Chapter 4
Results

4.1 Chapter Overview

This chapter presents the research results, and is presented according to the methodological steps introduced and detailed in Chapter 3. The chapter begins with an overview of the initial findings and then broadly follows the scope, select, solve, and sustain phases outlined in the previous chapter. It uses these phases to present detailed research results, as well as related discussion and analyses.

The research has gathered significant amounts of data in the form of questionnaires from parents at five primary schools and this data is discussed to show how important parents feel toward school safety. The research then moves into a deep analysis of the case study school, initially via questionnaires and interviews, and then via UML modelling of school safety processes. The solve phase then begins where the solution to the research problem is developed and reported, which includes value stream mapping to improve the school's safety processes, rapid process improvement workshops to instigate effective knowledge sharing and ensure people are part of effective school safety, and the AHP model to improve the school's management of safety suggestions. Finally the results show the results from stakeholder analysis and evaluation of individual tools adopted in the solution.

The first part of this chapter outlines the initial findings from the sample groups in order to provide a clearer context and foundation from which to consider the detailed results from each phase in the research.

4.2 Sample Reports and Initial Findings

This section of the results presents a summary of the initial findings, while the later parts of the chapter then provide an in-depth and detailed breakdown of these results, including discussion and analysis. The framework and rationale of this chapter is illustrated in Figure 4.1, which shows how the initial findings provide an overview and context to the work, while the detailed analyses and discussion of results provides clear insights, which then facilitate and feed the wider context and implications of the research.

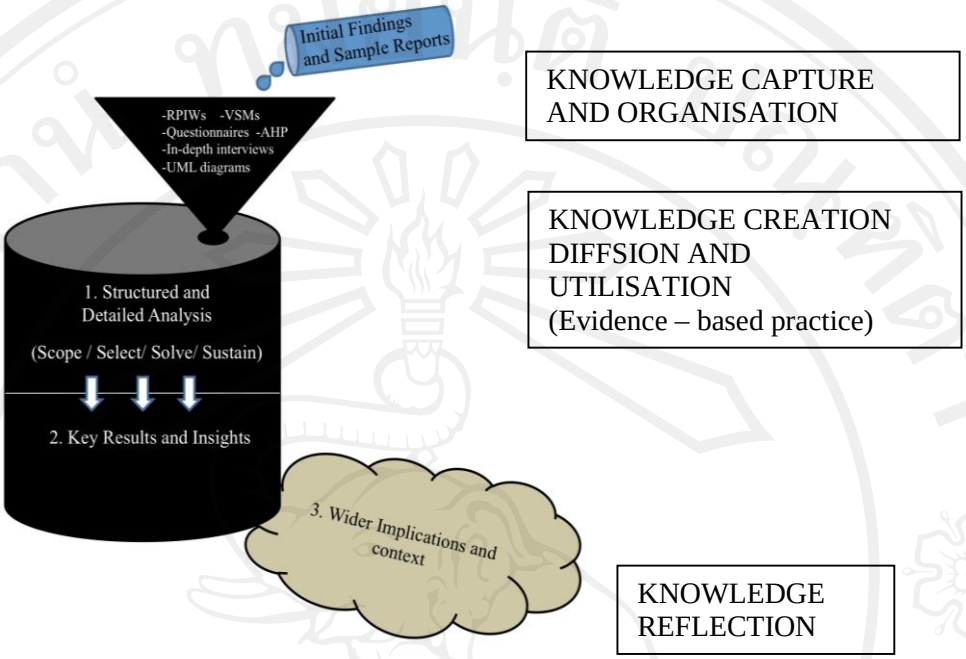

Figure 4.1 The structure/framework of the results presented in this chapter

Figure 4.1 illustrates the conceptual overview of this chapter and shows that the chapter begins with the initial research findings, and then moves to a more detailed analysis, which provides key insights and links to the wider implications and context of the research. Figure 4.1 illustrates that the initial findings and sample reports are summarised to give an overview, before being funnelled into the main discussion and analysis, where the results are analysed in a detailed structured way, before being assessed in relation to the overall research aim and objective, as well as the wider context. Figure 4.1 also highlights that each part of this results chapter represents a different aspect of the Knowledge Management framework. The presentation of the initial findings and sample groups relates to capturing and organizing safety related Knowledge.

The detailed and structured analysis according to the Scope, Select, Solve and Sustain phases then relates to Knowledge utilization as well as diffusion and the creation of new school safety related knowledge. Finally, the wider context and implications of the research are related to Knowledge reflection. The first part of this chapter now presents the initial findings and sample reports from the research.

4.2.1 Initial Findings from Questionnaires: Five Schools in Northern Thailand

The first part of the research interviewed parents and teachers from five schools in northern Thailand, and from a sample size of 540 parents and teachers, the following initial results were determined:

- Safety was considered critically important by parents and teachers.
- Overall, a higher proportion of teachers than parents rated safety as 'important' or 'very important'.
- Parents from private schools rated safety as more important than parents from government schools, meaning that for private schools, safety is even more critical than for government schools.
- Primary school parents considered safety as more important than secondary school parents, meaning that for primary schools (i.e. the case study), safety is more critical to maintain parental satisfaction than in secondary schools.
- The majority of parents who were questioned felt that although their school was somewhat safe, more could be done to improve school safety.
- Teachers were more positive about how safe their school was, probably as they feel the school environment and its safety is a direct reflection of their effectiveness as teachers.

After these initial results from five schools, the research then focused more specifically on the case study.

4.2.2 Initial Findings From Detailed Questionnaires at the Case Study School

The second part of the results focuses on the detailed questionnaires collected at the case study, where the sample sizes were 750 parents, and 93 teachers/staff. The key initial findings from these specific case study questionnaires were as follows:

- Parents at the case study considered the school's safety to be a very important issue.
- The majority of parents felt the school was either safe or very safe.
- About 40% of parents felt the school was unsafe.

- Teachers were again more positive than parents, with a higher proportion answering that the school was safe.
- Only 50% of parents and teachers believed the school was effective at sharing safety related knowledge.
- The school drop-off and pick-up locations were frequently mentioned as the most unsafe areas in the school.

Following the questionnaires at the case study to achieve breadth of understanding, in-depth interviews were undertaken to achieve a more in-depth understanding of safety at the case study.

4.2.3 Initial Findings from In-depth Semi-structured Interviews at the Case Study School

The third part of the results utilized semi-structured in-depth interviews at the case study, which aimed to add depth of understanding to the research. There were 15 interviews in total, five with parents, five with teachers, and five with staff. The key findings were as follows:

- Parents are fully aware of safety issues at the school, and expect a high quality of safety for their children.
- Parents felt that classrooms were the safest place in the school, while the drop-off and pick-up areas were considered unsafe.
- Teachers were all aware of, and involved in school safety.
- Teachers agreed with parents in terms of the safest place being the school classrooms, while the most unsafe places were considered to be the swimming pool and school drop-off and pick-up.
- Staff responses were skewed toward the school management's opinion and the related safety policies and processes.

The next set of results looked specifically at school safety and related processes via a hazard assessment and UML diagrams.

4.2.4 Initial Findings from School Hazard Assessment and UML Diagrams

The next results in the research are based on a hazard assessment at the case study school, and then UML diagrams to map school safety activities in order to make decisions regarding areas of focus when attempting to solve the research problem. The initial findings from these two data collection instruments were as follows:

- The school drop-off and pick-up areas were once again highlighted as being unsafe.
- Five key areas of school safety were mapped via UML diagrams, including students' safety, monitoring school safety, budgeting for safety, responding to the safety needs of parents, and finally, safety compliance.
- Based on a management burden score for each one of these five processes, three were chosen for the solve phase. These were responding to the needs and suggestions of parents, safety compliance, and finally, safety monitoring.

After identification of the school safety activities which required focus, the next stage analysed these via lean value stream mapping to determine areas of improvement,

4.2.5 Initial Findings from Lean Value Stream Mapping (VSM)

The UML diagrams allowed section of the processes to focus on, and the next step therefore utilized lean value stream mapping (VSM) to analyse the current processes according to the tools of lean thinking, and then improved these current state value stream maps to reduce waste and increase the amount of value added time. The initial findings from the value stream mapping were as follows:

- Three current state value stream maps were produced, and for each one, the waste was mapped using 5S and the seven wastes.
- There were too many non-value adding steps in each of the three VSMs.
- Three future state VSMs were created based on the waste identified from the 5S and seven wastes.

- The future state value stream maps produced an average increase of **38%** in the number of value added steps.
- The average number of steps required for school safety processes was reduced from 47 to 25.
- The percentage of value added time increased from 12.7% pre-lean to 19% post lean.
- Overall, the VSMs allowed for significant improvements to safety related processes in the school.

One of the key aims of lean is to reduce waste and standardize processes, and thus the next stage of the research applied AHP to school safety suggestions to standardize the process and reduce waste.

4.2.6 Initial Findings from the AHP Decision Support Model

A key aspect of the research relates to managing the large number of safety suggestions that the school receives from parents. Making decisions about whether to implement or reject the suggestions is a key contributor to the amount of waste and non-value added time related to school safety. The AHP model was thus implemented to solve this issue, and the initial findings are as follows:

- In line with the sentiments of the seven wastes and SSs the AHP provides a standardized way to approach school safety suggestions.
- The consistency of the model was high, with a low coefficient of variation in the scores given to safety suggestions by different school personnel.
- The number of processes associated with safety suggestions and the related processing time could be cut using the AHP model.
- The AHP model provides an effective solution to dealing with significant numbers of safety suggestions.

Chapters 1, 2 and 3 have already explained that there are both tacit and explicit components to this research, and while lean value stream mapping and AHP have addressed the explicit processes, Rapid Process Improvement Workshops (RPIWs) were utilised to address the tacit aspects of school safety.

4.2.7 Initial Findings from Rapid Process Improvement Workshops (RPIWs)

After focusing on the explicit aspects of school safety (i.e. the visible processes and tools), the tacit aspects were addressed using lean rapid process improvement workshops (RPIWs). The three RPIWs yielded the following initial findings:

- The first RPIW focused on developing awareness of lean and school safety, and then capturing the tacit knowledge from staff and teachers to utilise during the safety improvement process. Results were in the form of a CEDAC diagram, which provided a number of causes of school safety issues and allowed the capture of tacit safety knowledge in the school.
- The CEDAC was analysed using an interrelationship digraph to identify root causes of safety issues in the school, and thus provided a basis for solving some of the key issues related to safety.
- The first RPIW introduced school personnel to lean safety, and captured their knowledge for use during the safety improvement processes.
- The second RPIW focused on safety related knowledge sharing in the school, and the results from pretests and posttests showed statistically significant improvements in knowledge sharing awareness.
- The third RPIW was based on school leadership, and also showed statistically significant differences before and after the implementation of RPIW, which illustrates the improvement in the awareness of leadership and school safety.

The initial results illustrate the overall effectiveness of the approach to school safety, but do not synthesise and draw the results together. The next part of this chapter builds upon the initial results according to the scope, select, solve and sustain phases, which was introduced and explained in Chapter 3.

The results and associated discussion are related to knowledge creation diffusion and utilization. This is presented according to the scope, select, solve and sustain methodological framework, which was outlined in Chapter 3.

4.3 The Scope, Select, Solve and Sustain Phases: Detailed Analysis and Discussion

The initial findings and sample reports are now used as a basis for detailed analysis and detailed discussion to illustrate the new insights into school safety provided by the lean thinking knowledge management approach. The discussion also provides a wider context for the results, and seeks to bring together the diverse aspects of the results to show how the knowledge management approach provides a holistic method of addressing school safety.

Figure 4.2 illustrates the overview of the detailed results and discussion, which presents results according to the scope, select, solve and sustain phases, which were described in Chapter 3.

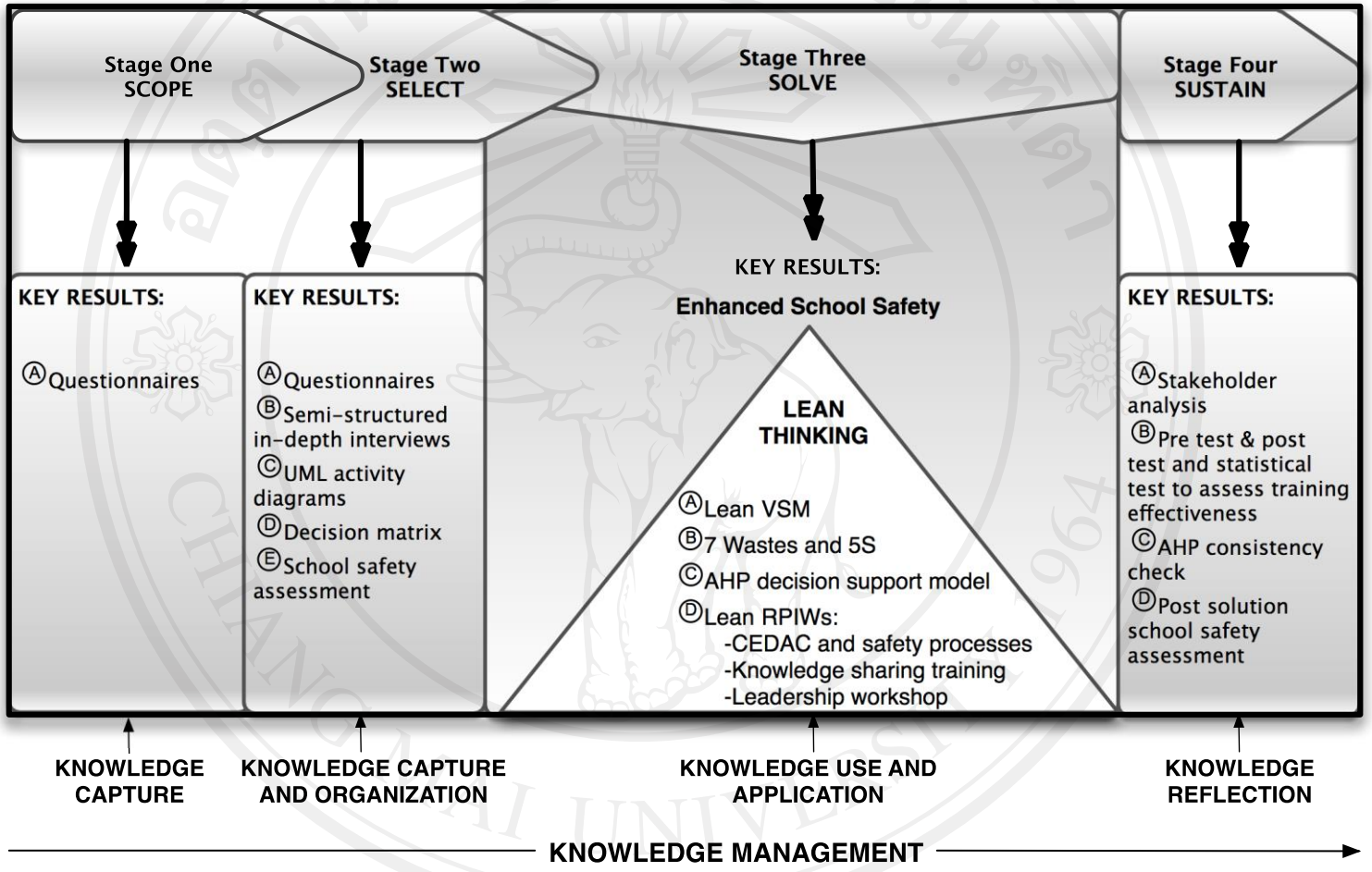

Figure 4.2 Overview of the results presented in this chapter and how they relate to the scope, select, solve and sustain methodology, as well as the knowledge management focus in each of the steps

4.4 Step One: Scope

Figure 4.3 illustrates the results presented in this section, which relate to the scope phase of the research. This phase captured relevant knowledge via questionnaires in order to scope the research problem before designing an appropriate knowledge solution.

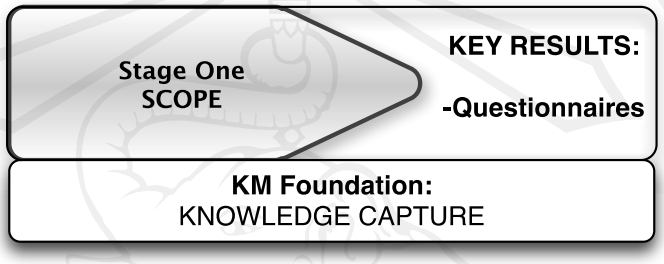

Figure 4.3 The scope stage of the results and its main task of capturing knowledge

Chapter 3 has already outlined the purpose of the scope stage, which is to ensure the research problem of school safety is adequately identified and understood before attempting to solve it. Thus this section presents detailed results from the five schools where questionnaires were undertaken. The scope stage of the research presents results related to the collection of tacit knowledge regarding school safety. This is in the form of questionnaires designed to capture the attitudes and opinions of school safety across a variety of school types in Thailand, and from various parents and teachers. When assessing the results from the questionnaires as a whole, it becomes apparent that parents, teachers and staff all feel school safety is important, however the questionnaires reveal interesting differences when private and government schools are compared, and when the differences between primary and secondary schools are taken into account.

4.4.1 School Safety Questionnaires

The total sample size of the school safety questionnaire consisted of 540 respondents at five schools. Of those 540 questioned, there were 226 teachers/staff, and 314 parents, as shown in Table 4.1.

Table 4.1 The sample groups and questionnaire respondents at the five sample groups (schools)

Designing the questionnaires: sample group details	Questionnaires respondents		
	Parents	**Teachers/Staff**	**Total**
1. Government primary school in Lamphun – operating in Lamphun only at the primary levels (P1 – P6). There are approximately 150 students, 22 teachers and 19 staff.	31	22	**53**
2. Private primary school in Lamphun (a). This is a private primary school (levels P1-P6) with approximately 806 students and 60 teachers and staff.	33	27	**60**
3. Private primary school in Lamphun (b) with 840 students and 93 teachers/staff.	200	107	**307**
4. Government secondary school in Lamphun. This is a large government secondary school (levels M1-M6) operating in Lamphun, with 259 teachers/staff and approximately 3300 students.	30	30	**60**
5. Private secondary school in Lamphun providing education from M1-M3 with 420 students and 36 teachers/staff.	20	40	**60**
Total respondents from all schools			**540**

There were 1,150 questionnaires sent to the three sample groups, which were 650 questionnaires to parents and 500 questionnaires to teachers and staff. The returned questionnaires and its response rate were as shown in Table 4.2.

Table 4.2 Response rates of parents and teachers from the questionnaires sent to the three sample groups during the scope phase of the methodology

Respondents	Total Questionnaires Sent	Total Returned	Response Rate
Parents	650	314	**48.3%**
Teachers	500	226	**45.2%**

A questionnaire honesty scale was calculated based on respondents' answers to two identical questions in the survey, which despite asking the same question, were separated into different sections of the questionnaire. The purpose of this honesty scale was to assess if there was a gap between declared preferences and revealed preferences. By computing the correlation between these two question responses, an estimation of how consistent or honest respondents had been could be determined. The Pearson correlation coefficient (r) was used to determine the consistency of responses between the two questions. Table 4.3 presents the results of this honesty scale, and suggests that overall, respondents were honest when completing the questionnaires, although there was some slight variation between different schools.

Table 4.3 Results calculated from the questionnaires to assess the honesty of the respondents using Pearson's correlation coefficient (r), the coefficient of determination (r^2) and finally, a percentage level of honesty.

Overall Honesty (average honesty rate)	**Secondary Government Respondents**	**Secondary Private Respondents**	**Primary Government Respondents**	**Primary Private Respondents**
R = 0.96 R^2 = 0.92 OR **92% honesty rate**	R = 0.98 R^2 = 0.96 OR **96% honesty rate**	R = 0.86 R^2 = 0.74 OR **74% honesty rate**	R = 0.99 R^2 = 0.98 OR **98% honesty rate**	R = 0.98 R^2 = 0.96 OR **96% honesty rate**

The overall honesty rate was 92% which can also be interpreted as a reliability rate, thus suggesting the results could be replicated if the survey was completed again (Brown, 1997). The lowest honesty rate was from a private secondary school, but the rate of 74% is still acceptable for the purpose of the surveys in scoping parental attitude and opinion toward school safety.

Figure 4.4 illustrates the results of the scope questionnaire, and of the 540 respondents, all felt that school safety was important, with approximately 62% of teachers and staff indicating that safety was 'very important' to them, and approximately 30% indicating that safety was 'important'. Approximately 8% felt that school safety was only 'somewhat important', however none of the respondents stated that safety was 'not important' or 'not important at all'.

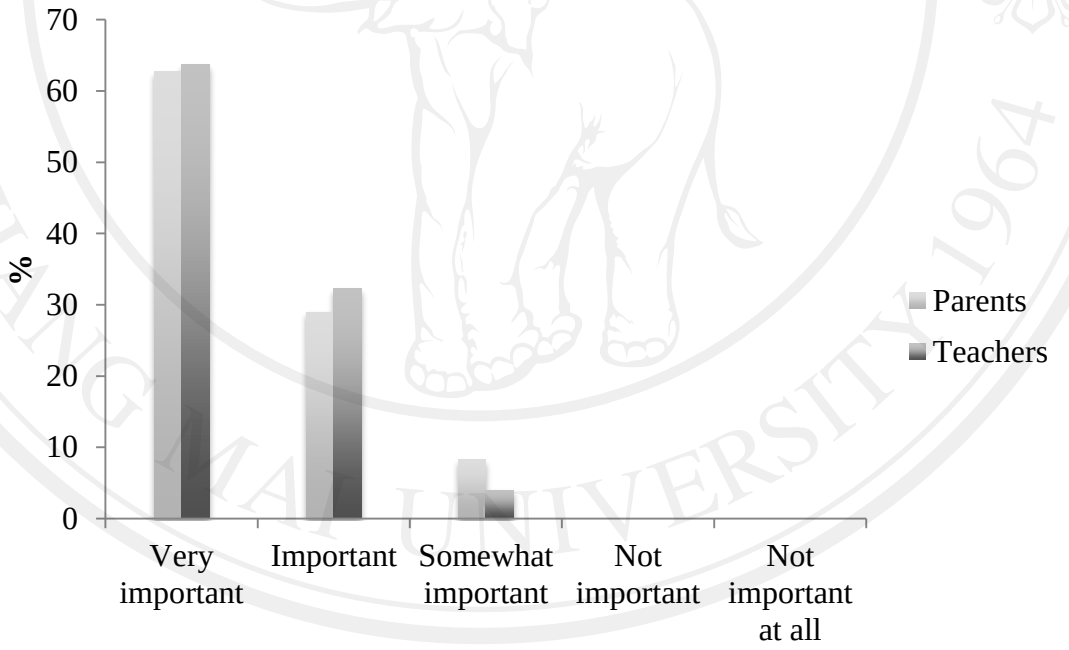

Figure 4.4 Bar chart showing the results from the scope questionnaire, which asked respondents, 'how important do you consider school safety to be?' (n = 540)

While Figure 4.4 shows that all respondents clearly thought school safety was an 'important', or 'very important issue', there was a distinct difference between teachers and parents in their attitudes towards school safety.

Overall, and perhaps surprisingly, a smaller proportion of parents than teachers, rated school safety as either ‘very important’ or ‘important’. When compared to parents, teachers rated school safety as more important, but only by a marginal amount. This can be explained by teachers who perceive safety as having a direct influence on their own job. For example, teachers feel that if the school is safe, the likelihood of their own conduct being scrutinized is lower than in an unsafe school. Teachers feel that a safe school reflects positively on them. This is corroborated by Jimerson and Furlong (2006), who illustrate that there is a strong relationship between school safety, and the way teachers are perceived.

When analyzing data according to the type of school, different patterns emerge regarding parental attitude towards safety, and these differences in attitude have significant implications for schools in terms of how they manage safety, and the way in which they respond to parents’ school safety needs. Figure 4.5 illustrates the differences between private and government school parents in response to the question, ‘how important do you consider school safety to be?’

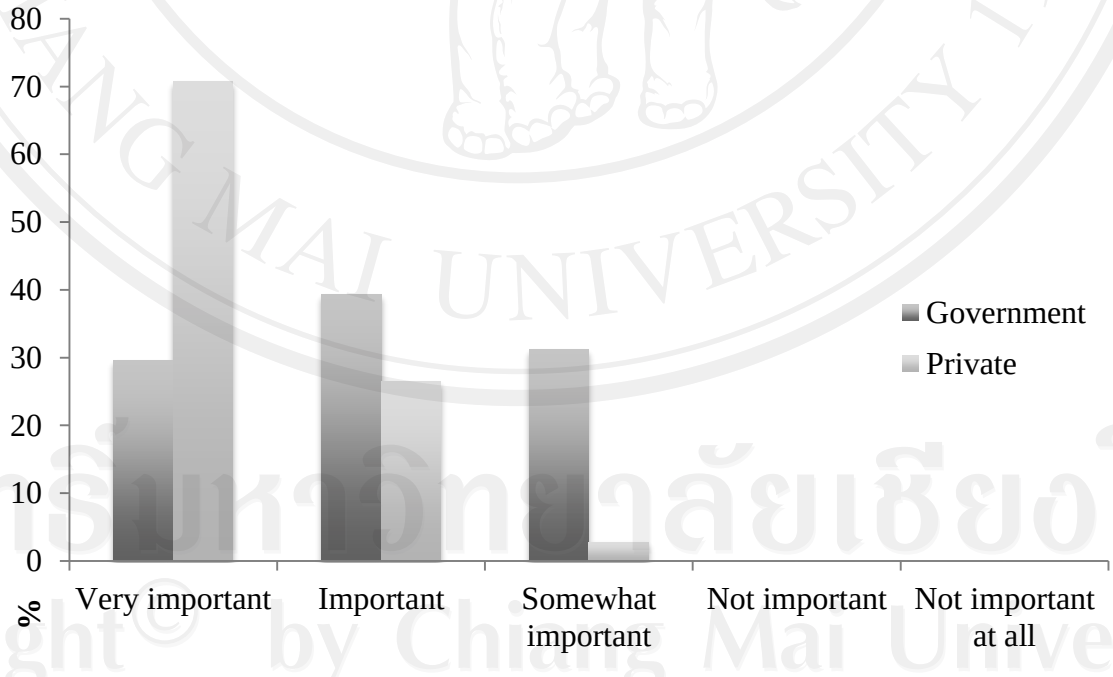

Figure 4.5 Bar chart illustrating the difference between government and private school responses to the question, ‘how important do you consider school safety to be?’ (n = 540)

Figure 4.5 shows that a significantly higher proportion of parents from private schools rated school safety as being ‘very important’, with over 70% of private school parents rating safety as ‘very important’, compared to only 29% of government school parents. This result is expected, as parents sending their children to private schools often do so due to the differentiation a private school provides. While Lockheed and Jimenez (1989) explain that in developing countries, excess demand is generally the main driver of private school growth, this is not the case in Thailand, where school differentiation is now a key driver of private school demand. Private schools also contain a larger proportion of students from higher income, white-collar backgrounds (Tsang and Kidchanapanish, 1992), where parents are more likely to be aware of safety issues, and select their child’s school based on safety and academic quality. In contrast, parents from government schools are more likely to send their children to the nearest school, or to the closest school with available spaces. To some extent, this presents a moral dilemma, as school safety should be important for all. However, for private schools trying to survive in a budget-constrained reality, they must compete for students, and ensure parental satisfaction through academic quality, and via issues such as school safety (OECD, 2011). This highlights the particular importance school safely has for private schools.

