CHAPTER 2: LITERATURE SURVEY/REVIEW~~hapter 2 Literature Survey/Review~~

2.1 INTRODUCTION

A literature review is written to consider the critical points of current knowledge including substantive findings, as well as theoretical and methodological contributions to a particular topic. These are secondary sources, and as such, do not report any new or original experimental work. They are often associated with academic-oriented literature, such as a thesis, and their~~its~~ main goals are to situate the current study within the body of literature and to provide context for the particular reader [29]. ~~[29]~~

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The review was arranged according to the topics that build up the research question. As the project cuts across several disciplines, the literature survey looked broadly into education and *Lean* manufacturing. The sub-categories for education included an understanding of the state of education, learning theory, and learning materials. Those under *Lean* included *Lean* in education, as well as ~~and~~ education as a process. This approach enabled the researcher to get a "big picture" view of the issues at hand and thus avoid a "one-dimensional" approach to the project.

2.2 EDUCATION

2.2.1 Background and importance

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As noted in Chapter 1, education systems aim to enable students to achieve curriculum outcomes that~~which~~ are necessary for the advancement of studies or as prerequisites for competencies required by employers [1]. The mass provision of formal schooling only started about 150 years ago and, for some Third World countries, ~~it~~ has been as recent as the last 50 years. Due to population growth and the global proliferation of compulsory education, UNESCO predicts that in the next 30 years, more people will receive formal education than in all of human history thus far [22].

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Public schooling is one of the largest and most important collective enterprises undertaken by modern societies. It generally consumes more money (aside from

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debt repayments in many developing countries), employs more people, and is commonly believed to have a more significant influence on citizens' values, skills, work and leisure habits when compared to other sets of public institutions [4]. As already noted, countries with more educated populations tend to exhibit much greater levels of socio-economic prosperity, scientific innovation, and military superiority, amongst other indicators [2]. As such, education continues to receive increased budget allocations globally. In addition, conferences, research reports, and programmes concerned with improving efficiency and effectiveness in education continue to receive global attention.

Today, education systems act not only as vehicles for redress and transformation but also produce citizens that improve atheir country'sies' global competitiveness. International reports on comparative standing in pupil attainment are conducted and taken more seriously more than ever before [67]. One of the modern-day global icons, Nelson Mandela, described education not only an engine for social development, but also as a great equaliser of opportunities, citing its ability to enable children of previously disadvantaged or low level workers to acquire better opportunities in life [4].

Despite the highlighted importance, schooling systems in many countries are reported to be in crisis, and change is high on the agenda. This is also very evident in South Africa and justifies the ever increasing requests for reforms in the education sector [4].

2.2.2 South African education: background and status

In 2010, South Africa had 12.3 million learners and, 386,000 teachers in 48,000 schools. Officially, primary schools comprise Grades 1 to 7 and high schools Grades 8 to 12. The government spends 20% of total state expenditure, on education, and is globally, one of the highest rates of public investment in education [3]. In spite of this, schools are still fraught with immense challenges that affect education throughput and quality [4].

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The Deputy President of South Africa, Kgalema Motlanthe, summed up the vision of the South African education system by asserting that examination results [quality] are a barometer of the learners' achievement and the efficiency of the education system. Further, he pointed out that a strong education system has~~d~~ the ability to empower ordinary citizens to respond with confidence to the imperatives of modern society [7].

Motlanthe's view is consistent with the need for implementation process improvement techniques to support quality and other improvements initiatives in schools.

South African education legislation

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The South African constitution has several provisions for regulations covering the governance of public and private institutions. The Constitution of South Africa, 1996 (Act ~~n~~No. 108 of 1996) is the country's main governing legislative document, and it sets forth the Bill of Rights in which Section 29 provides for education as follows :[3]:

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1.Everyone has the right

a. to a basic education, including adult basic education; and

b. to further education, which the state, through reasonable measures, must make progressively available and accessible.

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2. Everyone has the right to receive education in the official language or languages of their choice in public educational institutions where that education is reasonably practicable. In order to ensure the effective access to~~,~~ and implementation of this right, the state must consider all reasonable educational alternatives, including single medium institutions, taking into account

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a. equity and practicability; and

b. the need to redress the results of past racially discriminatory laws and practices.

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3. Everyone has the right to establish and maintain, at their own expense, independent educational institutions that

a. do not discriminate on the basis of race;
b. are registered with the state; and
c. maintain standards that are not inferior to standards at comparable public educational institutions.

4. Subsection (3) does not preclude state subsidies for independent educational institutions.

Further to this language in the Bill of Rights, there is additional enabling legislation, which supports ~~the~~ [-7-]:

- The South African Schools Act, 1996 (Act No. 84 of 1996) provides for a uniform system for the organisation, governance and funding of schools.
- The National Education Policy Act, 1996 (Act No. 27 of 1996) provides for the determination of national policy for education, including the determination of policy on salaries and conditions of employment of educators.
- The Employment of Educators Act, 1998 (Act No. 76 of 1998) provides for the employment of educators by the State and for the regulation of the conditions of service, discipline, retirement and discharge of educators.
- The Revised Regulations for Independent schools - Draft Regulations relating to the Registration of and Subsidies to Independent Schools (Excluding Independent Pre-Primary Schools)
- The Western Cape Provincial School Education Act, 1997 (Act No. 12 of 1997) and similar provincial acts, which provide for a uniform education system for the organisation, governance and funding of all schools and makes provision for the specific educational needs of the province.

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If the study's objectives are achieved, then this will result in the fulfilment of the provisions of the Bill of Rights and the related legislation with respect to education. This is so because the success of the research will potentially help to reduce costs of education in the future, thus making education more accessible to all. In addition, the study also aims to contribute to improving the quality of results, thereby helping to uplift the education standards in the country.

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2.2.3 Classroom PedagogyLASSROOM PEDAGOGY

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Any attempts to improve the quality while reducing the lead time in a classroom environment will affect the classroom pedagogy [1]. Per Dalin [1] noted that classrooms are the ultimate focus of the schooling system, and the terrain where the purpose of schooling - teaching and learning - comes to fruition. He adds that any attention to classroom pedagogy is paramount to the achievement of change in schools [38].

