Prevalence Study of Lean Management in Academic Education

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Abstract
A successful implementation of Lean Management requires specialists who understand the methods and techniques used in a company and know how to use them in a highly efficient way to optimize processes under review. Copying existing approaches is not sufficient. It is crucial to understand the concept of Lean Management. Institutions of higher education play an important role in teaching Lean Management to students. Additionally, higher education institutes (HEI) can contribute by offering executive education to non-students and other interested parties. The purpose of this study is to determine the degree of dispersion of teaching Lean Management in higher education and to analyze if the type of HEI affects prevalence. For the realization of the research objective, the cross-sectional study has been selected as an empirical approach. Based on a structured document analyze, course-relevant and legally binding documents of all departments were searched for Lean Management. Results indicated that there is no difference in teaching Lean between Hochschulen and universities. Offers in executive education are more common at universities, though. Additionally, the prevalence of Lean Management is higher for institutions of higher education that lie there focus on technical aspects.

Keywords
Lean Management, Higher Education, Prevalence
1. Introduction

Constantly increasing competition in manufacturing industry (Magenheimer, et al., 2014; Nadarajah, et al., 2014) forces pressure on concerned companies to adapt change to their manufacturing processes in order to stay competitive. (Allweyer, 2016) This requires continuous improvement of business-relevant processes, both in production and in administration. (Brenner, 2018: Ko, et al., 2009) Lean Management is a promising approach offering numerous methods and tools for a more efficient design and optimization of processes. (Gorecki & Pautsch, 2013) However, many companies fail to implement Lean Management because they do not consider it as a learning process. Ballé & Handlinger (2012) argue that it is not sufficient to copy existing approaches, but it is crucial to understand the concept of Lean Management. Therefore, a successful implementation of Lean Management requires specialists who understand the methods and techniques used in a company and know how to use them in a highly efficient way for process optimization. Among others, this knowledge must be taught at higher education institutes (HEI). The aim of this paper is to reveal and compare the degree of dispersion of Lean Management in higher education in Germany. The following research question is deduced form this consideration:

“Is the prevalence of teaching Lean Management affected by the type of HEI ?”

In the following, universities and Hochschulen are grouped under HEI. The term university refers to HEI that are authorized to confer doctorates. In contrast, Hochschulen are usually not authorized to award doctorates and often are characterized by a high practical relevance. Some Hochschulen opted to name themselves university of applied science. Additionally, so-called Cooperative State Universities that exist within the federal state of Baden-Württemberg have the status of Hochschule. The philosophy of Lean Management has its origins in the 20th century at Japanese car manufacturer Toyota. Womack, et al. (1990) studied the difference in manufacturing in the automotive sector and describe the concept of Lean Thinking. Lean Management and Lean Production are now successfully used in almost all industries worldwide and “found their home together in operations research.” (Agarwal & Elhajj, 2013) Proponents argue that it increasingly became an applied academic discipline. (Liker & Hoseus, 2010) Due to its high practical relevance and its proximity to industrial sectors, we argue that especially Hochschulen, respectively universities of applied science, should teach Lean Management. Womack and Jones (1996) do not describe Lean as simple toolbox, but as a total perspective. Consequently, practical research and the transfer of knowledge is crucial for a successful implantation in the industry sector. Both, specific professions and transfer of theory into practice are within the focus of Hochschulen. Accordingly, we formulate the following hypothesis.

Hypotheses 1: The prevalence of teaching Lean Management is higher for Hochschulen than for universities.

There are a number of highly specialized HEI in Germany. In addition to some, that specialized in arts, music or theology others lie their focus in administration, public management or technology. The latter, so-called technical Hochschulen and universities of technology are institutions of higher technical education. Most universities of technology had been transformed from technical Hochschulen during the reformation of higher education in the 1970s, which resulted in a greater share of basic research and in the introduction of accompanying faculties, like economics, to fulfill the demand for a universal orientation of teaching. Once founded to counteract the lack of practical and technical relevance of universities, they also offer a high degree of specialization in non-technical subject, today. Hereby they excel in a specialized and practical oriented apprenticeship. (Stölting & Schimank, 2013) They offer several variants of engineering management, in particular. These degree programs typically include instruction in operations research and management, as well as in process management and optimization. Lean Management is also assigned to this area. We therefore argue that technical HEI are more likely to teach Lean to students.

Hypotheses 2: Lean Management is preponderantly taught at HEI with a technical focus, such as universities of technology.

