.

10. Discussion

As shown in the results of the content analysis of the qualitative interviews, the cultural aspects of the PDCA cycle were discussed. The chief executive officer of a leading Chinese consulting company in the automotive industry mentioned that precise planning is typically German and that the PDCA cycle would be "a kind of German PDCA" with an additional "Plan" activity before taking corrective actions (act). This triggered the idea of indeed varying the PDCA.

Figure 13.
Kai (left ideogram) and Zen (right ideogram)

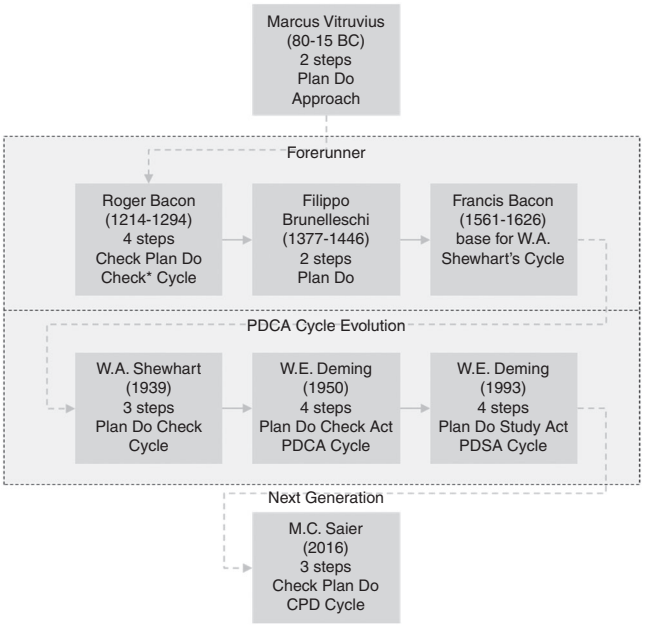


Figure 14.
Further evolution of the PDCA wheel

Note: *First check for examination last check for control

Another trigger for the variation of the PDCA cycle was the influence of those governance models mentioned above that might have a military background, which is supposed to be one of project management's historic roots (Lenfle and Loch, 2010; Shore and Zollo, 2015). As one interview partner who holds a PhD focusing on the history of military strategy mentioned: "The thinking models of military management processes and project management are identical." Furthermore, it was mentioned that military thinking processes or projects are more precise than processes or projects in enterprises and therefore valuable for practice.

The new CPD cycle is a variant of the PDCA cycle using the logic of application of the CPD cycle on macro, medium and micro levels, which is borrowed from the Lean management method hoshin kanri to continuously improve projects and to add customer value. This new CPD cycle could therefore be designated as a new project management or a new Lean project management tool.

11. Conclusion

The detection of the CPD logic in consulting projects shows that the CPD is already used in practice. By using the CPD logic combined with the hoshin kanri logic the quality of projects increases by setting up projects based on successful project standards (macro level), which are customized for the project (medium level) and detailed in short-term loops (micro level).

The original idea of the CPD cycle came from the investigation of models similar to PDCA cycles. However the paper (CPD cycle) also suggests that projects should be structured the way consultants do (standard) projects due to the fact that the research performed was based on interviewees with a strong consulting background (in the automotive industry).

Further research could involve comparing two similar projects one using conventional project management planning (or PDCA) procedures and one using the new CPD logic.

Going back to the roots of the Deming cycle, the newly defined CPD cycle is closer to the original idea of Walter A. Shewhart having a three-step instead of a four-step cycle model that starts with the activity "Check."

Glossary

APQP	Advanced Product Quality Planning
BML	Build Measure Learn
BMW	Bayrische Motoren Werke/Bavarian Motor Company
CEO	Chief executive officer
CIP	Continuous improvement process
Com	Command
CPD	Check Plan Do
GM	General Motors
DMAIC	Define measure analyze improve control
DMADV	Define measure analyze design verify
EFQM	European Foundation for Quality Management
Gemba	Place where value is added (shopfloor)
Genchi genbutsu	Japanese for go and see
GTS	Grasp the situation
Hoshin kanri	Strategic planning process in Lean management
KAIZEN	Japanese for change for the better
KATA	Detailed Sequence of Motions in Japanese Martial Arts (Aikido, Judo, Karate
KPI	Key performance indicator
LMBM	Learn Model Build Measure
Obeya	Japanese for big room (project room)
OODA	Observe orient Decide Act
PDCA	Plan Do Check Act
PDP	Product Development Process
PDSA	Plan Do Study Act
PMBoK	Project Management Body of Knowledge
PRINCE	Projects in controlled environments
QDA	Qualitative data analysis
SOP	Start of production
THW	Technisches Hilfswerk, civil protection and public aid organization
TPS	Toyota Production System
VDA	Verband der Automobilindustrie/Union of the Automotive Industry
VET	Vocational education and trainings
WoW	Way of Work

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