In 1996, the then president of South Africa, Nelson Mandela, commissioned the Presidential Education Initiative (PEI) research. The purpose of the research was to provide a scientific basis for the future planning and delivery of educator development and support programs to improve classroom pedagogy. The research focused on school and classroom context with one of the important objectives of this initiative being to improve the quality of education in schools [4]. The findings of the research, showed that the majority of South African teachers require much more attention in terms of developing their teaching techniques, if learning is to improve. In the context of applying *Lean* to educational change, this means that there will be need for proper sustained training and support if *Lean* initiatives are to be properly implemented in schools to achieve the anticipated objectives.

2.2.5.1 Learning Theory and Impressions

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Learning theories are conceptual frameworks that describe how information is absorbed, processed, and retained during learning. Cognitive, emotional, and environmental influences, as well as prior experience, all play a part in understanding how knowledge and skills are acquired, changed or retained [39].

Outside the realm of educational psychology, techniques to directly observe the functioning of the brain during the learning process, such as event-related potential and functional magnetic resonance imaging, are used in educational neuroscience. Learning theory advocates that if information is to be retained in the long-term memory, ~~then~~ a certain minimum number of activities should be imparted into the human brain over the medium to long-~~-~~term periods [19].

Figure 4 shows the scientific approach to determining the correct classroom activities in order to help students to retain what they learn. The figure shows that students retain more information if they do different activities that use different sense faculties and ~~use~~ active receiving approaches. These activities are called impressions and should be spaced out over time to enable the brain to process the information adequately and enable long-~~-~~term memory retention. This knowledge explains why the number and type of impressions are~~is an~~ important parts of the classroom pedagogy activities centred on achieving quality outcomes.

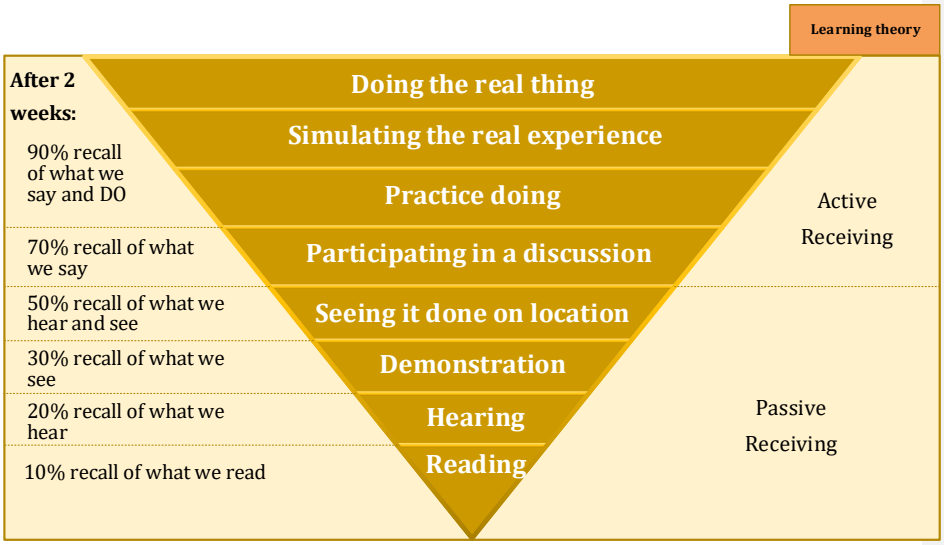

Figure 2 Applied Knowledge Transfer [41]

-Self-pacing and acceleration

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Self-pacing methods, such as the Montessori Method, use flexible grouping practices to allow children to advance at their own pace. Self-pacing can be beneficial for all children and is not targeted specifically at those identified as gifted or talented, but it can allow children to learn at a highly accelerated rate. Alternatively, there exist other acceleration programs in whichwhere pupils are advanced to a higher-level class covering material more suited to their abilities and preparedness. This may take the form of skipping grades or completing normal curriculum in a shorter-than-normal period ("telescoping"). Subject acceleration (also called partial acceleration) is a flexible approach thatwhich can advance a student in one field, such as mathematics or language, without changing other studies, such as history or physical education [39]. Taken a step further, some colleges offer early entrance programs that give gifted younger students the opportunity to attend college early. In the U.S., many community colleges allow advanced students to enrol with the consent of school officials and the pupils' parents.

Acceleration presents gifted children with academic material from established curricula that are commensurate with their ability and preparedness. For this reason, it is a low-cost option from the perspective of the school. This may result in a small number of children taking classes targeted at older children, but for the majority of gifted students, acceleration is beneficial, both academically and socially [40].

The literature suggests that “acceleration” is possible and is pursued in some countries. The Montessori approach has tried to formalise this, through enabling students by adopting self-paced learning for students. However, it is noteworthy that the methods used were not focused on advancing the whole class, and the approaches taken have not been centred on *Lean* techniques. This study took the learnings in these acceleration approaches to articulate the areas of focus in the *Lean* approach, in order to achieve lead-time reductions that are more or less similar to “telescoping.”

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Social considerations

White (2004) noted that "Radical acceleration (acceleration by two or more years) is effective academically and socially for highly gifted students." Some advocates have argued that the disadvantages of being retained in a standard mixed-ability classroom are substantially worse than any shortcomings of acceleration. For example, psychologist Miraca Gross reports, "The majority of these children [retained in a typical classroom] are socially rejected [by their peers with typical academic talents], isolated, and deeply unhappy and experience severe emotional distress." Therefore, it is reasonable to say that these accelerated children should be placed together in one class whenever possible [39].

The comment by Gross suggests that the *Lean* approach should ensure that classes are advanced at their own pace, simultaneously aiming to cover ensuring that the minimum requirements for the current grade are covered. It is ideal to keep students of the same age group in the same class to prevent social rejection and emotional distress normally experienced through mixing different age groups. This project considers that if lead times are to be reduced, then the same classes will move at the same pace to prevent social rejection and emotional distress.

