Implementing IT governance in the public sector

Learning how to implement Total Quality Management through the use of Pac-Man video game simulations

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Abstract

Transforming a public sector bureaucracy into a learning organisation by means of total quality management (TQM) can be a challenge when the politics of the organisation work against the process of trying to help individuals take responsibility for their own learning. In the TQM literature, a Pac-Man theory of implementing TQM has been suggested for dealing with these kinds of environments. However, as an understanding of the Pac-Man model requires a minimum understanding of how to play the Pac-Man video game, it remains to be known whether an effective learning strategy can be found. In this study an action research approach is used for testing the WikiHow strategy hypothesis on how to get good at video games by using Pac-Man as an example. Although the outcome of the experiment confirms the hypothesis by producing a recognisable learning curve, the learning did not reach a skill level of Pac-Man play needed for turning the video game into a practical simulator for implementing TQM. The contribution to theory and practice consists of confirming the relevance of “living theory” philosophy in the context of TQM while at the same time illustrating how scientific models depending on tacit knowledge may require a significant amount of time and effort to become scientifically useful.

Keywords: Organisational learning; total quality management; Pac-Man strategy; learning curves; action research.
1. Introduction

New Public Management (NPM) denotes a government policy, made popular in the early 1980s, aiming to modernise and render more efficient the public sector (Hood, 1991). The basic hypothesis of NPM holds that market oriented management of the public sector will lead to greater cost-efficiency for government, without having negative side-effects on other objectives and considerations. Total quality management (TQM) is an example of a management philosophy that has been used when trying to implement NPM in government, social services, health and education (Morgan & Murgatroyd, 1994).

TQM is an approach designed for improving cost-efficiency through a process of developing improvement hypotheses, designing organisational experiments and testing the hypotheses in action. This approach is sometimes referred to as the plan-do-check-act (PDCA) cycle or the Shewhart cycle as it creates a parallel between the industrial process of planning, producing and checking with the scientific process of developing hypothesis, designing experiment and analysing outcome of test (Shewhart, 1938). In other words, TQM is a change management method not only designed for creating change but also making theoretical and practical contributions to the understanding of organisational change.

What worries some people, however, is that the theoretical and practical knowledge developed through such a process can sometimes be seen as knowledge about how to control the organisation as a system through a process of deskilling the practitioners within this system and making them expendable (McNiff & Whitehead, 2006, pp. 173-178). This does not necessarily mean that there is something wrong with TQM per se, but it means that it matters whether the TQM programme is being implemented from a managerial perspective or a practitioner perspective (Lomax, Whitehead & Evans, 1996).

On the other hand, not all TQM implementation efforts succeed. In fact, it is estimated that about 80% of all TQM implementation efforts fail (Burns, 2004). According to Senge (1990), public sector organisations may be particularly resistant to change. As this resistance to change may have something to do with politics of knowledge, theories of TQM implementation based on critical social theory have been developed (Flood & Jackson, 1991; Flood, 1993). One particular TQM implementation model derived from this tradition is the Pac-Man model (Øgland, 2009). This particular model contributes to the development of the critical TQM tradition in two ways. Firstly, it aligns itself with the idea that critical social theory can be rendered more suitable for empirical research when formulated through the language of game theory (Elster, 1982; Gintis, 2009). Secondly, it aligns itself with the idea that use of game theory for understanding and designing actions in social reality should take into consideration that the kind of games that representatives of the “gamer generation” are familiar with are video games (Beck & Wade, 2004).

While video games can be thought of as mathematical games and thus explainable through the use of game theory, they are usually too complex to be understood analytically and need to be investigated through computer simulations. Furthermore, video games also have a physical and interpersonal existence in addition to being mathematical objects. These two aspects of video game models make Pac-Man a possibly interesting model for comparing insights from action research focusing on values, emotions and skills through the use of “living theories” (Whitehead & McNiff, 2006). To illustrate this point, the screenshot
from the Pac-Man game in figure 1 will be used for providing a very brief comparison between an action research account from a change agent trying to implement TQM in a Scandinavian governmental bureaucracy (Øgland, 2013) and a teacher fighting the bureaucracy within the UK school system (Whitehead, 1993).

![Figure 1. Detail from a Pac-Man screenshot](image)

The Pac-Man game consists of a little yellow mouth ("Pac-Man") trying to eat his way through a maze while being chased by four ghosts. It was developed by the Japanese game corporation Namco in 1979-80 and became a world-wide phenomenon and financial success in the early 1980s. There are various stories about what influenced the design of the game and why it became so popular. For instance, Pool (2001) suggests that the subtext of the game it could be interpreted as a conflict between the yellow mouth of Western consumerism and the ghostly representatives of the impoverished parts of the world. However, as pointed out by Gee (2007), video games are abstract semiotic systems that are open for different interpretations.

In the context of TQM implementation in political environments, Øgland (2009) uses the model by letting Pac-Man represent the change agent and the four ghosts being managers trying to track him down as he is upsetting their agenda by aiding practitioners to take responsibility for their own learning and own work. Using this perspective, the model is useful for translating strategies for winning at Pac-Man into strategies for implementing TQM in a politically tense environment. Strategy development involve finding useful paths through the maze, understanding the individual ghost psychology and how to utilise power pellets that reverses the dynamic of the game for short periods when Pac-Man is allowed to chase the ghosts. In the context of implementing TQM, such strategies are given concrete meaning in terms of tactics for designing and auditing quality management systems.

To illustrate how to gain insights from people fighting similar battles in different arenas, the Pac-Man model is used by letting Pac-Man represent a teacher and the ghosts represent school management in a story of a teacher dedicated to empowering his pupils...
while being chased by school management who sees his actions as a threat (Whitehead, 1993). In such a scenario the power pellets that reverse the dynamics of the game for shorter periods can be interpreted as the teacher receiving recognition from people that the administrative ghosts fear even more and thus allowing him to continue undisturbed for some time (ibid, pp. xx-yy). Fundamental breakdowns, however, like the teacher submitting his action research dissertation to a PhD committee and getting rejected can be interpreted as Pac-Man being eaten by the ghosts. Unless such events makes the teacher give up, a life is lost but the game continues. In this particular story, Pac-Man lost several lives until finally being awarded a PhD and allowed tenure (Whitehead & McNiff, 2006, pp. xx-yy).

By using the Pac-Man model as a reference for comparing the two stories, insights from the teacher story can be translated in a manner that make the insights relevant and useful for people involved in a TQM implementation story. Nevertheless, the comparison so far is based on a very rudimentary understanding of how the Pac-Man game works. In order to understand the model more deeply, and thus be able to find theoretical concepts for translating important but less obvious aspects of the school case into the TQM case, it is necessary with a much deeper understanding of how the Pac-Man model works. The researcher needs to not only a theoretical understanding of the Pac-Man model, but he needs to understand aspects of the model that can only be conveyed through skills and tacit knowledge.

According to overviews on theories of learning (Madsen, 1970; Stewart, 1996), the time it takes to skills like playing video games can often be modelled reasonably well by simple differential equations based on the assumption that the learning rate is proportional to the difference between the current level of competence and full competence. The pattern of the resulting learning curves will then be seen to grow asymptotically towards full competence and the speed of learning will be governed by coefficients associated with the exponential part of the learning function.

As the coefficients associated with learning speed reflect the training method used and the amount of effort used for training, the time it takes to become an expert can be estimated when the coefficients have been determined. General research on how to develop expertise suggests that setting the coefficients to reflect four hours of concentrated daily practice, full competence is expected to be reached within a period of ten years (Ericsson, 1996). This does not necessarily mean that the Pac-Man theory of TQM implementation requires this level effort to become useful. In fact, video game researchers claim that more than three hours of daily video game practice is likely to have negative impact on health (McGonigal, 2011).

Three hours of daily practice is still too much in terms of what action researchers would be expected to be willing to invest in Pac-Man practice. What is more relevant to know is whether it is possible to become sufficiently skilled at Pac-Man to be able to use the model for the kind of scientific purposes mentioned above by training for only a few minutes each day. By searching and reviewing the Pac-Man and video game literature, the strategies at the WikiHow internet site describing “how to become at good at video games with training” (Sirkin et al, 2008) and “how to win in Pac-Man” (Sondra et al, 2008) seem particularly relevant. In comparison to complex strategies described in books and elaborate guides (Uston, 1981; Consumer Guide, 1982; Zaviska & Beltowski, 1982; Killerklown, 2001; Balderramos, 2008), the WikiHow strategies are compact strategies aimed not only at
playing the original Namco version of Pac-Man but also the various clones and bootleg versions.

The purpose of this paper is to investigate the impact of the two nested WikiHow strategies on improving Pac-Man game play. The level of Pac-Man competence will be measured against the researcher’s ability to understand the Pac-Man model as a practical representation of the political dynamics involved in a process like trying to implement TQM in a political environment. The research will be carried out through the use of action research where the researcher will be trying to improve his own practice of Pac-Man game play.

The account of the study is reported by having the paper divided into several sections. After explaining the motivational challenge in this introductory section, there follows a literature review going into more detail by selectively reviewing literature on double-loop learning, strategies for how to win at Pac-Man strategy and strategies for how to become good at video games through practice. The review results in hypotheses of proposed causal relationships between training effort, training schedule and Pac-Man game results. Next follows a section on how an action research design can be used for studying the hypotheses through measurements and research model. This is followed by a section describing analysis of results, and is followed by a discussion of findings in the context of related research. The final part of the paper is a conclusion summarising contributions to research and practice plus comments on limitations and suggestions for further research.

