R&E-SOURCE *https://journal.ph-noe.ac.at*
Online Journal for Research and Education
Special Issue 24, July 2022, ISSN 2313-1640

Selected methods of Leagile processes in the field of education

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https://doi.org/10.53349/resource.2022.iS24.a1107

Abstract

This article focuses on the concept of lean and agile processes, compares these two methodologies in terms of added value for the supply chain and logistics and their applicability in education. This is not a new development phase, but a new perspective on this issue. Knowledge of methods and their optimization is a great advantage for every company because the supply chain and logistics as processes are more important from year to year and a properly functioning supply chain is a great advantage over the competition. That is why it is important to focus on educating people before starting work because in the future they will be co-responsible for the success of the business. Education should start in primary and secondary school because future graduates are often employees of companies implementing new processes. This article discusses the mentioned methods, especially from the application point of view, and suggests some ways that can help their successful implementation.

Keywords:
Lean
Agile teaching methods (example)
Optimization
Education

1 Introduction

These days, if a company wants to stay alive, it has to do its best to keep its competitiveness in both, domestic and foreign markets. The pressure of a competitive environment is greatly influencing the business activities, strategic goals and economic results of every company.

In the environment of business systems, the planning process requires not only an increase in flexibility and adaptability but the development of mutual activities that create and bring value to customers. As a result, principles such as cooperation or integration of information and communication technologies are being highlighted.

These methods (*Lean*, *Agile*, and *Leagile*) should not be isolated within the supply chain, even though they have some contradictory traits. On the contrary, compromises between these methods might help the company.

A trait that is common to all three methods is the necessity of sustainability of the established system. Here, the focus is not on the methodologies themselves, but on the people using them.

The aim of this article is to use the comparison of these methods and imply and discuss possible ways of successful implementation and consequent sustainability of the companies' established system.

Studies have estimated that 20% of logistic costs are related to warehousing and that up to 65% of total warehouse operating costs are because of order picking, that is, the process of retrieving articles from a storage area in a warehouse to satisfy customers' demands (Frazelle, 2002; Thompkins, 2003).

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2 Lean and Agile methods

The terms leanness and agility should not be interchanged, since they may intersect each other. Such intersection may offer a more significant effect than each of the methods separately (Christopher, 2000b). However, it can vary in each organization. It is therefore important to examine these methods and understand their benefit to society.

2.1 History of Leagile methods

Although most of the literature defines the terms Lean and Agile separately, several authors Mason-Jones & Naylor & Towill (2000), Christopher & Towill (2000) addressed a mutual intersection. The goal is to find mutual connections between agility within the supply chain and the leanness of the company as a whole. Knowledge of such relation is necessary when starting to implement these methodologies since both of them should be implemented concurrently. (Mollenkopf & Stolze & Tate & Ueltschy Green, 2010)

Leanness and Agility are models that are not nearly similar to each other. Both have their advantages in different areas and directions, however, both approaches may complement the other, thus enabling to establish of a hybrid strategy (Christopher, 2000). Such hybrid strategies may lead to the creation of cost-effective supply chains (Christopher, 2000).

2.2 Fundamental Principles of Leagile methods

Leagile Manufacturing is a combination of lean and agile methods in terms of the whole supply chain. It features a decoupling point placed to best suit the volatile demand and provides comfort planning and source optimization. (Naylor & Naim & Berry, 1999)

Basically, it uses the Agile Manufacturing principle in facilities with unstable demand, and the Lean Production where demand is stable. The practical way of combining the Lean and Agile methods may be for example when using the decoupling point. The purpose of such a point is to make the chain lean before this point and agile after this point (Hoekstra & Romme, 1992). The method allows high productivity, low costs of production, and agile processes. The whole system can be perceived and set from two perspectives – time and costs. (Tompkins & White & Bozer & Tanchoco, 2003).