2.2.2.3 Learning materials

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Learning materials are an important element in the education cycle. As demonstrated in the SIPOC diagram in Figure 4, ~~l~~Llearning materials are an input into the classroom processes without which the learning process wouldill be greatly impaired.

The DBE views adequate learning support materials as essential to the effective running of an education system. It asserts that these materials are an 'integral part of curriculum development' and a means of promoting good learning and teaching. The DBE includes a wide range of texts, resources, and equipment in its definition of learning support materials. These encompass 'more than just textbooks' and may be 'print–based, electronic, physical, combinative, human, and organisational.'~~,~~ Electronic resources include transparent slides, video, audiotapes, CDs, and computer software [43].

These various learning materials are process inputs thatwhich add value to the customer needs through providing the different sources of information for the passive and active reception and retention by students. Without these learning materials, the teaching process would be inhibited, resulting in poor outputs, which subsequently affects students' results. At the moment, this is one of the biggest inhibitors in schools, as not all schools have access to adequate learning materials [43]. Compared to a manufacturing process, it would be not possible to produce a good quality product without all the ingredients/inputs available. In manufacturing, the process would be stopped and the necessary inputs sourced first before the processes couldan continue. However, this seems not to be the same in the education process, and thus could be one of the sources of "defects," which are students not achieving the minimum expected outcomes.

The existence of various learning materials gives insights into the design of the most suitable learning materials for the classroom. Figure 4 shows that multimedia can enhance the learning and information retention process. This suggests that the

appropriate selection of learning materials may have an impact in the achievement of project goals.

Learning materials are normally incorporated into e-learning platforms which are the delivery mediums for learning materials. The tools have now gone beyond just delivering the materials, ~~but have~~ becominge ~~adaptive~~ learning systems that, allowing for highly individualised student practice and on-going objective assessment of scholar progress. Reports from these platforms inform educators of skills required for further differentiation or practise [44]. Thus, technology is a great enabler in modern learning.

Technology in education is described as an array of tools that might prove helpful in advancing student learning. Some modern tools include but are not limited to overhead projectors, laptop computers, and calculators. Newer tools such as Ssmartphones and games (both online and offline) are beginning to draw serious attention for their learning potential [44] Robert Travers [46] postulated that new technology was introduced to achieve the traditional goals of education more efficiently.

Some of the claimed benefits of incorporating technology into the classroom are listed below [15]:~~[15]~~

- *Easy-to-access course materials. Instructors can post their course material or important information on a course website, which means students can study at a time and location they prefer and can obtain the study material very quickly.*

- *Student motivation. According to James Kulik, who studies the effectiveness of computers used for instruction, students usually learn more in less time when receiving computer-based instruction and they like classes more and develop more positive attitudes toward computers in computer-based classes ~~.~~[17]. Teachers must be aware of their students' motivators in order to successfully implement technology into the classroom ~~.~~[18]. Students are*

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more motivated to learn when they are interested in the subject matter, which can be enhanced by using technologies in the classroom and targeting the need for screens and digital material [15] that they have been stimulated by outside of the classroom.

- *More opportunities for extended learning. As more households get connected to the internet, students can access course material at home and engage with the numerous online resources available to them. Students can use their home computers and internet to conduct research, participate in social media, email, play educational games and stream videos.*

- *Using online resources such as Khan Academy or TED Talks can help students spend more time on specific aspects of what they may be learning in school, but at home. These online resources have added the opportunity to take learning outside of the classroom and into any atmosphere that has an internet connection. These online lessons allow for students who might need extra help to understand materials outside of the classroom. These tutorials can focus on small concepts of large ideas taught in class, or vice versa~~the other way around~~.*

This means that technology has the potential to help schools ~~to~~ achieve their goals more efficiently. This literature review implies that using technology tools in delivery of curriculum materials may have the ability to improve the outcome of the study.

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2.2.4 Challenges in South African education

It has been previously stated that the South African education system has challenges that affect the efficiency and quality of education. These challenges include [4]: [4]

- High dropout rates, as only about 50% of students who enrol at gGrade 1 finish Matric. This is attributed to, among other factors, to poverty, inadequate assistance, poor academic support and family pressures.

- High failure rates, as only 25% of those who sit for Matric achieve the minimum pass requirements, mainly due to poor quality management systems in classrooms. Out of those who go into university, only half graduate. Thus, only up to about 5% of the original 1 million students enrolling infor gGrade 1 manage to graduate from university (shown in Figure 2).

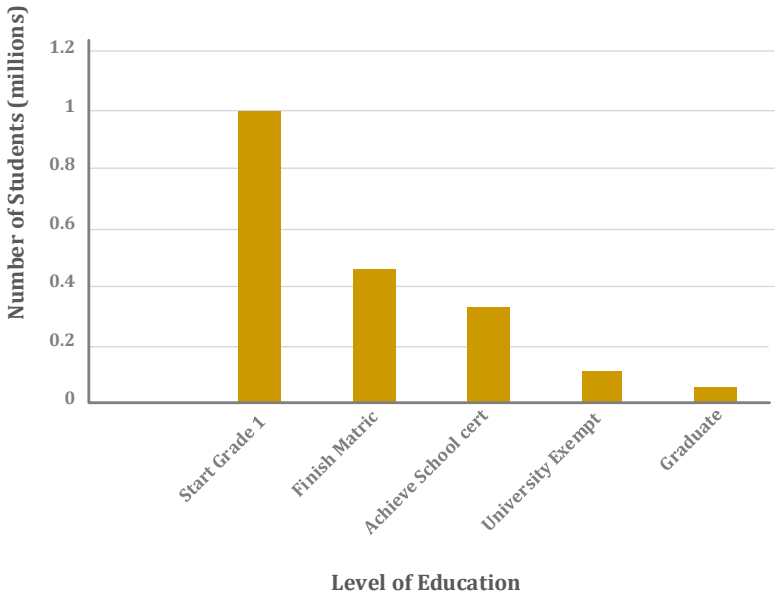

Figure 3: Throughput trends in South African education (author's interpretation from available facts)

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- Customers (e.g., employers, universities) complain of “quality” issues, ~~:~~ mainly due to “lowering of standards~~,~~” (e.g., ~~for example~~ lowering of the Matric pass mark).