2. Research background and hypotheses

2.1 Gamification as educational strategy

The motivational idea in the introduction section was that the people working with TQM implementation in political environments had difficulties coping with the situation because they were unable to make use of insights from similar stories such as the account of experiences from teachers working under similar conditions. The theory of learning through use of video games (Gee, 2007) was used as a diagnostic tool for analysing the situations. By focusing on the Pac-Man video game as a model for making sense out of the situation, what was suggested through this kind of learning theory was that the TQM implementation team should spend time playing the Pac-Man game in order to obtain simulation experience that would make it easier to apply Pac-man theory for understanding real world scenarios.

According to Schaffer (2006), the key to making video games into useful teaching tools is that the games have to model the decision spaces used by professionals within the learning domain of interest. As an example he mentions an engineering game where the player is supposed to create a machine that requires understanding certain laws of physics. In his empirical research he shows how learning from textbooks without doing these kind of simulations tend to result in shallow understanding while using the simulation tool makes the student think like an engineer and thus see how the laws and language of physics is natural and useful for solving engineering problems.
Learning how to implement TQM through the use of Pac-Man simulations

Some of the games Schaffer discusses are “serious games” designed specifically for teaching while others are popular games that have not been designed for learning purposes but may still function as teaching instruments. The important issue is that the game captures important decision problems associated with the professional making use of the kind of knowledge one wants the students to learn. The practice of a professional historian is used for teaching history. The practice of a professional visual designer is used for teaching mathematics. The way the games are designed to represent professional practice makes it possible to see video game learning theory as related to Schön’s (1983) theoretical framework of practitioner learning.

According to Øgland (2009), the Pac-Man video game can be seen as a representation of the decision problems facing TQM implementation professionals in political environments. Making use of Pac-Man theory involves several interpretations, such as identifying the individual conducts of the four ghosts with the four managerial styles described by Blake and Mouton (1964). Although this could be potentially useful in the sense that the activist (Pac-Man) may have to apply different types of strategies depending on the managerial style of his adversaries in the administrative bureaucracy, it is difficult to understand the practical implications of such tactics without having sufficient simulation experience through Pac-Man game play.

In the context of the double-loop learning model in figure 2, getting the practitioner to understand the Pac-Man model can be thought of as single-loop learning (inner loop learning) with the WikiHow strategy for “how to win in Pac-Man” as the action strategy. The success of learning this Pac-Man strategy, however, depends on double-loop learning (outer loop learning) with the WikiHow strategy for “how to become good at video game with training” as representing the governing variable.

![Figure 2. Double-loop learning (Argyris & Schön, 1978)](image)

From a game theoretical perspective the two WikiHow strategies represent strategies for playing two different kinds of games linked within each other. Within the inner loop of game play, Pac-Man is viewed as a single-shot game. As described by Balderramos (2008), among the best Pac-Man players in the world a single game of Pac-Man may last for 4-6 hours and result in a perfect score of 3,333,360 points. From this perspective the Pac-Man game has been solved. There is a strategy for obtaining a perfect score provided the player has the necessary skills for executing the strategy.
It is the governing variables in the outer loop in figure 2 that makes the Pac-Man game into a repeated game. The WikiHow training strategy suggests how the single-loop learning should be designed in order to make a Pac-Man novice turn into a Pac-Man expert with minimal effort. Of course the outer loop strategy may be contested, as is the purpose of double-loop learning, but from a game theoretic perspective repeated games are conceptually different from single-shot games. As there may be many solutions to the training game, in the sense of different training strategies that lead to the same results, a common solution concept for repeating games is ability of the chosen training strategy to survive the competition with alternative strategies.

In other words, from a game theoretical perspective the two WikiHow strategies are hypothesised as solutions to two fundamentally different games that operate with different kinds of solution concepts. This will be explained further as the WikiHow strategies are individually reviewed.

2.2 Action strategy: How to win at Pac-Man and liberate organisations

Action research on educational living theories can be thought of as engaging with the politics of knowledge (McNiff and Whitehead, 2006, chapter 18). From a managerial perspective it is important to develop and maintain knowledge that makes it possible to control the organisation as a system. From a practitioners perspective it is important to develop and maintain knowledge that serves the practitioner. Sometimes these types of knowledge clash. In the story told by Whitehead (1993) there was a conflict between the knowledge developed and maintained by the university administration and the knowledge developed and maintained by the university lecturer. In the story told by Øgland (2009) there was a conflict between the knowledge developed and maintained by the administration and the knowledge developed and maintained by the quality manager.

McNiff and Whitehead conceptualise this situation by taking a practitioner perspective and thus seeing the institutional use of knowledge as a means of oppression. By framing the situation as a game about oppression and freedom, the focal point of action research becomes to formulate and test strategies for freedom transformation. What strategies should be played depends on that nature of the game. Sometimes the nature of the game is such that confrontation is the only option, but in many games negotiation is a better strategy.

Negotiation means always leaving a loophole for the other to change their mind publicly, without damage to their image and self-esteem. Be sure that they, and you, know what is going on, but in situations of conflict it is essential that you both play a politically strategic game so that both emerge as winners (McNiff & Whitehead, 2006, p. 179).

As illustrated above, McNiff and Whitehead use game theory in an informal manner to explain and discuss the politics of knowledge in a mathematically precise manner, but they do not comment on whether game theory could be a natural language for articulating the dilemmas used by practitioners to develop self-improvement strategies. Gintis (2009), however, recommends doing this in the belief that game theory can be seen as a unifying theory of all behavioural sciences. Bennett et al (2001) show a process of how game theory
models can be developed from unstructured empirical data, and Camerer (2003) shows how
to design game theory experiments for investigating strategic interactions in the real world.

Linking these suggestions together, Øgland (2009) suggests using the Pac-Man video
game to represent the conflict described by McNiff and Whitehead in their account of the
politics of knowledge, and then engaging with the game theory and video game literature
for developing and testing strategies of transformation from oppression through action
research experiments.

A useful aspect of the Pac-Man game is that it is one of the most well-known of the
early video games, it is conceptually simple, and it has been extensively researched. As
mentioned earlier, most of the research has been published in books by various Pac-Man
experts who explain strategies for playing and mastering the game (Uston, 1981;
Balderramos, 2008).

Although this literature provides deep insights on how to play Pac-Man by explaining
different patterns that should be followed at different levels and how to group the monsters
in order to be able to eat them when powered up, this is written for people who are willing
to put in a large effort in order to achieve a high level of skill at a very difficult game. For the
purpose of this study it is more relevant to look at a basic strategy for playing Pac-Man at a
the level of competence needed for understanding how Pac-Man strategies translate from
the video game into the real world of conflicts based on power and politics.

The WikiHow strategy on “How to win at Pac-Man” in table 1 is much simpler than
what is explained in the Pac-Man strategy books, but it is easier to understand and each of
the five steps can be further detailed by consulting the books. From this perspective it looks
like the WikiHow strategy could be seen as an optimal Pac-Man strategy in the sense that
increased skill at game play would make it necessary to understand some of the individual
tactics in more detail but it would not mean that the strategy itself has to be changed.

Table 1. The inner loop WikiHow strategy (Sondra et al, 2008)

<table>
<thead>
<tr>
<th>How to win in Pac-Man</th>
<th>Illustration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Keep an eye on all your opponents; there are only four ghosts in the game. Keep your closest watch on the nearest ones. Also keep an eye on Blinky (red) and Pinky (pink) as they are the fastest and most skilled. In most Pac-Man versions, you will move faster than the ghosts, which means the only way they can catch you is for you to make a wrong turn, or for them to corner you.</td>
<td><img src="image" alt="Pac-Man Illustration" /></td>
</tr>
</tbody>
</table>
How to win in Pac-Man

2. Realise that you’re probably smarter than the game. The artificial intelligence in Pac-Man is very crude. Ghosts may appear to chase you, but many times they will turn off onto different paths when they’re right behind you. If it looks like you’re going to be cornered, move in the direction of the ghost that has to make a “choice” of whether to pursue you or take a different route. Many times you will get lucky. Try also to stay in areas with multiple turns offs and routes; it’s much easier for your to lose your pursuers there.

3. Once you have the basics down, concentrate on amassing as many points as possible. Clearing the map is a start, but also try to collect the fruit that will occasionally appear, as well as stalking ghosts when “powered up”. It’s generally a good idea to clear the map in quarters, using the “power-up” dots when two or more ghosts begin to congregate in your area. Ideally, you should wait until there are at least three ghosts in your area to use a “power-up”, since you collect an increasing amount points for every ghost you devour. If you can nab all four ghosts on one power-up, you’ll earn 200, 400, 800 and 1600 or 3,000 points (in most versions). Don’t waste your time chasing ghosts, but remember that every one you devour has to travel back to the map’s centre to be a threat. Therefore, you should make a decent effort to eliminate the threats in your area when powered-up. Don’t just try to send them in the opposite direction.

4. When you eat a ghost on a power-up, it becomes a pair of eyes, which gradually work their way to the centre of the maze (the jail area) to regenerate. If you are clearing an area near the centre of the map, watch these eyes! Don’t get caught at the “jail’s entrance” when a ghost regenerates!
How to win in Pac-Man

5. Learn how the ghosts think. There is literally no randomness to their movements. They start off each level aiming for their respective “home corners”: Blinky (red) heads to the top-right, Pinky (pink) to the top-left, Inky (blue) to the bottom-right, and Clyde (orange) to the bottom-left. After a few seconds, they start chasing you—you’ll know they’ve changed tactics when they make a 180 degree turn. Blinky heads straight for you position, Pinky heads for a spot just in front of you (unless you’re facing up, due to a glitch), Inky heads for one end of a line that has a spot just in front of you as its centre and Blinky as its other end, and Clyde chases you if he’s far away but heads back to his home corner when you’re nearby. They’ll alternate between these two strategies through the level, but eventually settle on chasing you.