As well as differences between government and private schools in terms of parental attitude towards safety, there is also a significant difference between parents at secondary and primary schools. This is most likely related to the age of children, and is supported by Yoon (2004), who shows a clear difference in accidents (and thus safety), between primary and secondary schools. Figure 4.6 shows the results from the initial scope survey in this research, and separates the results into primary and secondary parents, and their attitude toward school safety.

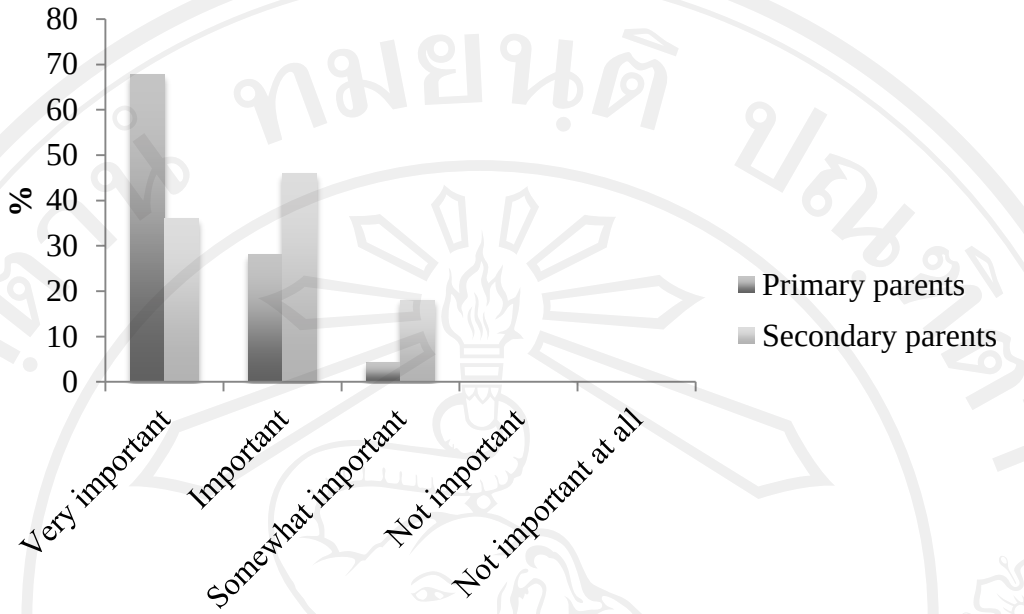

Figure 4.6 Bar chart showing the difference in attitude toward safety between primary and secondary school parents, based on their response to the question, 'how important do you consider school safety to be?' (n = 540)

Figure 4.6 indicates that when compared to secondary school parents, almost twice as many primary school parents rated school safety as 'very important'. Although all the secondary school respondents rated safety in one of the top three categories, the results indicate that in Thailand, according to the survey, primary school parents rank safety as more important than secondary school parents. This has important implications for primary school leaders, who must understand that safety is considered a very important issue for this particular group of parents.

The results presented so far indicate that of all the types of parents interviewed, school safety is considered most important for primary school parents sending their children to a private school. Thus for private primary schools in Thailand, there is a requirement to ensure the school is considered safe by parents, who are in effect customers of the school. While the questionnaire results have illustrated the importance of school safety to private primary schools, the questionnaire also gathered opinions from parents and teachers based on how safe they feel their school actually is. This question was necessary to ascertain the gap between what parents want in terms of school safety, and what they actually perceive they are getting.

While results from the questionnaire have shown the importance of school safety to primary school parents at private schools, a further question was elucidated by assessing parents' opinions on how safe they actually considered their school to be. The same sample groups (private, government, primary, secondary) were broken down to analyse and assess how safe parents and teachers considered their schools to be. Figure 4.7 illustrates that once again, teachers were generally more positive about the safety situation at their school. This is an expected result given that teachers and staff rely on the success of the school for their livelihood, and feel a sense of ownership toward the school.

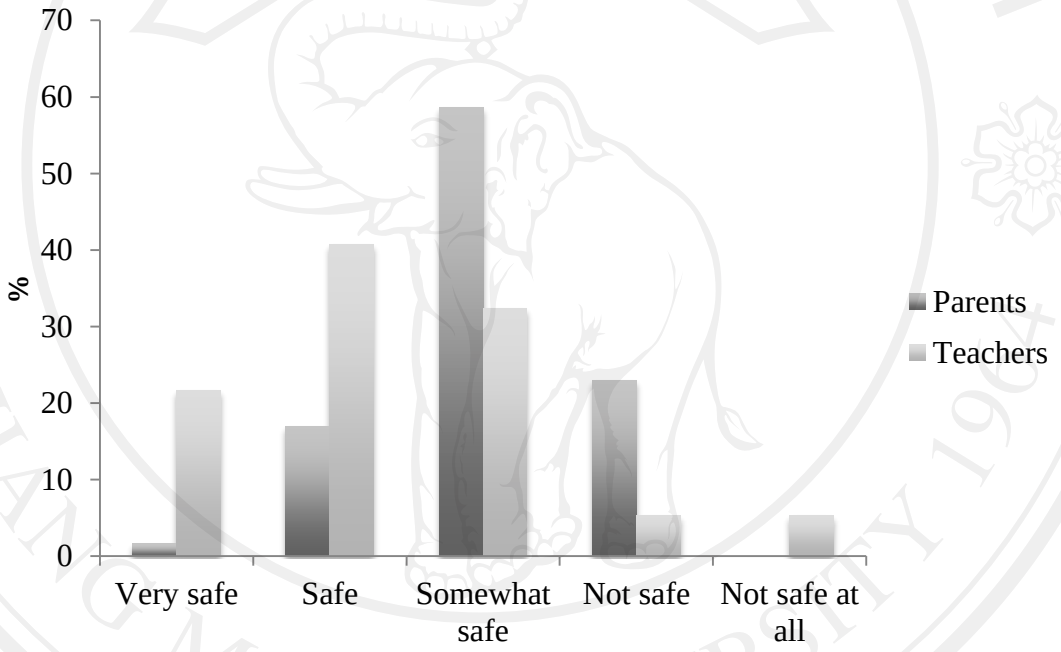

Figure 4.7 Bar chart highlighting a comparison of the response between parents and teachers/staff to the question, 'overall, how safe do you think your school is?'. (*n* = 540)

As shown by Figure 4.7, teachers were far more positive about the current state of safety in their schools than parents. Only 1% of parents thought that their schools were 'very safe', compared to over 20% of teachers. This pattern replicates itself in the 'safe' category, with only 16% of parents rating their school as 'safe', while in contrast, over 40% of teachers rated the school as 'safe'. When breaking down this data, and comparing government with private schools, the private school respondents ranked their school as safer than government respondents. Figure 4.8 illustrates the percentage of government versus private respondents who

rated their school as ‘very safe’, ‘generally safe’, ‘somewhat safe’, ‘not very safe’, or ‘unsafe’.

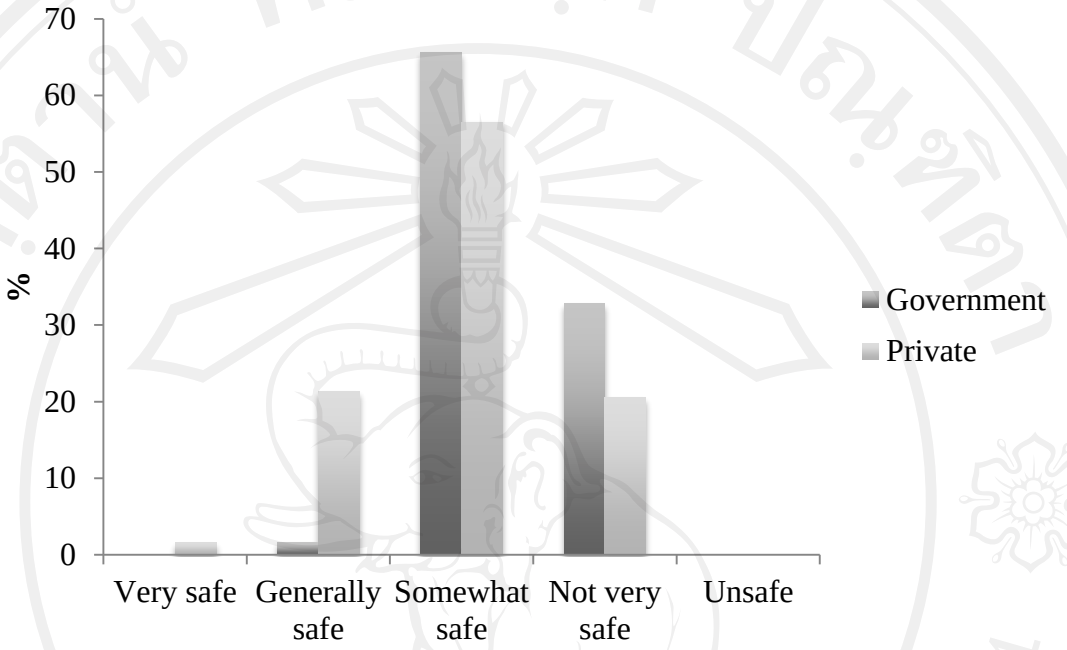

Figure 4.8 Bar chart showing the percentage of government versus private school respondents rating their school as either ‘very safe’, ‘generally safe’, ‘somewhat safe’, ‘not very safe’, or ‘unsafe’. (*n* = 540)

Figure 4.8 shows that no respondents from government schools rated their establishments as ‘very safe’, but a small percentage of respondents from private schools did. Over 20% of respondents from private schools rated their schools as ‘safe’, compared with only 1% of government school respondents. The overall trend shown by Figure 4.5 is that private school respondents generally felt their schools were safer than government schools. This corroborates the earlier results regarding parental attitude toward school safety, and illustrates that at private schools, safety is an important issue, and is given more attention than in government schools.

Finally, Figure 4.9 shows the difference between primary and secondary schools when considering opinions of the school’s safety. The graph shows that overall, respondents from primary schools considered their schools safer than those respondents from secondary schools.

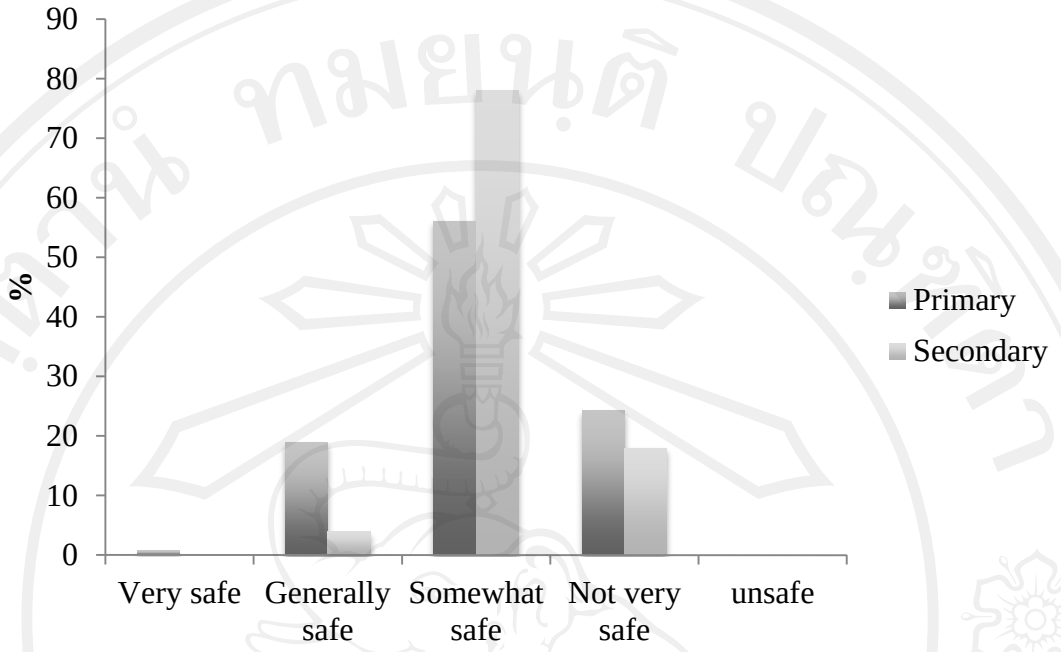

Figure 4.9 The percentage of primary versus secondary respondents rating their school as either ‘very safe’, ‘generally safe’, ‘somewhat safe’, ‘not very safe’, or ‘unsafe’. (*n* = 540)

According to Figure 4.9, approximately 20% of primary school respondents ranked their school as either ‘very safe’ or ‘safe’, while only 4% of secondary school respondents rated their school as ‘generally safe’. The majority of secondary school respondents considered their school as being ‘somewhat safe’. Interestingly, a higher proportion of primary school respondents rated their schools as ‘not very safe’ compared to secondary school respondents. Thus the overall opinion of primary school parents was bimodal, suggesting the school was either ‘safe’ or ‘not very safe’. In comparison, the majority of secondary school respondents ranked their school as either ‘somewhat safe’ or ‘unsafe’.

Summarizing the results of the questionnaires gives a critical insight into school safety in Thailand, and illustrates that primary school parents from private schools feel safety is most important. This suggests that schools operating in the private primary sector must ensure that school safety is effective, and meets the needs of parents, who are the school’s customers. Out of the four types of school where safety knowledge was captured, the

private primary school is the place where safety is considered most important.

To retain parents as customers, there is a need for private primary schools to at least maintain, or better still, improve safety. However, maintaining or improving school safety is set against increasing pressure on school budgets, and a strong requirement to focus on academic attainment, which takes focus away from the school's environment and safety. The questionnaires in this scope phase of the results have acted as knowledge capture tool, to show how school parents and teachers perceive school safety. This tacit knowledge is critical before focusing on an individual case study school, as the knowledge allows the solution to be based on a wider context. The next phase of the results now focuses on how schools in Thailand could achieve more effective safety without significant financial impacts.The select phase introduces the case study in this research, which is a private primary school in the north of Thailand (for case study details, see Chapter 3, section 3.6).

4.5 Stage Two: Select

Figure 4.10 shows the Select phase of results presented in this section, which reflect further knowledge capture (at the case study) as well as knowledge organization, prior to the development and implementation of a solution.

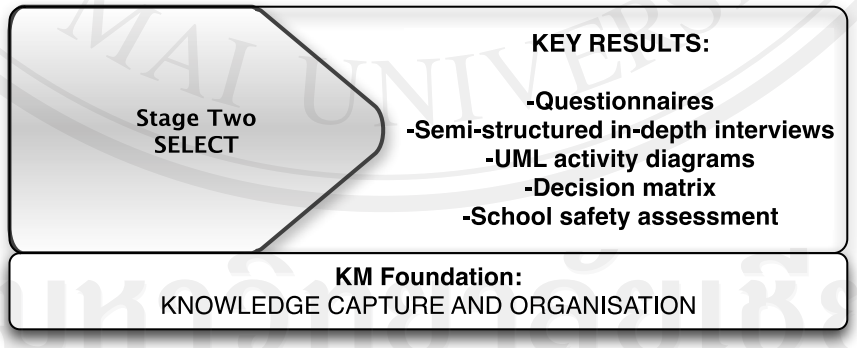

Figure 4.10 The select stage of the results and the main task of capturing and organizing knowledge prior to the development of a solution

In this stage, the adapted questionnaires were distributed to all parents, teachers and staff of the case study school, and the response rates are described in Table 4.4.

Table 4.4 Response rates of parents, teachers and staff from the questionnaires sent to the three sample groups at the case study school

Questionnaire Respondents	**Total Questionnaires Sent During Sampling**	**Total Returned**	**Sampling Response Rate**
Parents	1,100	743	**67.5%**
Teachers	82	82	**100%**
Staff	11	11	**100%**

This stage of analysis and discussion presents results from the detailed questionnaires collected at the case study school, as well as a set of semi-structured in-depth interviews, UML activity diagrams, a management decision matrix, and finally, a school safety assessment. Together, the results from these data collection instruments represent the tacit, explicit and embedded knowledge collected at the case study school with regard to the current safety situation.

As explained in Chapter 3, this section of the research enabled the case study to be analyzed in depth, before designing and implementing a solution. It was important to capture knowledge at the school regarding teachers' and parents' attitudes and feelings toward safety, so that a baseline could be reached from which to assess the solution. The questions asked were similar to those in the scope phase of the research, but on this occasion, all respondents were from the case study school, and the sample size was expanded to enhance the accuracy of the results, and assesses the diversity of opinion based on the range of attitudes and opinions toward safety at the school. Figure 4.11 illustrates the difference in attitude between parents and teachers when asked how safe they feel the case study school is.

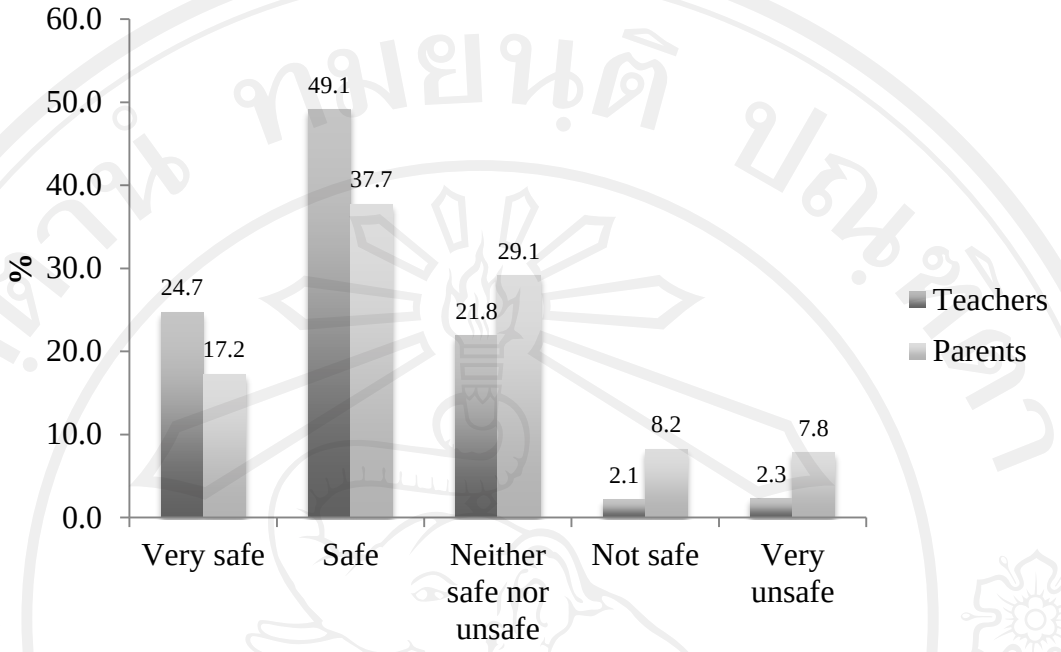

Figure 4.11 Responses of parents and teachers (%) in the case study school to the question, 'in general how safe do you feel your (or your child's) school is?'. (parents *n* = 750, teachers *n* = 93)

As shown in Figure 4.11, teachers at the case study school echo the teachers' responses from the earlier questionnaires in the scope phase, and teachers at the case study are generally more positive about the school's safety when compared to parents. Once again, this is to be expected given that teachers rely on the school for their livelihood, and have a sense of school ownership. Honingh and Ort (2009) support this view, and suggest that there are key behavioural and attitudinal differences between government and private school teachers, implying that the type of organization affects the way in which they feel about the school.

Parents were less positive than teachers at the case study school, but overall, approximately 55% considered the school as 'safe' or 'very safe'. The remaining parents were less enthusiastic about safety, but only 16% considered the school to be 'not safe', or 'very unsafe'. While this number is relatively low, when contemplating how important parents consider safety to be, the 16% of parents who consider the school as 'not safe' or 'very unsafe' represent a potential loss of students if they believe there is a safer alternative school that meets their requirements.

Parents and teachers were also asked a series of questions related to knowledge sharing practices in the school. This was to understand how the school is currently performing in terms of sharing safety knowledge between parents and teachers, and was related to the intrinsic and critically important link between safety and knowledge (highlighted in Chapter 3, section 3.4). Figure 4.12 shows parents' and teachers' opinions of knowledge sharing in the school.

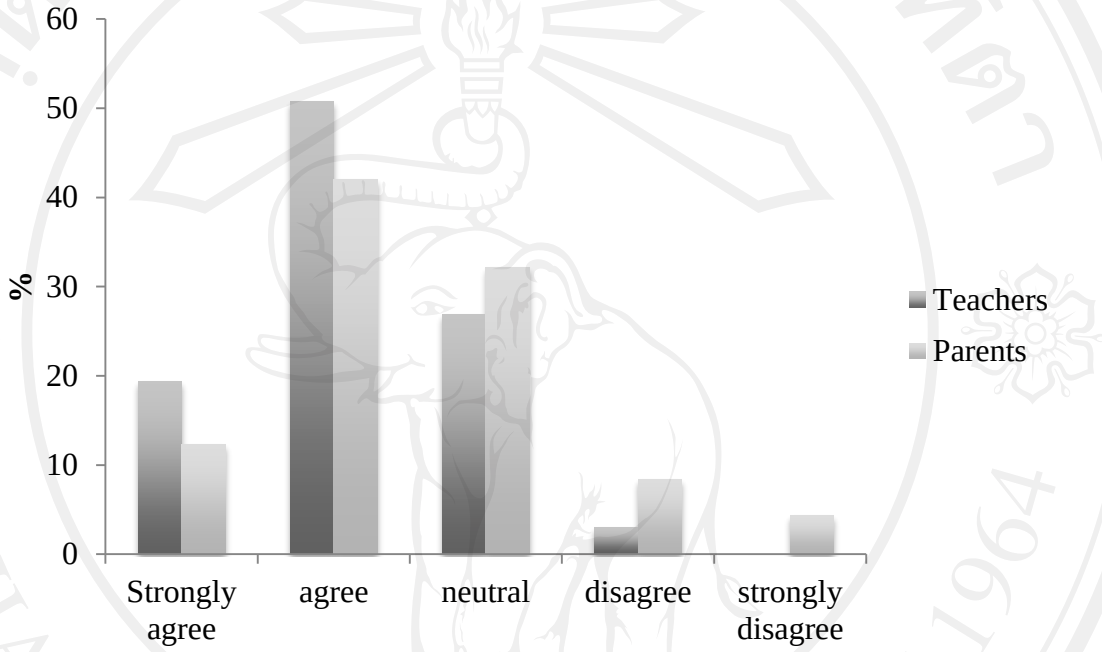

Figure 4.12 Parents' and teachers' opinions on knowledge sharing in the school based on the cumulative answers to five knowledge sharing related questions (parents n = 750, teachers n = 93)

According to the knowledge sharing questionnaire at the case study, teachers were once again more positive than parents, with 70% either answering 'strongly agree', or 'agree' to questions related to whether there is effective knowledge sharing in the school between parents and teachers. Approximately 54% or parents 'strongly agreed' or 'agreed' that safety related knowledge sharing was effective in the school, but almost 13% were negative about the school's knowledge sharing, either disagreeing or strongly disagreeing that safety knowledge sharing was effective. As with attitudes and opinions toward safety, 13% might seem a small proportion, but this represents a significant number of students in the school, and the potential loss of these students, if parents decided to move them elsewhere, could have critical implications for the school as an on-going business.

Figure 4.12 also illustrates that a high proportion of parents and teachers were neutral in their answers related to knowledge sharing effectiveness, signalling that a number of parents and teachers either do not understand the importance of safety related knowledge sharing, or more worryingly, could easily switch toward negative views regarding the school's knowledge sharing. Overall, while Figure 4.12 does illustrates some positive opinions on knowledge sharing in the school, the general context suggests that knowledge sharing between the school and parents should be further investigated and improved to ensure both a safer school, and a strong and effective relationship between the school and its customers (parents).

While the questionnaires have assessed the range and breadth of opinions regarding school safely, the next step of the research sought to gain an in-depth understanding of school safety at the case study via in-depth semi-structured interviews with parents, teachers, and staff.

4.5.1 In-depth Interviews at the Case Study

As described in Chapter 3, semi-structured in-depth interviews were undertaken at the school with three main groups of stakeholder (parents, teachers, staff), and were structured according to a matrix based on invitational theory. The results from these interviews are presented based on interview analysis from each of the three stakeholder groups, and then an overall summary of the results.

4.5.1.1 Parents In-depth Interview Responses

Parents were interviewed according to the semi-structured interview matrix, which was in turn created based on invitational theory, and centres on the components of safety as related to people, places, policies, programs, and processes. The interview analysis contains the main points from the interview transcripts, which aim to illustrate the range of opinions, thoughts and attitudes of parents toward school safety.

The first set of questions related to the people aspect of invitational theory, which focuses on how people affect the school and its overall environment (Purkey, 1992). According to the interviews, all parents agreed that people are aware of safety as a key issue in the school. In their answers, parents tended to suggest that because children are a key part of school, there is a natural and critical link to safety. For example, one parent stated:

"...My first priority in finding a school for my children is safety. I must have a serious look inside the school to see that it's safe enough for my children to join for their important period of time. Luckily, the school I chose is safe (or at least seems safe). The teachers are aware of safety and have good plans to prevent undesirable incidents. Everyone in the school considers safety as serious work..."