- The education sector is also inadequately funded, resulting in a shortage of learning materials and infrastructure, especially in rural areas and peri-urban areas.

These challenges result in inability to meet the desired outcomes in the schools, leading to ~~resulting in~~ poor results among students.

2.2.4.1 Resolving the current issues in South African education~~2~~

Funding

The government has been trying to increase funding through the increase of budgets for the DBE. However, it has been noted that funding policy cannot, on its own, resolve issues of inequitable access and poor quality. Commentators have noted the danger of regarding funding mechanisms as a substitute for more direct and difficult interventions to improve education quality. Comparative country studies have shown that financial inputs do not necessarily translate into improved educational outcomes [2]. Hanushek warns that South Africa should be wary of an approach, where “eager to improve quality and unable to do it directly, government policy typically moves to what is thought to be the next best thing — providing added resources to schools.” [4] This suggests that there could be evidence showing that just providing extra resources has proved not to result in the outcomes desired, such as improvement in student results.

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The Department of Education Action Plan to 2014

In 2010, the Minister of Basic Education, Mrs Angie Motshekga, announced a plan for South African schools called *Action Plan to 2014: Towards the Realisation of Schooling 2025*. It explains what the government will be doing to make ~~g~~Grades R to 12 schooling better and how communities can contribute towards making the goals of the *Action Plan* and *Schooling 2025* a reality. The *Action Plan* was made flexible so that any new stakeholder contributions can be incorporated.

Ten of the 27~~twenty-seven~~ goals in the plan deal with better school results [quality]. The other fourteen goals deal with things that must happen for the output goals to be realised. The goals are as follows [9]:

1. Increase the number of learners in Grade 3 who, by the end of the year, have mastered the minimum language and numeracy competencies for Grade 3.

2. Increase the number of learners in Grade 6 who, by the end of the year, have mastered the minimum language and mathematics competencies for Grade 6.

3. Increase the number of learners in Grade 9 who, by the end of the year, have mastered the minimum language and mathematics competencies for Grade 9.

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4. Increase the number of Grade 12 learners who become eligible for a Bachelors programme at a university.

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5. Increase the number of Grade 12 learners who pass mathematics.

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6. Increase the number of Grade 12 learners who pass physical science.

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7. Improve the average performance of Grade 6 learners in languages.

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8. Improve the average performance of Grade 6 learners in mathematics.

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9. Improve the average performance of Grade 8 learners in mathematics.

10. Ensure that all children remain effectively enrolled in school at least up to the year in which they turn 15.

11. Improve the access of children to quality Early Childhood Development (ECD) below Grade 1.

12. Improve the grade promotion of learners through Grades 1 to 9.

13. Improve the access of the youth to Further Education and Training (FET) beyond Grade 9.

The absence of concrete tools to enable this plan to happen also makes it difficult for schools to achieve the improvements. In the absence of specific solutions to achieve the stated goals, academic critics such as Graeme Block have proposed that "good technical solutions" are needed to resolve problems [6].

Specific improvement tactics in South African schools

Various role players such as the government, schools, and NGOs have been focusing on specific interventions to improving quality in schools. The measures have included extra lessons in schools. This has mainly involved students staying after hours or coming over weekends and holidays to catch up on the perceived areas of difficulty or to practice for examinations. As poverty has also been identified as a contributor to poor results, food has also been provided to students at the poorer schools to improve their morale, which they believe will then reduce absenteeism and eventually improve school results [4].

The government has also identified the quality of teachers as an important factor in the achievement of good results. To this extent, they have been motivating good teachers to consider rural schools, and there have been even proposal to ensure that all newly qualified teachers should have time in rural schools soon after graduation [4].

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As most public schools are underfunded, the government has also been implementing several measures to improve the budget per pupil. “No fee schools” have been introduced. This takes away the burden of fees payment from poor parents while increasing the government contribution per student [2].

The private sector has also been contributing in various ways, which include “adopting” hundreds of schools [7]. The companies identify the needy schools and then provide learning materials, and pay for improvements as well as fees for deserving pupils, among other interventions.

Learnings from other countries

South Africa is not the first country to encounter such problems. Other countries have also implemented various measures to improve their schooling systems.

In neighbouring Zimbabwe, for example, the education system implemented three major national examinations before the actual high school exit examinations. These examinations at Grade 7, Form 2 (Grade 9) and Form 4 (Grade 11) were used as “quality control” points to assess the capabilities of the students and then make informed decisions as to the “academic paths” of each of the students instead of just pushing the students along the system. There was also a focus on construction on schools, and the first eleven years of education were made free and compulsory. The pass marks were also set high at 50%. This resulted in Zimbabwe having the highest literacy rate in Africa.

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Singapore, which is recognised as having one of the best schooling systems in the world, identified the role of the teacher as the paramount. The country then implemented a strict teacher recruitment policy and also rewarded them well. It has been observed over the years that just by improving the quality of teachers, the quality of results has also improved [1]. In the Nordic countries, the emphasis has been on small classes. When classes are small enough, teachers can attend to students individually and student issues can be resolved at an individual level. Here, it has been possible to do so through reducing the student-to-teacher ratio to even

less than 15. In this way, it has been possible to improve results and maintain them at acceptable figures [1].

The solutions discussed suggest that there exist various workable solutions thatwhich have already been used in other countries. These have been mainly technical, which add weight to proposals to seeking technical ways to resolve the existing issues in South African education.

Learnings from industry

As already noted, in the past, industry struggled with product and service quality, but employed various tactical tools such as TOC, Lean, and Six-Sigma. These tools were chosen according to their suitability in the various situations, as shown in Figure 3.