Since Womack, et al. (1990) popularized the Toyota manufacturing approach in the 1990s, it became popular among researchers and practitioners. Likewise, Lean topics have aroused an increased interest in German research, in recent years. The adaption of Lean Management to affect external organization of companies also became popular among researchers. (Shah & Ward, 2007) At its core, Lean Production is an approach that focuses less on technical process automation than emphasizes the principles of a lean organization. (Womack, et al., 1990) With regard to publications on Lean Management, it can be stated that most scholars publish within a business studies related setting. (Danese,
Even the methodology of Lean Management is addressed to several sectors today; we argue that Lean Management is most often taught in business classes, since most scholars have an economic background.

**Hypotheses 3: Lean Management is most often taught within department of business administration and economics.**

Recently organizations are more and more recognizing the potential of Lean Management for different services and industries, resulting in new approaches for and adaption to the respective area, with Lean Management serving as a basis. (Marhani, et al., 2018) It is transferable to a wide variety of industrial areas. (Čiarniene & Vienazindiene, 2012) By way of example, the following approaches are mentioned:

- **Lean Administration** aims at removing the complexity from administrative processes in advance by adjusting the organizational environment and reducing the number of cost drivers.
- **Lean Logistics** focuses on the design of logistic systems with the primary goal of avoiding waste of resources and increasing flexibility of logistic systems and supply processes.
- **Lean Hospital** aims at achieving a higher quality of treatment for patients in hospitals while reducing costs and increasing employees’ performance.
- **Lean Construction** refers to the adaption of Lean Management to end-to-end construction processes to optimize resource consumption for construction projects, as well as maximize customers’ value.
- **Lean Government** aims at increasing the efficiency of governmental services in a value added way.
- **Lean Higher Education** refers to the adaption of Lean thinking to higher education for the benefit of improving academic and administrative operations.

Although the benefits of Lean Production have been studied and put into practice in many organizations, Lean Management is less common outside its natural context. We therefore argue that other Lean Management variants are rarely part of basic education programs. They are rather part of single graduate courses with a higher degree of specialization. The following hypotheses is deduced.

**Hypotheses 4: Lean Production is the most prevalent taught Lean form. Other Lean Management variants are less common in academic education.**

Regarding executive education we argue, that there is a correlation between the offer for external interested parties and the general dealing with Lean Management in teaching and research activities.

**Hypotheses 5: HEI that teach Lean to their students are more likely to offer Lean within executive education.**

2. **Method**

The cross-sectional study has been selected as the empirical approach for the realization of the research objective. According to Mann (2003) this kind of research design is primarily suitable to determine the number of cases in a population. For this purpose, either the entire population or a subset thereof is selected to collect data from individuals. One of its key characteristics is that the information gathered represents a set point in time. Therefore, the prevalence of the variable of interest can be assessed. (Setia, 2016)

Based on the lists on German HEI of Studis Online¹ (Studis Online, 2018) and Hochschulkompass² (Wurm, 2018), both available online, institutes of higher education were identified. Initially, redundant entries were removed. Further mandatory prerequisites for the identified HEI to be considered are:

1. **HEI is still existing:** For example, the university of applied science Bamberg could be identified. However, the course program was submitted to the private, state-recognized university of applied science Bielefeld as of September 1, 2013.

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¹ https://www.studis-online.de/Hochschulen/  
² https://www.hochschulkompass.de/home.html
2. HEI is recognized either as university or Hochschule by German education law: For example, the International University of Education Freiburg was listed on Studis Online. However, this educational institute is not accredited.

3. The identified institute is not a satellite campus. These were not handled separately, hits were attributed to the headquarter instead.

To identify the prevalence of teaching Lean Management within degree programs current module handbooks of all departments of 428 German HEI were requested or downloaded. Qualifying date for valid documents was 01.07.2018. Subsequently, the documents were searched systematically for modules dealing with Lean Management. To cover all forms of Lean Management with the search, only the word Lean was searched. The used integrated document search function shows everything as a hit that contains the entered letter combination without being case sensitive. Thus, the displayed results are independent of the spelling. All displayed hits were content analyzed to identify which Lean Management are taught in connection with this specific module handbook.

In a second step, the websites of all HEI were searched for further education courses offered to external interested parties. Therefore, the search bar, if available, was used to search for the term “Lean”. All displayed search results were subsequently analyzed for Lean Management. Findings have to be focused on knowledge transfer to executives in order to be considered. Whenever a search bar was not available, the navigation was used to identify executive education offers. In addition, the student service centers or the contact person for executive education, if available, was contacted either by phone or through chats to receive the necessary information. The quantitative measure was carried out in the period from 01.07.2018 to 16.07.2018.