Another perspective on this hybrid strategy may be dividing the portfolio into two parts, the first part will relate to good prediction and stable demand (using Lean Production), and the other part is unstable custom production (using Agile Manufacturing), similarly to the description of in (Mason-Jones & Naylor & Towill, 2000).

Additionally, it is possible to divide the demand into the fundamental part governed by means of the Lean method and balance the deviations using Agile methods. (Christopher & Peck & Towill, 2006)

Regarding the frequency of changes in market conditions, this strategy will be modified several times during a life cycle of a product.

3 Application in the warehouse

A well-established technique for optimizing order picking is order batching (de Koster & Roodbergen & van Voorden, 1999), that is, grouping orders and picking them in a group in a single picking tour. Thus, the order batching problem seeks to cluster orders into groups so as to minimize the total order processing time, which includes travel time, search time, pick time and setup time. Travel time refers to the time required for an order picker to travel between locations in the order picking tour, search time refers to the time required to identify the articles to be picked, pick time refers to the time required to transfer the required number of articles from their storage locations to the cart or vehicle and setup time refers to the time required for administrative and setup tasks at the beginning and the end of each picking tour (Chew & Tang, 1999). A typical distribution of order processing time can be found in Figure 1.

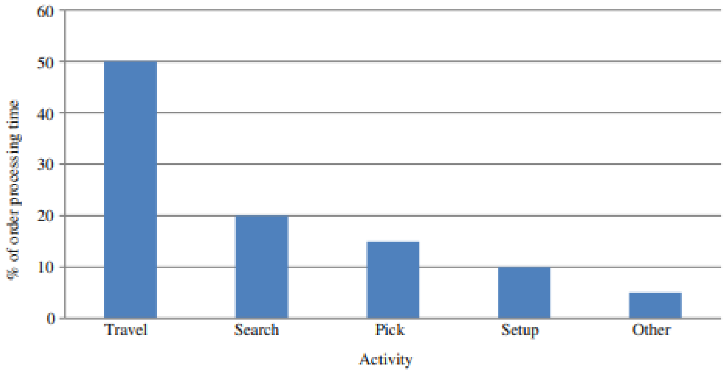

Fig. 1: Typical distribution of order processing time (Thompkins, 2003)

Because of the significance of travel time, the objective function in the order batching problem is usually the minimization of the travel time (or distance) across all picking tours.

The picker routing problem seeks to minimize the distance traveled by a (single) picker, given a set of pick locations that have to be visited. It is a special case of the traveling salesman problem due to the typical rectangular layout of the storage area in a warehouse. Ratliff & Rosenthal (1983) have shown that the picker routing problem can be solved in polynomial time. However, their algorithm is too time-consuming to be incorporated as a subroutine in the algorithms for the order picking problem. Furthermore, the resulting order picking tours are not necessarily intuitive and may, therefore, increase the number of picker errors. As a consequence, researchers have focused more on restricted routing strategies, that is, routing strategies that produce pick tours with a specific structure. Figure 2 displays the S-shape, the return, the largest gap and the combined strategies (Hall, 1993)

- In the S-shape routing strategy, an order picker enters an aisle and traverses the aisle if there exists at least one article that has to be picked from that aisle, then goes to the next aisle. The order picker returns to his starting point after traversing the last aisle which has to be visited.
- In the return strategy, an order picker enters an aisle and returns after visiting the most distant pick location.
- In the largest gap strategy, an order picker traverses the first and last aisles from which articles have to be picked entirely, whereas the other aisles are traversed partially, in and out, from both ends, in such a way that the distance that is not traversed is maximum.
- In the combined routing strategy, each aisle is either traversed entirely or entered and left from the same end, which usually generates a near-optimal solution (Bartholdi & Hackman, 2011).