Six- sSigma was mainly chosen when there was a need to reduce variation in a process. The term originated from terminology associated with statistical modelling of manufacturing processes. It is a set of techniques for process improvement and was developed by Motorola in 1986 and popularised by Jack Welch at General Electric in 1995. It is now widely used in industry and commerce to improve the quality of process outputs by identifying and removing the causes of defects (errors) and minimizing variability in manufacturing and business processes. It achieves this through the use of a set of quality management methods, including statistical methods, and creates experts in the methods ("Champions," "Black Belts," "Green Belts," "Yellow Belts," etc.) [13]. The Six-Sigma project follows a defined sequence of steps and has quantified value targets such as, for example: reducinge process cycle time, reducinge costs, increasinge customer satisfaction, and increasinge profits. The maturity of a process can be described by a sigma rating indicating its the percentage of defect-free products it creates. In a sSix- sSigma process, 99.99966% of the products manufactured are statistically expected to be free of defects [20].

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Tool Box	Six Sigma	Lean	Theory of constraints
Theory	Reduce variation	Remove waste	Manage constraints
Focus	Problem focused	Flow focused	Systems constraints

Figure 4: Choosing the right tool for resolving issues in manufacturing

The theory of constraints (TOC) is used where there is a need to manage constraints. It was introduced by Eliyahu M. Goldratt in his 1984 book titled *Goal*, and is based on the premise that there is always at least a constraint in a process, which can be logically identified and used to restructure the rest of the organization around it [14]. Further, organizations can be measured and controlled by variations on throughput, operational expense, and inventory.

For most businesses, the goal is to maximize profitability. If there is nothing preventing a system from achieving higher throughput, then its throughput would be infinite — which is impossible in a real-life system. Only by increasing flow through the constraint can overall throughput be increased [75]. Assuming the goal of a system has been articulated and its measurements defined, the five steps in TOC are [76]:

1. *Identify the system's constraint(s) (that which prevents the organization from obtaining more of the goal in a unit of time).*
2. *Decide how to exploit the system's constraint(s) (how to get the most out of the constraint).*
3. *Subordinate everything else to the above decision (align the whole system or organization to support the decision made above).*

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4. *Elevate the system's constraint(s) (make other major changes needed to increase the constraint's capacity).*

5. *Warning! If, in the previous steps, a constraint has been broken, go back to step 1, but do not allow inertia to cause a system's constraint.*

The five focusing steps aim to ensure ongoing improvement efforts are centered on the organization's constraint(s). In the TOC literature, this is referred to as the *process of ongoing improvement* (POOGI).

On the other hand, *Lean* has been used in industry to identify and eliminate “wastes” in value streams. Commonly known as *Lean manufacturing*, or often simply *"Lean,"*; it is a practice thatwhich considers any expenditure of resources for any goal other than the creation of value as wasteful, and thus targets such wastefulness for elimination. In this context, "value" is any action or process for which a customer would be willing to pay [13]. It uses defined principles to eliminate non-value-adding activities (referred to as “waste”) in order to improve quality; and reduce lead time, and costs, among other objectives [15]. It has been used in industry and commerce for generations. This has led to improvements lead time, costs and quality.

Lean thinking changes the focus of management from optimizing separate technologies, assets, and vertical departments to optimizing the flow of products and services through entire value streams that flow horizontally across the value streams. Eliminating waste along entire value streams, instead of at isolated points, creates processes that need less human effort, space, capital, and time to make products and services at lesser costs and with much fewer defects, than traditional business systems. Companies are able to respond to changing customer desires with high variety, quality, low cost, and with very fast throughput times. In addition, information management becomes much simpler and more accurate [10].

The researcher believes that current school improvement initiatives have never really addressed “waste” issues in the education value stream. Of relevance here, the DBE Education Plan to 2014 is flexible as toon the manner in which schools and

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communities conceptualise the “how” aspect of improving the education system [9]. It is in this context that the researcher wishes to test *Lean* as a tool to resolve some of the fundamental issues in South African education

2.3 LEAN

2.3.1Background

Lean manufacturing, or often simply *"Lean,"* is a production practice thatwhich considers any expenditure of resources for any goal other than the creation of value as wasteful, and thus targets such wastefulness for elimination. In this context, "value" is any action or process for which a customer would be willing to pay [13]. *Lean* uses defined principles to eliminate non-value-adding activities (referred to as “waste”) in order to improve quality; reduce lead time, and costs among other objectives [15]. *Lean* has been used in industry and commerce for generations. This has led to improvements lead time, costs and quality.

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2.3.2 Principles of *Lean*

The five-step thought process for guiding the implementation of *Lean* techniques, which is commonly referred to as the five principles of *Lean*, is as follows [15]:

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1. Specify value from the standpoint of the end customer by product family.

It is an established marketing idea that customers buy results and not products. We have to understand who the customers for each process are, as well as who the customer's customer is, so that product designs or service operations are not constrained by existing facilities or processes. The goal of any process should be to satisfy this customer.

2. Identify all the steps in the value stream for each product family, eliminating, whenever possible, those steps that do not create value.

This is a sequence of all processes all the way from raw material to final customer, or from product concept to market launch. The value stream should be mapped with the viewpoint of the object (or product or customer), and not from the viewpoint of the department or the process step.

3. Make the value-creating steps occur in tight sequence so the product will flow smoothly toward the customer.

Make the value flow. Avoid batch and queue, or at least continuously reduce them and obstacles in their way. Try to design according to Stalk and Hout's golden rule: never to delay a value--adding step with a non-value--adding step, although temporarily necessary step, -try to do such steps in parallel. Flow requires much preparation activity. However, the important thing is vision; that is, have in mind a guiding strategy that will move towards simple, slim and swift customer flow.

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4. As flow is introduced, let customers pull value from the next upstream activity.

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Having set up the framework, only operate as needed. 'Pull' in service terms means short–term response to customers' rate of demand and not overproducing. In service, it is often capacity that is pulled, not inventory or product.

5. As value is specified, value streams are identified, wasted steps are removed, and flow and pull are introduced. Begin the process again and continue it until a state of perfection is reached in which perfect value is created with no waste.