In the language of game theory, if each player has chosen a strategy and no player can benefit by changing strategies while the other players keep theirs unchanged, then the current set of strategy choices constitute a Nash equilibrium (Binmore, 2007). When it was suggested above that the WikiHow “how to win in Pac-Man” strategy is an optimal strategy, the strategy is assumed optimal in the sense of playing the WikiHow strategy against the algorithms defining the strategies of the ghosts results in a Nash equilibrium.

Hypothesis 1. The WikiHow Pac-Man strategy is optimal in the sense of being a Nash equilibrium when paired with the computer algorithm.

2.3 Governing variables: Parameters used to define the training method

When Lomax, Whitehead and Evans (1996) discuss the use of action research for organisational change through the use of total quality management and similar quality management philosophies, their focus is on how organisational learning and change can be achieved by making practitioners carry out action research on how to improve their own practice.

In the context of using Pac-Man theory as a basis for organisational learning, the implications of this perspective is for the TQM implementation practitioner to improve his skills in political game play by improving his ways of executing the WikiHow Pac-Man strategy in table 1. However, as there many ways of training for getting good at playing video games, the strategy set for the training game has to be defined and the optimal strategy needs to be chosen.

The Pac-Man training game can be thought of as playing Pac-Man repeatedly until a certain score level has been reached or the practitioner decides to give up or is otherwise prevented from continuing the training. The payoff of the game is defined as the highest score achieved through the training period or the average score reached between round $n$ and the final round $N$. From the game theoretical study of repeated games, it is known that
a Nash equilibrium for a stage game (the single-shot game being played repeatedly for training) may not be a Nash equilibrium for the repeated game. For instance, a two-player version of the Prisoner’s Dilemma has defect-defect as the only Nash equilibrium as a single-shot game, but have more effective strategies such as tit-for-tat when defined as a repeated game (Binmore, 2007).

In the case of Pac-Man it was assumed in hypothesis 1 that the WikiHow Pac-Man strategy formed a Nash equilibrium when paired with the computer algorithm, but this does not necessarily imply that training should consist of only playing this strategy. As part of the training strategy it may be necessary to focus on becoming good at particular aspects of the game that does not necessarily result in winning individual Pac-Man games, but will nevertheless be important for becoming competent at Pac-Man play.

Although the Pac-Man literature provides advice on how to practice in order to master the game (Uston, 1981; Balderramos, 2008), for the purpose of this study it seemed more useful to consider a WikiHow strategy in table 1 that has a more general explanation of how to get good video games by training. The reason for preferring the WikiHow training strategy (table 2) to the literature provided by the Pac-Man experts is the same as when choosing the WikiHow Pac-Man strategy. The kind of training programme needed for the action researcher considering Pac-Man theory as a way of understanding conflict is not the same kind of training that is needed for becoming a Pac-Man world champion. What is needed though is a simple and structured framework that makes it easy both to analyse game play and to incorporate more advanced training techniques without having to change the overall training strategy.

Table 2. The outer loop WikiHow strategy (Sirkin et al, 2008)

<table>
<thead>
<tr>
<th>How to get good at playing video games by training</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Keep a schedule of playing.</strong> Playing a game for hours on end leads to problems, such as addiction and obsession. Play for an hour or two without any distractions to build up knowledge of the game. If you are playing at night, be sure that parents don’t find out and you have the volume on low.</td>
</tr>
<tr>
<td><strong>2. Get an interest in a game.</strong> Games are dull and boring if it’s not what you like to play, too challenging, or too confusing. Experiment by borrowing games from friends or renting games from video stores. If you grow into liking it, convince a parent to buy it for you.</td>
</tr>
<tr>
<td><strong>3. Train by starting off on easy levels.</strong> Avoid using cheats, if possible. Cheats can ruin the fun of the game, especially if you’re just starting it. Spend a few days or so on easy levels of the game so that you can familiarize yourself with it.</td>
</tr>
<tr>
<td><strong>4. Advance to higher levels once you get the hang of everything.</strong> Get your friends to help you if you’re stuck on something or if you want to play multi-player.</td>
</tr>
<tr>
<td><strong>5. Learn the controls well.</strong> Often, mastering the controls to a game will help you do better than if you hadn’t.</td>
</tr>
</tbody>
</table>

In the language of game theory, as explained by Binmore (2007), if a strategy that is adopted by a population in a given environment cannot be invaded by any alternative strategy that is initially rare, it is referred to as an evolutionary stable strategy (ESS). An ESS is an equilibrium refinement of the Nash equilibrium. An ESS is a Nash equilibrium that is
“evolutionary” stable: once it is fixed in a population, natural selection alone is sufficient to prevent alternative (mutant) strategies from invading successfully.

When choosing the WikiHow training strategy, it is because of the belief that this strategy is an ESS. In other words, once the WikiHow training strategy has been implemented there is no reason to change strategy despite the fact that the nature of the training will change as a consequence of increase in skill and the Pac-Man game being potentially more difficult to play as the more skilled player is able to reach higher levels of game play.

**Hypothesis 2.** The WikiHow training strategy is optimal in the sense of being an evolutionary stable strategy.

### 3. Research methodology

The action research design has been developed by following the guidelines by McNiff and Whitehead (2006). Often action research is conceptualised as a cyclic process, similar to what is illustrated in figure 1, where the steps involve issues like diagnosing the situation (observe), hypothesising a treatment (reflect), administering the treatment (act), analysing the outcome (evaluate), making contributions to theory and practice (modify) and pointing out directions for future research (move in new directions).

![Figure 3](image)

**Figure 3.** Action research cycle (McNiff & Whitehead, 2006, p. 9)

The intermediary steps of reflecting, acting and evaluating relate to the process of making the treatment hypothesis testable (statement of population and sampling procedure), data collection and data analysis. As the methodological framework by McNiff and Whitehead deals primarily with qualitative data, guidelines on how to apply statistical methods in single subject research (Robson, 1993) have been used as an additional reference. For the more general purpose of trying to make the research design fit with principles of statistical thinking and proper use of statistical methods, the statistical primer by Rowntree (1981) has been consulted. The use of statistical control charts is based on Clark (1999).
3.1 Population and sampling procedure

The population for this study consists of change agents wanting to improve their conceptual understanding of organisational politics through the use of Pac-Man simulations. To study this population the researcher uses himself as single subject sample.

Prior to Pac-Man experiment starting towards the end of week 17 in 2014, the researcher had little experience in playing video games. He had tried playing the original Namco arcade version of Pac-Man in the early 1980s, but only a couple of times. At this time, however, he was teaching himself computer programming by developing computer games, so various versions of Pac-Man were developed for the Sinclair ZX Spectrum home computer using the BASIC computer language. The final Pac-Man version was developed around 1989 as part of a personal project of trying to learn assembly programming for the Z80 processor. Although these exercises were useful for thinking about the nature of the Pac-Man game from a designer’s perspective, they did not result in the development of any significant skill in Pac-Man game play.

When getting his first personal computer in 2004, the researcher made some minor attempts to identify different Pac-Man versions on the internet and to try them out, but nothing serious. However, the awareness of the internet online versions of Pac-Man games was relevant some years later as he was trying to analyse TQM implementation through the use of systems theory and game theory. In 2008, when developing a paper on how to use the Pac-Man video game as a scientific model of understanding the politics of TQM implementation, some attempts were also made at playing Pac-Man. Like the earlier attempts, the approach was not serious as the paper dealt with the conceptual aspects of the Pac-Man game without paying attention to whatever skills a person would have in playing it.

3.2 Data collection

There have been three purposes for collecting data. Firstly, data have been collected for monitoring and controlling the way the WikiHow strategies have been implemented. Secondly, data have been collected for keeping track of how the WikiHow strategies impact on learning by keeping track of Pac-Man scores. Thirdly, qualitative data have been collected for keeping track of reflections about rules, strategies, game design context and possible implications for TQM practice when gradually learning to play Pac-Man.

Monitoring the implementation of the WikiHow strategies

The first step in the WikiHow strategy on how to get good at playing video games is to keep a schedule of playing. After two weeks of experimentation, a training schedule was established in week 19 of 2014 where practice should consist of playing a single game of Pac-Man each day of a seven-day week until the experiment is terminated. In order to monitor the daily Pac-Man practice, both the starting time and duration of practice is recorded. The weekly average and standard deviation for both parameters are calculated
and plotted in control charts according to the methods described by Clark (1999). The daily recordings are not maintained.

The second step in the WikiHow strategy is to make sure the game remains interesting. As this is more difficult to monitor in an objective manner, this step is interpreted as a termination criterion in the sense that the experiment will be terminated when learning slows down in the sense of reaching a platform. The operational definition of the learning curve and platforms within the learning curve will be explained below as part of commenting on how to keep track of the Pac-Man results.

The third and fourth step of the WikiHow strategy emphasise starting off on easy levels and advance to higher levels once the player gets the hang of everything. As the levels in Pac-Man can only be reached by starting at the easiest level and gradually advance towards the higher ones, this part of the strategy is handled by default.