With regard to the way in which people affect the safety in the school, some parents argued that everyone in the school had a responsibility toward safety, while others were not sure about how people and school safety were related. One parent was aware that everyone must be involved in safety and suggested that:

"...in my son's school, all teachers and staff are responsible for safety. They all must work or support school safety. In one semester, it is a must for everyone to perform or attend safety activities..."

Interview results suggested that parents have a wide variety of viewpoints with regard to who are the key stakeholders of school safety. Some believed everyone was a stakeholder, while others thought the staff or teachers were stakeholders. Interestingly, parents did not believe themselves to be key stakeholders of safety, thus suggesting they expect the school to be safe, but do not feel it is their responsibility.

The responses to questions regarding specific safety responsibilities were also mixed, with some believing everyone should be involved in safety, and others thinking that teachers should have the main responsibility. Most frequently, parents believed that teachers should be responsible for safety at the school, with one parent exemplifying this by saying:

"...the most important people who must provide safety while our children are in school are teachers. Personally I expect teachers to keep their eyes on the children at all times..."

When asked whether everyone was involved in school safety, all interviewees agreed, and when asked about the effect on the workload of staff and teachers, some parents didn't know whether there was an impact, while others assumed there would be. Parents stated that the role of teachers, staff and school leaders was to take care of students and pay attention to students, but no specific details were given.

The second set of questions in the in-depth interviews corresponded to the places aspect of invitational theory, and parents were questioned about safety in the school in relation to the physical places around the school, and whether they are particularly safe or unsafe.

When asked whether any places were particularly safe or unsafe, parents repeatedly mentioned the traffic in front of the school, and with specific reference to drop – off and pick – up times. For example, one respondent said:

"…the difficulty for parents is traffic. There are so many cars getting in and out of the school in the morning and after school. The traffic is jammed and sometimes that causes another problem."

This was echoed by another respondent, who also indicated that the school drop-off and pick-up areas were particularly problematic:

"…when I drop my daughter off in the morning, I see that the drop-off/pick-up area seems dangerous for children because there are rushing vehicles, and the area is quite narrow to accommodate a large number of vehicles. Furthermore, some parents are free to drop-off their children anywhere within the vicinity of the school campus, but not in the drop-off area…"

The playground itself was also frequently mentioned, along with the cleanliness of the bathrooms. One parent suggested that the school bathrooms and hygiene in general, should be a particular area of focus, for example:

"…my daughter has never used the school's toilet. She told me the toilets are dirty and stinky. When I go to the school in the evenings, I can see that there are not enough clean toilets. The school should realize that there are many students who need a clean bathroom, toilet and environment. The school must improve hygiene..."

Parents were also asked whether the school was a pleasant and attractive environment. Answers were mixed, with some answering no, and others saying yes. The lack of lawns, gardens or green areas came up as a common issue for some parents. One parent stated that:

"...I came to the school during the lunch break. The students played around the school without any shade from trees. I wondered if they would be affected by this. The school is in the serious shortage of green areas. There are no trees, and no grass for the students to play on. All the areas are

cement and hard surfaces. Although, the school is known for its academic performance, lacking green areas might change the parents' mind in choosing the school…"

In terms of safety improvement, parents indicated that the school was fundamentally limited in what it could do with regard to traffic due to its location on a busy road. Parents also indicated that the classrooms were often too hot (lacking air conditioning), and some of the desks and chairs were too old.

Overall, in relation to the place aspect of invitational theory, most parents could not answer why the school was safe or unsafe, but repeated the issues of traffic, unhygienic bathrooms, and the lack of trees, gardens, or green space.

The next part of the in-depth interview questioned parents regarding safety programs in the school. Parents commonly cited CCTV when questioned about the existence of school safety programs, and believed that the CCTV was a physical representation of a school program to improve safety. This highlighted parents' propensity towards physical/tangible aspects of school safety rather than the frequently intangible (tacit) school programs, policies and processes. This also highlights the difficulty for school management, who must turn school safety programs into visible and effective action in terms of school safety. Tangible safety aspects were again mentioned with reference to programs, and related to the ID card system that is in place for parents when they pick up their students. One of the interview respondents stated:

"…I was impressed by the program to install CCTV. That reassured me about my daughter's safety. You feel confident when you know that there is at least one person watching your child all the time. This makes parents satisfied…"

With reference to the last two invitational theory aspects of policies and processes, parents were far less communicative during the interviews, and did not have many comments regarding these issues. This is due to two main reasons, firstly, a lack of communication and knowledge sharing between parents and the school, and secondly, the fact that when compared to teachers and staff, parents are not as intrinsically involved in day-to-day aspects of the school.

In terms of policy, all parents believed that the school's current educational policies were effective, and said that school safety policy was designed in conjunction with parents and teachers. With regard to safety processes, parents were most impressed with aspects of knowledge sharing that were already in place, in particular, the school's social networking (e.g. Facebook, school's website/blog). One parent epitomized this by stating:

"...I watch the school's safety via many channels, such as the school's Facebook and letters to parents…and I admire the strong safety intentions the school provides for my son."

In contrast, other parents felt they knew little about the school's safety processes or policies, for example, one parent stated:

"I don't think any parents know much about the school's safety processes. They are the internal working processes inside the school. Even for me, who closely watches the school's performance, I don't know the processes and think that safety process should be communicated more clearly to parents."

The contrasting opinion of parents is representative of the earlier questionnaire results, and shows that while some parents are satisfied with the school's safety, other parents feel that safety must be improved. This shows that there is a difference between individual parents, and the school must ensure its safety programs, policies and processes are consistent and efficient. The schools' processes, programs, and policies must be conducive to safe places, and must also ensure that the school's people can effectively implement and sustain these programs, policies, and processes. This illustrates the requirement for the approach proposed in this thesis, which brings together KM and lean thinking to ensure the school is able to effectively manage school safety via the five Ps of invitational theory.

After parents had responded to the in-depth interviews, teachers were also interviewed to capture their safety knowledge, which both contrasted and corroborated what parents stated in their interview responses.

4.5.1.2 Teachers' In-Depth Interview Responses

Reflecting the earlier results from the school questionnaires, teachers were generally positive about school safety, and more so than parents. Again, this is to be expected given that the school is a reflection of their work, and represents their livelihood. As with parents, the five teachers in the in-depth

interview were questioned based on the invitational theory matrix, with a structure following people, places, programs, policies, and processes. The results of these in-depth interviews are now presented according to the five aspects of invitational theory.

In relation to the people aspect of invitational theory and school safety, teachers tended to focus on the workload associated with providing a safe school. This corroborates the need for the lean knowledge management approach in this research in order to ensure that safety in the school is efficient and effective, without becoming a financial or human burden. One teacher stated in the interview that:

"...I have to teach up to 25 out of a total 35 periods each week. But to provide a safe school for students, I must attend safety promotion activities. That means my workload increases further. Everyday the teachers must perform student supervisory duties, which require a significant amount of time."

In terms of place, the teachers' comments echoed those of the parents, and the drop-off and pick up areas were once again mentioned as being dangerous, although the school's swimming pool was also mentioned as one of the most unsafe areas, probably as teachers have regular access and knowledge of the swimming pool, whereas parents do not. One interviewee commented that:

"...I think the most dangerous places in this school are the swimming pool and the drop-off/pick up area. Although the swimming pool is not too deep, we can't help but wonder when one of the students will slip over and injure themselves, or possibly even drown."

The teachers corroborated the parents' views about a lack of green space in the school, but often, the teachers would make suggestions about how this issue could be overcome, for example, one teacher noted that:

"...I know that in this school we lack green areas, but one of the solutions should be putting in more mobile plants and green trees. This could give us and the students a green view and refresh us after hard work."

A key point emerging from teachers responses with regard to places in the school related to the position of the school's office, which is currently situated at the back of the school (see Figure 4.13). Teachers stated that:

"When a parent comes to the school they must park outside and then go deep inside the school. I think that is very dangerous for students. In Bangkok, there was an intruder who harmed a student with a knife because the school allowed people to come inside. The school should have an administration office at the front, not hidden away inside."

Overall, teachers' viewpoints during the in-depth interviews echoed those of the parents, but they provided additional Knowledge, and often went further, by attempting to provide solutions to problems. This is most likely due to the teachers' deep tacit and explicit knowledge of the school, which must be captured and used to develop the school's safety, and shows why the knowledge management approach to school safety in this research is so important.

With regard to policies, teachers gave two main insights, which reflect the school's approach to its safety policy. The first is that the school designs and implements policies based on parents' needs and expectations, while the second related to the government's requirement for specific safety policies in school. One interviewee captured the need to respond to parents by stating:

"Our safety policies come from parents' needs. We collect and analyse them throughout the year. During the 1st meeting of each year, we discuss these needs, and then design the school safety policies."

With reference to government regulation and safety policies, teachers in the school suggested there is little governmental guidance related to school safety policy. This supports the background and contextual information introduced in Chapter 1 and expanded in Chapter 2, which suggests that school safety policy in developing countries and in Thailand, is rather *laissez-faire*, and without any real governmental policy to help design and expand safety policies and practice throughout Thai schools. An interview respondent stated:

"We need to provide safety for our students and also follow the government's regulations. But we don't know what to do, and we don't know what is right or wrong, because the government doesn't provide appropriate guidelines or good regulations to schools."

With regard to the programs aspect of invitational theory, teachers were fully aware of the various programs the school provides to ensure school safety and safety-related learning. Interviewees specifically mentioned the schools' healthy eating program, and noted that:

"The school prepares food and beverages for all teachers and students. Each month, the service staff create a lunch list and then give it to parents, teachers and students. All the food provided is clean, tasty and healthy for everyone. I think healthy eating in this school can support students' growth."

Another aspect of the school's safety programs related to the fire drill in the school, which is an annual event designed to test the school's emergency preparedness with particular reference to potential fire. Teachers were aware of this aspect of the school's safety, and stated that:

"Every year, we must attend a fire/disaster drill. All the teachers are informed about how to save lives, and then we teach this information to students. We also train students to escape from undesirable situations. While participating in having the drill, we explain to all students so they know how to protect themselves."

While teachers were generally positive about the school's approach to safety programs, some suggested that the school could do more in this area. For example, one interviewee noted:

"Supervising students is the only program for school safety. I think there should be more programs to take care of students' safety throughout the school day, so that we can be confident that all students are safe at school."

Teachers were also aware of the school's expense related to safety, and showed understanding of the school's difficulty in balancing costs and safety. One of the teachers stated:

"In providing a safe school, we must have enough money to run the activities. Without money, the work may not be successful. There are several valuable safety programs in this school, but all need money, so the safety programs cause expense and require money for sustainability."

The final aspect of the interviews for teachers related to the processes component of invitational theory. The common responses among the interviewees related to the need for strong and appropriate communication between parents and teachers to ensure a safe school. This relates to the need for effective knowledge sharing in the school, to make sure everyone is involved in creating effective safety processes at the school. The efficiency and effectiveness of school safety processes must also be constantly

monitored and adapted to achieve school safety, and this supports the application of lean thinking to the school safety processes in order to ensure they add value to the school's safety, and are as efficient and effective as possible. One of the interviewees exemplified the need for communication and the effective sharing of safety related knowledge between teachers and parents by stating:

"In providing school safety, we need effective cooperation and sharing of knowledge between all parents and teachers. According to this, an effective communication process between the school and parents must be integrated with school safety to achieve a high rate of cooperation."

Teachers also responded by stating that some safety processes in the school must be adjusted, and in particular, the safety process related to visitors in the school. For example, one interviews noted that:

"When coming to the school, some parents don't know who is a teacher and who is not. Sometimes the teachers also don't know whether individuals are visitors or staff from other departments. I think a visitor identification process should be put in place at the school so we know who is a visitor and who is the school's staff. This will make students safer."

As expected, teachers had a good overview of the school's approach to safety, and showed awareness of school aspects of safety, and the need for parents to be involved with school safety. This supports the need for their involvement in the research solution via rapid process improvement workshops (RPIWS) and training. The next step of the in-depth interviews was to assess staff views towards school safety, and once again this was achieved by capturing their knowledge through the invitational theory matrix.

4.5.1.3 School Staff Responses to In-Depth Interview

Staff responses were generally skewed to match the school management's viewpoint. This is likely because the staff work in close contact with school management. With regard to the people aspect of invitational theory, staff generally considered the school management's approach to safety as omnipresent and effective. One staff member noted that:

"The management initiates every aspect of safety at the school. After analyzing parents' needs and expectations, we (management and staff) agree on the conclusions, but the management must announce the safety measures for teachers and staff. So, in my opinion, the key people for school safety are the director, the manager and administration team."

The administrative staff felt that in terms of place, the classrooms represented the safest areas in the school. One staff member elucidated by noting that:

"During the lunch break, students run and play around the school, and we must ensure effective supervision. However, sometimes we cannot stop accidents and falls. But when they (students) go back into their own classrooms, teachers and staff feel relief. The safest place in the school is the classrooms."

While the staff members felt the classrooms were safe, they still felt that the school environment was not safe enough, and more could be done to improve it. For example, one interviewee said that:

"I think the school environment is currently not safe enough because the school area is limited and there are not enough trees. Students must play in the middle of the burning sun and there is no shade and no trees to hide from the heat."

This supports what parents and teachers noted about the school in terms of place; that there are not enough green areas or shade in the school. Moving on to programs, the staff noted the healthy eating program in the school, stating that:

"The kitchen staff provide clean and tasty food. The quality is also controlled by the management to ensure they provide healthy food. I admire this healthy eating. This is very good for all of us."

In terms of policies, the staff viewpoint again related to management aspects of school safety policies, such as how policies were matched to governmental guidance. An interview respondent noted that:

"All policies of the school follow Thai laws and regulations. Because we need to do our best for school safety, the policies meet the governments' guidance."

Finally, in terms of processes, staff were positive, and felt that the school's safety processes resulted in a safe school. This indicates that the administrative staff are not as well informed with regard to school safety as parents or teachers, who have more direct experience of school safety and how it affects students. For example, one member of staff responded in a way which was representative of all the administrative staff by suggesting:

"Apart from our education quality, I think the parents are satisfied with the school's performance on the safety of the students throughout the school day. We work hard and look after the students all day to make their parents satisfied, and we succeed."

This shows that staff have a more insular and isolated view of school safety, and do not realize the attitude of some parents toward school safety. This in turn indicates that there is a general lack of communication and sharing of knowledge between the school's staff, and parents and teachers. This again supports the need for improved safety knowledge sharing in the school, and highlights the importance of this research and the proposed KM solution.

Following the detailed analysis of the in-depth semi-structured interviews, Table 4.5 provides an overall summary of the findings according to the invitational theory structure used during the interviews.

Table 4.5 Summary of the in-depth interviews with teachers, staff, and parents

Invitational Theory Categories	**Teachers' Response**	**Staff Response**	**Parents' Response**
People	All school stakeholders are aware and involved of safety in the school because, if students get safe, they can concentrate in learning. Parents can be assured about their children's safety at school. The school will be more popular to its	People are aware of safety as an issue at school. Parents pay most concern to school safety, and all teachers want to provide good and safe environment to students. The key stakeholders of school safety are the	Parents are aware of school safety very much because when talking about school, that means about children. Parents must first pay attention in their children's safety. The key stakeholders of

Table 4.5 Summary of the in-depth interviews with teachers, staff, and parents(Continued)

Invitational Theory Categories	**Teachers' Response**	**Staff Response**	**Parents' Response**
People (Continue)	customers. Teachers-in-duty of each day must take care on this. But safety sometimes causes workload to teachers. Administrator selected policy to implement, then teachers & staff take action on safety.	director, the manager and administration team. Teachers and staffs are to taking care when students arrive in the morning and depart school in the evening. In the afternoon, the duty teachers will observe the students to prevent them from the unsafe situations. The school leaders will plan, provide policy and support.	school safety must be the director and the teachers. Parents expect high quality of school safety, the key main focus.
Places	The safest place for students is classrooms. And the most dangerous place should be the swimming pool and drop-off/pick up area. Teachers must keep eyes on them all the time. The other place that should be careful is the toilet's hygiene. We must keep toilet clean at all time. The school provides safe places to everyone. As the shortage of	Safe place is classroom and the unsafe places are the field, drop-off area and the back of each building. The classrooms, bathrooms and offices at the school are clean. But sometimes, toilets need more often cleaning. The school environment is not	In parents' opinion, the safest place should be the classrooms and the unsafe place was the drop-off and pick-up area. Moreover, school should provide more green areas, which could improve safety within the school environment. The classrooms are clean and good, but

Table 4.5 Summary of the in-depth interviews with teachers, staff, and parents(Continued)

Invitational Theory Categories	**Teachers' Response**	**Staff Response**	**Parents' Response**
Places (Continue)	green area, the school put on more movable green corners inside the rooms and buildings. To improve school safety, the school should have an office of administration in the front, not hiding itself inside, to avoid from intruders. Classrooms are clean but toilet needs to get more at tent ions. The school is safe, showing by statistics or records of accident and sickness.	safe enough because the school area is limited and there are not enough trees.	toilet should be cleaner. The school's environment is unsafe because the shortage of green area and the process of drop-off and pick-up. If those are improved, the school should be better.
Policies	The school focuses on looking after the students all the time as a main policy. And this safety policy works. Staff and teachers can work with confidence. Parents admire the way the school treat the students. The school safety policies are designed from the discussion of the 1st meeting of each year,	Safety polices the school has in place is observing quality of food regularly. Providing CCTV in every area. The Junior FDA Program. The teachers in duty are responsible in each assigned areas and scheduled time. Those can be very effective in a long term. The policies were designed by teachers	Parents admire the access policy, which is effective. Teachers can protect students. Most parents don't know about the steps of creating policy/process, but they know that school's policies meet government's.

Table 4.5 Summary of the in-depth interviews with teachers, staff, and parents(Continued)

Invitational Theory Categories	**Teachers' Response**	**Staff Response**	**Parents' Response**
Policies (Continue)	which were analyzing parents' needs. The school's policies get on well with the government's. But government doesn't provide appropriate guidelines or good regulations to school. The school regularly update safety guidelines / policies via weekly meeting.	brainstorming and team discussion. Also, the policies meet the governments' guidance, but there still be observations from government staff every semester.	
Programs	The school has safety programs e.g. healthy eating, supervision at break times, fire/disaster drill. But there should be more programs on taking care of students' safety through out school day. The programs can make students and teachers learned to save themselves in case of the unexpected incident. The safety program may cause expenses, but not the main workload to teachers. But instead, it can help teacher in teaching students, too.	The school has special safety programs in place, which are healthy eating, supervision at break times, and teachers in duty program.	Parents see safety programs via school's activities/ letters/ and social network(Facebook). They agree on healthy eating, supervision at break time's programs. And there should be more safety programs for students. If parents can feel safety for their students, they are certainly willing to support all activities. Parents don't know about safety expenses, but they expect to get high safety quality.

Table 4.5 Summary of the in-depth interviews with teachers, staff, and parents(Continued)

Invitational Theory Categories	**Teachers' Response**	**Staff Response**	**Parents' Response**
Processes	Safe dropping–off and picking-up students process has currently operated in the school, also effective communication process from school to parents has been involved into school safety, too. But visitor identification process should be put to the school. All safety process causes expenses to the school. The processes are designed by safety team and implemented by teachers and staff.	The safety related processes has currently operated in the school is taking care students, stewardship of the student throughout school day process.	Parents don't know much about safety processes in the school. But they can see and check their children's safety from what the school has done. Also, they expect high safety rate from the school.

4.5.2 School Safety Assessment

In the discussion and analysis so far, the school's parents as well as teachers and staff have responded to various data collection instruments related to school safety. The final stage in the select phase was a school safety and hazard assessment undertaken by the school's management. This consolidates the views of parents, teachers, and staff, by providing a final piece of knowledge about the school's safety; the perception of school management. This data is then brought together in synergy with information from interviews and questionnaires to create the UML activity diagrams, which show the explicit safety processes in the school, and enable decisions to be made about which processes to prioritize in the research solution. However, before the presentation and discussion of these UML activity diagrams, Figure 4.13 shows a site plan of the case study school, which then

informs and provides the necessary background for analysing and understanding the hazard assessment.

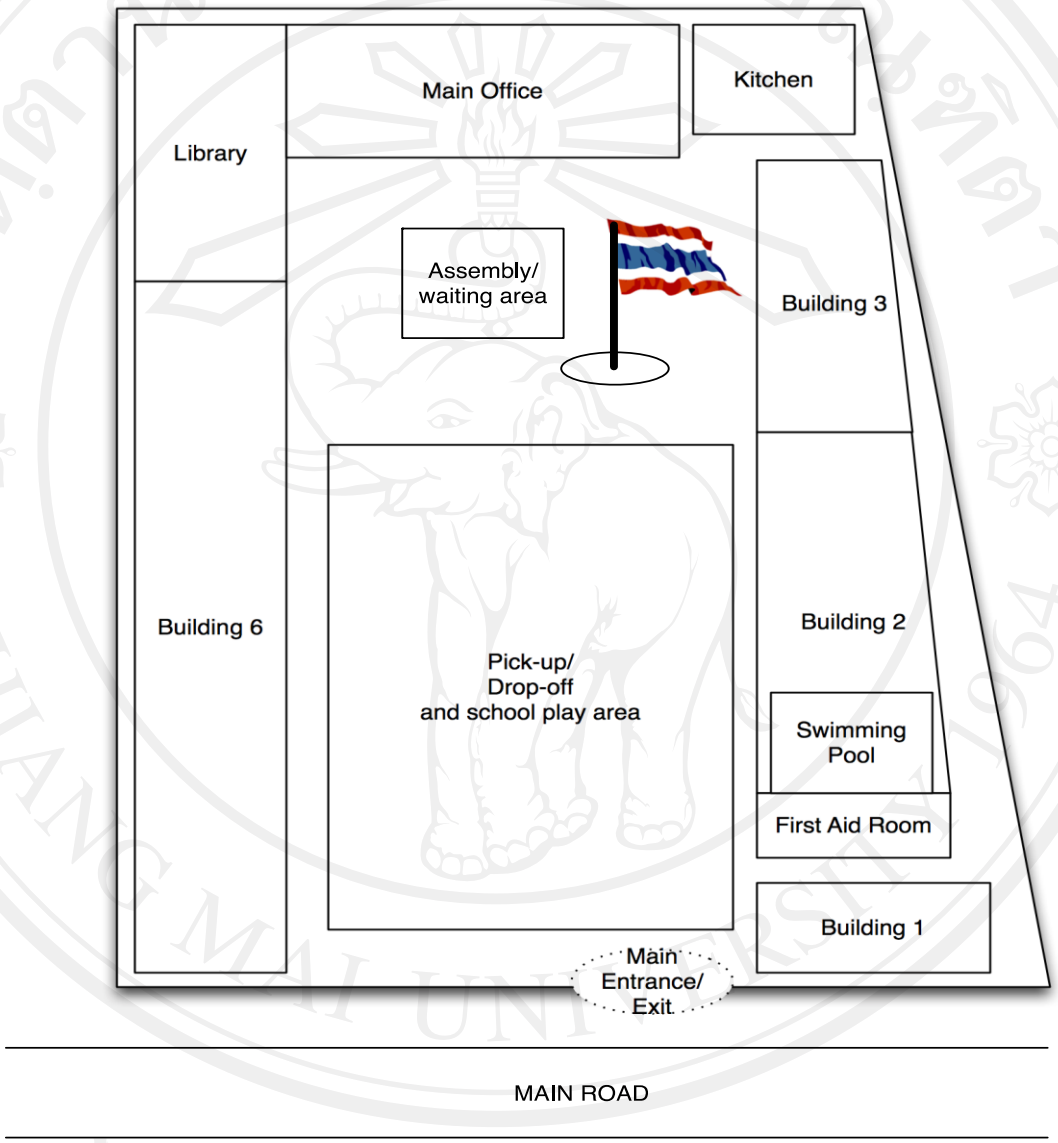

Figure 4.13 Site plan of the case study school

As shown in Figure 4.13, the school is a rectangular shape, with the main entrance on a busy road. This explains why parents frequently mention the school drop-off and pick-up time in relation to school safety, as cars must enter the school and playground areas to drop-off and pick-up their children. Across the school site, there are a variety of hazards, as shown by the photographs in Figure 4.14, which show some of the main hazards within the school environment.

Figure 4.14 A sample of frequently reported hazards at the case study, including hazards in commonly used areas (A), hazards relating to building work in the school (B), and finally, tripping hazards and road safety (C).

Figure 4.14 exemplifies some of the key hazards within the school environment. These were mentioned by parents and noticed by school management. The most commonly described issues related to the play equipment, tripping hazards, and building materials in communal outdoor areas. As previously noted, road safety during the school pick-up and drop off times was also reported as a common issue.

The next part of the school safety assessment involved an investigation of the school budget and accident records. The annual school budget over the three semesters of data collection is shown in Figure 4.15, which indicates that as a percentage of the total school budget, safety expenditure currently represents between 3% and 5% of the budget, averaging 3.2%. In comparison, US schools spend approximately 5% of their school budget on safety (Chase et al., 2008). The key point regarding school safety expenditure is that it is relatively low when compared to other budgetary categories (e.g. teachers and staff) and therefore maximum value must be extracted from any safety expenditure. Maximizing value of this safety budget can be achieved through the application of the lean thinking knowledge management approach in this research.