> *Perfection means delivering only what the customer wants, exactly when and immediately, at a fair price and minimum waste. The real benchmark is zero waste and not what competitors or 'best practice' are doing.*

These five principles are not sequential, once-off procedures, but rather a journey of continuous improvement.

2.3.3 Goals of *Lean*

The espoused goals of *Lean* manufacturing systems differ between various authors. While some maintain an internal focus (e.g. to increase profit for the organization) [20], others claim that improvements should be done for the sake of the customer. Some commonly mentioned goals of *Lean* are: [20]

2.3.3.1 Goal 1: Improve quality

To stay competitive, a company must understand its customers' needs and design processes to meet their expectations. Juran defines quality as "fitness for intended use," which is the ability to "meet or exceed customer expectations." Further, according to Deming, the customer's definition of quality is the only one that matters [20].

There are three broad concepts in quality: [20]

1. Quality assurance (QA) focuses on the entire quality system, including suppliers and ultimate consumers of the product or service. It includes all activities designed to produce products and services of appropriate quality.

2. Quality control (QC) has a narrower focus, which looks on the process of producing the product or service with the intent of eliminating problems that might result in defects. QC includes the operational techniques and the activities which

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sustain the quality of product or service that will satisfy given needs including the use of such techniques and activities.

3. Quality management is the totality of functions involved in the determination and achievement of quality and includes quality assurance and quality control [20].

An understanding of the definitions of quality helps in the design of the quality system for the classroom by including and managing the quality from the perspectives highlighted in this review.

As highlighted earlier, the quality of results for South African schools needs to improve to enable more students to qualify for tertiary studies, and eventually improve the economy and reduce social upheavals, as most citizens will have better access to the basic human needs. Accordingly, the DBE identified this as a key area of focus in the *Action Plan* to 2014 [9].

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For this dissertation, "quality" is the ability of schools to meet curriculum outcomes, thus enabling students to achieve results that open further opportunities for them. The internal customer (~~for example~~ in this case, the ~~g~~Grade 4 teacher) expects the ~~previous grade~~ teacher for the preceding grade (~~g~~Grade 3) to have adequately provided all the prerequisites; otherwise, the "product" (e.g., the students' results) will fail to meet the quality specifications. The external customers in this case are the students' parents, and they have their own quality expectations, which include the need for their children to move to the next grade (in the shortest possible period after having achieved the best possible results). After students matriculate, universities, colleges, and workplaces become schools' external customers.

In South Africa, the government's aim is to have more students qualifying for and completing tertiary education. Currently, only about 5% of South Africa's adult population has completed tertiary education as compared to 50% in Canada, for example [67]. Improvement in educational quality will help the South African government to:

- meet skills demand, both in quantity and quality;

- improve global competitiveness through better alignment of skills to the economy's needs; and
- reduce social upheavals and crime due to an improved education base [22].~~[22]~~

2.3.3.2 Goal 2: Reduce time:

Reducing the time it takes to finish an activity is one of the most effective ways to eliminate waste and lower costs [28]. Lead time is the total time that a customer must wait to receive a product after placing an order. If an organisation is to become world class, then it should target reducing its lead time [20]. Lead time actually consists of three components:

- Pre-processing lead time (also known as "planning time" or "paperwork"): It represents the time required to release a purchase order (if you buy an item) or create a job (if you manufacture an item) from the time you learn of the requirement. In the classroom context, this is the time from the planning of a lesson to the start of execution of that lesson.

- Processing lead time: It is the time required to procure or manufacture an item. In the classroom context, this is time required to execute a classroom lesson and activities, for example.

- Post-processing lead time: It represents the time to make a purchased item available in inventory from the time you receive it (including quarantine, inspection, etc.). In the classroom context, this is the time to mark and make assessment results available to the students.

An illustration of these lead times and how they relate to the various *Lean* classroom impressions is shown in ~~a~~Appendix B.

Lead ~~T~~time is only one of the three important times in *Lean* and process improvement in general. Whereas lead time measures the time between customer

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order and delivery of the product or service, cycle time measures the time needed to accomplish the standard work sequence for one product or service, excluding queue time. The third important time is called takt time, which is the period for every item or service to be produced in a day. Without emphasis on these three times, and continuous improvement through *Lean* tools, one will ~~then you'll~~ never advance~~go~~ to *Lean*, world class performance [16]. However, in order to improve these three times, standard work (that is, the tasks to be completed and their sequence) must be established.

~~All t~~These three important times were evaluated in the context of this research's case study in pursuit of reducing lead time to complete the curriculum.

The lead time of the South Africa Matric curriculum has remained static at twelve years, regardless of the customer's changing environment and the availability of tools, which could help to reduce it. Each grade has a one-year lead time, although the amount and complexity of the content changes each year. Within each grade there are terms, lessons and other forms of "standardised work" whose duration has also remained fixed. [Refer to Appendix B]

Improvement in Matric lead times can have profound effects for the state of education. For example, if the twelve-year lead time is reduced by one year, about 8% of the education budget – about R20 billion at today's rates would be saved each year [23]. This saving excludes the further savings the customers (parents) would save through cutting a year of fees and other related costs. These savings can be invested back into schools to address the current financing deficits. In addition, more time available for students could be used in further value-adding activities, such as emphasizing ~~on~~ other identified talents within each student. This saving in time will also improve the throughput from schools.

2.3.3.3 Goal 3: Eliminate waste:

Waste is any activity that consumes time, resources, or space but does not add any value to the product or service. While the elimination of waste may seem like a

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simple and clear subject, it is notable that waste is often very conservatively identified. This then hugely reduces the potential of such an aim [28].

The elimination of waste is the goal of *Lean*, and Toyota has defined three broad types of waste: muda, muri, and mura. However, it should be noted that for many *Lean* implementations, this list shrinks to the first waste type only. Non-value adding work is waste within the process. One key is to measure, or estimate, the size of these wastes, to demonstrate the effect of the changes achieved and, therefore, the movement toward the goal [29]. The original seven muda are as in Table 1:

Table 1: The seven wastes of *Lean* [16].