The fifth step of the WikiHow strategy is to master the controls. As will be explained below, the particular Pac-Man version chosen for the experiment is an online computer version that is controlled through the use of the four arrow keys. As it is impossible to survive many minutes of Pac-Man game play without mastering the controls, the design of the game makes sure that also this part of the strategy is handled by default.

**Keeping track of the Pac-Man results**

As explained earlier, Pac-Man results are created by moving around the maze, avoiding the ghosts when they are in the aggressive mode and eating various objects. How these moves translate into scores are hinted at in the Pac-Man strategies (table 2) and explained more fully in the literature (Uston, 1981; Killerklown, 2001; Balderramos, 2011). However, this literature refers to the original Namco Pac-Man version while the version used for conducting the experiment is a free online version developed by Paul Neave.

The snapshots from the Neave Pac-Man in figure 4 shows that it is visually more or less identical to the Namco version. It also sounds similar, and felt similar to the researcher when testing it in comparison to some other free online versions of Pac-Man found on the internet. When trying to find out more about it on the internet, the general consensus among gamers and commentators seem to be that it is good but programmed in a slightly different manner to the Namco version. Although this should not matter when using the WikiHow strategy, the detailed Namco strategies developed and described by people like Uston (1981) may not apply.

In other words, part of the learning challenge in the Pac-Man experiment is not only developing skills, but also learning the specific rules of the Neave version of Pac-Man in comparison to the Namco version and then developing and testing strategies needed for playing this particular version. However, if the WikiHow strategy hypothesis is correct, the required learning about rules and strategies should only be minor adjustments to what is already described in the WikiHow strategy.

The first experiment was carried out in April 2014 on the last day of week 17. As this single game lasted less than one minute, the next week consisted of playing several games each day, resulting in 12 minutes of average daily game play. It was then decided that it
would be better to play just one game per day and see how long it would take to master the game. The recording of the starting point for daily Pac-Man training began in week 19.

![Pac-Man Game](Image)

**Figure 4.** Paul Neave’s Pac-Man ([http://www.thepacmanwebsite.com](http://www.thepacmanwebsite.com))

A challenge during the first seven weeks of the experiment was that the computer used for practice was a Packhard Bell 2004 laptop that was running on a Windows XP operating systems that had become obsolete and was no longer supported by the Microsoft Security Essentials anti-virus software. As a consequence of this, the Pac-Man training was sometimes carried out in sub-optimal conditions where the game played in a jerky mode where it was difficult to control the Pac-Man character.

On Monday the 2nd of June, the internet broke down and the computer remained unconnected for a couple of days. As this prevented the continuation of daily experiments, action had to be taken and a way was found for downloading the Neave Pac-Man game onto the computer on the 5th of June. Not only would this make it possible to carry out daily training without depending on being connected to the internet, it also made the game play more smooth as the local version of the game was not affected with lack of memory and insufficient CPU for making the internet connection stable. The version of the Neave Pac-Man downloaded and used for the remaining parts of the experiment was dated October 2nd, 2003.

The Pac-Man score displayed when the daily practice signalled “game over” was the only piece of data collected and used as an indicator of learning. Similar to how the schedule was monitored through the use of weekly averages and standard deviations, the effect on learning as measured through the Pac-Man score was monitored in a similar way. The weekly calculations were plotted as time series. The daily recordings have not been maintained.
Using a research diary for reflecting on action

Although the research is a continuation of earlier ideas (Øgland, 2009; 2013; 2014), the first entry in the research diary relevant for this particular study was in the context of learning curves and game theory on April 25th, 2014. From then on the research diary has been used for reflection on action in terms of writing and making diagrams for the purpose of understanding the relationship between the Pac-Man game as an isolated video game and the Pac-Man theory of applying the game model for analysing the politics of TQM implementation.

3.3 Data analysis

A five level framework for characterising learning resulting from playing video games (Prensky, 2006, chapter 8) will be used for analysing the results. The framework starts with learning game skills at the lowest level and gradually advances towards learning about implications for game strategies in the context of real world situation at the highest level.

The first level is learning how to operate the game. The aim of analysis at this level is to make sure that the training schedule is operated in a stable manner. Following the recommendations of Clark (1999), the method of analysis is statistical process control (SPC) by plotting both weekly averages and standard deviations to see whether the process behaviour is within statistically estimated control limits. Both the daily starting point of practice and the duration of practice are monitored in this manner. The SPC design is meant to be thought of as a design for controlling the implementation of the outer loop WikiHow strategy describing how to become good at playing video games by training.

The second level is to understand the game rules. In this case the data are sensory data observed in action during game play. For the simplest rules, such as similarities or differences between the score board for Neave Pac-Man as compared to Namco Pac-Man, the analysis consists only in confirming or disconfirming the correspondence. For more sophisticated rules, such as understanding the artificial intelligence algorithms used for programming the psychology for each of the ghosts, it may be necessary to write down hunches in the research diaries after game play and then try to test these hunches later on.

The third level is to use the combination of operational skills and understanding of rules for developing and testing strategies. From the viewpoint of double-loop learning, the training method (outer loop WikiHow strategy) provides the governing variables for how to win at Pac-Man (inner loop WikiHow strategy). The belief that this approach will work, however, is based on hypothesis 1 claiming that the implementation of the inner loop WikiHow strategy will result in becoming a competent Pac-Man player. In figure 5 this hypothesis is illustrated by a causal relationship between training effort and Pac-Man score.

As training effort is measured in minutes of daily game play (X) and Pac-Man skill (competence) is measured in daily score (Y), the impact of training on competence can be analysed through the use of regression techniques provided the nature of the relationship between the two variables can be estimated. Although increase in Pac-Man game play competence will increase the length of the daily practice game, it should also increase the number of points achieved relative to length of game play. In other words, the relationship...
between $X$ and $Y$ should be expected to be a strictly convex curve such as $Y$ being an exponential function of $X$. Using the methods described Rowntree (1981, chapter 8), the exponential relationship will be tested at significance levels 0.05 and 0.01.

![Diagram of causal relationships](image)

**Figure 5. Causal relationships in for developing Pac-Man skills through training**

As any strategy for learning how to play Pac-Man requires training effort, it is possible to look at the relationship between $X$ and $Y$ from the single perspective the inner loop WikiHow strategy. The impact of the outer loop WikiHow strategy, however, is that it provides rules for defining a daily training schedule, including guidance on how much effort should be spent on daily training (1-2 hours) and when the training should be conducted (e.g. at night when there are few distractions). In figure 5 the hypothesis 2, relating to the belief that the outer loop WikiHow strategy works, is represented by the moderator variable $Z$ representing the daily start point for training. In principle the duration of game play $X$ should also be seen as part of the training schedule, but as duration of game play depends on the skill level $Y$, this is not a variable that can be controlled until a high level of game skill has been reached ($E[Y] > Y_0$).

The relevance of including the variable $Z$ in the study is to test whether different schedules will change the strength and nature of the relationship between $X$ and $Y$. A natural design for studying this would be to investigate a period $A$ with a certain schedule, the change the schedule and test for a period $B$, and then test back to $A$ conditions again (Robson, 1993). Such a study would be important for developing an optimal training schedule. In this particular study, however, only the first $A$ of such as design has been implemented in order to provide reference data for further research.

The fourth level is to understand the game from the viewpoint of the game designer. The data analysis at this level is primarily based on historical reflection, trying to understanding of the game from a designer perspective by reflecting on the economic, geographic and technological factors that provided the context when Namco Pac-Man was developed in 1979-80 and the factors that provided the context when Neave Pac-man was developed in 2002-03.

The final level is to consider the game as a possible representation of a real world situation. The data analysis consists of reflecting on how the combination of the design perspective and the skill perspective might lead to novel insights on how to deal with the politics of TQM implementation in the real world.
4. Analysis of results

4.1 Learning at level one: Mastering the controls

According to Prensky (2006, p. 64), the most explicit kind of learning in video and computer games is how to do something. In the case of a video game like Pac-Man hardly any level of higher learning can happen before the player has achieved a minimum level of knowing how to manoeuvre the Pac-Man character around the screen by use of the video game controller or the keys on the computer keyboard.

The WikiHow strategy for getting good at playing video games (table 2) consisted of five steps. The first step was to keep a schedule of playing. Keeping a schedule means to allow for game play training at regular times for a certain amount of time. The statistics below show the weekly average and standard deviation for the start of the daily Pac-Man practice.

The diagrams in figure 6 show that there is day-to-day variation on when daily Pac-Man practice is carried out. Typically the Pac-man practice is carried out at the end of the working day to make sure that it does not interfere with more important issues. On the other hand, it is also useful to make sure that it is carried out before having to engage in daily family issues. Usually this means that daily Pac-Man practice is carried out around 3:10 p.m. As can be seen from the diagrams, there is much variation both on a day-to-day and on a week-to-week basis. Some of these variations can be explained by irregularities having to do with business travels, weekends and holidays.
As each daily Pac-Man practice consists of playing a single game of Pac-Man, the amount of practice time is expected to increase as one becomes more skilled. During the first couple of months, a single game of Pac-Man took on average about four minutes to play and the weekly standard deviation was about two minutes. From the viewpoint of how to schedule the daily training this offered no problems as it was always possible to find time for 4-5 minutes for daily Pac-Man practice. If one becomes more skilled and the game starts to require more time, it may be necessary to play in the evening rather than the afternoon.

As seen in figure 7, the first two weeks of Pac-Man practice follow a slightly different schedule. The reason for the low effort in week 17 and the high effort in week 18 was that the research design was not fully determined, so rather than just playing one game each day the focus was rather on playing for whatever period of time that felt appropriate. In week 17 this effort was less than a minute per day while in week 18 it resulted in an average of twelve minutes per day.