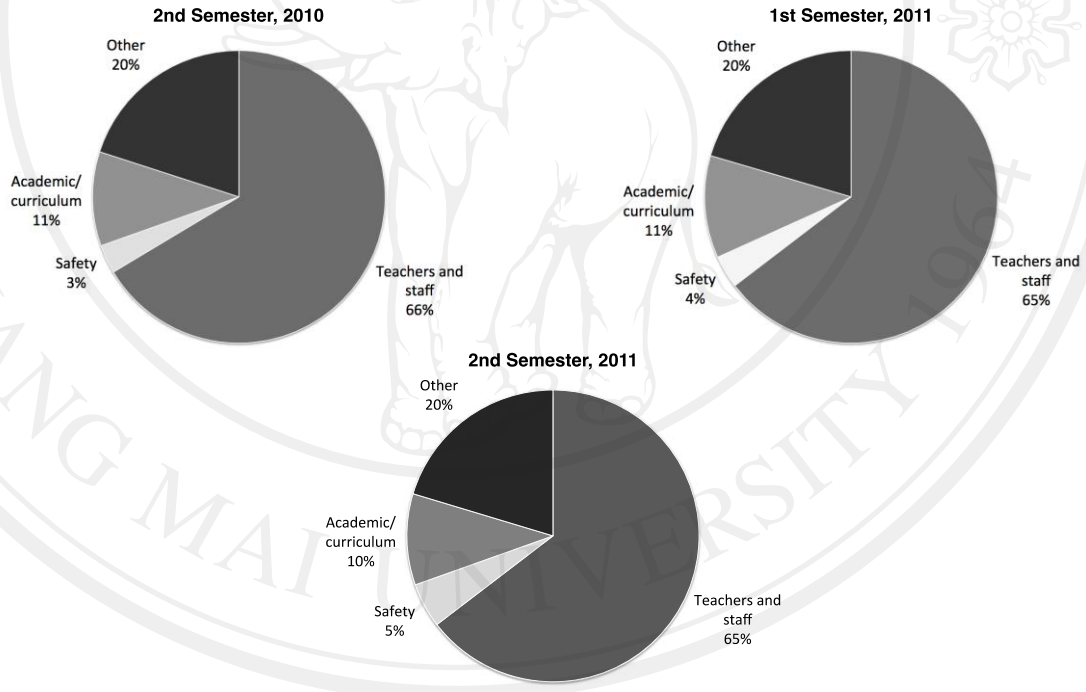

Figure 4.15 Safety expenditure over three semesters

Figure 4.15 shows the accident records and safety statistics over the same three school semesters as the budgetary data. Chapter 1 (Section 1.5) and 2 (Section 2.5) have already described the danger of using school safety statistics as an accurate measure of school safety, but the statistics do provide a useful overview of any serious accidents or safety problems within the school.

Table 4.6 Number of safety incidents and associated accident rate over three semesters

Safety Aspect	Number of incidents				
	2nd semester 2010	**1st semester 2011**	**2nd semester 2011**	**Totals**	**Average per semester**
1.Physical well-being	22	40	19	81	27
2.Environmental hygiene	8	2	6	16	5.3
3.Road safety	-	-	-	-	-
Accident rate	**2.1%**	**3%**	**1.8%**	**6.8%**	**2.3%**

Table 4.6 illustrates that over the three semesters, the average accident rate was low, with an average accident rate (percentage of students involved in an accident/incident) of 2.3%. There were no incidents of road safety, and most accidents related to physical wellbeing, such as students falling while playing. The low accident rate corroborates the literature and discussion on the fallacy of safety numbers and statistics. Although the accident rate is low, the parental perception of safety does not correlate with this. In addition, the school must manage large numbers of safety suggestions from parents and utilizes significant amounts of time and money in managing safety. To improve school safety is therefore not simply about accident numbers, as the school must pacify parents, and ensure its whole approach to safety is one which is cost effective and visible to parents and other school stakeholders.

The questionnaires, semi-structured interviews and hazard assessment have shown the current state of safety in the case study school, and the next section selects the appropriate aspects of school safety for focus during the Solve phase. Therefore the next stage of the results presents the UML activity diagrams, which capture the explicit safety related knowledge in the school, and visually represent this in an appropriate order, so that the school's activities related to safety can be clearly represented in preparation for decision making and prioritization in the Solve phase, and which are most suited to the KM and lean approach proposed in this research.

4.5.3 UML Activity Diagrams of the School Safety Processes

After questionnaires and in-depth interviews regarding school safety at the case study, the key safety processes at the school were mapped by creating UML activity diagrams. UML diagrams have been shown to be effective when applied to issues of safety (Jürjens, 2003), and these diagrams allowed the captured knowledge to be placed into the safety processes in the school so that the management difficulties associated with each of the different aspects of safety could be assessed. The UML methodology is explained in more detail in Chapter 3, but there were five key safety activities in the school which were mapped via UML. These were:

- **Ensuring student safety from morning until evening** – this was completed to illustrate the safety processes required when taking care of students throughout the school day. This UML activity diagram provided an overview of the whole safety process in the school and how it affects students.
- **Responding to the needs of parents** – this was completed to show how the key process of meeting parents' need is met in terms of school safety.
- **Safety budgeting and planning** – budgeting and planning are a key aspect of safety for a private school (see Chapter 2) and this UML activity diagram therefore outlined all the steps involved in budgeting and planning for school safety.
- **Safety compliance** – all schools, whether government or private, must adhere to a set of government frameworks and laws, and this UML diagram illustrates the process of managing school safety compliance.
- **Safety monitoring and observation** – to ensure the school is safe requires a process of continuous monitoring. This UML diagram shows how safety is monitored throughout the school.

Figures 4.16 and 4.17 show the UML activities related to ensuring student safety from morning until evening. There are 46 activities in this process, as shown across the two UML diagrams representing these activities. Figure 4.14 shows that this process begins with parents dropping off students in the morning, and ends in Figure 4.15, with parents picking their children up from school. The diagram is split into five time periods: morning, mid-morning, lunch, afternoon, and then evening (pick-up).

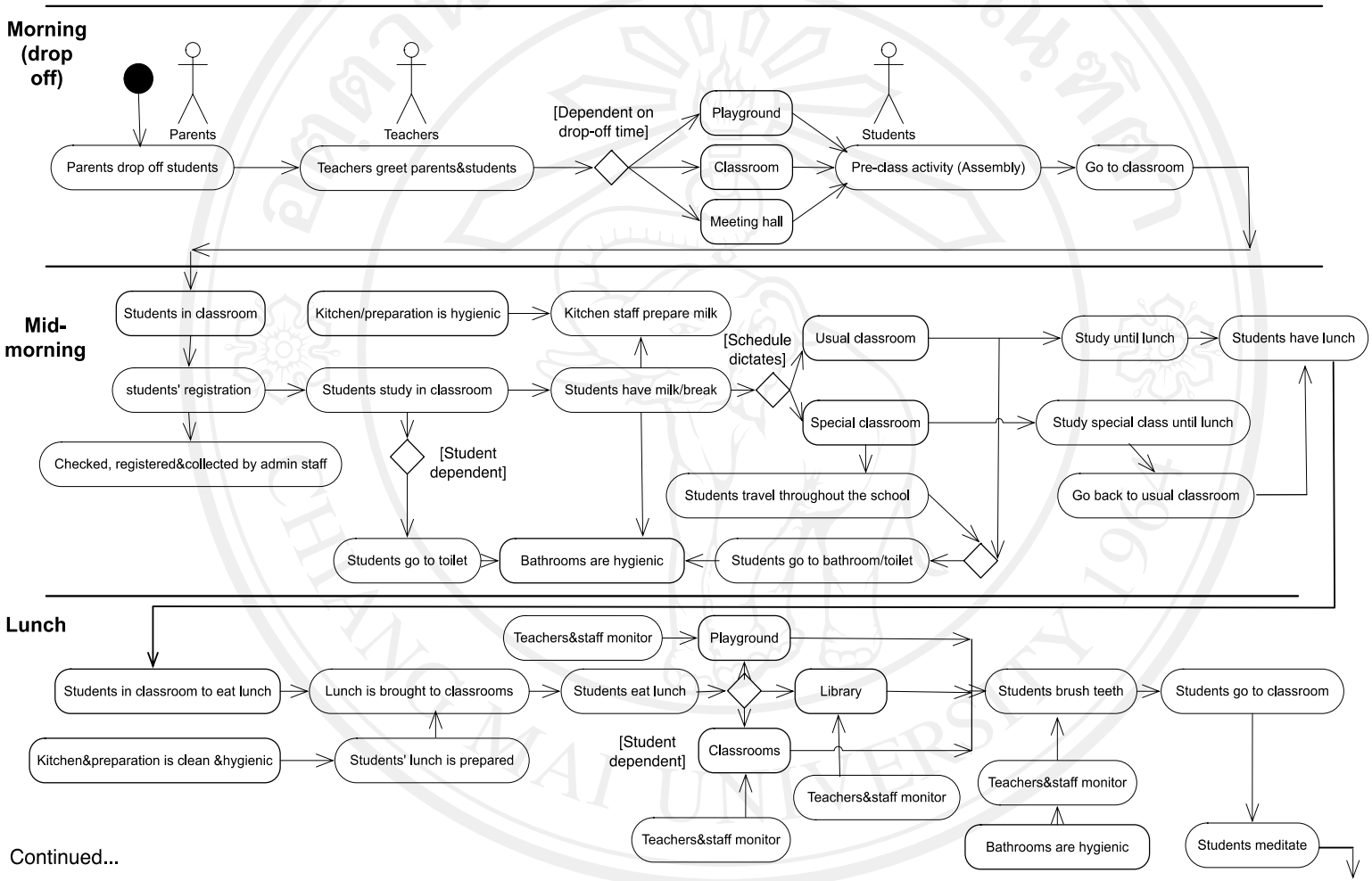

Figure 4.16 The UML activity diagram for student safety from morning until evening (part one)

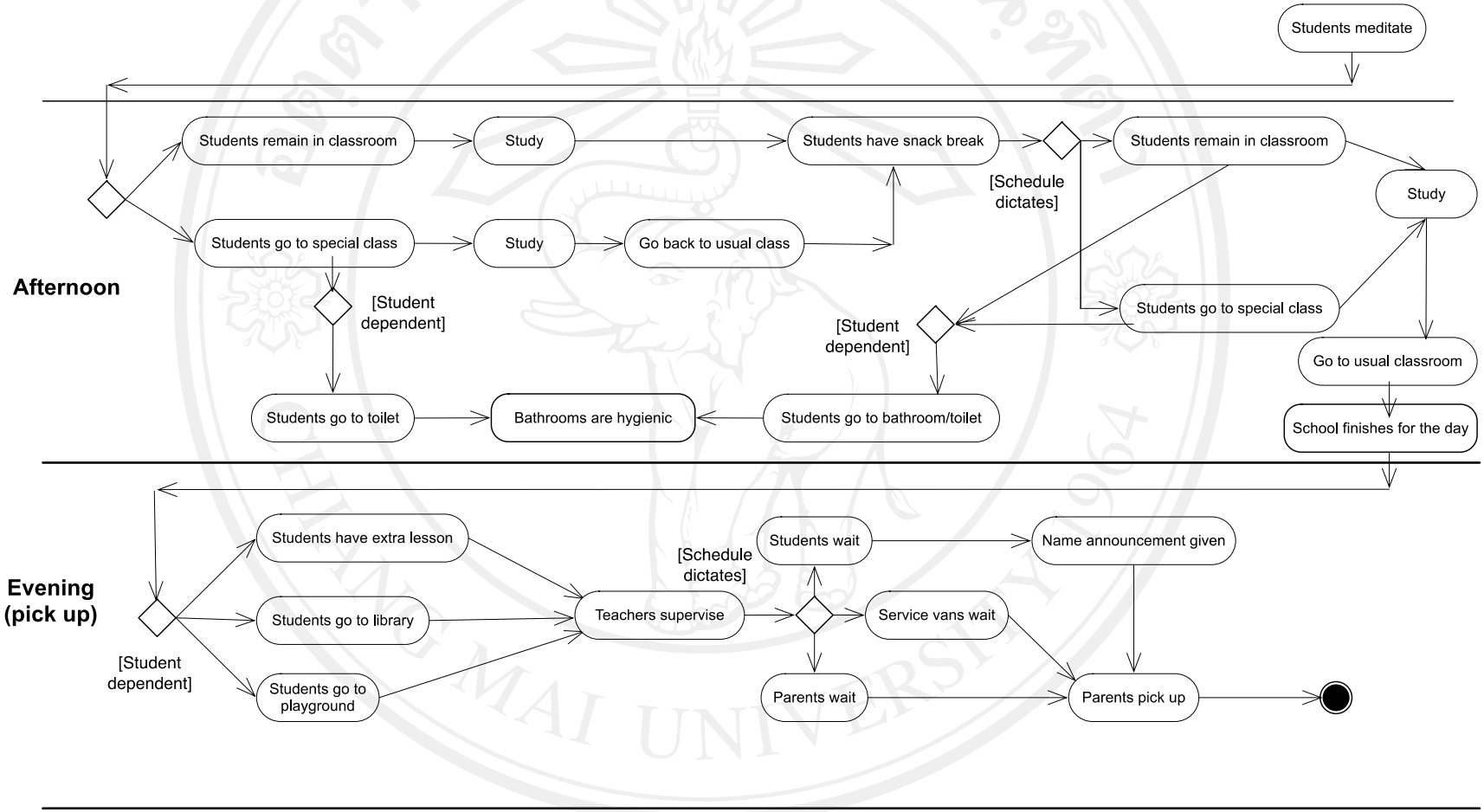

Figure 4.17 The UML activity diagram for student safety from morning until evening (part two)

The UML diagrams in Figures 4.16 and 4.17 represent a total of 46 activities throughout the school day that are related to ensuring the safety of students, and thus the satisfaction of parents (customers). These 46 activities were then assessed by school administration and management to rate each of the activities in terms of their management burden (for details on management scoring process see Chapter 3, section 3.7.7). Table 4.7 shows the management burden of the 46 activities related to managing student safety throughout the school day.

Table 4.7 The management processes associated with the UML activity diagram for student safety and the associated management burden score (ordered from highest to lowest)

Process	**Management Burden Score (%)**
Parents drop-off students	85.71
Teachers greet parents & students	85.71
Teacher & staff monitor	80.00
Students study in classroom	74.29
Study until lunch	74.29
Study special class until lunch	74.29
Students have lunch	74.29
Students eat lunch	74.29
Study	74.29
Students go to special class	74.29
Study	74.29
Students go to special class	74.29
Study	74.29
Kitchen staff prepare milk	72.86
Students in playground	72.86
Students' lunch is prepared	70.00
Parents pick up	70.00
Pre-class activity (Assembly)	68.57
Students have milk/break	68.57
Students have snack break	68.57
Service vans wait	60.00
Parents wait	60.00
Students go to playground	58.57
Lunch is brought to classrooms	57.14
Teachers & staff monitor	57.14

Table 4.7 The management processes associated with the UML activity diagram for student safety and the associated management burden score (ordered from highest to lowest) (Continued)

Process	**Management Burden Score (%)**
Teacher & staff monitor	57.14
Teacher & staff monitor	57.14
Teachers supervision	54.29
Students wait	54.29
Students travel throughout the school	51.43
Students go to bathroom/toilet	50.00
Students in classroom	50.00
Name announcement given	50.00
Go back to usual classroom	48.57
Students brush teeth	48.57
Students meditate	48.57
Students have extra lesson	48.57
Students remain in classroom	45.71
Students remain in classroom	45.71
Students registration	44.29
Students in library	44.29
Students go to library	44.29
Students go to toilet	42.86
Students go to classroom	42.86
Go back to usual class	42.86
Go to usual classroom	42.86

According to Table 4.7, the activity requiring the most management input and time, is school drop-off, with a management burden score of 85.71%. This supports the view given by parents and teachers in the in-depth interviews, and questionnaires suggesting that drop-off is a particularly problematic time during the school day. The lowest management burden scores come from activities where students are in their usual classrooms (management burden score of 42.86%). The overall picture which emerges from Figures 4.16, 4.17 and Table 4.7, is that safety and management burden is most difficult when there is movement of students around the school and where staff involvement is required. Students in their usual classroom settings represent the lowest safety and management burden. While Figures 4.16, 4.17 and Table 4.7 give an overview of the entire safety activities in the school, some of the processes and activities which underpin and facilitate

student safety represent a lager management burden. For example, Figure 4.18 now shows the UML activity diagram for responding to the needs and suggestions of parents, which is a particularly difficult safety task for the school.

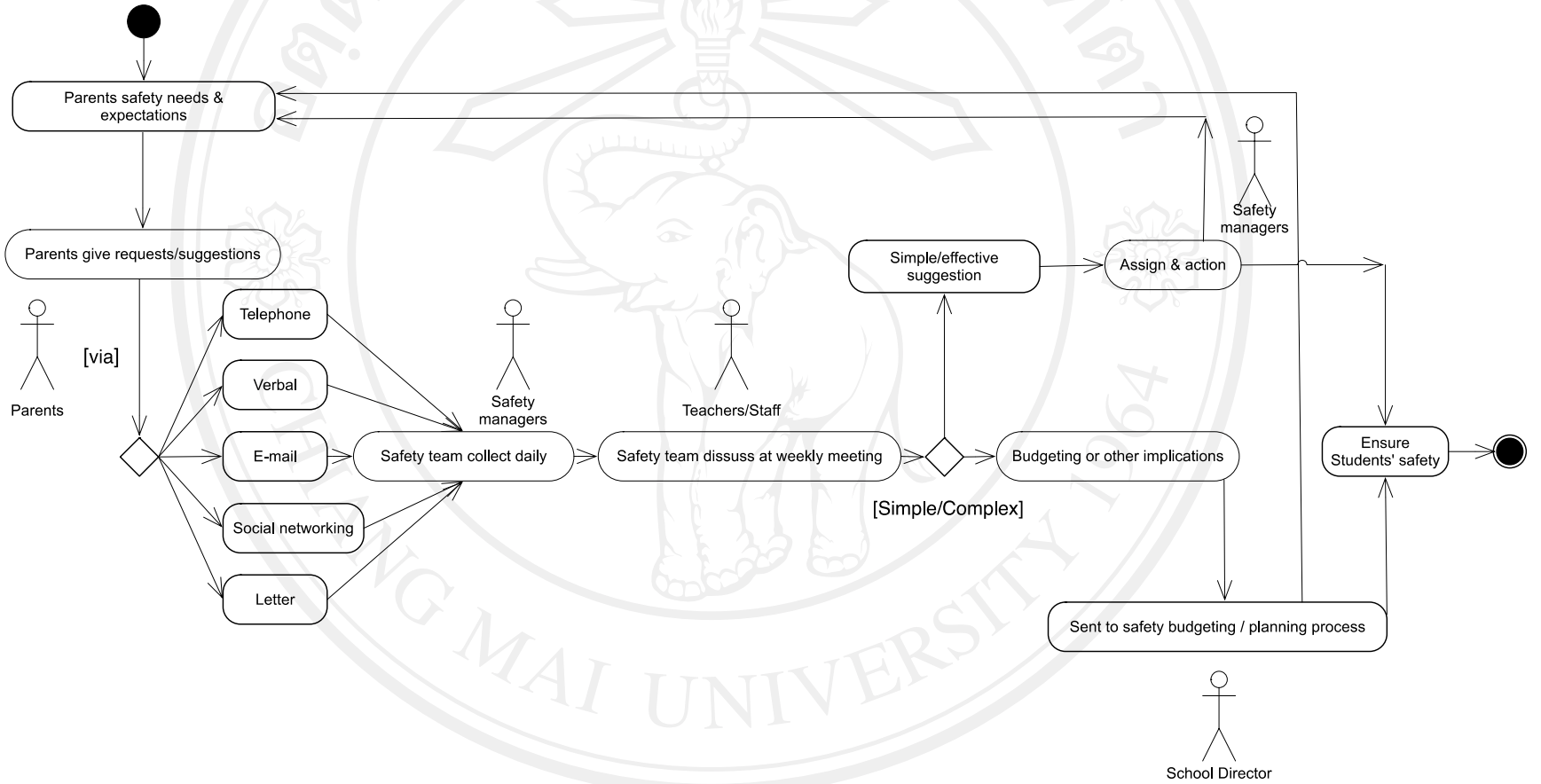

Figure 4.18 The UML activity diagram for responding to the needs and suggestions of parents

Figure 4.18 shows there were six key activities related to responding to the needs and suggestions of parents. These processes were also rated according to their management burden, and the results are shown in Table 4.8.

Table 4.8 The management processes associated with the UML activity diagram for responding to the needs and suggestions of parents, and the associated management burden score

Process	**Management Burden Score (%)**
Assign & action	88.57
Safety team collect suggestions daily	84.29
Safety team discuss at weekly meeting	78.57
Budgeting or other implication	74.29
Parents give requests/suggestions	72.86
Sent to safety budgeting/planning process	65.71

Table 4.8 shows that the activity of assigning and acting upon parents' suggestions has the highest management burden, with a score of 88.57%. The lowest management burden score for this UML diagram is the activity of sending suggestions to the budgeting and planning process. Overall, the six activities in this UML activity group have relatively high management burden scores. This reflects anecdotal evidence from around the school, as well as the knowledge captured in the in-depth interviews and questionnaires, which suggest that responding to parents' suggestions is a significant issue in the school, and requires a high management input. The next UML activity diagram is presented in Figure 4.19 and maps the activities related to safety budgeting and planning.

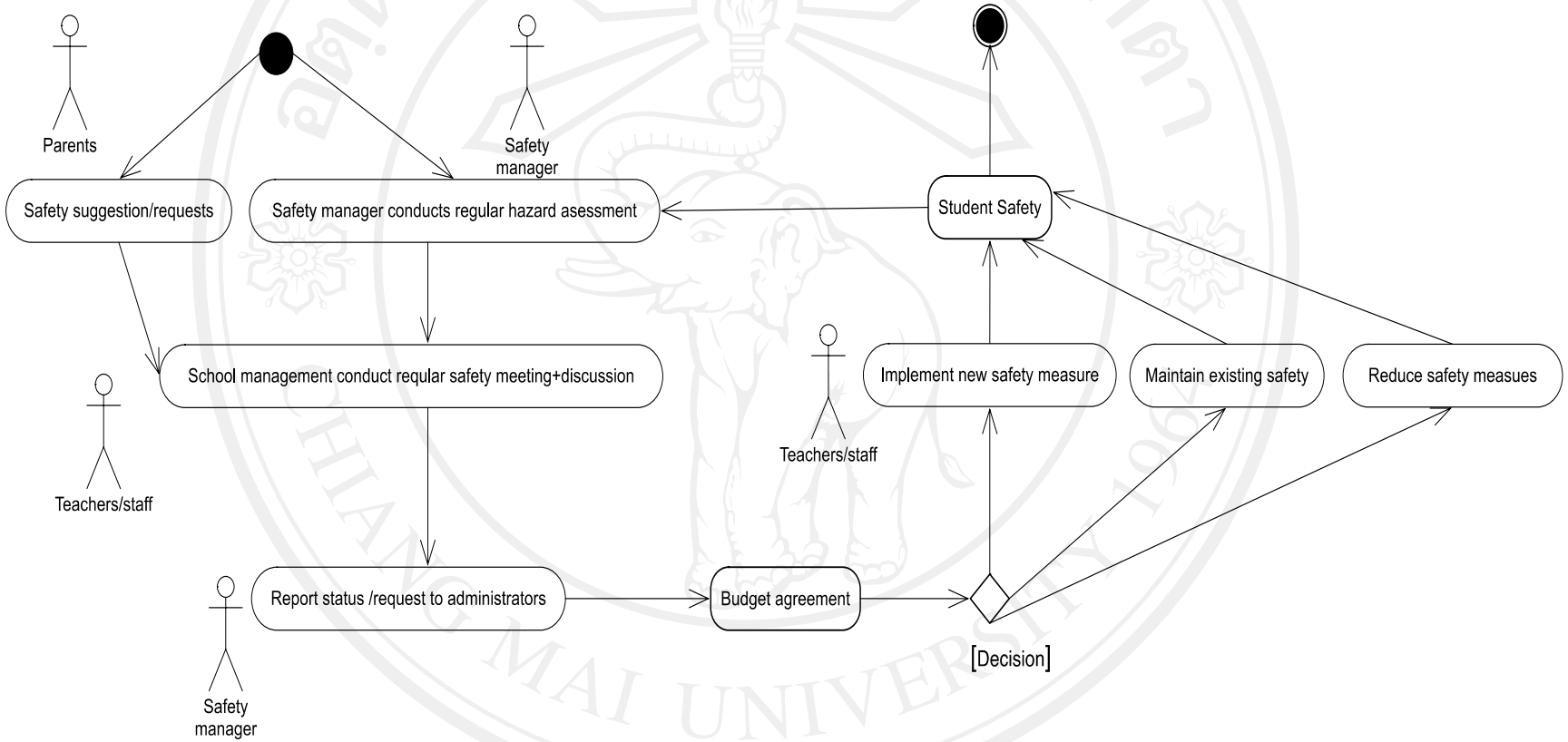

Figure 4.19 The UML activity diagram for safety budget and planning

Figure 4.19 illustrates there are seven key activities related to safety budgeting and planning and in terms of the management burden score, Table 4.9 shows the ranking of these seven activities.

Table 4.9 The management burden associated with the processes related to safety budgeting and planning.

Process	**Management Burden Score (%)**
Implement new safety measure	82.86
Maintain existing safety	82.86
Reduce safety measure	80.00
Safety manager conducts regular hazard assessment	71.43
School management conduct regular safety meeting & discussion	71.43
Safety suggestion/requests	68.57
Report status /request to administrators	67.14

In terms of safety budgeting and planning, Table 4.9 shows implementing new safety measures, has the greatest management burden. This is to be expected, given a new safety measure requires significant budgetary planning and attention. Maintaining the existing school safety measures also indicates a relatively high management burden, at 82.86%. Again this is to be expected given that these management processes deal with the fixed and variable costs related to school safety. The fourth of the five UML diagrams relates to safety compliance, and the UML diagram is shown in Figure 4.20.