Seven Wastes	Description
Overproduction	Making something before it is needed. This is a particularly serious form of waste because it leads to excess inventory that is often used to mask other underlying problems and inefficiencies.
Waiting	Time when work-in-process is waiting for the next step in production (no value is being added). It can be truly illuminating to look at the time from order to shipment and ask how much of that time is actually spent on true value-added manufacturing.
Transport	Unnecessary movement of raw materials, work-in-process or finished goods.
Motion	Unnecessary movement of people (e.g., movement that does not add value).
Over processing	More processing than is needed to produce what the customer requires. This is often one of the more difficult wastes to detect and eliminate.
Inventory	Product quantities (e.g., raw materials, work-in-process, or finished goods) that go beyond supporting the immediate need.
Defects	Production that is scrap or requires rework.

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Others have added the waste of “unused human talent" to the original seven wastes, which has been found to be a useful addition. This form of waste results in a variety of lost opportunities such as lost motivation, lost creativity, and/or lost ideas. One of the reasons that this form of waste is often underemphasized, or even ignored, in companies is that its responsibility lies squarely on the shoulders of management because unused human potential usually results from management policies and styles that diminish employee contributions [31].

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2.3.3.4 Goal 4: Reduce total costs:

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To minimize costs, a company must produce only to customer demand. Overproduction increases a company’s inventory costs due to increased storage needs, while over-processing increases costs by overusing resources on activities that do not add value. Transporting items and unnecessary motion consumes resources that could otherwise be utilised in a value adding manner [30]. It has been noted earlier that reducing lead time by eliminating waiting time, for example, also directly reduces costs. As *Lean* manufacturing focuses on eliminating non-value adding processes (e.g. wastes), the result is a subsequent reduction in costs [10].

2.3.4 Tools of *Lean*~~OOLS OF *LEAN*~~

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Lean thinking offers many tools that can be successfully used in isolation, but the benefits of *Lean* techniques will compound as more tools are used, since they do support and reinforce each other. Following is an outline of some essential *Lean* tools, each of which is distilled into a simple description of what it is and how it helps [18].

Table 10: Tools of *Lean* [*32*]

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Lean Tool	What Is It?	How Does It Help?
Bottleneck Analysis	Identify which part of the manufacturing process limits the overall throughput and improve the performance of that part of the process.	Improves throughput by strengthening the weakest link in the manufacturing process.
KPI (Key Performance Indicator)	Metrics designed to track and encourage progress towards critical goals of the organization. Strongly promoted KPIs can be extremely powerful drivers of behaviour, so it is important to carefully select KPIs that will drive desired behaviour.	The best manufacturing KPIs: ▪ Are aligned with top-level strategic goals (thus helping to achieve those goals) ▪ Are effective at exposing and quantifying waste (OEE is a good example) ▪ Are readily influenced by plant floor employees (so they can drive results)
Muda (Waste)	Anything in the process that does not add value from the customer's perspective.	Eliminating muda (waste) is the primary focus of *Lean*.
PDCA (Plan, Do, Check, Act)	An iterative methodology for implementing improvements: ▪ Plan (establish plan and expected results) ▪ Do (implement plan) ▪ Check (verify expected results achieved) ▪ Act (review and assess; do it again)	Applies a scientific approach to making improvements: ▪ Plan (develop a hypothesis) ▪ Do (run experiment) ▪ Check (evaluate results) ▪ Act (refine your experiment; try again)
Root Cause Analysis	A problem solving methodology that focuses on resolving the underlying problem instead of applying quick fixes that only treat immediate symptoms of the problem. A common approach is to	Helps to ensure that a problem is truly eliminated by applying corrective action to the "root cause" of the

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	ask why five times – each time moving a step closer to discovering the true underlying problem.	problem.
Value Stream Mapping	A tool used to visually map the flow of production. Shows the current and future state of processes in a way that highlights opportunities for improvement.	Exposes waste in the current processes and provides a roadmap for improvement through the future state.

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2.3.5 *Lean* in the classroom

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Schools and school systems are organizations in which workers must rely on multiple complex processes to accomplish tasks and provide value to the customer (e.g., students and parents). These processes occur at the administrative, instructional, and student learning levels [36].

2.3.5.1 Goals of *Lean* in the classroom

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Several goals have been pursued to help achieve the *Lean* objectives in education. Wilson's project, which focused on higher education, and set out to prove that *Lean* tools used within traditional manufacturing environments can be transferred to an educational context to reduce assessment workload for both staff and students [24]. Wilson tested the hypothesis by simulating a cellular manufacturing environment. Component parts and machines were replaced by learning outcomes, units and a programme. Production Management staff were replaced with subject experts and Quality Assurance staff replaced with an external verifier. The PDCA Cycle was used to ensure the inquiry continued in the vein of creating a sense of cellular manufacturing and one that produced results through continuous improvement.

Similarly, Ziskovsky successfully redesigned a high school geography curriculum with the view of ensuring that a class completed their curriculum in the required time [27]. The class had been failing to complete itstheir curriculum in a normal academic year. ZiskovskyBetty identified the wastes of *Lean* in the classroom and used load assessment tool to complete the curriculum within the required time. Salewski (2009)

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also indicated that– *Lean* interventions have been carried out in administrative functions in universities and there have been proposals for *Lean* interventions to be done directly on classroom processes [36].

2.3.5.2 Wastes of *Lean* in a classroom

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Betty Ziskovsky [19] and Arokiiam [69] repackaged the wastes in an academic environment as in ~~f~~Figure 11. The two classifications have common areas but Ziskovsky renamed some of the wastes to make them more suitable for the academic environment, whereas Arokiiam maintained the wastes' names mostly as they are used in the manufacturing context.

Table 11: Tools of *Lean* [*32*]

Type of waste	Arokiiam's Education Example	Ziskovsky's Education example
Transport/Motion	• Photocopying department is on a different site to the delivery of lessons, hard copy sent to reprographics via internal mail, copying completed and returned to site of origin (___).	• ~~t~~The unnecessary physical or electronic movement, searching or transporting of items, people, or information that does not add value. If it is unnecessary, then it is inefficient to do it.
Skills ~~u~~Utilisation/Talent	• Teachers delivering above their own knowledge as a stop-gap, or even in reverse, covering classes that do not utilize their full potential • Not placing a person where they will use their skills and abilities to their fullest to the benefit of the organisation	• ~~t~~The failure to realise full potential and experience its benefits. Not utilising the students, teacher staff and community or organisational capabilities to achieve the best possible educational outcomes.