Figure 7. Weekly effort of Pac-Man practice (average + standard deviation)

The second step of the WikiHow strategy says that successful interest in learning to play depends on a balance between the game not being too simple and too challenging. The fact that the charts in figure 7 present data from several months of game play indicates that the balance between skill and challenge still makes it possible to continue the experiment.

The third and fourth steps of the WikiHow strategy deal with the issue of starting off at easy levels and gradually advancing towards higher levels to maintain the initial flow achieved by having a balance between skill and challenge. With a game like Pac-Man this is something that is automatically taken care by the way the game is designed.
The fifth step of the WikiHow strategy is to develop control skills. In the case of the Pac-Man game this consists of improving the eye-hand coordination by observing the movements within the maze and using the arrow keys on the keyboard for manoeuvring the Pac-Man character around the screen. The increased level of skill can be observed (figure 7) by the increasing time the researcher has been able to survive the Pac-man games as the practice has continued over the weeks.

4.2 Learning at level two: Understanding the rules

According to Prensky (2006, p. 65), most non-electronic games require that players learn at least some of the rules before starting while for electronic games the rules are built into the programming and have to be learned by trial and error. This also applies in this Pac-Man experiment. Although there are numerous books and internet resources explaining the rules and strategies for playing Pac-Man, most of this refers to the original Namco version of the game. Although the Neave version of the game looks more or less identical to the Namco version, as seen by comparing Neave visuals in figure 4 with the Namco strategy diagrams in table 1, learning by trial and error is necessary for understanding whether the games are identical the rule level.

After some weeks of game play, it could be confirmed that the Neame version would award an extra life after reaching a score of 10,000 points. It was also possible to confirm that the scores for various events followed the pattern of the Namco version. For instance, eating a dot was awarded 10 points, a power pellet 50 points, the first ghost 200 points, the second 400 points, the third 800 points and the fourth 1600 points.

In case of the bonus fruits, it will take more game experience to verify that the score for the Neame fruits correspond with the Namco fruits. So far it has been possible to verify correspondence by noticing that eating the cherry is awarded with 100 points, the strawberry 300 points and the orange 500 points.

A more sophisticated aspect of the rules, however, is the nature of the algorithms used for programming the artificial intelligence of the ghosts. As explained in the WikiHow Pac-Man strategy, each ghost is programmed in a manner to represent different types of personality. The learning about the Neame game through trial and error has so far not resulted in understanding whether the Neame ghosts are similarly programmed to have different personalities or whether they all behave in the same way. So far it looks like they have less individuality.

What was easier to discover about the ghosts, however, was that the Neame ghosts move around the maze in a more random manner than the Namco ghosts. The Pac-Man literature, in fact, explains that the Namco ghosts move around in deterministic ways, so the way this particular difference in the rules means that slightly different strategies are needed for playing the two different versions of the game.

It should also be mentioned that the Namco game is a finite game in the sense that the screen breaks down into a “split screen” after reaching level 256 due to an error in the original software. Reaching this stage while eating all ghosts and fruits is sometimes referred to as “perfect game”. Reaching the maximum score of 3,333,360 points represents the ultimate level of skill in Pac-Man and has been recorded to take about 6 hours of...
continuous game play. Whether the Neame version of the game will break down in the same manner and a perfect game can be reached is beyond the scope of the trial- and error research in this study.

4.3 Learning at level three: Detailing the strategy

As pointed out by Prensky (2006, pp. 66-67), strategy depends on and flows from the rules. Unlike the previous steps of learning skills and rules, strategy learning may be more reflective in the sense that it may result from analysis or observations based on a deeper understanding of the game. Whenever a strategy has been hypothesised, however, empirical tests in terms of actual game play are needed to investigate whether it will work out as hoped for.

In this Pac-Man experiment a WikiHow strategy on how to win at Pac-Man has already been provided, so the previous learning about skills and rules are supported by a theoretical foundation. As one of the reasons for choosing this particular WikiHow strategy from the rich Pac-Man strategy literature was that it was tailored not only for the canonical Namco version of the game. This seems good on the basis that the learning about Neave rules indicate that they deviate slightly from the Namco rules.

The first WikiHow tactic is to keep an eye on the red and the pink ghosts as they are the fastest and most aggressive. The experience from playing Neave Pac-Man confirms that these two ghosts are the first ones to break out from their home in the centre of the game, but so far the psychology of the individual ghosts are not sufficiently understood to make use of this in an overall strategy.

The second WikiHow tactic is to keep close to decision points in the maze as this will confuse the ghosts and make them turn in random directions. This tactic has been confirmed in game play. It doesn’t necessarily mean that they will make the wrong turns, but often they do. On the other hand, ending up in corners where being attacked from both sides is one of the most frequent ways of loosing.

The third WikiHow tactic is to find ways of eating as much as possible, including bonus fruits and ghosts. In order to eat as many ghosts as possible, it seems useful to make sure that they are close before they start to scatter.

The fourth WikiHow tactic is to be aware of the jail entrance at the centre of the game when the eatable ghosts return there to regenerate. This is a simple but useful tactic that has been confirmed in game play.

The fifth WikiHow tactic is to understand and exploit the individual ghost psychology. The tactic is detailed by explaining how the individual ghosts are expected to behave, but so far it is not clear whether the ghosts in the Neave version of the game behave in the same way, so it is necessary with a deeper understanding of the rules that drive their behaviour before developing explicit tactics in how to exploit this.

The diagrams in figure 8 show the strategy learning in the shape of learning curves based on the weekly average and standard deviation for the daily score achieved in Pac-Man practice. The average is expected to follow something similar to a logarithmic development.
as the learning rate is expected to be proportional to the difference between current skill and maximum skill. The standard deviation is expected to follow the law of exponential decay as increased skill will reduce the variation.

$$y = 6819.8 \ln(x) + 2949.6$$

$$R^2 = 0.6476$$

**Figure 8.** Weekly results from daily Pac-Man practice (average + std. dev.)

Although Pac-Man can be seen as a game about survival, it does not necessarily mean that there is a linear correlation between the daily Pac-Man score and the duration of the game. At least based on the experiences so far it seems like it could be possible to survive by eating dots and power pellets while ignoring the much richer payoff from eating fruits and ghosts. Also, the value of the bonus fruits increase with each level. From this viewpoint one might expect that the correlation between duration of play and game score can be described by a strictly convex curve if there is strategic learning.

The scatter plot and exponential regression curve in figure 9 is used for testing this idea. So far the results are not convincing as there are not enough observations and the inclusion of data from the first two weeks when the experiment was not yet fully determined tend to distort the general picture. Nevertheless, as the Pac-Man score achieve during these two first weeks are important as a baseline for measuring the learning in figure 8, it seems reasonable to include them in figure 9 as well.

$$y = 2520.7 e^{0.4262x}$$

$$R^2 = 0.7985$$

**Figure 9.** Pac-Man score as a function of play time; weeks 19-25 and 26-47
4.4 Learning at level four: Context and meaning

According to Prensky (2006, p. 68), video and computer games can be understood in the context of how a game designer expresses himself. As mentioned in the theory section, there are written interviews with game designer Toru Itwani where he talks about the ideas behind the making of the game. However, when using the process of reflection-on-action before a session of daily Pac-Man practice, the researcher made the following entry in his research diary.

The Pac-Man game makes me think of Japanese culture in a stereotypical manner. Certain friends of mine with an Asian background are similar to Pac-man in the sense that [...] they tend to think in action (Pac-Man moving his lips while running around in non-stop motion), they are persistent in their aims, they respond to group behaviour, and they have a frantic tempo. (Diary entry, June 10th 2014)

In the context of TQM implementation one could say that it would be possible, at least on a superficial or cartoon-like level, to think of the Pac-Man game as a representation of the mentality of Japanese quality management at places like the Toyota Motor Corporation. In this context, the skills and values developed by playing Pac-Man could be seen as similar to how to develop skills and understanding in disciplines like Japanese archery (e.g. Herrigel, 1953), and consequently how culture and religion has influenced the philosophy and practice of Japanese quality management (Ishikawa, 1985).

4.5 Learning at level five: Implications for real world problem solving

The final level mentioned by Prensky (2006, p. 69) is learning about how the relevance of the video game as a model for representing social reality. The following diary entry resulted from a reflection-on-action before engaging in game play.

Although Whitehead’s stories about conflicts with the school administration has been an inspiration for much of the TQM implementation so far, perhaps additional insights could be found by looking at the action research accounts of people like [...] Moira Laidlaw who have been developing theories of self-improvement for teaching school in Asian cultures. (Diary entry, June 10th, 2014)

In order to characterise this final step as learning it would be necessary to consult the work of the people mentioned and verify that this could be a viable approach for improving the contextual understanding of how to implement TQM. However, as this kind of evaluation would be a natural point for “moving in new directions” (figure 3), the important thing to consider here is that the Pac-Man exercise has resulted in ideas that may result in further investigations. From the viewpoint of analysing the outcome of the experiment, this should be sufficient to say that there has been learning on all the five levels that Prensky (2006, chapter 8) define.
5. Discussion

The theoretical claim in this study is that the WikiHow Pac-Man strategy is an optimal strategy that can be implemented in an optimal manner by using the WikiHow training strategy. Through the use of an action research experiment, a learning curve has shown how the WikiHow strategies resulted in improvements in Pac-Man game play through training.