For this study, only HEI that provide the requested information on both, degree programs and executive education, were considered. Of the 429 HEI under investigation, 416 provided current module handbooks and additional information on executive education. The present database forms a cross-section of universities and other HEI throughout Germany. Figure 1 illustrates the composition of the sample. In total, the sample consist of 106 Universities and 310 Hochschulen. The higher education landscape in Germany is characterized by a great variety of specialized HEI. In addition to 18 Universities of Technology and 17 Hochschulen with a technical focus, 28 Hochschulen of public administration, 22 Conservatories, 22 Hochschulen of Art and 14 Hochschulen of Theology are part of the sample. Given the size of the sample and the response rate, statements about significant trends in higher education can be made.

![Figure 1 Composition of Sample](image-url)
3. Results

Of the surveyed 416 German HEI, 28.8 percent teach a form of Lean Management to their students. Another 13.4 percent offer seminars or lectures on Lean topics to professionals or other interested parties. While only 1.2 percent included Lean in their curriculum and also offer it to externals in the form of seminars. For the remaining 59.0 percent of German universities and Hochschulen Lean Management is neither part of the curriculum nor is it offered in any form to interested parties. Figure 2 breaks down the results by university and Hochschule respective university of applied science.

![Figure 2 Percentage of university and Hochschulen teaching Lean](image)

The percentage for Lean-teaching universities (34.9%) is slightly higher than the percentage for Hochschulen teaching Lean Management (27.2%). The gap for executive education offers is even much bigger. While only 7.7 percent of Hochschulen offer seminars on Lean Management, more than one out of five of the universities have such executive classes. However, it must be noted that the focus for both, universities and Hochschulen, lies either in degree programs or in executive education. Only two out of 310 Hochschulen have included Lean Management in their syllabus and are also teaching this philosophy to externals.

The population consists of all state-recognized HEI. Consequently, there are also specialized Hochschulen such as art colleges, conservatories and theological Hochschulen. One might argue that these Hochschulen should not be part of the sample because of their high degree of specialization in Lean-atypical subject areas. However, some of the aforementioned also offer modules in health-care management, business administration or architecture and civil engineering. Nevertheless, none of these Hochschulen teaches Lean Management in any form. (see Figure 3) Such specializations do usually not exist for universities. Although the percentage of Lean-teaching Hochschulen increases when not considering such specialized Hochschulen, there still is no significant difference between universities and Hochschulen. Therefore Pearson's chi-squared test was performed. There neither is a statistical significant difference between non-specialized Hochschulen and universities, $\chi^2(1, N=330)=0.143$, $p=0.705$, nor between Hochschulen in general and universities, $\chi^2(1, N=416)=2.545$, $p=0.11$. Consequently, hypothesis 1 must be discarded. The prevalence of teaching Lean Management is no higher at Hochschulen than at universities. In contrast, the share of Hochschulen offering Lean Management in form of seminars for professionals is significantly lower than for universities.
Additionally, Hochschulen of public management and administration exist in Germany, where civil servants and public service employees are trained. While for none of them Lean Management are part of the syllabus, 16.7% cover the philosophy within executive education. Consequently, one can state that highly spatialized Hochschulen in Germany are less likely to teach Lean Management.

In addition to the aforementioned highly specialized Hochschulen, some HEI specializes in engineering, technology and natural science. Two out of three universities of technologies added Lean Management to their curriculum. A few less have an offer for external interested parties, with over 20 percent of universities of technology offering both, degree programs and executive education. These proportions are significantly higher than those for non-technical universities are. A chi-squared test of independence is performed to examine the relation between HEI type and teaching Lean Management. The relation between these variables is significant, \( X^2 (6, N=416) = 50.046, p<0.001 \). Non-technical HEI are less likely to add Lean Management to their module handbooks for either degree programs or executive education. Consequently, hypothesis 2 can be accepted. Lean philosophy is increasingly taught at HEI with a technical focus.
Universities of technology and technical Hochschulen often have non-technical units as well, such as social science, economics or arts. To verify hypothesis 3, departments of technical and non-technical HEI, that included Lean to their curriculum, are considered. With regard to Figure 5, it is striking that Lean Management is most frequently taught in the field of business and economics. Almost three out of four HEI teaching Lean, do so within the department of business and economics. Figure 5 shows a marginal difference between technical HEI and non-technical HEI, only. Department of business is followed by Departments of Engineering, which compile the results of the module handbooks for any engineering study, but mechanical and civil engineering. 36.7 percent of all Lean-teaching HEI included Lean Management to the syllabus of these engineering programs. Solely 18.3 percent offer lectures on Lean Management within the department of mechanical engineering. The share of mechanical engineering for Lean-teaching Hochschulen is almost twice the share of Lean-teaching universities. The fourth most frequently Lean Management is taught to informatics students.