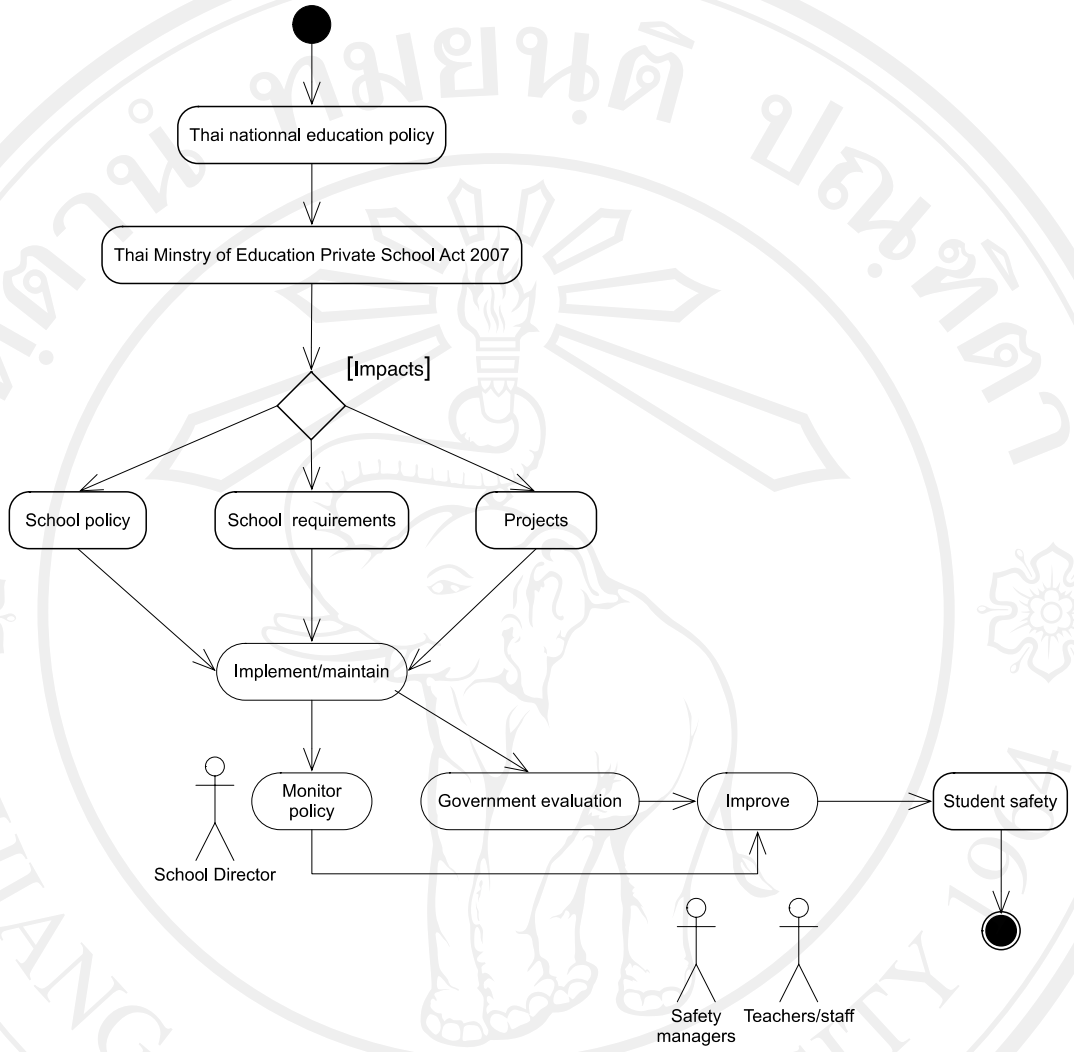

Figure 4.20 The UML activity diagram for safety compliance

According to Figure 4.20, there are nine safety activities related to compliance. Table 4.10 shows the management burden score for these activities.

Table 4.10 The management burden associated with the processes related to safety compliance

Process	**Management Burden Score (%)**
Implement/maintain	90
Monitor	90
Improve	90
Project	77.14
Government evaluation	72.85
Thai national education policy	68.57
Thai Ministry of Education Private School Act 2007	68.57
School policy	62.85
School requirement	62.85

Table 4.10 shows a generally high management burden for the compliance related safety activities. Monitoring, improving, and maintaining safety compliance all had scores of 90%, representing the significant input by management when establishing and maintaining compliance to meet government requirements and regulations. The school's own policies and requirements had lower management burden scores of 62.8%. This is because the school's management is focused on other aspects of safety rather than creating it's own compliance issues. Figure 4.21 illustrates the final UML activity diagram, which is for monitoring and observing safety.

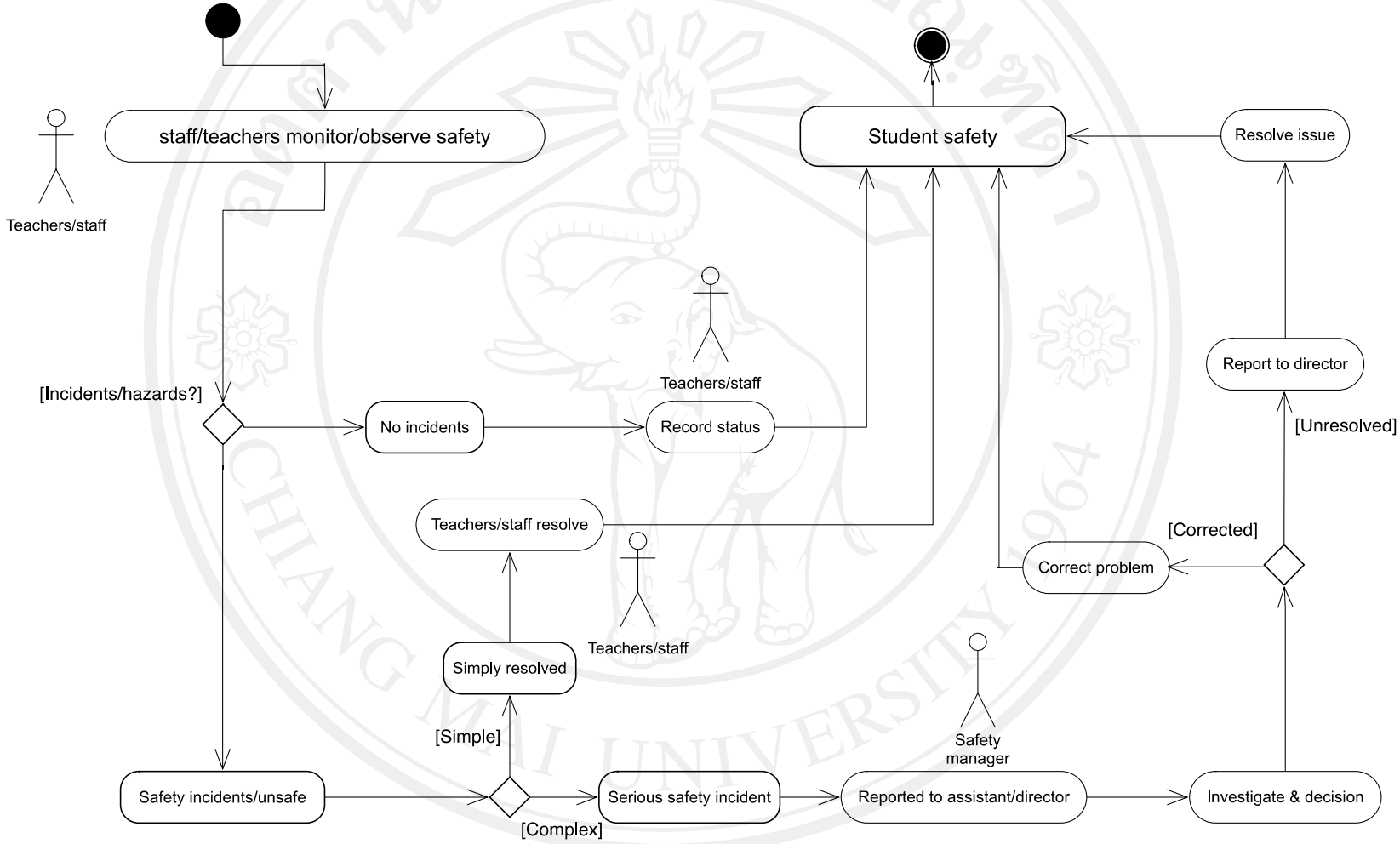

Figure 4.21 The UML for monitoring and observing safety

Table 4.11 The UML for monitoring and observing safety

Process	**Management Burden Score (%)**
Staff/teachers monitor/observe safety	84.29
Investigate & decision	81.43
Correct problem	81.43
Resolve issue	81.43
Teachers/staff resolve	80.00
Record status	67.14
Reported to assistant director	58.57
Report to director	58.57

Based on the five UML diagrams, and according to the methodology presented in Chapter 3, the total management burden of each activity in the diagrams was sorted and ranked. This ranked management burden score for every activity in the five UML activity diagram is shown in Table 4.12.

Table 4.12 A summary of the decision matrix where all activities have been sorted and ranked according to the management burden score

Activities	**Management Burden Score (%)**
Implement maintain	90.00
Monitor	90.00
Improve	90.00
Assign & action	88.57
Parents drop off students	85.71
Teachers greet parents &students	85.71
Staff/teachers monitor/observe safety	84.29
Safety team collecting daily	84.29
Implement new safety measure	82.86
Maintain existing safety	82.86
Investigate& decision	81.43
Correct problem	81.43
Resolve issue	81.43
Teacher&staff monitor	80.00
Teachers/staff resolve	80.00
Reduce safety measure	80.00

Table 4.12 A summary of the decision matrix where all activities have been sorted and ranked according to the management burden score (Continued)

Activities	Management Burden Score (%)
Safety team discuss at weekly meeting	78.57
Project	77.14
Students study in classroom	74.29
Study until lunch	74.29
Study special class until lunch	74.29
Students have lunch	74.29
Students eat lunch	74.29
Study	74.29
Students go to special class	74.29
Study	74.29
Students go to special class	74.29
Study	74.29
Budgeting or other implication	74.29
Kitchen staff prepare milk	72.86
Students in playground	72.86
Parents give requests/suggestions	72.86
Government evaluation	72.86
Safety manager conducts regular hazard assessment	71.43
School management conduct regular safety meeting &discussion	71.43
Students' lunch is prepared	70.00
Parents pick up	70.00
Pre-class activity (Assembly)	68.57
Students have milk/break	68.57
Students have snack break	68.57
Safety suggestion/requests	68.57
Thai National Education Policy	68.57
Thai Ministry of Education Private School Act 2007	68.57
Record status	67.14
Report status /request to administrators	67.14
Sent to safety budgeting / planning process	65.71
School policy	62.86

Table 4.12 A summary of the decision matrix where all activities have been sorted and ranked according to the management burden score (Continued)

Activities	Management Burden Score (%)
School requirement	62.86
Service vans wait	60.00
Parents wait	60.00
Students go to playground	58.57
Reported to assistant director	58.57
Report to director	58.57
Lunch is brought to classrooms	57.14
Teachers &staff monitor	57.14
Teachers &staff monitor	57.14
Teachers &staff monitor	57.14
Teachers supervision	54.29
Students wait	54.29
Students travel throughout the school	51.43
Students go to bathroom/toilet	50.00
Students in classroom	50.00
Nameannouncement given	50.00
Go back to usual classroom	48.57
Students brush teeth	48.57
Students meditate	48.57
Students have extra lesson	48.57
Students remain in classroom	45.71
Students remain in classroom	45.71
Students registration	44.29
Students in library	44.29
Students go to library	44.29
Students go to toilet	42.86
Students go to classroom	42.86
Go back to usual class	42.86
Go to usual classroom	42.86
Average management burden	66.54

The UML activity diagrams and ranking acted as a form of qualitative feature selection to choose areas for further focus and analysis. When all safety activities are ranked and sorted as one group of activities, there is no clustering according to the previously defined UML activity groups/diagrams. This highlights that all safety activities require management effort, and represent a school wide management burden, and are

not separated into management silos. Table 4.9 shows that the top activities in terms of management burden are implementing, monitoring and improving safety. Conversely, at the bottom, and having least management impact, is when students are in the classrooms. Figure 4.22 shows a bar graph where the management burden score has been merged according to each of the UML activity diagrams, and then ranked. This allows for decisions to be made about which areas of school safety to focus on in the solve phase, and which processes might be most suitable for application of lean thinking.

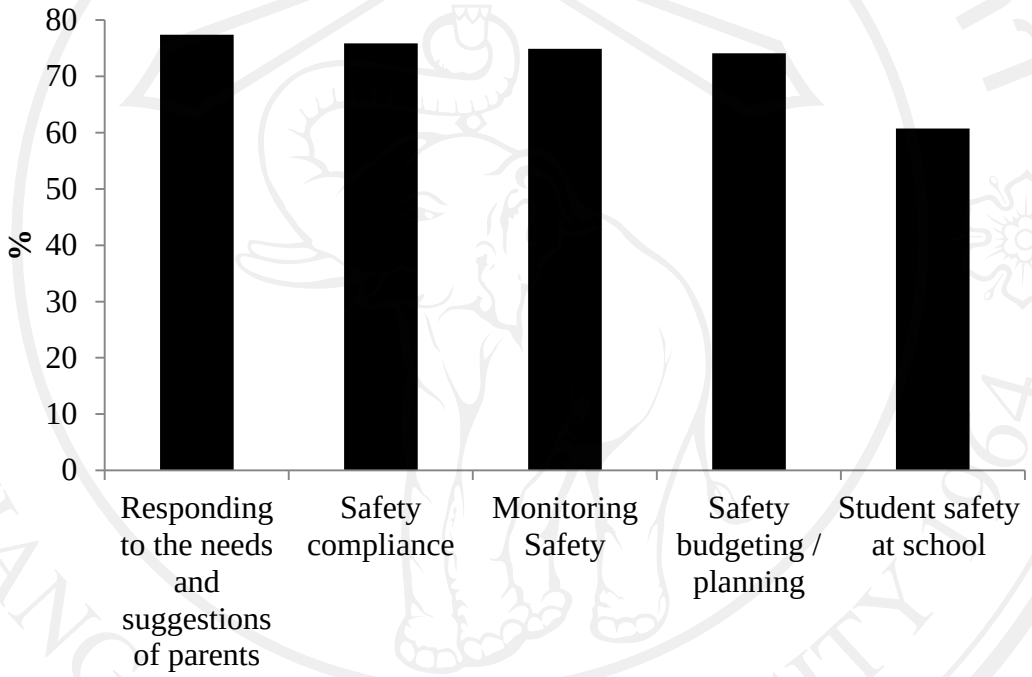

Figure 4.22 The results of the decision matrix regarding which school safety processes to focus on in the solve stage

As shown by Figure 4.22, the main safety processes in the school which require management input, are ‘responding to the needs and suggestions of parents’, followed by ‘safety compliance’ and ‘monitoring safety’. Thus these three areas of school safety that form the focus of the solve phase.

4.6 Stage Three: Solve

This section of the results analyses the solve stage of the research, which includes the main results of the research and shows how the captured knowledge was organized and applied in synergy with lean thinking to solve the issues of school safety. Figure 4.23 illustrates this stage of the research, and its relationship with knowledge management.

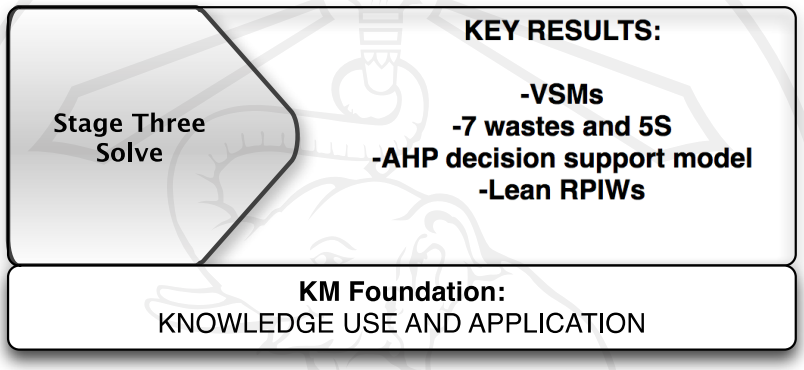

Figure 4.23 The solve stage of the results and the main task of using and applying captured knowledge to arrive at a solution to the research problem

The solve phase was separated into two key parts: firstly, the explicit parts of school safety, and secondly, the tacit aspects of school safety. Figure 4.23 provides a reminder of the key parts of the solve phase, and how they relate to the overall knowledge management framework in this thesis. The results of the solve phase are presented and discussed according to the two knowledge approaches presented in Figure 4.22, and begin with the discussion and analysis of the lean value stream mapping along with the 7 wastes, and 5S tools. The second part of this section then moves to discuss and analyse results from the tacit part, including the lean rapid process improvement workshops (RPIWS) to capture tacit and embedded knowledge, the knowledge sharing activities and leadership workshops. Finally, the two explicit and tacit parts are brought together in synergy to show how knowledge management can be combined with lean thinking to improve school safety.

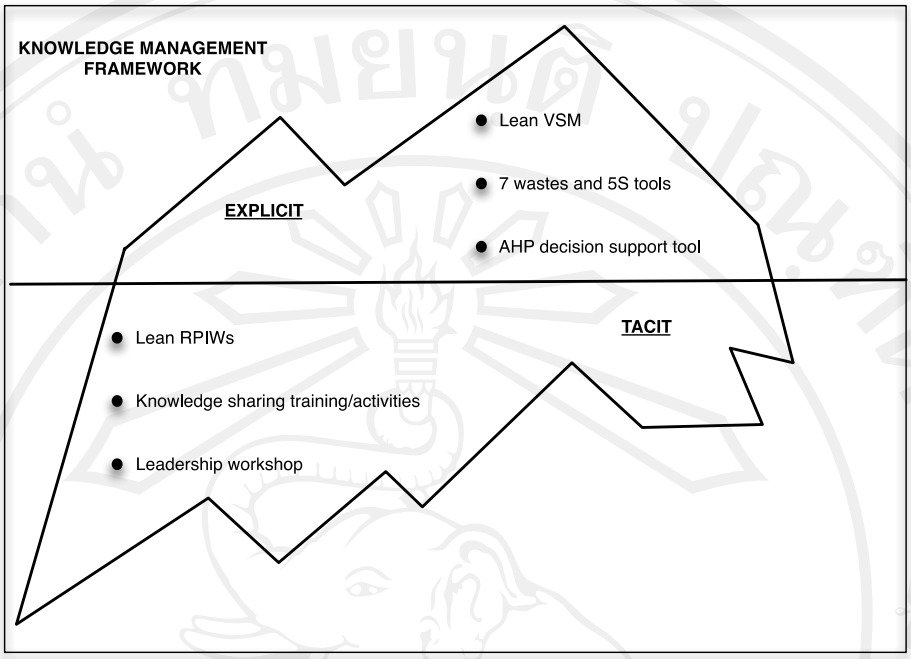

Figure 4.24 The two key parts of the results in the solve phase, including tacit and explicit parts of the knowledge management framework to improve school safety

4.6.1 Responding to Explicit Processes: VSM Maps and Explanations

After the feature selection via UML diagrams and the subsequent ranking, value stream mapping (VSM) was applied to the three selected areas of school safety. The first value stream map presents the results of the current state value stream map for the activity of responding to the needs and suggestions of parents.

4.6.2 Value Stream Mapping: Responding to the Needs and Suggestions of Parents

Figure 4.25 illustrates that the VSM for responding to the needs and suggestions of parents is complex and comprises of a number of steps.

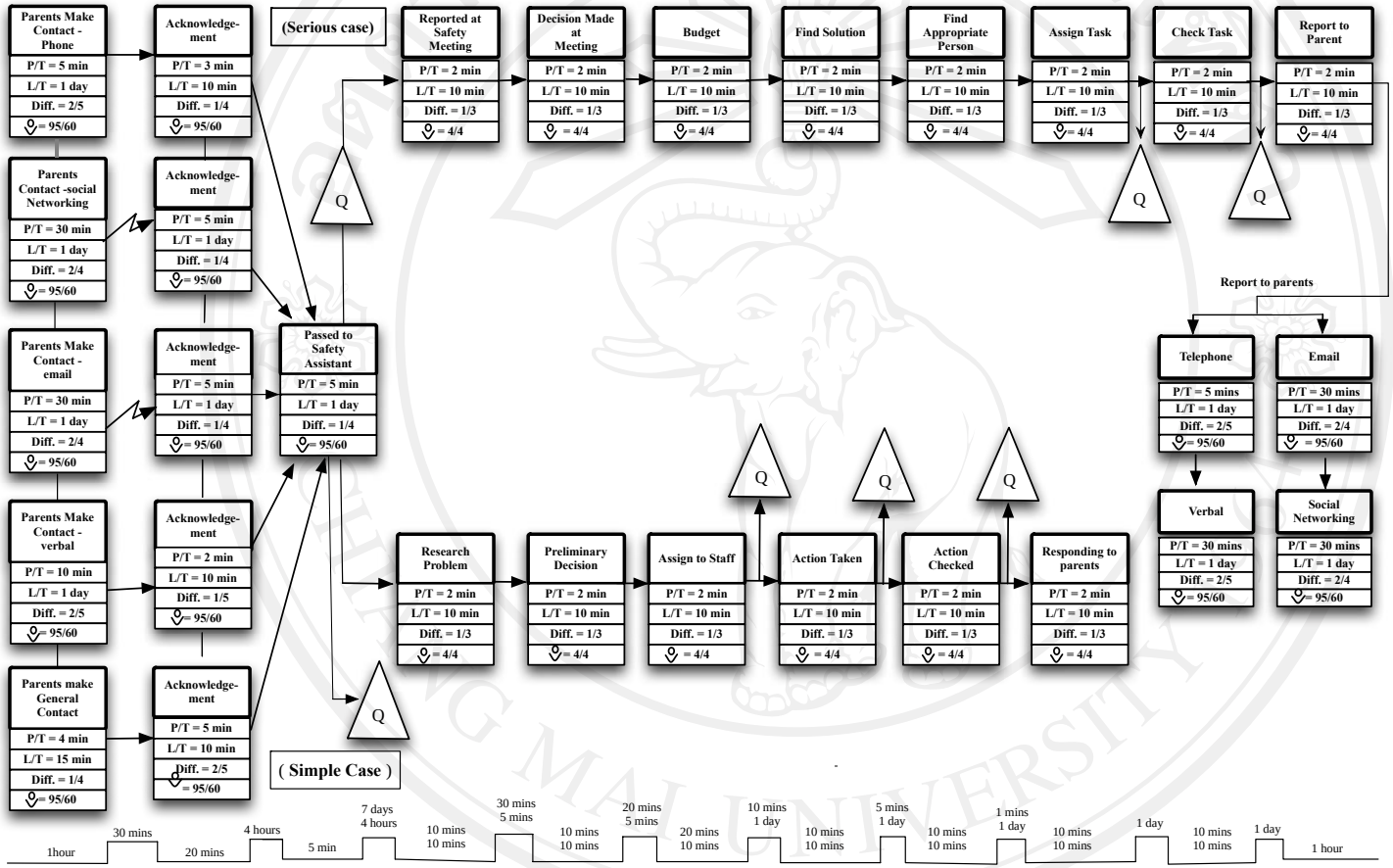

Figure 4.25 The current state VSM for responding to the needs and suggestions of parents

The VSM for responding to the needs and suggestions of parents shows a relatively long and convoluted process, with a small proportion of value added steps. In total, there are 17 steps involved in the process of responding to parents safety suggestions. The assessment of this VSM also illustrates that approximately 53% of the steps are value adding steps, which translates into 25% value added time in the overall process. The overall analysis of the current state VSM for responding to the safety suggestions of parents is shown in Table 4.13.

Table 4.13 The lean analysis of the current state VSM for responding to the safety suggestions of parents

Factor	**Lean Analysis**
No. of steps	17
No. of value added steps	9
% of value added steps	52.95%
Lead time	4 days, 2 hours, 10 minutes
Value added time	1 day, 20 minutes
% of value added time	25.05%

The next step was to apply value stream mapping to safety compliance. The safety compliance value stream map is shown in Figure 4.26.

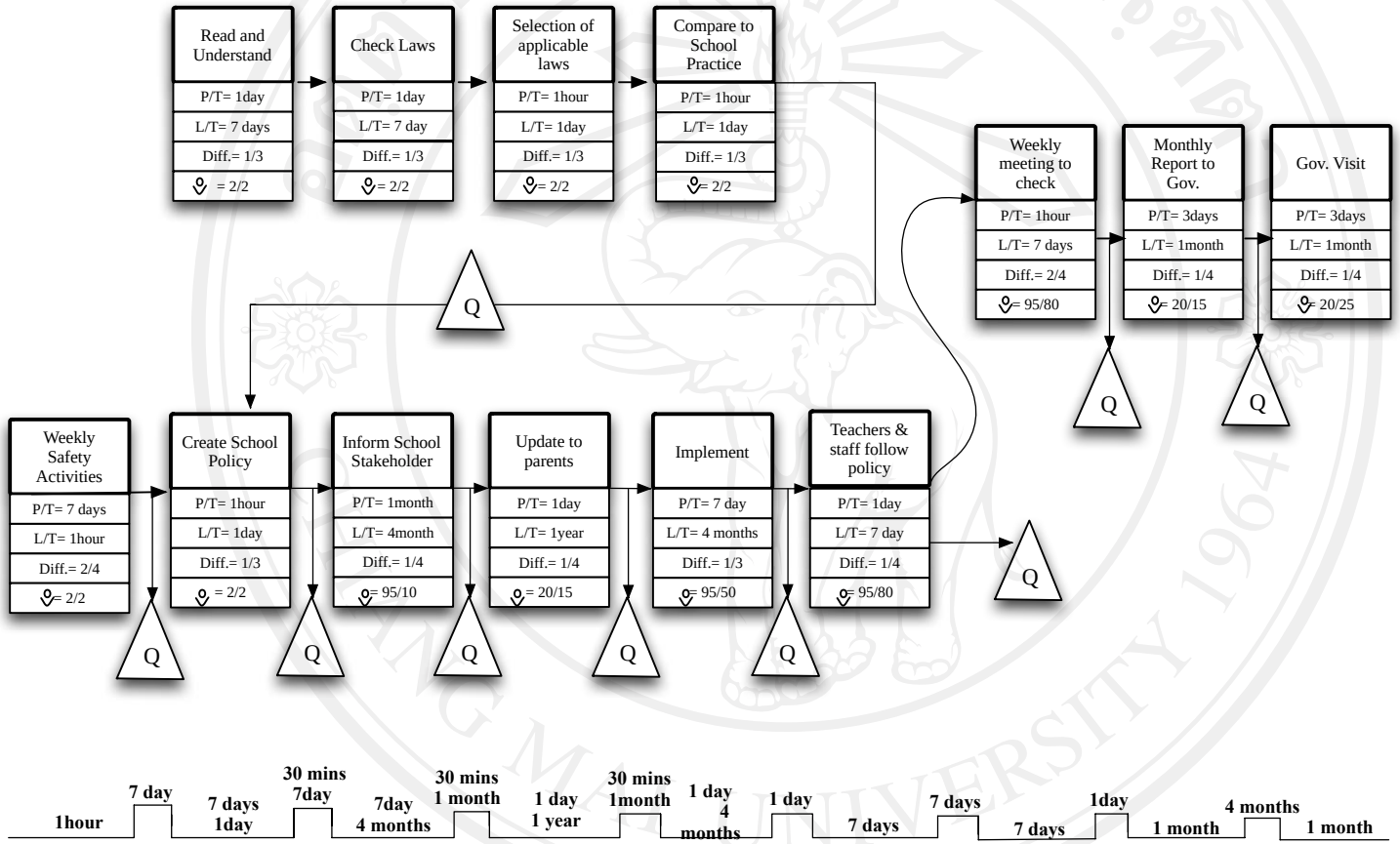

Figure 4.26 The current state value stream map for safety compliance

After creating the current state map for compliance, there were a variety of areas noted for improvement. Table 4.14 illustrates that in total, there are 13 steps in the VSM, with nine of these being value added steps (69%). Due to long lead times in the process related to the timing of meetings and external factors, only 37.79% of the total time in this VSM was value adding time. The current state VSM thus shows potential for improvement.