The purpose of this section is to discuss the empirical results against the theoretical predictions. This will be done by first considering the observed learning curve in relation to the expectations of the WikiHow training strategy. Then the outcome described as five levels of Pac-Man learning will be discussed against the expectations of the WikiHow Pac-Man strategy. Finally the overall outcome of the study will be compared to the general expectations of double-loop learning theory.

5.1 Expectations and observations for the WikiHow training strategy

The theoretical expectations for the WikiHow training strategy, as expressed in hypothesis 2, was that it could be seen as an evolutionary stable strategy (ESS). As was observed in the analysis of results, the WikiHow training strategy was mostly run in a state of statistical control and it resulted in getting better at playing the Pac-Man video game. Although this could be partly seen as evidence in support of the training strategy being an ESS, the competence level for Pac-Man game play at the end of the experiment was still far below having mastered the game. The high score of 47,650 points from June 15th 2014 is far below the high score of 9,500,000 points at http://www.thepacmanwebsite.com. In fact, the score does not even come close to the level represented by the end of the high score list with the person on the 300th ranking position having achieved a score of 376,460 points.

If the WikiHow training strategy was an ESS, why did the researcher not learn to master the Pac-Man during the course of the experiment? There are several possible explanations relating to how the training strategy was implemented. In the discussion of the WikiHow training strategy that follows, the five strategies listed in table 2 will be addressed before returning to the question of whether the study support the hypothesis of the training strategy being an ESS.

Training tactic 1: Schedule

The first tactic in the training strategy was to develop a training schedule in terms of spending an hour or two playing without any distractions. For the action researcher this kind of intensity in training was not possible. The statistics show that the average practicing effort was 5 minutes per day (35 minutes per week) for a period of 16 weeks. This would amount to a series of about 112 trials or 9 hours of training. Although a Pac-Man world champion like Balderramos (2008) does not explain in detail how many hours he spent practicing, it is obvious from his descriptions of training schedules that his practice effort was of a completely different order. Empirical research on developing expert skills of all
kinds suggests that expertise usually arrives after about 10,000 hours practice distributed as four hours of daily practice over a period of ten years (Ericsson, 1996).

The second part of the schedule tactic was to make sure there were no distractions. In the WikiHow strategy it is suggested that playing by night could be a relevant option. As the average game in the study lasted for about five minutes, the schedule used during the first eight weeks of the study was to have a game of Pac-Man in the afternoon in order not to interfere with other work. Towards the end of week 25, however, the schedule was changed as it seemed easier to get a few minutes without distractions earlier in the morning. As the starting point for daily training could be seen as an important aspect of the WikiHow training strategy, the change could be seen as a change of strategy, meaning that the earlier strategy was not an ESS.

**Training tactic 2: Motivation**

The second tactic dealt with the issue of motivation. According to Csikszentmihalyi (1992), a psychological state of “flow” can be achieved when there is a balance between skills and challenges in performing a task. Balderramos (2008, p. 43) refers to this state when playing the game levels 10 to 255 as these do not require the same need for concentration as the first 9 levels and the final level 256. In the Pac-Man experiment, however, the challenges were always greater than the skills, thus making the game potentially frustrating, but as the training efforts were kept low by playing one single game per day, the game was challenging without becoming too challenging. It was never experienced as confusing. It never got dull and boring.

The Pac-Man score was also an important motivational factor. The fact that video games provide immediate feedback on performance is one of the reasons Gee (2007) believes they are more efficient vehicles for learning than traditional teaching methods. Balderramos (2008) also spends much time discussing scores, both how his own score advanced as a consequence of being more competent, and how the updated recordings of Pac-Man scores in the Guinness book of records and elsewhere were both creating motivation and frustration. In the Pac-Man experiment similar emotions were observed when trying to reach platforms of learning by maintaining certain levels of score as skill was gradually being developed.

**Training tactic 3: Identifying game components**

The third tactic dealt with the issue of trying to mastering the easy parts of the game before trying out the more difficult bits. In practice this meant that the first months of game play consisted of practicing the controls and developing an intuition for the game. Sometimes this resulted in lower scores because training consisted in developing a feel for when and how to move at a short distance from the ghosts. In the Pac-Man literature (e.g. Uston, 1981; Killerklown, 2001; Balderramos, 2008), there is a much deeper understanding of Pac-Man game play by discussing tactics of which are the optimal paths to follow on each individual level and how the group the ghosts. As the WikiHow training strategy is designed for getting good at video games in general, it is necessary to experiment and consult the Pac-
Man literature in order to get an overview of the skills needed for dealing with various aspects of Pac-Man game play.

Training tactic 4: Learning through chunking

The fourth tactic dealt with the issue of developing advanced game play. According to the power law chunking model (Newell & Rosenbloom, 1981), the shape of the learning curve is a reflection of the chunking strategies used by the learner. It matters how the practitioner chunks or groups together elementary skills to be learned as complex Pac-Man manoeuvres depend on being skilled at simpler manoeuvres. As an example, Balderramos (2008, p. 42) comments on how Billy Mitchell developed his skill towards managing perfect game by focusing on grouping the monsters and ignoring patterns (optimal paths). In order to achieve perfect game, Mitchell would reject the key idea in all Pac-Man theory published so far to develop his own theory which would then ultimately prove sufficient for solving the game.

Implementing tactic 4 and 5 of the WikiHow training strategy implies going deeper into the WikiHow Pac-Man strategy and trying to implement this strategy by reading Pac-Man literature, watching Pac-Man videos on YouTube, and taking part in Pac-Man discussion forums. Due to the limited nature of the Pac-Man experiment in this study, some efforts could be made in this direction, but not enough to fully understand what competent Pac-Man gaming feels like.

Training tactic 5: Mastering the controls

The fifth and final tactic was learning to master the controls well. In the Pac-Man version being used, the controls consisted of the four arrow keys on the keyboard. Despite using only three fingers for managing the four keys, this did not seem to represent a problem. On the other hand, as explained by Balderramos (2008, pp. 30-31), mastering a sufficiently smooth touch on the computer to make perfect Pac-Man game possible is hard. This presumably means that the experiment did not result in a sufficient level of skill where the necessarily complexity of Pac-Man movement would make the controls difficult to master.

The failure in being able to develop advanced skills could perhaps be seen is the most problematic outcome of the study. In order to make the Pac-Man game into a viable model for understanding social conflict, it would be necessary to have an operational and intuitive understanding of issues such as the Pac-Man tactic that suggests learning and exploiting the psychology of the ghosts. In the experiment the behaviour of the ghosts appear more random than what was described in literature, but it never became clear to which extent parts of the artificial intelligence of the ghosts used in the original Pac-Man version had been used in the alternative version. As a consequence of this, applying the Pac-Man strategy of understanding and exploiting the psychology of the ghosts in real world scenarios would remain a theoretical exercise without the necessary tacit understanding of how this would work in the simulation model.
Is the WikiHow training strategy an evolutionary stable strategy?

As a result of discussing the expectations and outcomes from how each of the WikiHow training tactics, it becomes obvious that it is not possible to confirm the hypothesis about the training strategy being evolutionary stable. First of all, in order to secure validity and reliability for this kind of claim it would be necessary with a more elaborate game theory experiment (Cramerer, 2003). The strength of an action research study, however, is that it can be used in an exploratory manner for investigating aspects of a strategy like the WikiHow training strategy that does not empirically comply with the theoretical expectations of an ESS. As the strategy survived unaltered as the experiment drew to a close, there is nothing in this experiment that suggests that the WikiHow training strategy should not be an ESS.

5.2 Observations and expectations for the WikiHow Pac-Man strategy

The theoretical expectations for the WikiHow Pac-Man strategy, as expressed in hypothesis 1, was that it could be seen as optimal in the sense of creating a Nash equilibrium when played against the computer strategy. What this means in practice is that the WikiHow Pac-Man strategy should be sufficient for reaching the 3,333,360 score at maximal speed for the original Namco version of Pac-Man or beating the 9,500,000 high score for the Neave version.

As was pointed out when discussing the WikiHow training strategy, far more training is necessary for reaching a level of skill needed for executing the WikiHow Pac-Man strategy in a competent manner. This means that a comparison between the expectations of the WikiHow Pac-Man strategy and the observations made while trying to execute the strategy has to focus on observed failures and projected success. In the discussion of the WikiHow Pac-Man strategy that follows, the five strategies listed in table 1 will be addressed before returning to the question of whether the study support the hypothesis that playing the WikiHow Pac-Man strategy against the computer strategy gives rise to a Nash equilibrium.

Pac-Man tactic 1: Knowing the maze and keeping overview

To be able to read the whole game while focusing on the particularities is a fundamental tactic that involves all the five levels of learning from the analysis. As with all the Pac-Man tactics, having developed skills in how to master the controls (level 1) is essential for being able to execute the tactic. When using Bewersdorff’s (2007) three dimensions of skill, luck and strategy to classify games, Pac-Man is represented in important ways along all three dimensions but the relative score along the dimensions would be low on luck, moderate on strategy and high on skill.

In the analysis section it was mentioned that game play resulted in a fair amount of learning about the rules (level 2) concerning the differences between the Pac-Man version being used in the experiment and the original Pac-Man version that is the main source of Pac-Man theory. Although there were numerous findings concerning matches and mismatches, when consulting the Pac-Man literature there are numerous rules embedded in...
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the original Pac-Man software that includes “safe spots”, “blind alleys”, “home corners” for the ghosts, and software glitches that makes the game sometimes behave in ways that were obviously unanticipated by the game designers (Balderramos, 2008).