Table 1 shows absolute numbers of departments that teach Lean. The cross-table does not show if several modules for a single department included Lean Management. Nevertheless, it becomes clear that Lean Management is taught in the field of business studies in particular. Only occasionally, it is taught in the field of civil engineering or health-care. Others include departments of mathematics, architecture and psychology, for example. Hypothesis 3 can be confirmed, $X^2 (5, N=847) = 234.402$, $p<0.001$. Departments of Business Administration and Economics are definitively the most common to deal with Lean philosophies in higher education.

The grand total of departments that included Lean Management to their syllabus is 201. The high number stems from the fact that for each HEI the module handbooks of all departments were analyzed. Comparing the number of universities respective Hochschulen teaching Lean Management with the marginal numbers of Table 1 it shows that most HEI offer Lean Management in several departments, not just one. Lean-teaching Hochschulen offer Lean Management in more departments ($M=1.83$, $SD=1.10$ $N=83$) than universities ($M=1.32$, $SD=0.62$, $N=38$), $t(117)=-3.0$, $p=0.003$. 

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With regard to different manifestations of Lean Management, it is striking that Lean Management is the most popular within academic education. Half of HEIs give lectures on Lean Management. Within a module handbook several lectures concerning Lean Management can emerge. Figure 6 illustrates the share of Lean-teaching HEIs for each manifestation. The top three are: Lean Management, Lean Production and Lean Startup, with one out of three Lean-teaching HEIs offering classes on Lean Production. The share of Lean Logistics and Lean Supply Chain Management, for example, is below 3% and therefore not in the Top 10.

![Figure 6 Top 10 Lean Management taught within degree programs at HEI in percentage](image)

If universities and Hochschulen are considered separately, it becomes apparent that Hochschulen, in particular, teach Lean Management. Out of 83 Hochschulen 48 cover Lean Management. Universities, on the other hand, cover Lean Start-Up almost as often as Lean Management. Hochschulen only cover the topics of Lean Health Care and Lean Six Sigma. Except for a single university Lean Construction is taught by Hochschulen only.

<table>
<thead>
<tr>
<th>Management</th>
<th>Production</th>
<th>Start-Up</th>
<th>Administration</th>
<th>Development</th>
<th>IT</th>
<th>Six Sigma</th>
<th>Thinking</th>
<th>Health Care</th>
<th>Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>University</td>
<td>12</td>
<td>9</td>
<td>11</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Hochschule</td>
<td>48</td>
<td>32</td>
<td>6</td>
<td>8</td>
<td>4</td>
<td>6</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>HEI</td>
<td><strong>60</strong></td>
<td><strong>41</strong></td>
<td><strong>17</strong></td>
<td><strong>10</strong></td>
<td><strong>8</strong></td>
<td><strong>6</strong></td>
<td><strong>6</strong></td>
<td><strong>4</strong></td>
<td><strong>4</strong></td>
</tr>
</tbody>
</table>

Table 3 shows the result for executive education offers. Lean Management is also in the top position for executive educational offers, followed by Lean Start-Up and Lean Production. While Lean Logistics is not within Top 10 for degree programs, three HEIs cover this topic within executive education. Consequently, hypotheses 4 can be accepted. \( \chi^2 (9, N=1210) = 239.153, p<0.001 \) Lean Production is the most prevalent variant of Lean Management in academic education. Other variants are way less common.

<table>
<thead>
<tr>
<th>Management</th>
<th>Start-Up</th>
<th>Production</th>
<th>Administration</th>
<th>Six Sigma</th>
<th>Thinking</th>
<th>Logistic</th>
<th>Development</th>
<th>Lean Consulting</th>
<th>Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>University</td>
<td>14</td>
<td>8</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Hochschule</td>
<td>15</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>HEI</td>
<td><strong>29</strong></td>
<td><strong>13</strong></td>
<td><strong>7</strong></td>
<td><strong>5</strong></td>
<td><strong>4</strong></td>
<td><strong>3</strong></td>
<td><strong>3</strong></td>
<td><strong>3</strong></td>
<td><strong>1</strong></td>
</tr>
</tbody>
</table>
Regarding executive education, only two out of 310 Hochschulen have included Lean Management in their syllabus and are also teaching Lean Management to externals. Due to low sample size, no statistical test can be performed. Therefore, hypothesis 5 cannot be confirmed.