Table 4.14 The lean analysis of the current state VSM for safety compliance

Factor	**Lean Analysis**
No. of steps	13
No. of value added steps	9
% of value added steps	69.23%
Lead time	1 year, 11 months, 1 day and 1 hour
Value added time	8 months, 23 days
% of value added time	37.79%

The next step was to create the current state value stream map for monitoring safety, and Figure 4.27 illustrates this current state value steam map.

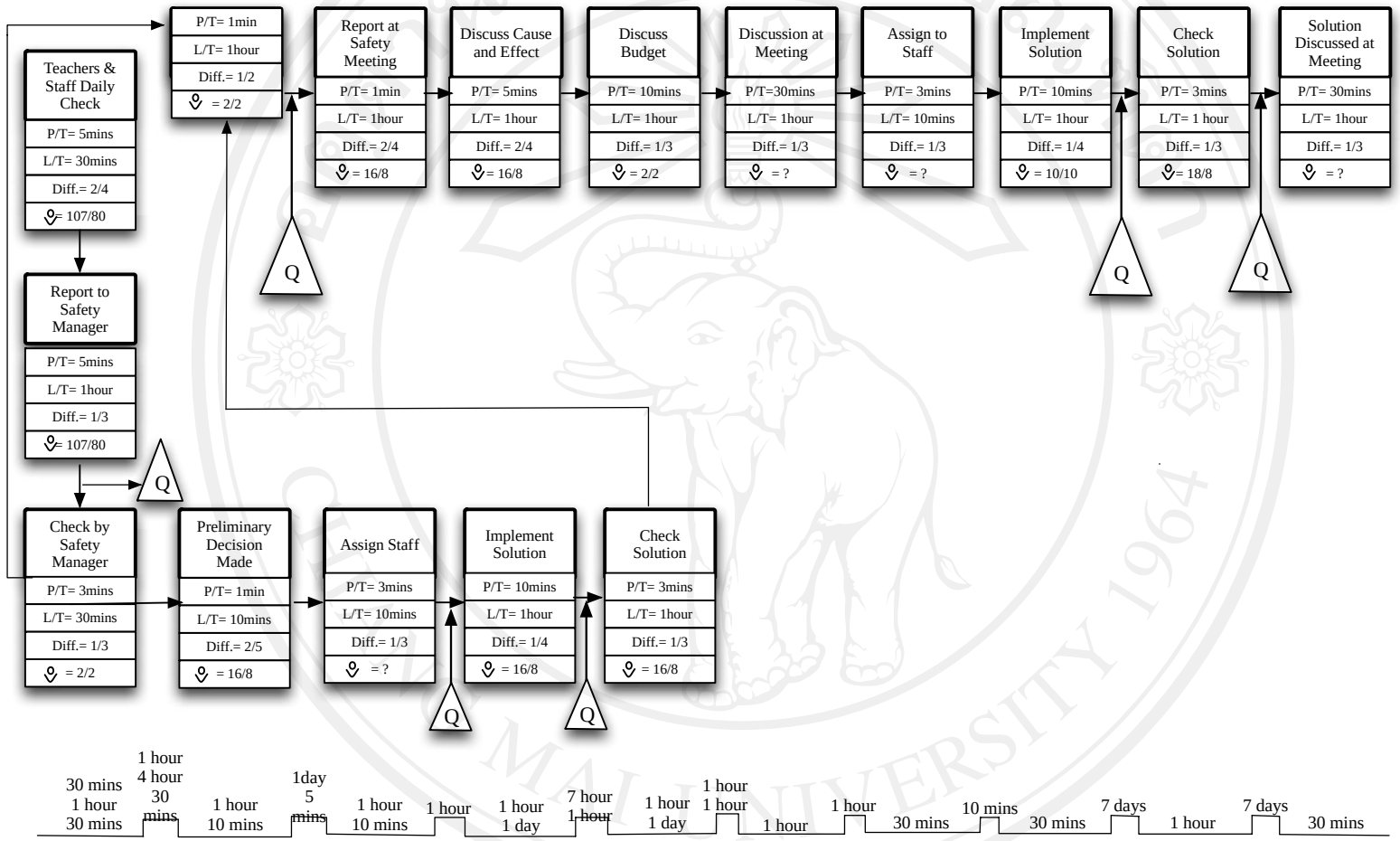

Figure 4.27 Current state value stream map for monitoring safety

Table 4.15 indicates that there were 16 steps in total related to monitoring safety in the school. Of these, only 6 (42.86%) were value adding steps. In addition, only 12.23% of the time spent on monitoring safety could be classified as value adding time.

Table 4.15 The lean analysis of the current state VSM for monitoring safety

Factor	Lean Analysis
No. of steps	16
No. of value added steps	6
% of value added steps	42.86%
Lead time	12 hours
Value added time	1 hour, 28 minutes
% of value added time	12.23%

After completing the three current state value stream maps, the processes were analysed using the 5S methodology and the seven wastes. Each value stream map was then modified to create a future state value stream map for application at the school. Figure 4.28 illustrates the future value stream map for responding to the needs and suggestions of parents', while subsequent discussion and analysis shows how the 5S, and seven waste tools were applied to create this future state VSM.

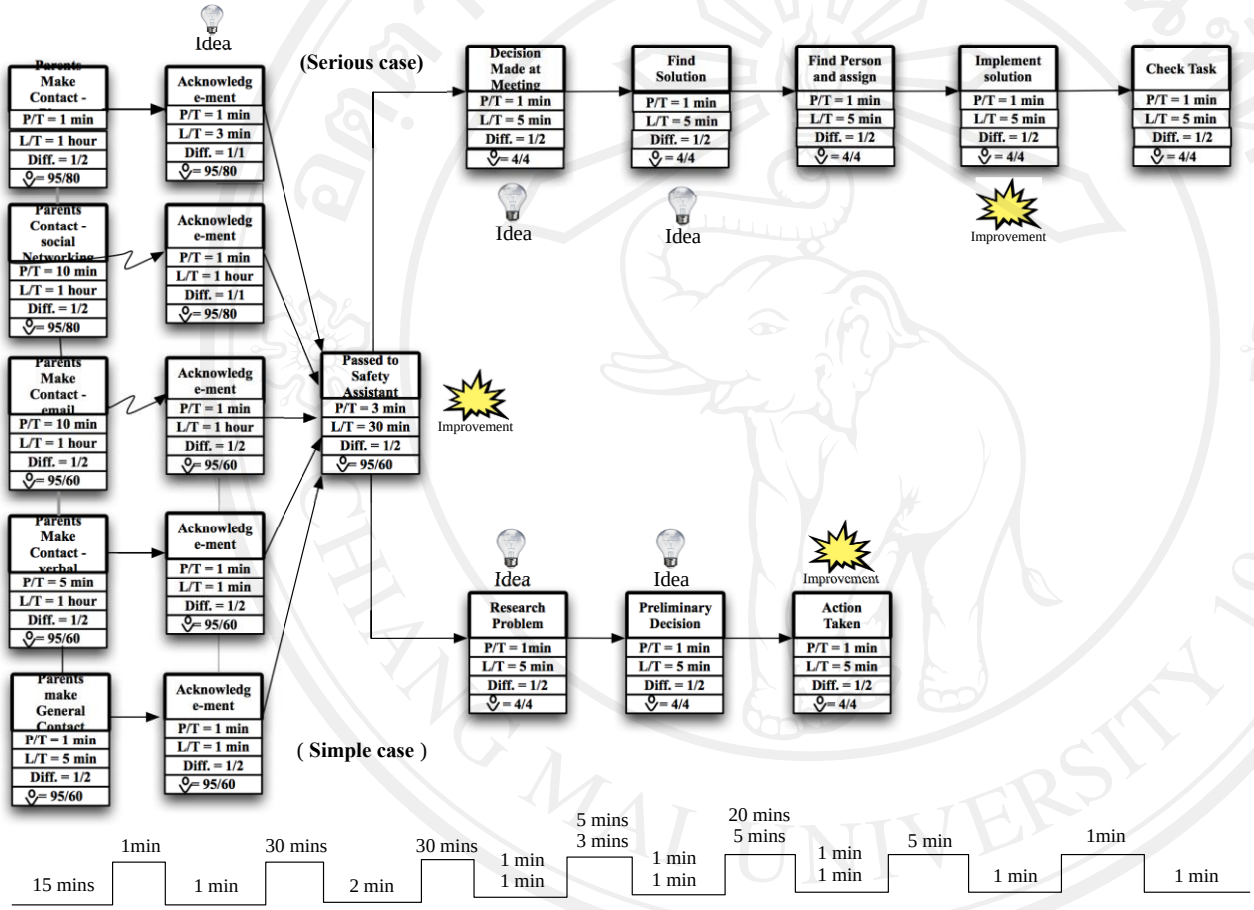

Figure 4.28 The future state VSM for responding to the needs and suggestions of parents

The modifications to the value stream for responding to the needs and suggestion of parents had been significantly improved according to the seven wastes and 5S methodology. Table 4.16 illustrates that the number of steps in the process has been reduced from 17 to 11, with 10 of those 11 steps adding value to the process. This means 90% of the steps are now value adding compared with only 50% in the old process. Value added time has increased from only 25% to over 84%. The improvement in the process has come from the use of lean tools, which have identified wasteful processes and streamlined the process to ensure as many parts of the process as possible are value adding. The AHP model is a key part of reducing this waste, as well as standardizing and sorting suggestions. The AHP process is therefore responsible for much of the improvement in this process. The inconsistencies and unevenness associated with making decisions about suggestions have been removed, and the time taken to make these decisions and the lead time have been minimized thanks to the AHP model, which allows more staff to make decisions about safety suggestions while remaining consistent.

Table 4.16 The lean analysis of the future state VSM for responding to parents suggestions process

Factor	**Lean Analysis**
No. of steps	11
No. of value added steps	10
% of value added steps	91.00%
Lead time	3 hours 10 mins
Value added time	2 hours 40 mins
% of value added time	84.21%

The next step is the future state VSM for safety compliance, which is illustrated in Figure 4.29.

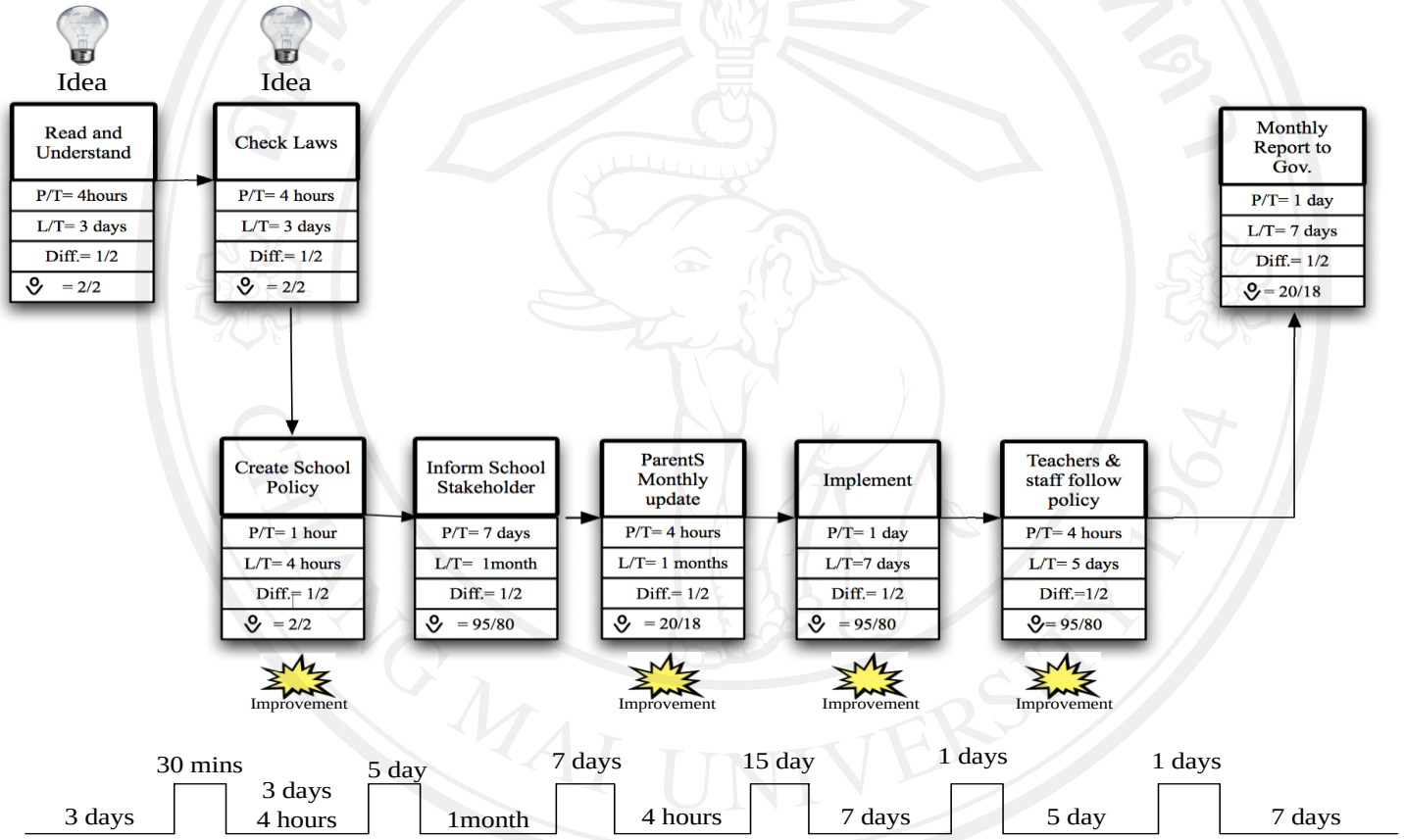

Figure 4.29 The future state VSM for safety compliance in the school

Table 4.17 shows that the application of lean to the safety compliance process has resulted in improvements by reducing the number of steps from 13 to 8, which represents an increase of value added steps from 69% to 87%. The lead time has been reduced significantly, and the value added time has also been increased from 37% to 64%.

Table 4.17 The lean analysis of the future state VSM for safety compliance in the school

Factor	**Lean Analysis**
No. of steps	8
No. of value added steps	7
% of value added steps	87.50%
Lead time	2 months 25 days 4 hours
Value added time	1 months 25 days 4 hours
% of value added time	64.87 %

The final future value stream map is for safety monitoring, and is illustrated in Figure 4.30.

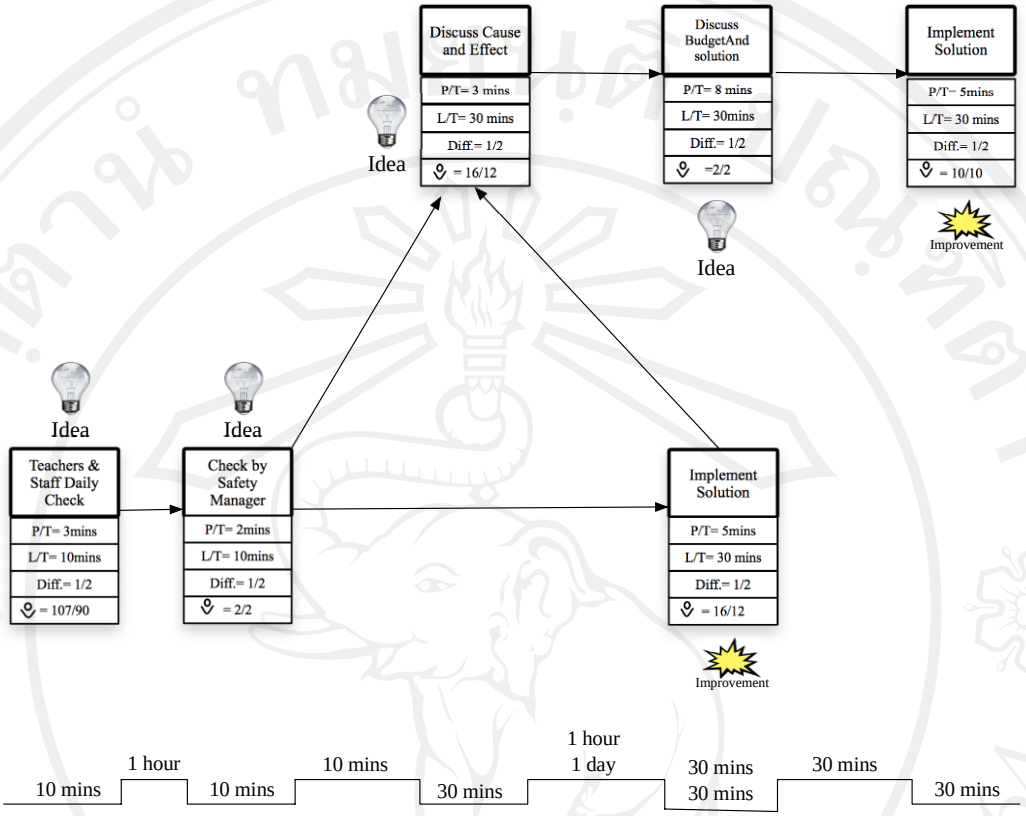

Figure 4.30 The future state VSM for safety monitoring at the school

Table 4.18 illustrates that in terms of the safety monitoring process, the application of lean has resulted in a reduction of the number of steps from 16 to 6, with only 46% of original steps being value adding, while 100% of steps are value adding after the application of lean. Lead time in the process has been reduced significantly, from 12 hours to only 2 hours, with the amount of value adding time going from 12% to 100%.

Table 4.18 The lean analysis of the future state VSM for monitoring safety

Factor	Lean Analysis
No. of steps	6
No. of value added steps	6
% of value added steps	100%
Lead time	2 h 20 mins
Value added time	2 hours 20 mins
% of value added time	100%

Having considered each of the current and future value stream maps in turn, Tables 4.19 to 4.22 now directly compare the pre and post lean safety processes to more clearly show the improvements arising from the implementation of lean thinking and the value stream maps. Following this overall summary of the improvements, the actual changes arising from the use of the 7 wastes and 5S tools are considered with reference to the value stream maps.

Table 4.16 illustrates the overall improvement from pre lean to post lean in relation to responding to parents' suggestions.

Table 4.19 Process matrix based on the pre and post lean implementation for the responding to parents suggestions process

Factor	PRE Lean	POST Lean	Improvement
Process measure	Responding to parents' suggestions and comments		
No. of steps	17	11	Reduction of 6
No. of value added steps	9	10	Increase of 1
% of value added steps	52.95%	91.00%	Increase of 38.05%
Lead time	4 days 2 hours 10 mins	3 hours 10 mins	Reduction of 3days 23 hours
Value added time	1 day 20 mins	2 hours 40 mins	Reduction of 21 hours 40 mins
% of value added time	25.05%	84.21%	Increase of 59.16%

As Table 4.19 shows, there is significant improvement in all lean measures when comparing the current and future state value stream maps for responding to parents' suggestions. The number of steps was reduced from 17 to 11, and the number of value adding steps was increased from 52% to 91%. Lead time was reduced by almost 4 days and the percentage of value added time increased from 25% to 84%. As a key measure of lean thinking, the percentage of value added time in a process is of particular importance, and when comparing pre and post lean, this measure can provide a quick snapshot of the success of the lean approach. In keeping with this sentiment, Figure 4.31 shows the percentage of value added time before (pre) and after (post) implementing lean, for the process of responding to parents' suggestions.

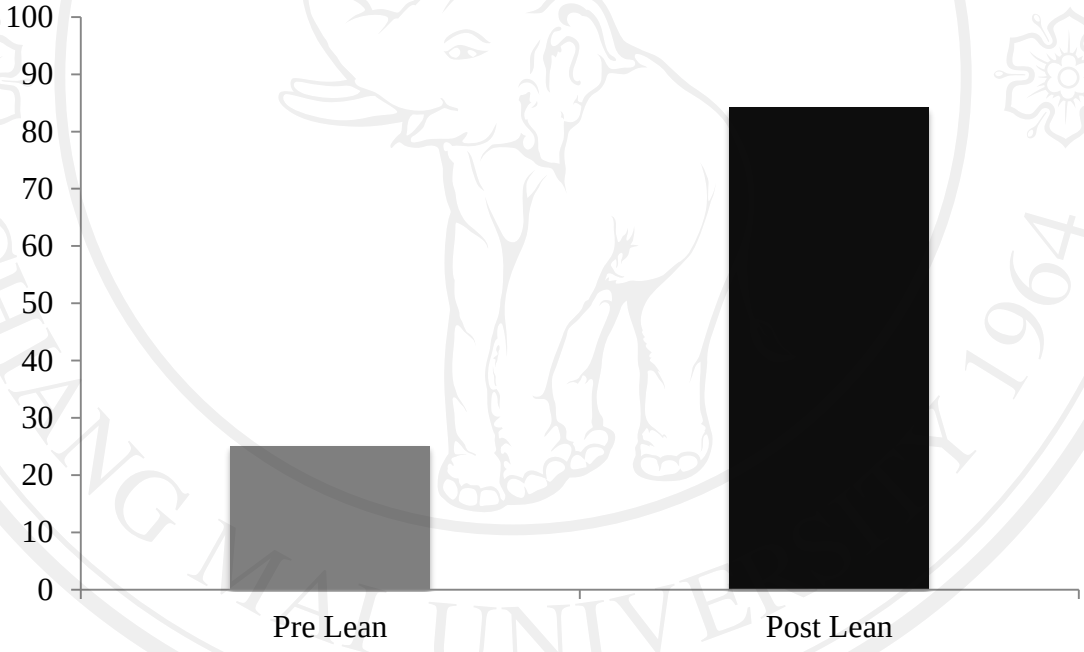

Figure 4.31 Percentage of value added time in the process of responding to parental suggestions both before and after lean implementation

Figure 4.31 shows that there is a highly significant improvement in the percentage of value added time and that the implementation of lean has increased the percentage from only 25% to almost 85%. This has been mainly through the use of the AHP model, which enabled a consistent method to sort and standardize suggestions and allowed staff to be autonomous in their decision making.

Table 4.20 summarises the improvements resulting from lean implementation to the process of safety compliance in the school. Once again, the application of lean has resulted in significant improvements.

Table 4.20 Process matrix based on pre and post lean (VSM) implementation for the process of school safety compliance

Factor	**PRE Lean**	**POST Lean**	**Improvement**
Process measure	Safety compliance		
No. of steps	13	8	Reduction of 5
No. of value added steps	9	7	Reduction of 2
% of value added step	69.23%	87.50%	Increase of 18.27%
Lead time	1 year 11 months 1d 1h	2 months 25 days 4 hours	Reduction of 1 year 8 months 5 days 21 hours
value added time	8 months 23 days	1 month 25 days 4 hours	Reduction of 6 months 27 days 20 hours
% of value added time	37.79%	64.78%	Increase of 26.99%

Figure 4.32 highlights the extent of the lean improvement by once again showing the percentage of value added time before and after the implementation of lean. This time, the graph represents improvements in managing school safety compliance.

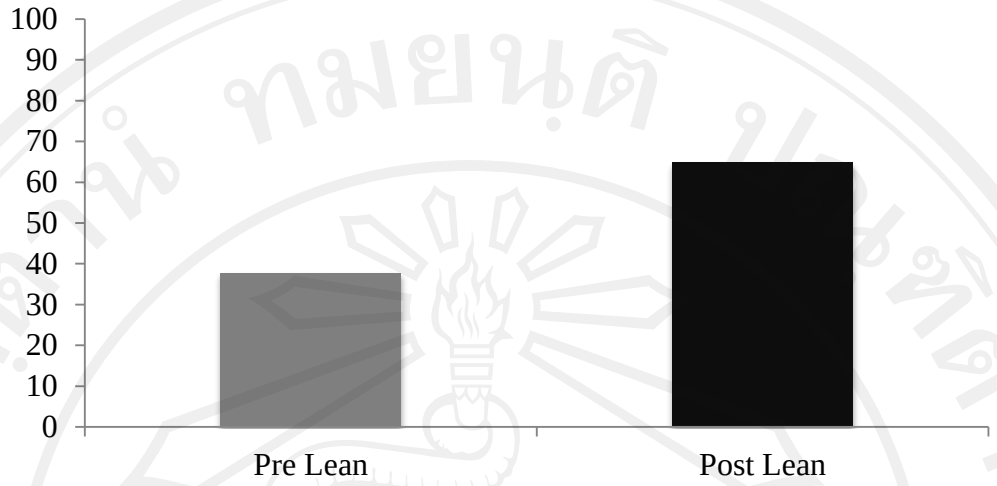

Figure 4.32 Percentage of value added time in the process of school safety compliance, both before and after lean implementation

As with responding to parents' suggestions, there is a significant increase in value added time, with the percentage rising from 37% to almost 65%. Table 4.121 now summarises the extent of improvement pre and post lean implementation for the process of monitoring safety in the school. As with the other two key processes, there is significant improvement.

Table 4.21 Process matrix based on pre and post lean (VSM) implementation for the process of monitoring school safety

Factor	**PRE Lean**	**POST Lean**	**Improvement**
Process measure	Monitoring safety		
No. of steps	16	6	Reduction of 10
No. of value added steps	6	6	No change
% of value added step	42.86%	100%	Increase of 57.14%
Lead time	12 hours	2 h 20 mins	9 hours 40 mins
value added time	1 hour 28 mins	2 hours 20 mins	Increase of 52 mins
% of value added time	12.23%	100%	Increase of 87.77%

Figure 4.33 provides a clear view of the improvement pre and post lean, and indicates that the percentage of value added time has risen from just 12% pre lean implementation to 100% post lean.