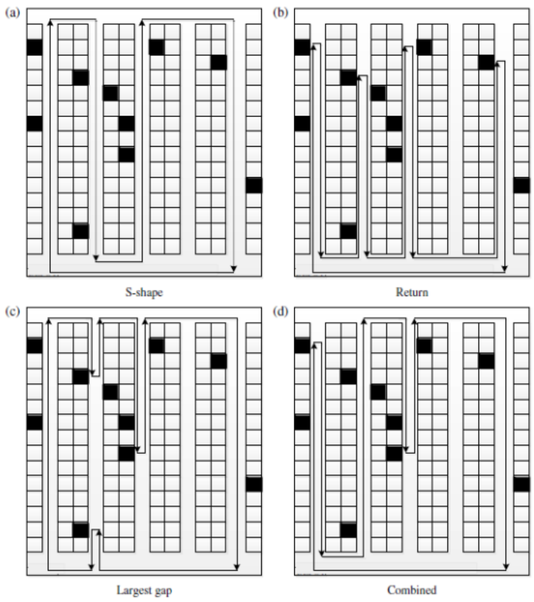

Fig. 2: Restricted routine strategies

All strategies involve the solutions to two fundamental aisle routing problems (see Figure 3):

- optimally pick all required items while traversing the entire aisle (referred to as the passing strategy);
- optimally pick all required items and return to the end of the aisle were entered (referred to as the returning strategy).

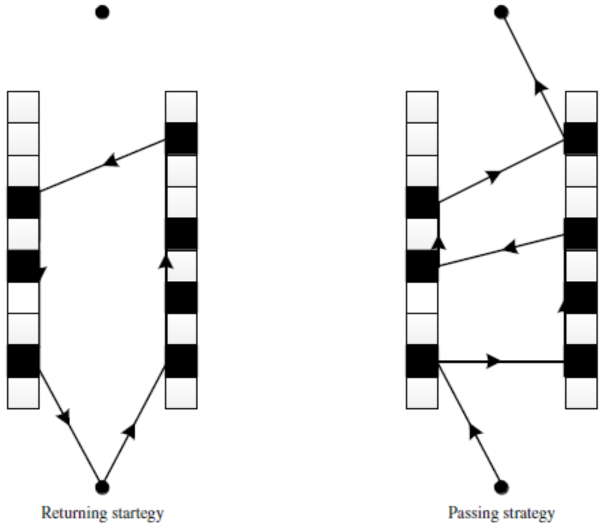

Fig. 3: Two aisle routing problems.

In most of the algorithms for the order batching problem, the travel time incurred while crossing from one side of the aisle to the other side of the aisle is ignored for efficiency reasons. In this paper, we show that these two aisle routing problems, which are special cases of the travel salesman problem, can be solved efficiently: for the passing strategy in $O(n^2)$ time and for the returning strategy in $O(n)$ time, where n is the number of pick locations in an aisle. Because $O(n^2)$ time may be computationally prohibitive when solving large instances of the order batching problem, we show that an approximate cost for the passing strategy, derived from the minimum spanning tree for the pick locations, can be computed in $O(n)$ time. The details are provided in the next section.

4 Case study

4.1 Warehouse picking operations simulation

Due to the huge number of orders for picking in modern warehouses, multi-person and multi-review stations are usually applied to improve the efficiency of operations. Therefore, this chapter explores the process of multi-person and multi-orders by opening four review stations FH01, FH03, FH10, and FH12 to provide the optimal picking path. The random number is generated by the Monte Carlo method to assign the initial position of the picker stochastic as the initial parameter of the algorithm, and the optimal picking path of the order is calculated by the simulated annealing algorithm. In addition, the optimal distribution of orders is achieved by following the shortest waste road principle, maximizing the efficiency of delivery and the utilization rate of the review station.