Although the WikiHow Pac-Man strategy does not specifically address all these details, the first tactic could be thought of as a means for strategic learning (level 3) about “knowing the maze” tactics. The WikiHow strategy is not designed as a strategy for winning the original Namco version Pac-Man but for winning Pac-Man in general as long as the Pac-Man version being used is reasonably consistent with the original designs.

The general insight from the study when looking at Pac-Man from a designer perspective (level 4), was to think of it as a reflection of Japanese culture in general and the TQM culture at places like the Toyota Motor Corporation in particular. A stereotypical view of Japanese culture is that it is a culture based on group thinking. The first Pac-Man tactic addresses the issue of keeping an eye on the trouble-makers as a group while dealing with the individuals one by one.

The implications of this interpretation in terms of how to apply the tactic in the real world (level 5) is to understand management as a group when trying to prevent them from terminating the TQM implementation effort. It could also be mentioned that Simon (1996) describes the maze as a highly useful representation for any kind of decision problem. In the context of TQM, the movement around the maze does not necessarily correspond to any physical movement within the organisation. It is a topological map describing the nature of how the potential decision points are linked together. Øgland (2009) gives a detailed account of how the different Pac-Man symbols and decision points can be interpreted in the context of designing and auditing quality management systems.

Pac-Man tactic 2: Options and patterns

The focus of the second WikiHow Pac-Man tactic builds on the first tactic in the sense that it suggests how to exploit the knowledge of the maze and the nature of how the ghosts are programmed for moving around and cleaning the board. The tactic consists partly of exploiting parts of the maze where there is a short distance between the decision points and partly in discovering patterns (optimal paths) for traversing the whole maze. This latter part of the tactic is widely discussed in the Pac-Man literature and is described as the key for mastering the game (Uston, 1981; Balderramos, 2008). However, as was discovered when testing the rules of Neave’s Pac-Man against the original rules (level 2 learning), the behaviour of the ghosts in Neave’s version appears to be more random. This may imply (level 3 learning) that the idea of looking for patterns is not be equally relevant.

When trying to understand the differences in game design from a cultural perspective (level 4 learning), a stereotypical view is that Japanese managers may be more driven by a combination of aggressiveness and elaborate ceremonies, like martial arts warriors, while European or American management practice could be seen as mixing aggressiveness with behaviour that looks more random. One way of characterising the difference between the ghosts in the Namco version of Pac-Man and the Neave version could thus be to say that in one version they are like samurai warriors while in the other version they are more like cowboys.
The implications of this interpretation when considering the implications of the Pac-Man tactic in real-life situations (level 5 learning) is that bureaucracies and cultures drives by predictable rule behaviour should be exploited when trying to implement TQM. In a similar way it is necessary to exploit the predictably unpredictable behaviour in organisations that are less ceremonial.

**Pac-Man tactic 3: Concentrate on amassing as many points as possible**

There are two messages in the third tactic that are consistent with the strategies described in the Pac-Man literature. While the aim of the game is to amass as many points as possible in the shortest time possible, this is not possible unless one has developed an extreme level of skill (Balderramos, 2008). This means that less skilled players should start by learning to how clear the map, learning how to eat the bonus fruits and learning how to eat as many ghosts as possible. In the original Pac-Man version the game gets progressively more difficult with each level. When analysing the outcome of playing the Neame game, however, there seems to be less difference between each level (level 2 learning). If this should be true, then a much lower level of skill is needed for playing Neame’s Pac-Man than the original Namco Pac-Man (level 3 learning).

One explanation for some of the differences between Asian and European culture is that methods for surviving in a rice economy are very different for methods needed for surviving in a European farming culture (Gladwell, 2008). As rice cultivation requires less space and more time and precision, this could explain the extreme complexities of the original Namco Pac-Man (level 4 learning). In terms of level 5 learning, applying the Pac-Man tactic in real-world problem solving consists of attention to detail, persistence and continual learning. In the world of Pac-Man it took almost 20 years before somebody were sufficiently skilled to be able to play a "perfect game" that would result in a score of 3,333,360 points. In the world of TQM, at Toyota they introduced statistical quality control (SQC) in 1949, but it was not until about 20 years later, in 1970, that they won the Japanese Quality Control Award (Liker, 2004).

**Pac-Man tactic 4: Beware of the jail entrance**

The fourth WikiHow Pac-Man tactic about be aware of the time and place where the blue ghosts regenerate as dangerous adversaries is a general insight that applies to all Pac-Man versions. The relevance of this tactic was experienced many times while experimenting with Neave’s Pac-Man. At the first three levels of learning there is little to add about this tactic beyond saying that it is important and relevant. However, at the fourth level of learning the design of a jail area at the centre of the maze is an interesting metaphor that fits well with the idea of making use of critical theory as a foundation of TQM implementation (Flood & Jackson, 1991; Flood, 1993).

When Foucault (1975) uses the prison as a metaphor for describing various institutions such as schools and universities, the main line of conflict is between the institution on the one side and the students on the other. When Whitehead (1993) describes his experience as a teacher and lecturer, he describes the challenge though a
dilemma of wanting to help the students in accordance with his beliefs in values like justice, freedom and care for the other while on the other hand experiencing that the values being imposed on him from the institution makes it difficult to implement this agenda.

If one were looking at the situation from a more general perspective, as a conflict between capital and labour (Braverman, 1974), the position taken by Whitehead could be thought of as the position of science and technology in an intermediary position that can be used alternately for the purpose of oppression and emancipation. Whitehead could either see himself as an instrument of discipline and punishment for making the students align with the requirements of the institutions, or he could see himself as an instrument of emancipation in helping the students evolve into responsible individuals. As a consequence of experiencing this kind of dilemma he is lead towards a path of self-improvement in trying to live in accordance with his ideological beliefs while at the same time trying to survive within the institutional setting. The result can be described as a sequence of moves and counter-moves as he tried to work his way through this game-like complex scenario.

The autobiographical story told by Øgland (2013) is similar to Whitehead’s story in many ways. Like Whitehead he is trying to help a group of people to develop as responsible professionals by living according to his beliefs, values and feelings about care, trust and workplace democracy while observing how such ideals are often difficult to follow when they are inconsistent with the beliefs, values and feelings expressed by the institution itself. He consequently tells a story about implementing TQM through the use of critical theory for the purpose of aiding the workforce against the oppression of management. In a similar way to how Whitehead told his story, also in this case the Foucault perspective on organisations as prisons makes sense. Like the jail entrance in the Pac-Man game, implementing TQM represents a moral dilemma as it can be used as a tool for deskill ing and making the workforce expendable and it can be used as a tool for professionalizing the workforce.

The practical implications of the jail entrance tactic in terms of real-world applications (level 5 learning) can perhaps be best articulated in terms of what Lomax, Whitehead and Evans (1996) say about the importance of developing an epistemology for quality management. Unlike theories of knowledge about quality management based on how researchers visit and interpret TQM implementation in action or how questionnaires are used for polling the opinions about TQM implementation, it is self-study action research describing the struggles of TQM implementation from a first-person perspective that is necessary for understanding how to succeed in the long run (Øgland, 2013).

**Pac-Man tactic 5: Learn how the ghosts think**

The final WikiHow Pac-Man tactic is perhaps the most important and difficult of all the tactical aspects that make up the WikiHow Pac-Man strategy. As pointed out by Balderramos (2008), it is possible to achieve extremely high Pac-Man scores by using the previous tactics at a high level, such as knowing and following the patterns associated with each level, but perfect game play cannot be achieved without understanding the psychology of the ghosts. As pointed out earlier, the psychology of the ghosts in Neave’s Pac-Man may be simpler than the original version of the game (level 2 learning), which would then make the overall strategy less complex (level 3 learning), but the empirical data collected through game play indicates that the game is still a difficult game to master.
A stereotypical observation of Japanese management as compared with Western management is the focus on teamwork. The ghosts in the original Namco version of Pac-Man work as a team. Although the psychology for each of the ghosts is different, and it is sometimes possible for Pac-Man to outmanoeuvre an individual ghost, they are much more difficult to handle as a group. It has been pointed out that the psychology of the four ghosts resemble the four corners of Blake-Mouton management grid (Øgland, 2009), but as the ghosts in Neame’s Pac-Man are more individualistic than their Japanese colleagues they do not pose a threat in the same way.

An implication for real-world problem solving (level 5 learning) is that management culture plays an important part in TQM implementation. In order to play a perfect game it is necessary to chase down and eat each and every ghost, which can only be done by having a deep psychological understanding of how each of the adversaries think as individuals and as a group. When implementing TQM it is similarly necessary to develop a psychological understanding of how all powerful people within the organisation think and act as individuals and as a group.

**Does the WikiHow Pac-Man strategy create a Nash equilibrium?**

Similar to the final comment about the WikiHow training strategy, it is not possible to confirm the WikiHow Pac-Man hypothesis based on observations made in this study alone. In order to secure validity and reliability for this kind of claim it would be necessary with a more elaborate game theory experiment (Cramerer, 2003). Where an action research study can be of practical use, however, is in searching for empirical evidence to refute the claim that WikiHow Pac-Man strategy is not optimal. However, nothing has been found in this study to refute this claim. As the study has not found anything to gain by replacing the WikiHow Pac-Man strategy with a different strategy when playing against the machine, this should be read as a strengthening of the hypothesis that the WikiHow Pac-Man strategy is optimal.