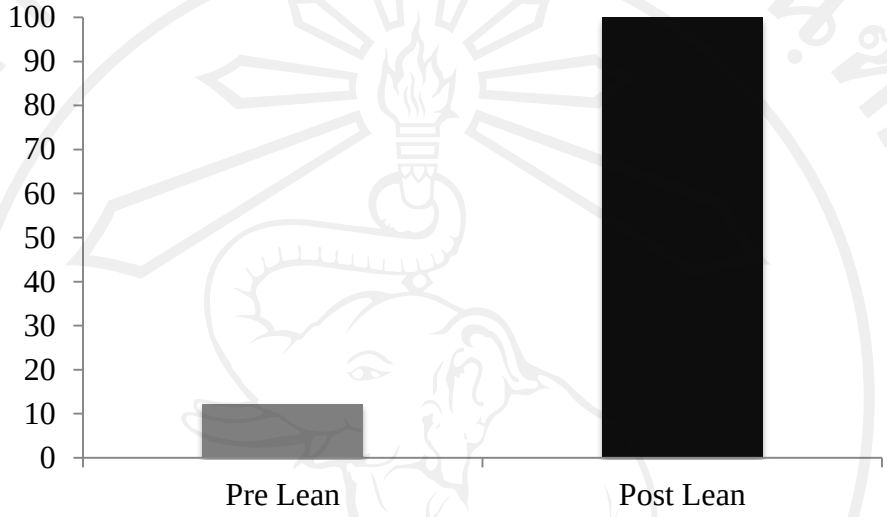

Figure 4.33 Percentage of value added time in the process of monitoring school safety, both before and after lean implementation

The final part of the lean analysis investigates the overall improvement to school safety from the use of lean. Table 4.22 thus includes the overall improvement based on all the processes where lean was applied in the school (responding to parents' suggestions, compliance, monitoring safety). The total number of steps and time was calculated both before and after lean implementation and the result gives an overall indication of the impact of lean thinking on school safety.

Table 4.22 Lean assessment based on pre and post lean (VSM) implementation for all processes

Factor	PRE Lean	POST Lean	Improvement
No. of steps	47	25	Reduction of 22
No. of value added steps	25	23	Reduction of 2
% of value added step	53.19%	92%	Increase of 38.81%
Lead time	1 year 4 months 8 days 15 hours 22mins	6 months 26 days 6 hours 22mins	9 months 14 days 9 hours
value added time	2 months 2 days 6 hours	1 months 9 days 7 hours 7 mins	22 days 22 hours 53 mins
% of value added time	12.74%	19.05%	Increase of 6.31%

The summary of the impact of lean provides a useful snapshot of how successful the lean approach is, but is also skewed due to the effects of some processes and time on the overall result. Table 4.22 shows an improvement of approximately 7% in value added time, but when considering the improvements in individual processes, the increase in value added time is much greater. The total number of steps was reduced from 47 to 25, which represents a 46% reduction. While the total number of value added steps were reduced, the overall efficiency (percentage of value added steps) increased significantly.

As well as increasing the amount of value adding time to processes and cutting out waste, lean thinking is often considered as a cost reduction tool. However, Hines et al. (2004) suggest that this is a common shortcoming in the understanding of lean thinking, noting that increasing the amount of value added time and cutting out waste are not equal to cost cutting. However, lean thinking is about making processes efficient and optimizing the processes. The philosophy of lean thinking in this research has also been to ensure that schools can cut down on the budgetary burden represented by school safety. As such, Figure 4.34 and Figure 4.35 illustrate the safety

expenditure over the two semesters after the implementation of lean value stream mapping to indicate the effect on the school's safety budget.

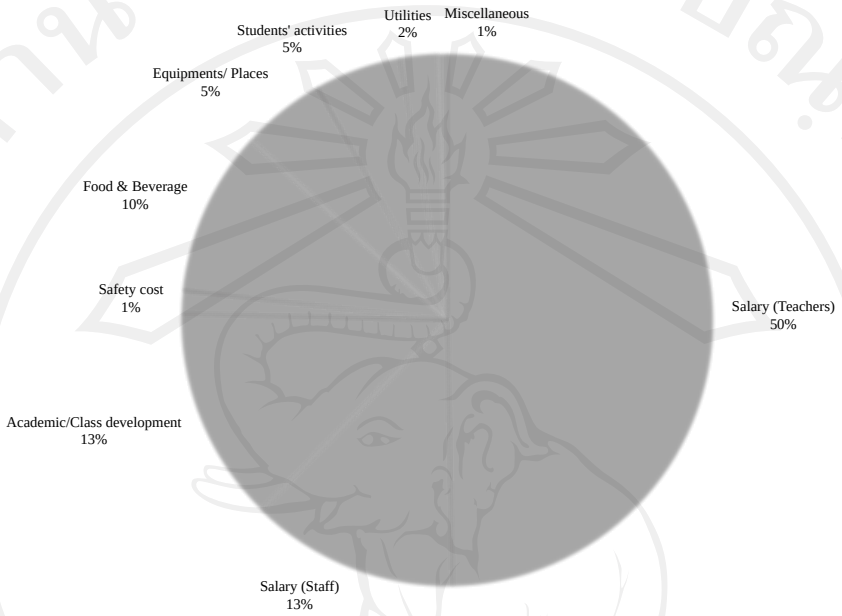

Figure 4.34 School Expenditure as a Percentage of Total Budget: First Semester 2012

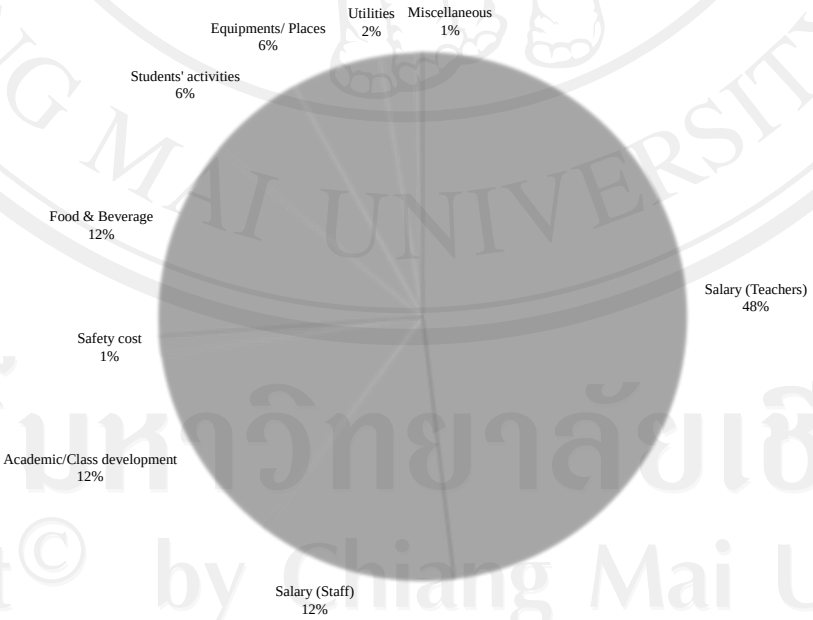

Figure 4.35 School Expenditure as a Percentage of Total Budget: Second Semester 2012

Figures 4.34 and 4.35 show that the percentage of the school budget used on school safety is now approximately 1% in each of the two semesters. This is noticeably lower than before the implementation of lean, where the school safety expenditure was between 3-5% of the school budget. Figure 4.36 illustrates the difference between the average safety expenditure (as a % of total school budget) both pre and post lean implementation.

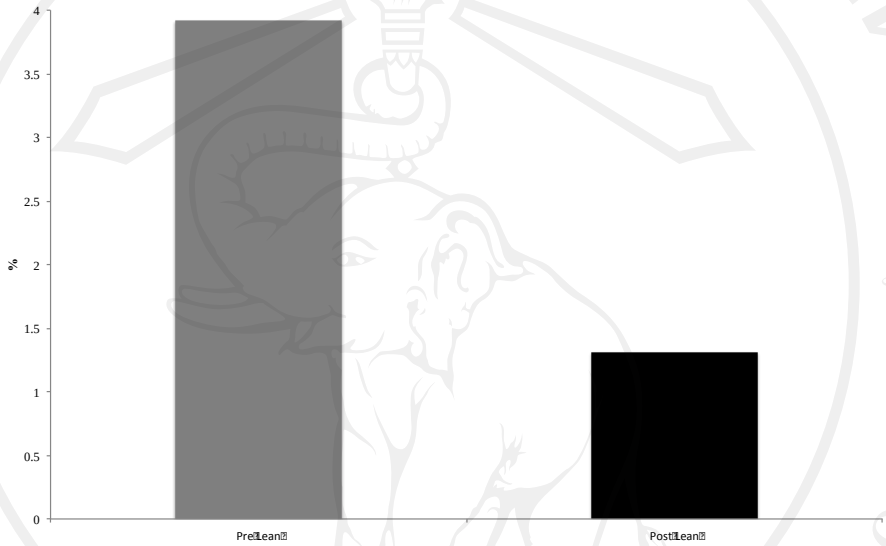

Figure 4.36 Average safety expenditure as a percentage of total school budget for three semesters pre lean implementation and two semesters post lean implementation

Overall, the results regarding the school's safety expenditure show that the implementation of lean thinking has reduced the proportion of the budget spent on safety. This reduction is set against an overall improvement in the safety processes and better awareness and knowledge sharing about safety due to the RPIWs. It is important to note that some may see reduced expenditure on safety as a negative impact. For example, if parents were given access to private budgetary data they might feel that the school is ignoring or reducing its focus on safety. However, the school's budgetary expenditure in the two semesters after lean implementation indicate that a higher proportion of the budget is now spent on academic matters and teaching. Therefore while the proportion of budget spent on safety has reduced after the implementation of lean, it has allowed the school to reallocate funds and focus on other important aspects of the school. This is against an overall improvement in school safety awareness and a better response to parents' suggestions. The lean thinking approach has therefore

not simply cut costs associated with safety, but reduced unnecessary and wasted expenditure and rechanneled it to other areas of the school.

The next section of the results considers how the improvements were achieved through the use of the seven wastes, 5S and AHP model.

4.6.3 The Seven Wastes to Improve Safety Processes

The seven wastes are shown for each of the three processes, including responding to parents' suggestions, compliance, and safety monitoring. For each of these safety processes, a table of seven wastes is completed, and shows where lean improvements were made. Table 4.23 illustrates the 7 wastes for the responding to parents' suggestions process.

Table 4.23 The seven wastes and lean solutions for the process of responding to parents' safety suggestions

Seven Wastes (See Chapter 3, Table 3.8)	**Evidence in Responding to parents suggestions process**	**Lean solution**
1. Motion (human movement)	• Movement of teachers around the school to report problems to the safety manager or school director	• Teachers directly report safety problems to one of the safety team
2. Waiting time	• Teachers and staff must wait to report the problems if they have classes or work to finish • There are up to 7 days of waiting to report safety suggestions or issues at the school meeting	• The safety manager collects all suggestions every morning • The AHP model is immediately used to make decisions about the suggestions
3. Overproduction	• Repeated complaints or suggestions from different parents	• The safety team is the center of the suggestions • The AHP model records suggestions and decisions

Table 4.23 The seven wastes and lean solutions for the process of responding to parents' safety suggestions (Continued)

Seven Wastes (See Chapter 3, Table 3.8)	**Evidence in Responding to parents suggestions process**	**Lean solution**
4. Processing time	• Long processing time in finishing or responding to the suggestions	• The AHP model processes suggestions almost immediately • There are fewer steps and less processing for each suggestion
5. Rejection	• Many unsuccessful suggestions or inconsistent decisions about suggestions	• Consistency and standardization of safety suggestions via the AHP model • More successful suggestions
6. Inventory	• Over purchasing of tools of equipment according to parents' suggestions • Inconsistency in decision making means some suggestions that are infeasible are implemented	• AHP ensures only feasible suggestions are implemented, thus cutting waste • Equipment purchased as needed
7. Transport	• Paper or reports are transferred to all departments or classrooms	• The AHP is electronic, cutting out transport of paper and allowing anyone to see safety suggestions via the school's networked

Table 4.24 shows how lean has improved the process of responding to the needs and suggestions of parents, and in particular has highlighted the utility of the AHP model in sorting, standardizing and making decision making consistent. Table 4.x now illustrates the results of the seven wastes in improving the process of safety compliance in the school.

Table 4.24 The seven wastes and lean solutions for the process of responding to parents' safety suggestions

Seven Wastes (See Chapter 3, Table 3.8)	**Evidence in school safety compliance process**	**Lean solution**
1. Motion (human movement)	• Long time required to read/understand safety regulation/laws	• More people involved in understanding laws so sections can be delegated • Spend less time in understanding laws
2. Waiting time	• Long time spent implementing the regulations in the school • Parents' conference to inform about school progress is once a year	• Safety team and RPIWs ensure school is already safe and meeting regulation • Spend less time implementing laws • Communicate to parents in different ways such as monthly webcasts to cut waiting time
3. Overproduction	• Too many activities and people in the school are responding to the government's regulations	• Perform only needed regulations and remain proactive and forward thinking to ensure school already meets or surpasses government regulation
4. Processing time	• Long time spent implementing regulations/laws	• Less time spent implementing regulations/laws as school already exceeds regulation • Safety team are empowered and work is delegated to speed up processing
5. Rejection	• Wrong activities implemented when responding to the government's regulation	• Right activities to respond to the government's regulation

Table 4.24 The seven wastes and lean solutions for the process of responding to parents' safety suggestions (Continued)

Seven Wastes (See Chapter 3, Table 3.8)	**Evidence in school safety compliance process**	**Lean solution**
6. Inventory	• Over purchasing of tools or equipment according to safety compliance	• Purchase only as needed • Use the AHP model to assist with purchasing decisions
7. Transport	• Spend time and money to transport school's report to the government office	• Introduce different ways to report school safety

Table 4.24 indicates how the seven wastes, in combination with the value stream mapping, has enabled improvement in the processes of safety related to compliance. The main change here is the empowerment of people and awareness of knowledge sharing throughout the school to cut the workload associated with understanding and implementing government safety regulation. There is also a move from a reactive to a proactive approach toward school safety which should mean the school is already meeting or exceeding government regulation, thus cutting down the time associated with meeting these requirements. The AHP model once again assists by ensuring any possible change in school safety can be assessed via the AHP model to assess its feasibility. Table 4.25 now illustrates the seven wastes as they were applied to the process of monitoring school safety.

Table 4.25 The seven wastes and lean solutions for the process of monitoring school safety

Seven Wastes (See Chapter 3, Table 3.8)	**Evidence in monitoring safety process**	**Lean solution**
1. Motion (human movement)	• Staff and teachers walk around the school to observe safety	• Staff and teachers walk in predefined times and areas to increase efficiency
2. Waiting time	• Teachers wait for their free time to report to the safety manager or meeting	• Teachers report directly to whoever is currently responsible
3. Overproduction	• Same problems reported from different teachers and staff	• Predefined responsibilities, times and areas cut out duplication • Fast discussion, defined responsibility and AHP model make the problems specific and manageable
4. Processing time	• Long time in solving problems	• New processes and awareness from RPIWs reduce time • AHP can assist in making safety related decisions

Table 4.25 The seven wastes and lean solutions for the process of monitoring school safety (Continued)

Seven Wastes (See Chapter 3, Table 3.8)	**Evidence in monitoring safety process**	**Lean solution**
5. Rejection	• Too many steps mean staff cannot implement the solution	• Less steps due to value stream mapping and increased efficiency mean staff can solve problem quickly and easily
6. Inventory	• Over purchasing of tools or equipment according to safety monitoring	• Purchase things as needed • AHP model helps to ensure things are only purchased if new safety activity is feasible
7. Transport	• Objects paper or report are transferred to all departments or classrooms	• Only ones who are involved get paper or report • Electronic records available to all school staff cut out paper reports

Table 4.25 shows that the way in which school safety is managed has the most impact on safety monitoring. The seven waste improvements have come mainly from delegation of duties to staff and efficiently organizing methods to monitor school safety. The RPIWs are a key part of empowering staff, increasing awareness of safety and increasing safety related knowledge sharing. The AHP model also cuts down on processing time related to safety monitoring by increasing the speed at making safety related decisions. As well as the seven wastes to improve the school safety processes, the 5S were also a key part of improving these processes.

4.6.4 5S to improve Safety Processes

The 5S (sort, set, sweep, shine, standardize) were used when developing the future state value stream maps and the key findings are shown in Table 4.26.

Table 4.26 The key results from the 5S analysis when creating the future state value stream maps

5S	**Processes**		
	Safety Suggestions	**Monitoring safety**	**Safety Compliance**
Sort	Sorting safety suggestions from worthwhile to not worthwhile. This is predominantly achieved through the utilization of the AHP decision support model.	Staff were effectively sorted to ensure an efficient method at monitoring school safety and one which fits with the other school safety processes.	Regulations and government directives are now assessed by more than one person to clear rubbish.
Set	Establishing a new procedure for dealing with safety suggestions, which reduces the time taken to report and assess the safety suggestion.	A new new procedure was set for monitoring school safety which increased efficiency and in combination with the seven wastes, cut out wasteful activities.	A new proactive safety policy introduced should reduce the time taken to implement government directives on an ad hoc basis as the school should already be exceeding government requirements.
Sweep /shine	In combination with the seven wastes, unnecessary and non value adding processes were removed	The philosophy of lean thinking fits with continuous improvement and thus value stream mapping will be continuously updated and improved to maintain school safety efficiency.	Government policies are regularly compared to the school's and implemented rather than being compared annually.

Table 4.26 The key results from the 5S analysis
when creating the future state value stream maps (Continued)

5S	Processes		
	Safety Suggestions	**Monitoring safety**	**Safety Compliance**
Sweep/shine	In combination with the seven wastes, unnecessary and non value adding processes were removed	The philosophy of lean thinking fits with continuous improvement and thus value stream mapping will be continuously updated and improved to maintain school	Government policies are regularly compared to the school's and implemented rather than being compared
Standardize	A consistent procedure was created using the AHP decision support system, which standardizes the way in which safety suggestions are assessed.	As with the AHP for safety suggestions, the monitoring of school safety was turned into a consistent procedure without variability to ensure efficiency and the elimination of repetition or waste associated with the seven wastes.	The procedure is standardized as with any other key aspect of the school's management.
Sweep/shine	In combination with the seven wastes, unnecessary and non value adding processes were removed	The philosophy of lean thinking fits with continuous improvement and thus value stream mapping will be continuously updated and improved to maintain school safety efficiency.	Government policies are regularly compared to the school's and implemented rather than being compared annually.
Standardize	A consistent procedure was created using the AHP decision support system, which standardizes the way in which safety suggestions are assessed.	As with the AHP for safety suggestions, the monitoring of school safety was turned into a consistent procedure without variability to ensure efficiency and the elimination of repetition or waste associated with the seven wastes.	The procedure is standardized as with any other key aspect of the school's management.

Table 4.26 has shown how the 5S are a critical part of improving school safety, but one of the key aspects in improving the safety related to people and the tacit parts of safety, hence the RPIWs and CEDAC are critical to effective school safety.

4.6.5 RPIW and CEDAC

While the lean thinking approach and value stream mapping has provided a way to improve the explicit processes involved with school safety, the thesis has made it clear that tacit aspects are just as critical to school safety. The advantage of the synergy between knowledge management and lean thinking is that both tacit and explicit factors are considered with regard to the school's safety. This section outlines the results of the explicit aspects of school safety, which mainly focus on knowledge sharing, leadership and other dimensions related to tacit aspects of school safety. Chapter 3 outlined the three RPIWs, which were conducted with all staff and teachers at the school. One of the aims of the RPIWs was to capture tacit safety knowledge to use in improving school safety management. The RPIWs resulted in the completion of an overall fishbone diagram which illustrates the causes leading to school safety problems. This then allows the school to focus on how best to manage these issues to improve school safety. Figure 4.37 illustrates the overall results from the fishbone analysis of the issues arising from the first RPIW. The fishbone analysis resulted from the technique known as the cause and effect diagram with the addition of cards (CEDAC) (see Chapter 3, section 3.8.10).

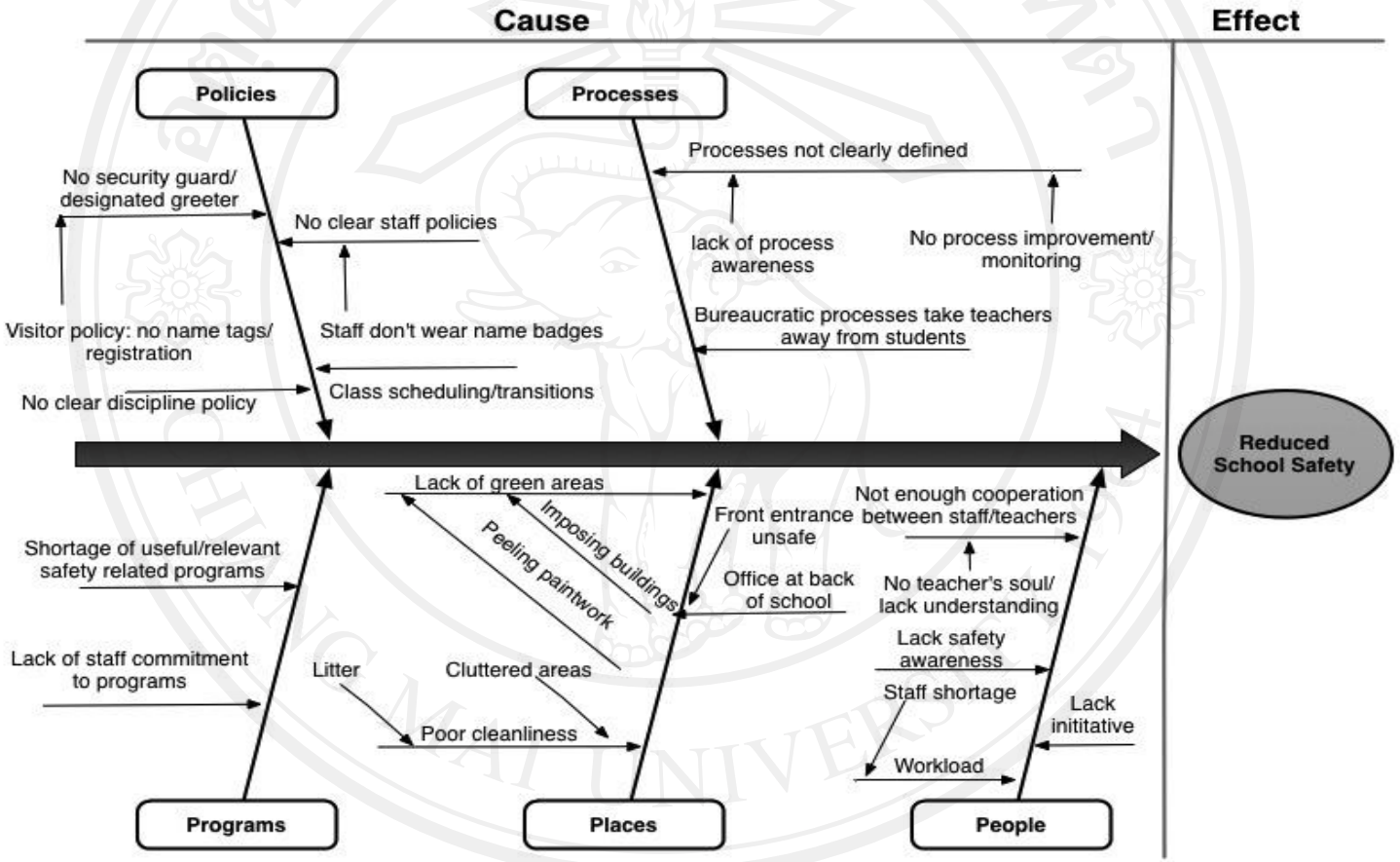

Figure 4.37 The fishbone analysis resulting from the CEDAC session in the first RPIW

After the CEDAC and fishbone analysis, an interrelationship digraph was created based on inputs from the fishbone analysis. This enabled the key root causes of safety problem to be identified. Figure 4.35 shows the interrelationship digraph.