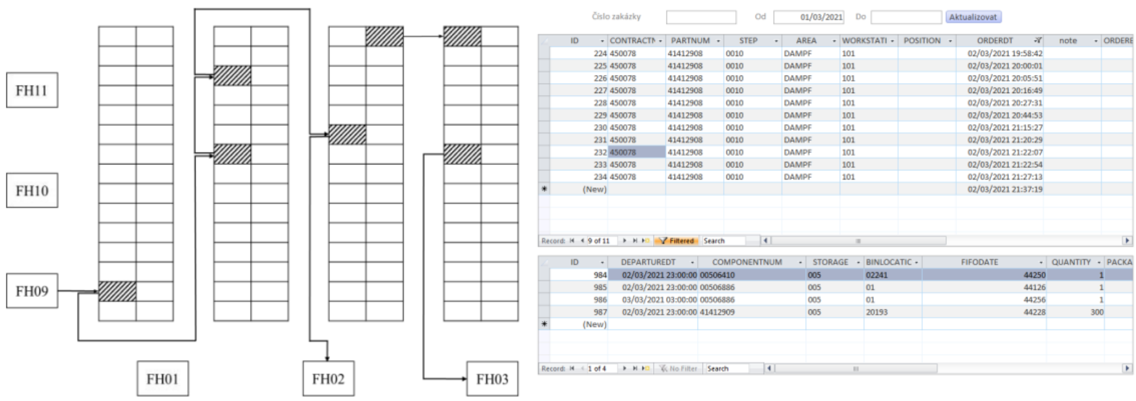

Fig. 4: Part of the warehouse route

Taking 9 pickers processing 49 combined orders as an example, the pickers are regarded as equivalent individuals, so the initial locations are randomly assigned. Initially, only 4 review stations FH01, FH03, FH10, and FH12 will be opened, which are set to serial numbers. Generate random numbers by the Monte Carlo method and assign them to pickers 1-9 as their initial location

In order to shorten the shortest picking path, waste roads need to be reduced. In other words, the sum of the distance from the initial review station to the first cargo box and the distance from the last cargo box to the return review station should be as short as possible, thus the waste function of the *n*-th order is defined:

$$h(x)^{(n)} = x_{0i}^{(n)} + x_{i0}^{(n)},$$

Where $x_{0i}^{(n)}$ represents the distance between the first review station and the first cargo box in the *n*-th order and $x_{0i}^{(n)}$ represents the distance between the first box and the final check box in the *n*-th order. Based on the shortest waste road principle, the most suitable orders are selected for 9 pickers from 49 orders to achieve the optimal distribution of orders.

4.2 Obtain the optimal route through a simulated annealing algorithm

This part discusses the problems of multi-person, multi-order, multi-review stations, and solves the travel salesman model through the simulated annealing algorithm. The simulated annealing algorithm is a greedy algorithm, which is a random optimization algorithm based on Monte-Carlo iterative solution. This algorithm escapes the trap of local optimal solution and obtains the approximate optimal solution through iteration. Based on the above model, the optimal picking path and the optimal distribution method, and the delivery time of each order picker are obtained (Khairuddin & Zainuddin & Jiun, 2017). Since more orders are processed through fewer review stations, and it takes an extra 30s to pack, queuing may occur when only 4 review stations are open. Therefore, the total order processing time includes picking time and queue time. From Table 1, the utilization rate of each review station is 1.7%, 7.5%, 13.3%, 5.8%, respectively. The low utilization rate of FH01 and FH12 is attributed to the fact that their location is far from the centre of the warehouse, which leads to a longer waste distance when starting again. The higher utilization rate of FH03 and FH10 is due to their superior location. In this way, the goods can be placed in zones to reduce the distance of waste, thereby balancing the utilization rate of the review station and making full use of limited resources. The review station closer to the warehouse centre should be opened first when there are fewer orders, so as to improve the efficiency of warehouse delivery.