**5.3 Observations and expectations for Pac-Man double-loop learning**

When framing the Pac-Man learning experiment within the context of double-loop learning, the expectations are that learning will most likely happen within the inner loop of procedural learning but hopefully also in the outer loop of challenging some of the governing variables (Argyris & Schön, 1978). In other words, the expectations of the experiment is that learning will emerge in the sense of not only improved skilled in executing the WikiHow Pac-Man strategy but also questions about how the WikiHow training strategy should be implemented in order to make learning more effective.

When comparing these expectations with the observations reported as part of the analysis of the study, the learning curve shows increase in skill and changes in the schedule parameters show reflections on how the training strategy was implemented. One governing variable that was left untouched, however, was the implied hypothesis that playing a game like Pac-Man impacts on how a person deals with real world decision situations (Wade & Beck, 2004).
One common criticism of video game learning is that people may not necessarily learn the kind of knowledge they were designed to teach. For instance, the game of Monopoly was originally designed as a critical tool for teaching about the dangers of capitalism and the importance of tax reforms (Orbanes, 2006), but is today perhaps better understood as a game teaching exactly the opposite values (Wuffle, 1978). The Pac-Man model was conceptualised as a critical tool for teaching how TQM can be implemented for the purpose of professionalizing the workforce, when reviewing literature on how TQM can be applied in the school, Lomax, Whitehead and Evans (1996, p. 2) observe how TQM implementation often has to align with the dominant organisational ideology in order to get implemented. In other words, is there a risk that the interpretation of the conflict between Pac-Man and the ghosts as a conflict between the change agent and representatives of management may be more easily understood as a conflict between the change agent and representatives of the workforce when used in practice?

As this is indeed a valid point, it only makes the key idea of living theory action research more relevant, namely that theory is always expressed within an ideology of a living individual or a group of individuals. In other words, the governing variable that is left unchanged in the double-loop learning is the ideology of the researcher which gives allows the Pac-Man model to be a meaningful representation of the dilemma the practitioner-researcher is experiencing in terms of being challenged on his own values, emotions and beliefs and how he is trying to improve himself by trying to live in harmony with his own ideals (Whitehead, 1989).

6. Conclusions

The conclusion section discusses the implications of the study for research and practice. It then indicates some limitations due to the nature of the research method and directions for future research.

6.1 Implications for theory and practice

The investigation has made it possible to empirically confirm the impact of applying the WikiHow strategy for learning how to understand the Pac-Man model of TQM implementation. Previous research has either focused on the Pac-Man model as a semiotic system that can be used for representing various types of mechanisms and conflicts, including TQM implementation in political environments, or it has focused on the history, social context and mathematical nature of the Pac-Man video game. No previous research has been found dealing with the interface between these two approaches in terms of investigating and applying “living theory” to investigate how a person may improve his skills in TQM implementation through the use of Pac-Man simulations.

For the action research community developing educational living theories for individuals and organisations, the main contribution to theory and practice from this study is in pointing out the usefulness of models such as the Pac-Man video game model for translating both declarative and procedural knowledge from one particular action research study into another. In the introductory part of the paper it was suggested that the Pac-Man
model could be used for mapping insights from an action research study in a school environment (Whitehead, 1993) into a public sector TQM implementation environment (Øgland, 2013), but it was argued that a mapping of this sort would be superficial unless the potential learners developed an understanding of the model as a “living model” corresponding with the ontological and epistemological aspects of action research based on the “living theory” philosophy.

As the action research experiment confirmed that the WikiHow strategy for learning Pac-Man resulted in actual learning, although not necessarily optimal learning, the practical understanding of the Pac-Man model made it possible for the TQM implementers to identify with the action researcher fighting the school bureaucracy by way of feeling the frustrations and challenges within the school scenario through the simplified yet challenging Pac-Man simulation. Although the use of video game models has become more pronounced in educational research (e.g. Schaffer, 2006), the educational focus has primarily been on the use of game models for helping the pupils or students to learn – not the action researchers.

More specifically, the outcome of the research presented in this paper makes an explicit contribution to the theory of TQM and organisational learning as developed by members of the “living theory” community (Lomax, 1996; McNiff & Whitehead, 2000). While this kind of living TQM theory stresses the importance of understanding people, organisations and dilemmas involved in trying to improve, the richness of these action research studies can make it difficult for one action researcher to grasp relevant findings from action research conducted in a very different organisational environment. The Pac-Man video game model, however, is an example of what might be described as a “living model” in the sense that it not only works as a traditional scientific model in the sense of providing a method of providing a mutual representation for different social systems but it is also a “living theory” model in the sense that a proper understanding of the model that goes beyond the mathematical. A living model should also represent values, emotions and paradoxes in the same way as a deep understanding of people and organisations can only be achieved by focusing on issues like values, emotions and paradoxes (Whitehead, 1989).

The TQM action research was motivated by the way the New Public Management (NPM) ideology suggests that public sector organisations can be rendered more cost-efficient without having significant negative side-effects by applying market-oriented management. The research thus makes a contribution to practice in suggesting how the Pac-Man model and related models are important for understanding the differences and similarities between public sector and private sector organisations when trying to implement TQM. In traditional game theory, it is usually sufficient to think of man as a rational actor trying to optimise his payoff. When extending the class of game models used in game theory by including video games that can only be understood through skill and practice, economic man is substituted with learning man as a role model. The metaphor of the market place is replaced by the metaphor of the university. Payoff measured in dollars and pounds is replaced by payoff measured in citation indexes and impact factors.

In other words, what the research suggests about how to think about NPM in practice is that the Pac-Man perspective on action research is a world where the action researcher is in constantly on the move through the maze of data collection while being chased by the administration or others who base their positions on hiding knowledge. The
dynamics of the game may be occasionally changed when the action researcher publishes important work, and thus causing panic among the antagonists, but not for long. The impacts on the organisation as a whole depend on how long the action researcher is able and willing to survive. If the action researcher is as addicted to his work as a Pac-Man enthusiast is to beating the Pac-Man game (Balderramos, 2008), he will not give up doing action research until he is forced to do so.

What living TQM theory can say about NPM is that the development of learning organizations may be more easily facilitated by looking at universities and R&D departments as models for the organization as a whole rather than looking at the marketing, sales and finance departments.

6.2 Limitations and directions for future research

This study has several limitations that may suggest further possibilities for empirical research. Unlike other types of research, like behavioural studies through laboratory experiments or questionnaire research aiming to poll the opinions of large samples, action research of the type used in this investigation is primarily designed for single subject research in the sense that the researcher is trying to poll his own mind and control his own behaviour. On the other hand, the target population is quite wide as the outcome of the research claim to say something meaningful about the implementation of TQM in political environment in a rather general context. A natural direction for further research based on this premise is to have the study replicated by different researchers to see whether this would result in different learning curves and different insights on how the growth in practical skill at playing Pac-Man would influence the understanding of TQM implementation.

Another limitation has to do with the use of statistical methods and methods of research control. Although the use of statistical process control (SPC) was ideally suited for making sure that the action research process worked in a predictable manner, the independent variable used for defining the daily training schedule was conditioned by practical issues of when it was possible to play and thus not something that could be easily controlled. This is reflected in the research outcome where it is reported that learning happened under conditions A rather than using something like an A-B or A-B-A design to compare how the training schedule might effect the learning process. Although an action research is often more controlled by the environment than the researcher, by continuing the research the environment may result in needs to redesign the schedule which could then be used for making the current research design part of a larger A-B or A-B-A design.

A third limitation in the study is that the WikiHow strategies were chosen from the viewpoint of convenience rather than being the result of a theoretical understanding of learning theory and Pac-Man theory. The only reason to believe that the WikiHow strategies would work were due to the fact that they had been designed by skilled enthusiasts and they seemed more relevant for the Pac-Man clone being used for empirical experiments than the strategy literature that provide insights about the original Namco Pac-Man game. Unfortunately, this means that it is difficult to use the strategy hypotheses for explaining defects or inefficiencies in learning. Although the research could be seen as a starting point
for discovering optimal strategies for learning Pac-Man game-play, further research in this direction would require mathematical analysis and computer simulations.

A fourth direction for future research is to study the correlation between practicing TQM implementation through Pac-Man simulations and actual TQM results from trying to implement TQM in real life organisations. Previous research (Øgland, 2009) has looked at the Pac-Man model as an explanatory model for investigating the impact of change agent’s skill in Pac-Man game-play on the TQM implementation results for the organisation as a whole. The current findings shows that it takes time to develop skills in Pac-Man game-play, but it is still not clear to which extent these skills will impact on the actual TQM implementation for the organisation as a whole. Further research is needed for analysing the causal relationship between understanding of the Pac-Man model (X), ability to put the model to use (Y), and impact on TQM implementation success (Z).

The motivation for investigating how to develop skills in Pac-Man game play came from the idea of using the Pac-Man video game to simulate TQM implementation in political environments. It had already been suggested that the Pac-Man game could be used for such purposes, explaining how the game can be used for representing the dynamics of TQM implementation in such environments, and what this mean in terms of strategies for the people in charge of TQM implementation.

A fifth limitation involves the nature of the Pac-Man game as a survival game. The more skilled a person is in playing Pac-Man, the more time the daily practice will take. On the other hand, if the Pac-Man model should be of practical use for somebody interested in it as a model for TQM implementation and organisational change, the aim of the study was to investigate strategies for developing skills in running the Pac-Man simulator with a minimum level of effort. The findings indicate that it is possible to develop reasonable skills with reasonable little effort, but further research is needed for understanding what level of effort is needed for developing higher levels of skill.

References


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