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Over-Production	• Multiple copies of hand-outs just in case students have mislaid their copies. • Developing too many different lessons/subjects that are not adding the required value.	• ~~t~~The generation of more than is needed at that moment for example duplication not needed, redundancies, unwarranted changes for the sake of change that are not part of continuous improvement activity.
Over- Process	• Over-assessment of same outcome which appears in different subjects/modules, students undertaking additional subjects outside the ones required to get the next job • Providing much more than what is required for the validation process (this can also be in the form of too many individuals involved in checking the same work)	
Defects	• Students not achieving the required learning outcomes or having to re-sit/re-submit course work. Lecture staff marking and giving feedback more than once on the same piece of work.	• ~~h~~Human errors, honest mistakes, or any number of things that contain omissions or inaccuracies that needs to be done again.
Waiting	• Feedback on assessment or achievement of learning outcome(s). • Long waiting to start the next academic year. • Waiting for lectures to be done in class.	
Inventory	• Students can be classed as inventory - they are raw material at enrolment, work in progress for the period of programme study and	

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	finished goods until the qualification is obtained.	
Time		• ~~i~~Idleness created when actions, information, people or equipment are not really where they are needed.
Process Handling		• ~~d~~Doing extra unnecessary processes, steps, reviews, or requirements that are mandated but not necessary.
Assets		• ~~u~~Using more resources, money, inventory, books, people, facilities or information than are needed.
Knowledge		• ~~t~~The re-creation of knowledge that already exists. It can affect students, teachers, and other staff. Knowledge waste can include poor planning, incomplete delivery, or mastery of curriculum, redundant or omitted courses, poor organisation, or communication or restricted possession of needed information by other groups.

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2.3.6 Technology and Lean

Some commentators have argued that the debate about the role of technology and *Lean* is often misplaced. The reason is that the debate tends to be too black and white: technology is not needed at all versus technology regarded as~~is~~ essential [77].

As complexity rises, the need for intelligent tools clearly increases, to the point where it seems hard to imagine how many manufacturing operations could successfully implement *Lean* without them. Optimal scheduling, routing, WIP sizing, and other decisions are beyond the capabilities of human beings and spreadsheets in these environments.

In between, the need still exists, but in some cases at a more basic level of capabilities and sophistication.

Today's technology tools should not be seen as the enemy of *Lean*, but rather enabling tools that help companies achieve and sustain the core goals of *Lean*: pull-based processes, inventory reduction, waste elimination, level scheduling, repeatable processes, etc. Companies must make honest assessments of the level of technology support that is needed to achieve these *Lean* benefits.

Many ERP providers have made tremendous progress in supporting *Lean*, and a few of them have notably focused their product and marketing efforts on *Lean* solutions. A newer class of focused *Lean* manufacturing solutions have also emerged from best-of-breed providers, in some cases by more established vendors, and in other cases by newer companies focused specifically on *Lean*. Traditional MES solutions can also play a role, and some~~in some cases~~ *Lean* technology providers are incorporating "light" MES capabilities that may meet the needs of many manufacturers.

As Toyota's then CIO, Yoshikazu Amano, said in 2006: ~~"~~ "There are cases when people become desperate for help in achieving their goals, they ask me: ~~"~~ 'Can we use IT for this?'~~"~~ When information made visible is used to do kaizen according to proper thinking, you can achieve results that traditional thinking could not."

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2.4 SUMMARY - LITERATURE REVIEW

The literature review has considered the elements that are important in considerations for a *Lean* intervention in classroom, including a. These are a knowledge of education, legislation, *Lean,* classroom pedagogy, and learning materials, among other items.

For years, The government has for years been implementing various measures to improve school results and ensure adequate financing of education institutions. These measures have included introducing supportive legislation, introduction of "no-fee" schools, and even providing free meals at schools. Further, in 2010, the DBE, announced the Education 2014 Action Plan, which provided a framework for resolving the problems in schools.

In the past, other countries had similar problems in their education systems. To counter this, Zimbabwe, for example, implemented "quality control" examinations at key grades, which were used to determine those who proceeded to the next level. Singapore emphasised on ensuring the recruiting of the best possible teachers while Nordic countries focused on reducing the teacher to student ratios.

Industry has also faced similar problems like South Africa education faces today. To improve, they have developed and adopted several quality and process improvement techniques, including *Lean* manufacturing, which has resulted in improvements in quality while reducing lead time and costs among others.

Lean is process-focused, and follows a five-step sequence principles focused on satisfying the customer goals. It was noted that the classroom processes can be represented using the SIPOC process in which the education system is regarded as having inputs, processes and outputs. Using this process, the inputs for the education process includes the students who are also works-in-process at different stages of the schooling grades. These students attend a series of lessons, which are similar to the work centres in the manufacturing process. The teachers, like operators of the manufacturing process, add value by imparting new knowledge and

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skills to the students. Over a period of seven years, the primary school process will deliver students as finished products, which then become the inputs to the high school education system. The seven wastes of *Lean* have been redefined for the education environment by Arokiiam and Ziskovsky, enabling their identification and gradual elimination.

Classroom reforms may have pedagogic implications. This requires interventions to enable the achievement of the research question goals without negatively affecting the classroom. Some of the pedagogic changes may require the use of technology to succeed, as technology has been shown to bring visibility and efficiencies while enabling achievement of *Lean* objectives.

Previous research points to the possibility for portability of *Lean* in education. However, no research thus far has ~~so far~~ been found to have focused solely on assessing if results can be improved while the lead times are being reduced in a South African or international classroom environment. As a result, ~~T~~this has ~~thus~~ pointed to the possibility of an existing gap in current knowledge, which needs to be pursued.

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