Review station	**FH01**	**FH03**	**FH10**	**FH12**
Utilization rate	1,7%	7,5%	13,3%	5,8%

Table 1: Utilization rate of four review stations

5 The Travelling Salesman Problem at School

In previous sections, we have discussed the Travelling Salesman Problem from a corporate perspective. This goes hand in hand with employee training. There are two options, either to train employees during their employment or to prepare future employees during their time at primary or secondary school. According to the Framework Education Programme (FEP) for ISCED 2 (ISCED = International Standard Classification of Education), some objectives of basic education that will help us, in this case, are (FEP, 2017):

- encourage students to think creatively, reason logically and solve problems;
- to develop students' ability to work cooperatively and to respect their own and others' work and achievements.

These objectives are linked to the key competences (FEP, 2017): Working competences

According to the FEP (FEP, 2017), at the end of primary education a student:

- Uses materials, tools and equipment safely and efficiently, follows defined rules, fulfills duties and obligations, adapts to changed or new working conditions;
- he/she approaches the results of work activities not only in terms of quality, functionality, economy and social significance but also in terms of protecting his/her health and the health of others, protecting the environment and protecting cultural and social values.

Now we are going deeper and deeper into the Objectives of the Educational Area Mathematics and Its Application (FEP, 2017):

- developing combinatorial and logical thinking, critical reasoning and clear and factual argumentation through mathematical problem solving;
- to build up a vocabulary of mathematical tools (numerical operations, algorithms, problem-solving methods) and to use the acquired mathematical apparatus effectively;
- performing problem analysis and solution plan, estimating results, choosing the correct procedure to solve a problem and evaluating the correctness of the result given the conditions of the problem or task.

Finally, the Expected Outcomes according to (FEP, 2017) are:

- M-9-1-08 formulate and solve a real-world situation using equations and systems of equations
- M-9-1-09 analyse and solve simple problems, and model-specific situations using the mathematical apparatus of integers and rational numbers
- M-9-2-05 mathematizes simple real situations using functional relationships
- M-9-4-02 solves spatial imagination problems, applies and combines knowledge and skills from different thematic and educational areas

Analogous extracts could be made from other Educational Areas of the revised FEP (FEP, 2021). In the same way, we can look at education in secondary schools (ISCED 3), in whose FEP we could again find objectives, competences and expected outcomes that support this work in warehousing and order processing at the lowest possible cost. When examining the FEP for Vocational Education (FEP VE), this task would already be more difficult. The individual FEP VE differ in some parts, but a generalised look at the FEP VE shows that they also support work with the above practices.

Students do not only encounter these problems during their studies or while working in the warehouse but also in everyday life. If we stay with the storage of products so he is close to the shop. As customers, we move between the shelves and put the goods in the basket. Our movement in the shop can be chaotic. However, we can move according to the list of items in the shopping list and our knowledge of the goods arrangement in the shop/market. The beginning and end points are usually the same door.

We can still stay in the shop, on the sales floor, looking from the other side, the employee side. We will be dealing with the task of replacing the price tags on the goods. The beginning and end point, in this case, will be the employee's office.

Other activities that we perform in our daily lives using their planning and execution The Travelling Salesman Problem are:

- waste collection;
- delivery of goods/food;
- Street cleaning (spring cleaning or removing snow);
- mail delivery;
- Lawn mowing;
- electricity, gas distribution;
- shift management;
- security service work in guarding a large building.

Example: Let's imagine a lawn with dimensions N×M that we want to mow. We have a mower that can only be moved horizontally or vertically. We start in the bottom left corner, and we want to pass each box just once (start is an exception) and return to the beginning. There are flowers growing on the lawn that we do not want to mow (one box).

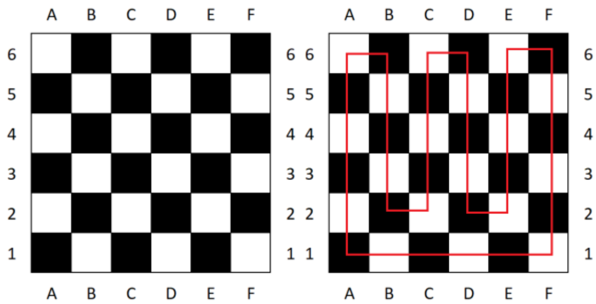

Fig. 5: Lawn segmentation into squares (left); Lawn segmentation into squares with solution (right)

We want to go through all the boxes one by one, each just once, and go back to the beginning. This can only be done if we have the same number of black and white boxes. This occurs when at least one dimension (number of boxes) of the lawn is even.