4. Discussion

Although Lean Management is becoming more popular with industrial companies and organizations, it is apparent that the prevalence of Lean Management in academic education is rather modest. Less than one third of HEI included this philosophy to their syllabus. Results show that there is no difference between universities and Hochschulen. On the one hand, Hochschulen focus on practical research and education, as well as on the transfer of theory into practice. Transferred knowledge is crucial in a successful implementation of Lean Management, since it is rather a set of simple toolboxes, but a total perspective. The Ballés (2005) argue that it is not sufficient to study theory, but it is necessary to see how said theory applies to each industrial situation. This is the core problem of a successful Lean turnaround. To implement a Lean culture it needs people who think and act lean. This special skill must be learned and put into practice. An in-depth understanding on how to apply Lean theory to an observed situation is necessary. Hochschulen can support by educating people, which might also act as multipliers, to reach a critical mass of people who think and act lean. On the other hand, results showed that it is not so common to include Lean Management in fundamentals courses. In Germany most students study at an university. However, there are about three times as many Hochschulen as universities. In consequence, universities have bigger departments, which allows for more specialization and a greater variation in lectures. Therefore, such departments are more likely to cover Lean Management. On top of that, universities have a bigger focus on research activities than Hochschulen. This is about to change, though. (Stölting & Schimank, 2013) However, researchers dealing with theories of Lean Management might also be more likely to include it into their teaching record. This might also add to the reason for Lean Management being the most prominent with business departments.

Although no significant difference in the prevalence of Lean between universities and Hochschulen was found, the prevalence is affected by type of HEI. With regard to the specialization of HEI types, it can be state that Lean is neither taught at art colleges, conservatories, theological Hochschulen or Hochschulen of public management and administration. It may not be too surprising for the three-mentioned first, but the latter educates the majority of future civil servants and public service employees. Especially for them principles like Lean administration or Lean governance are of interest. After all, two of these colleges offer these principles in executive education, as a kind of follow up. In contrast to those four types of Hochschulen, Lean is most prevalent for technical HEI. It has shown, that universities of technology are most likely to teach Lean to students as well as to interested external parties. All universities of technology offer lectures on Lean, with almost 70 percent reading Lean Management to their students. The proportion is significantly higher than for technical Hochschulen and more than twice as high as for non-technical universities. Most universities of technology had been transformed from technical Hochschulen during the reformation of higher education in the 1970s. They thus combine above arguments. Today’s universities of technology were once founded to counteract the lack of practical and technical relevance of universities. However, they also offer a high degree of specialization in non-technical and technical subjects, today. Hereby they excel in a specialized and practical oriented apprenticeship. (Stölting & Schimank, 2013) Furthermore the fact that both, technical Hochschulen and universities of technology, offer undergraduate and graduate degrees on engineering management, might act to the fact that Lean Management are most prevalent for technical HEI. Hereby it also shows that technical HEI, in particular, teach Lean Management in several departments.

With regard to Lean theories and principles, it can be stated that Lean Management is the most widespread. It showed, that Lean Administration and Lean Six Sigma are mainly read by Hochschulen. Almost no university deals with those topics. In contrast, many universities read lectures on Lean Start-Up, while a similar amount of Hochschulen do so, compared to the aforementioned principles. In addition to its high practical relevance, it is characterized by the fact that it has increasingly been the subject of research in the field in recent years. (Danese, et al., 2017) We argued befor, that researchers dealing with a specific topic might be more likely to also read lectures on this topic.

In order to reinforce a company’s competitiveness, management styles must be adjusted to meet current challenges. Shah and Ward (2007), among others, detected a trend to adapt Lean Management to meet these challenges and optimize processes with a high customer orientation. Especially the latter becomes more and more relevant in today’s economic competition. This study investigated the prevalence of Lean Management in academic education, only. This
can be a basis to investigate correlations of teaching Lean Management in academic education with successful Lean implementation within a geographical region. The influence of academic education on successful Lean implementations should be further investigated in the future.

References


Biographies

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