Let us assume that at least one dimension of the lawn is even and try to construct a solution. The starting box is A1. We will start right up to the edge (box F1). Then in alternating columns, we will go up and down until we get back to the beginning. See Figure 5.

We have the same number of coloured boxes only if the lawn has both dimensions odd and the flowers lie on the black box. Otherwise, we know that the lawn cannot be mowed.

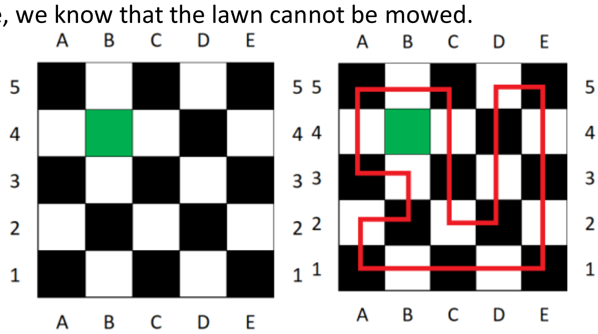

Fig. 6: Lawn segmentation into squares with flower box (left); Lawn segmentation into squares with flower box with solution (right)

For odd dimensions and flowers on the black field, we construct a similar solution as for a lawn without flowers. Starting on box A1. Go right (E1) and then alternate up and down. The difference is that in some of the pairs of columns containing flowers we will zigzag to encircle the flowers. And when to zig? It will be when we first enter the flower column. See Figure 6.

It can be seen that in all cases we can perform this task manually without the help of technology. Such simple, but time-consuming examples can already be handled by students at primary school. Such tasks, however, have a cross-curricular relationship between Mathematics and Computer Science and a great deal of overlap with the practical life for which Primary, Secondary and G schools prepare. The above-presented examples have a cross-curricular relationship between Mathematics, Computer Science or Physics and great relevance to the practical life that Primary and Secondary schools prepare.

6 Conclusion

In current conditions, orienting on Leanness is no longer sufficient and the principles of Agility are joining the game. A mutual and important perspective is that these methodologies do not have their added value in simple implementation in the given company, but in setting behaviour for the whole supply chain, where everyone solves the occurred problems and shares information with each other.

We investigate two fundamental aisle routing problems that arise in the context of order picking in the warehouse. The routing problems can be viewed as Euclidean traveling salesman problems with points on two parallel lines.

Picking operations is an important part of logistics warehouse operations, and a reasonable selection of picking paths can reduce operating costs and improve logistics efficiency. In response to this problem, the simulated annealing algorithm is designed according to the shortest waste road principle and the travel salesman problem model. Finally, this article obtains the optimal allocation method of orders, the optimal picking path of the order, and the utilization rate of the review station. In addition, through the analysis of the results, suggestions are made to improve warehouse delivery efficiency.

The Travelling Salesman Problem is a combinatorial optimization problem, therefore we have given a link to the school curriculum and its mathematical parts.

Not only in school practice, but we can also extend the task to more " Salesman". Every Salesman has one starting point to which they return after completing their route. The goal of the multi- Salesman problem is to minimize the length of all routes taken by all Salesman. The goal of a task with multiple Salesmen is to minimize the length of all routes and reduce the working time of all Travelling Salesmen. This simulates multiple machines handling our goods.

We have shown examples that can be included in school practice and prepare pupils/students for such tasks that relate to work in warehouse management or reducing time in performing necessary activities.

Acknowledgements

This paper was supported by Masaryk University - Specific research - support for student projects, Reg. No.: MUNI/A/1356/2020.

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