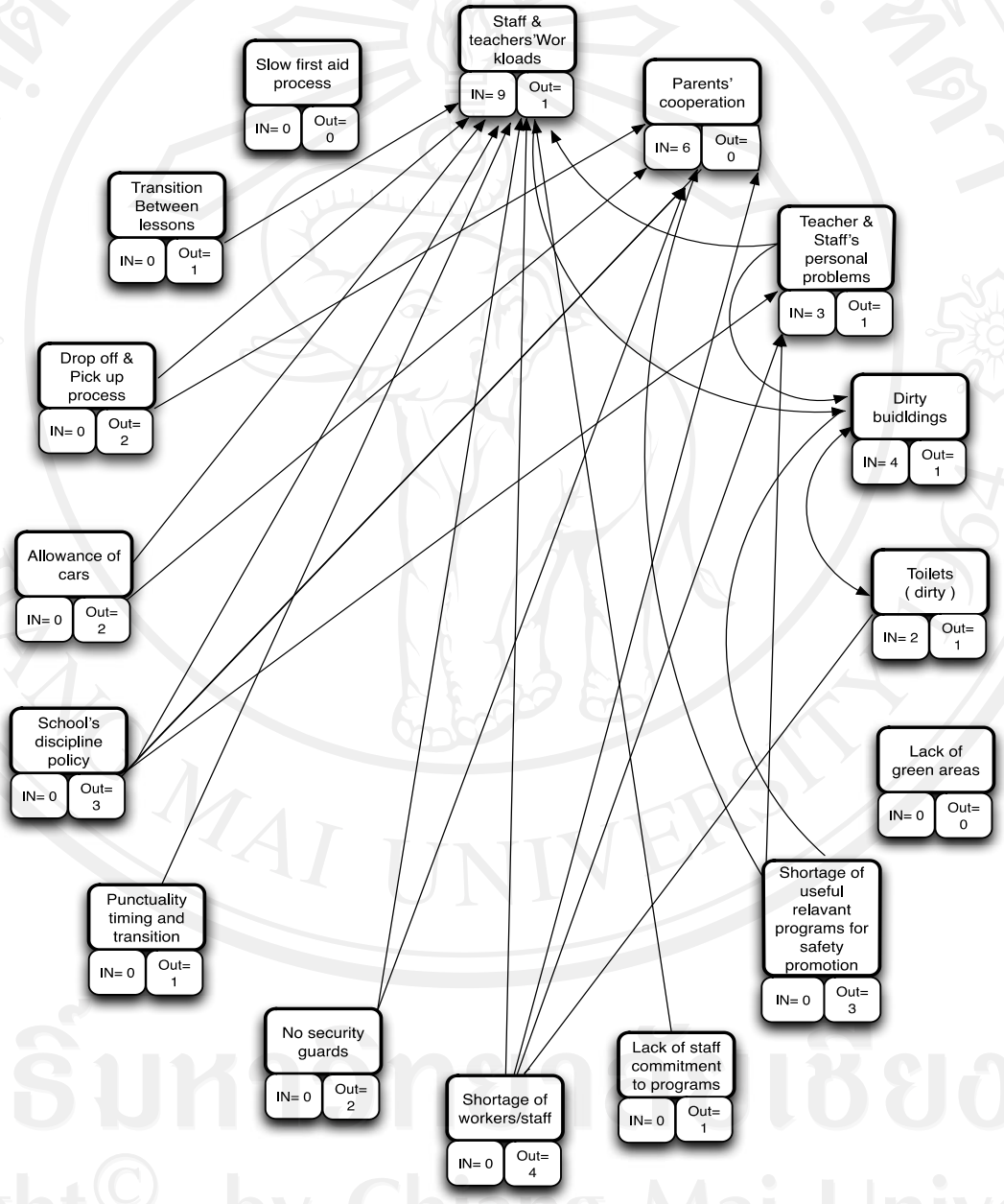

Figure 4.38 The CEDAC diagram created from the RPIW to capture tacit knowledge

Figure 4.38 shows that the item with the most inputs is parental cooperation. This suggests that parental cooperation is the root cause of effectively managing safety in the school. Parental cooperation is strongly linked to knowledge sharing and the explicit process related to managing parental suggestions. This suggests that the focus on adding value to parents through lean is a highly appropriate way to manage school safety.

The second RPIW was based around safety knowledge sharing. Chapters 2 and 3 have shown that effective knowledge sharing is critical to school safety. The staff and teachers were tested both before and after the RPIW to assess their improvement with regard to awareness of knowledge sharing. There was also a long term posttest to see if they retained the information and awareness learned during the RPIW. Table 4.27 indicates the results of a t-test to assess whether there was any statistically significant difference before or after the RPIW.

Table 4.27 T-test results for the RPIW based on knowledge sharing

Sample Group and Size	**T-value between pretest and post test**	**T-value between pretest and long term posttest**	**Critical t-value required for statistical significant at 99% CI**
Experiment (n=73)	20.04	32.36	2.66
Control (n=11)	0.66	0.36	3.106

Table 4.27 indicates that the RPIW was effective at increasing awareness of knowledge sharing, as shown by the statistically significant t-value between the pretest and posttest and long-term posttest. The control group, which consisted of staff and teachers who did not take part in the RPIW showed no statistically significant improvement in their understanding or awareness of knowledge sharing.

The third and final RPIW was based on leadership and empowerment to improve school safety. As with the second RPIW, staff and teachers took part in a pretest, posttest and long-term posttest. Table 4.28 indicates the t-test results from this RPIW.

Table 4.28 T-test results for the final RPIW based on leadership and empowerment

Sample Group and Size	T-value between pretest and post test	T-value between pretest and long term posttest	Critical t-value required for statistical significant at 99% CI
Experiment (n=73)	19.05	20.21	2.66
Control (n=11)	0.54	0.38	3.106

As with the previous RPIW, Table 4.27 shows the difference between the pretest, posttest and long-term posttest was statistically significant. This again points to the effectiveness of the RPIWs at improving staff and teacher awareness of safety, and the importance of effective leadership and empowerment for staff and teachers. The final aspect of the lean knowledge management approach to assess is the AHP decision support model which is a key part of the lean knowledge management approach to school safety.

4.6.6 AHP Decision Support Model

A key measure of the success of the AHP was its consistency. This was measured via the coefficient of variation. The coefficient of variation was calculated by dividing the standard deviation by the mean, and then multiplying by 100 so the variation in response could be interpreted as a percentage. Two comparisons of the AHP model were made. The first was a comparison of the variation produced by the model when used by the administrative/management staff, to see how consistent the model was when assessing safety suggestions. Table 4.29 indicates the coefficient of variation for five staff, assessing ten safety suggestions using the AHP model.

Table 4.29 AHP Coefficient of variation for administrative staff and school management

	AHP Response Score							
Suggestion Number	**School Director**	**School Manager**	**Safety Manager**	**Administrative Staff**	**Administrative Staff**	**Average**	**St. Deviation**	**Coefficient of variation (%)**
1	3.6	3.5	3.6	4	3.9	3.72	0.22	**5.83**
2	4	4.1	4.4	4.6	3.9	4.20	0.29	**6.94**
3	3.3	3.4	5.4	4	3.6	3.94	0.86	**21.80**
4	4.6	4.7	4.3	4.8	5	4.68	0.26	**5.53**
5	4.4	4.5	3.9	4.8	4.6	4.44	0.34	**7.57**
6	4.2	4	3.5	4.4	4.4	4.10	0.37	**9.13**
7	3.4	3.3	4.7	5	3.8	4.04	0.77	**19.06**
8	6.4	6	5.4	4.7	4.5	5.40	0.82	**15.10**
9	4.5	4.7	4.1	4.8	4	4.42	0.36	**8.06**
10	4.1	4	5.1	4.8	3.5	4.30	0.64	**14.98**
							Average	**11.40**

Table 4.29 shows that the AHP model is consistent in its assessment of safety related decisions across a wide range of safety related suggestions and when used by a wide variety of school safety personnel. This corroborates the utility of the AHP model in its ability to sort, standardize and maintain consistency in making decisions about school safety suggestions from parents. Table 4.30 and Figure 4.39 now indicate the degree to which the AHP model was able to reduce safety suggestions.

Table 4.30 The reduction rate achieved by the AHP model in reducing the number of suggestions the school must consider for implementation

Source of Suggestion	**Channel**	**Number of Suggestions**	**Total**	**Number of Implemented Suggestions Approved by AHP**	**Total**	**AHP Reduction Rate (%)**
Parents	Face-to-face	93	**332**	19	**87**	**79.57**
	Telephone	105		21		**80.0**
	E-mail	38		18		**52.63**
	Letter	0		0		**0.00**
	Facebook	96		29		**69.79**
Teachers/ Staff	Meeting	35	**182**	11	**59**	**68.57**
	Web-blog	11		4		**63.64**
	Telephone	14		2		**85.71**
	E-mail	37		10		**72.97**
	Letter	0		0		**0.00**
	Facebook	62		24		**61.29**
	Suggestion cards	23		8		**65.22**

According to Table 4.30, there has been a significant reduction in the number of suggestions the school has to deal with and this is due to the AHP model, which has filtered and reduced suggestions. Figure 4.39 shows how the AHP model reduces the overall number of suggestions which must be considered by the school and splits this reduction into parental suggestions, those from staff/teachers, and finally, an overall reduction rate.

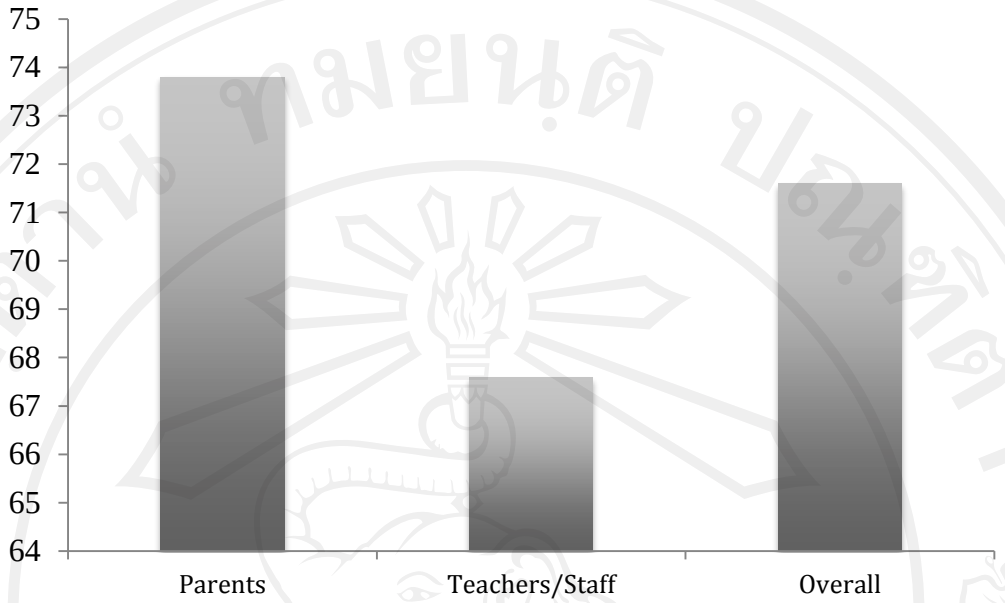

Figure 4.39 The reduction rate in suggestions achieved by the AHP model for parents, teachers/staff and the overall reduction rate

Figure 4.39 indicates that AHP was most successful in reducing the number of parental suggestions to be considered. There was also a significant reduction in the number of teacher/staff suggestions to be considered. It was expected that the AHP model would reduce more parental suggestions as teachers are more fully involved and integrated in the school's safety and therefore are likely to submit only valid/sensible suggestions. Overall, the AHP model allowed for a 71% reduction in the number of suggestions which must be significantly considered by the school's management. This reduction fits in with the lean approach and the cost savings provided by the lean KM approach.

The next stage of the results brings all aspects of the lean knowledge management approach together to assess sustainability and stakeholder satisfaction with the new approach.

4.7 Stage Four: Sustain

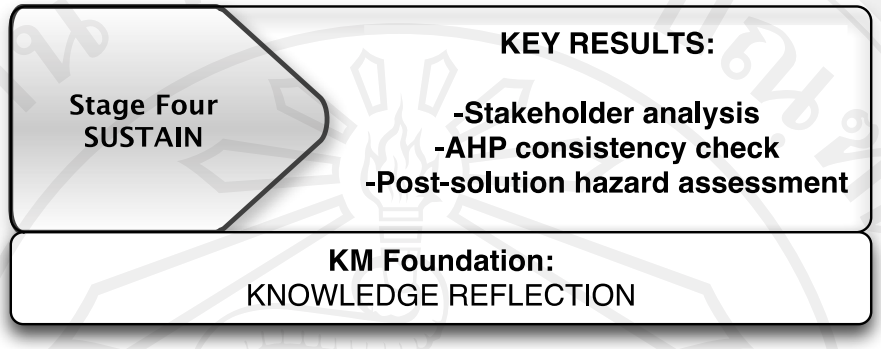

Figure 4.40 The key results in the sustain phase relate to stakeholder analysis

Figure 4.40 The sustain stage of the results and its main task of evaluating the solution and reflecting upon the knowledge to ensure sustainability and continuous improvement

The main stakeholder analysis involved parents, teachers, staff and management at the school. The key results from each stakeholder are illustrated in Table 4.31.

Table 4.31 The key results stakeholders analysis

Parents	Teachers	Staff	Management
• Increased satisfaction with new safety suggestions are managed • Perception of school safety has improved due to new processes and safety knowledge sharing	• Feel empowered to make decision (using AHP model) about school safety • Are more positive about school safety • See school safety as less of a burden and more manageable	• See safety as a unique selling point of the school • Feel empowered to act upon issues of safety • Feel safety is more efficient and takes less time	• Realise the competitive advantage of school safety • Feel school safety is more efficient and less burdensome • See increased parental satisfaction

Table 4.31 The key results stakeholders analysis (Continued)

Parents	Teachers	Staff	Management
Parents have noticed real changes to how safety is managed and implemented at the school	Know their responsibilities related to safety		Realise advantages of bottom up management approach

As part of the stakeholder analysis, parents (customers) were interviewed both pre and post lean implementation in order to compare their level of satisfaction with school safety before and after the lean implementation which then provides an indication of how successful the new lean knowledge management approach is at satisfying parents.

4.8 Parental Satisfaction Pre and Post Lean

To compare parental satisfaction before and after implementation of the lean knowledge management approach, parents were asked the question, "to what extent do you consider the school to be safe?" The answers were then compared according to five levels (very safe, safe, neutral, not safe, very unsafe). These answers are shown below in Figures 4.41 to 4.43. It is important to note that no parents considered the school to be 'not safe' or 'very unsafe' after the implementation of the lean knowledge management approach, so there are only three graphs which display the pre and post lean results for the percentage of parents considering the school to be either 'very safe', 'safe' or 'neutral'.

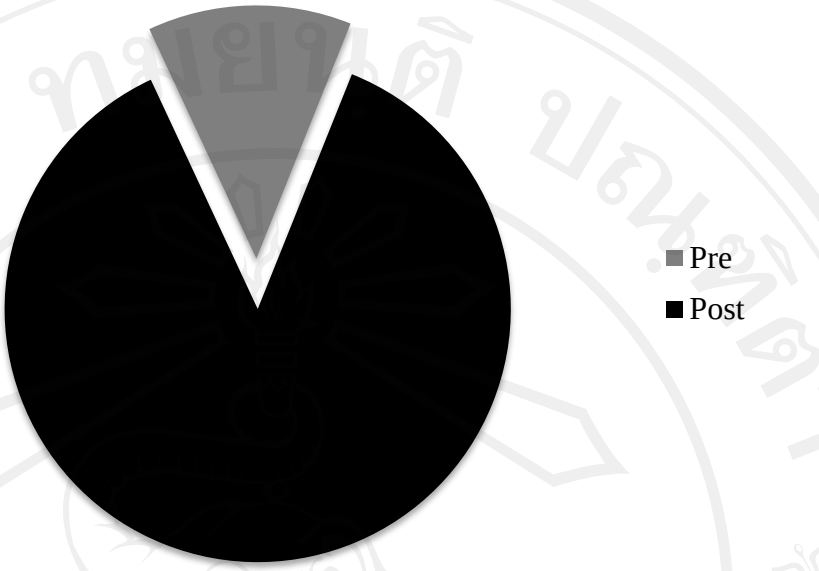

Figure 4.41 Percentage of parents pre and post lean who considered the school to be ‘very safe’ *n = 90*

Figure 4.41 shows that just below 14% of parents considered the school to be ‘very safe’ prior to the implementation of the lean knowledge management approach. After implementation of lean, the percentage of parents who consider the school to be ‘very safe’ has risen by 76% to 89%. This demonstrates the highly significant effect on parental satisfaction and shows how powerful the approach can be at enhancing parents’ (customer) satisfaction with the school. Figure 4.42 now indicates the proportion of parents’ pre and post lean who considered the school to be ‘safe’.

Figure 4.42 Percentage of parents pre and post lean who considered the school to be ‘safe’ *n = 90*

Figure 4.42 indicates that the percentage of parents who consider the school as ‘safe’ has reduced from 35% to approximately 8%. This is due to the relatively large increase of parents who consider the school to be ‘very safe’. This indicates that a large proportion of parents have changed their opinion of the school’s safety due to the lean knowledge management approach. Figure 4.43 now highlights the proportion of parents who remained neutral regarding the school’s safety.

Figure 4.43 Percentage of parents pre and post lean who considered the school to be ‘neither safe nor unsafe (neutral)’ *n = 90*

Figure 4.43 shows that pre lean implementation, almost 30% of parents remained neutral regarding the school's safety, deeming it neither safe nor unsafe. After implementation of the lean knowledge management approach, only 1.8% remained neutral highlighting the number of parents whose satisfaction has now increased to either considering the school as 'safe' or 'very safe'.

After the implementation of the lean approach, no parents considered the school as 'unsafe' or 'very unsafe', showing the success of the lean KM approach in increasing parental satisfaction at the school. Figure 4.41 and 4.42 show that after the implementation of the new approach, almost 100% of parents considered the school to be either 'very safe' or 'safe', which is a significant improvement in parental perception and satisfaction with the school.

From a knowledge management perspective, the balanced scorecard approach provides a useful way to integrate the knowledge and results of the new approach into a strategy for the school. Before summarizing this chapter, the balanced scorecard perspective is considered regarding the lean knowledge management approach and the case study school.

4.9 The Balanced Scorecard

The balanced scorecard suggests four perspectives from which to analyse processes or work performance. These four perspectives allowed development of metrics to be implemented into the multi-criteria knowledge management system for lean school safety. The balanced scorecard is a strategy management tool (Cobbold and Lawrie, 2002) and was first developed by Kaplan and Norton (1992). The balanced scorecard mixes financial and non-financial metrics to assess and report on an organization's progress. Figure 4.44 indicates the overview of the balance scorecard perspectives and how they are interrelated.

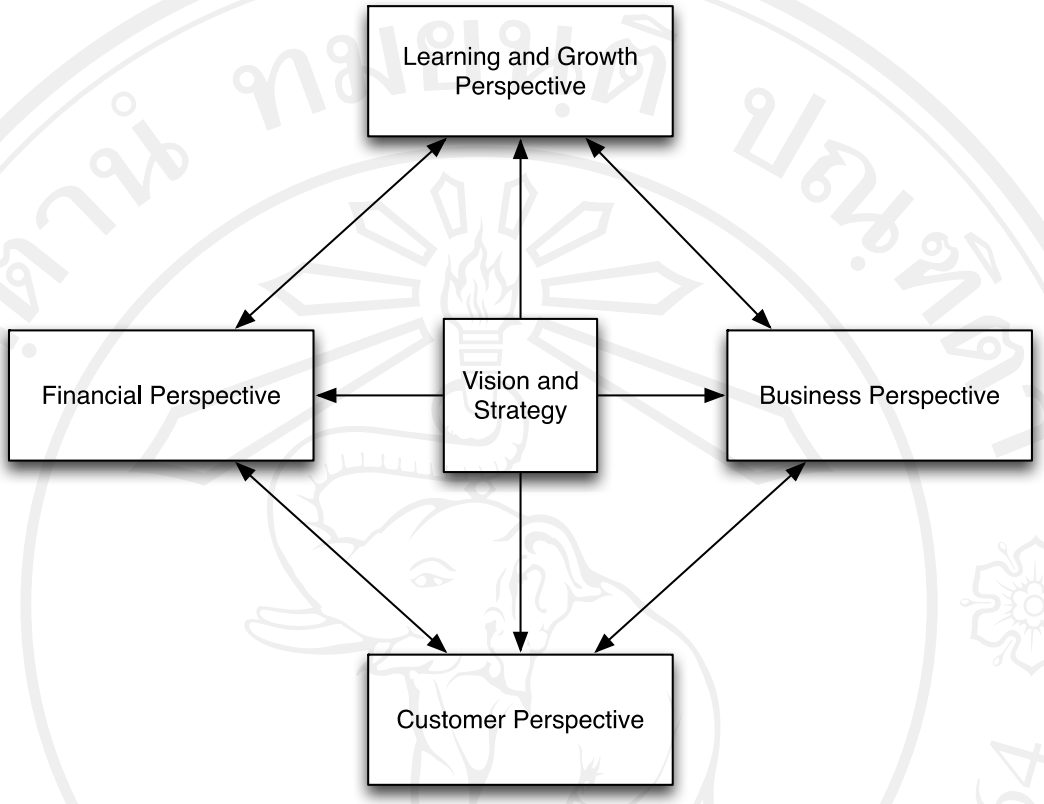

Figure 4.44 The perspectives in the balanced scorecard approach (adapted from Kaplan and Norton, 2002)

Each of the perspectives in the balanced scorecard are now discussed in terms of how they affect school safety and how the new multi-criteria knowledge management approach contributes to school safety.

4.9.1 The Learning and Growth Perspective

In the new multi-criteria knowledge management approach to lean school safety, this perspective is represented by teacher and staff training in the form of RPIWs. The first RPIW taught school personnel about lean safety, and captured their knowledge, which could then be used during the safety improvement process. The second RPIW taught teachers and staff about safety related knowledge sharing in the school, and the results from pretests and posttests showed statistically significant improvements in knowledge sharing awareness. Finally, the third RPIW was based on school leadership and also showed statistically significant differences before and

after the implementation of the RPIW. The RPIWs are thus a critical part of the learning and growth perspective.

While working together and sharing knowledge, teachers, staff and parents provided cultural attitudes related to both individual and corporate self-improvement. Teachers and staff could learn useful experiences from parents in terms of the parents' perspective toward safety, while parents could learn how to cooperate with the school in taking care of their children safely.

When parents provide safety suggestions to the school, teachers use the multi-criteria knowledge management tool (AHP) as a method to help in deciding and responding to parents' needs. Teachers and staff can also learn how to use the AHP, which supports continuous learning within the school.

School management realized that learning is more than training and took action in supporting teachers and staff to learn for lifelong improvement. Best practice in the school relates to mentors and tutors within the school for staff and teachers. After improvement using the multi-criteria knowledge management, the school's administrator continued activities in the form of Baiboonlamphun mentoring and tutoring. The activity contributes to the school's best practice in terms of knowledge sharing regarding school safety. Baiboonlamphun mentoring and tutoring provides teachers and staff to have their own personal supervisor who can help each other, and also provides an easy communication system that allows them to readily get help when it is needed.

4.9.2 The Business Process Perspective

This perspective refers to internal business processes. School management understands how well the school is running and compared with the number of students over the last two years, there has been a substantial increase. Before improving the school using the multi-criteria knowledge management lean school safety system, there were only 1,100 students at the case study school. After implementation of the new lean knowledge management approach, and together with parents' word-of-mouth, there are now over 1,600 students, which shows the business progress of the school. While such increases in students may be due to other factors, it illustrates the improvement in school safety and how this conforms to customer's (parents') requirements (which is the main mission of the school).

4.9.3 The Customer Perspective

Initial results in this research shows that parents in Thailand believe that a school's quality is not based only on academic issues, but school safety too. Schools do not show accident records or statistics to parents due to the previously noted fallacy of safety statistics; however, one thing school management can do to improve school safety and parental attitude toward it is to involve parents in school safety, as shown in this thesis. The management at the case study school focused on the importance of parents' satisfaction in its business. In the stakeholder analysis, parents reflected that they were satisfied with the school's improvement due to the new lean knowledge management approach. As parents are involved intrinsically with the school's safety, they achieve a quick response from the school when making suggestions and admire the process in place at the school.

School management realized that if parents are not satisfied, they will eventually find other schools that meet their needs and expectations. Thailand's regulations allow parents and students to choose what and where they can learn, so improving the parental satisfaction thorough improved safety processes is critical for the school.

4.9.4 The Financial Perspective

Before improving school safety via the lean knowledge management approach, school safety expenditure was between 3-5% of the school budget. After implementation of the new multi-criteria lean knowledge management approach, the percentage of the school budget used on school safety was reduced to approximately 1% in each of the two semesters where data was available. This is noticeably lower than before the implementation of lean and indicates how the school benefits financially from the new approach to safety.

4.9.5 Balanced Scorecard Summary

For each of the key perspectives of the balanced scorecard, the new multi-criteria knowledge management approach to school safety offers significant improvements and feeds the overall business strategy of the school. Thus the balanced scorecard shows how school safety is not simply a moral or peripheral aspect of a school, but a central and critical part of a successful school, and one which must be considered by schools running as a

business. For private schools, this new multi-criteria knowledge management approach offers significant benefits, although these benefits are not exclusive to the private sector and government schools could also see the many benefits associated with the new lean knowledge management approach to school safety. The balanced scorecard indicates how school safety feeds all the key business perspectives of the school and indicates how the new lean knowledge management approach contributes significantly to each of these perspectives.

4.10 Chapter Summary

Key results of the lean thinking knowledge management approach to school safety presented according to the scope, select, solve and sustain phased used as the framework in this chapter and are as follows:

Scope Phase:

- Questionnaires show parents at schools consider safety as very important
- In particular, parents from private primary schools see safety as highly important
- Teachers were more positive about their school's safety status than parents

Select Phase:

- Parents at the case study school see safety as very important
- Approximately 40% of parents feel the school is unsafe
- Only 50% of teachers and parents see knowledge sharing as effective in the school
- From five key safety processes, those with the biggest management burden are responding to the needs and suggestions of parents, safety compliance, and monitoring school safety on a daily basis

Solve Phase:

- Lean thinking can effectively reengineer the explicit school safety processes
- Lean value stream mapping can improve value added time by an average of 58% across the three most burdensome school safety processes
- Lean tools have reduced the percentage of school expenditure on safety from an average of 4% to an average of 1%

- The AHP decision support system provides a consistent way to manage parental safety suggestions and feeds the other lean reengineering tools such as the value stream mapping, seven wastes and 5S
- The three RPIWs focused on tacit school safety processes.
- The initial RPIW focuses on capturing tacit safety knowledge for improvement and results were in the form of a CEDAC diagram, fishbone analysis and interrelationship digraph.
- The fishbone analysis captured key tacit knowledge regarding factors affecting safety in the school.
- The interrelationship digraph highlighted that parental involvement was the root cause of effective safety in the school, thus corroborating the use of AHP, and lean value stream mapping to improve the way in which parents are involved in school safety.
- The second RPIW focused on knowledge sharing awareness and techniques and the pretest, posttest and long term posttest showed statistically significant improvements in awareness of safety knowledge sharing and how best to accomplish it.
- The third and final RPIW was related to school leadership and raised awareness to empower staff and teachers and begin a shift from a top-down to bottom-up leadership approach. Again, results show statistically significant improvements between the pretest, posttest and long term posttest.
- The lean knowledge management approach in the solve phase shows significant success in improving parental satisfaction and overall school safety management in the school.

Sustain Phase:

- The AHP model showed consistency across a variety of safety suggestions and a number of different users.
- Stakeholder analysis showed that parents, staff, teachers and management were positive about the new approach to school safety.
- Parents were more satisfied and saw improved knowledge sharing and safety communication.
- Management saw fewer burdens, improved efficiency and more consistency related to school safety.
- Staff saw increased efficiency and felt more empowered to be part of school safety.

This chapter has detailed all results from the research and has done so by initially providing an overview of the key results, before using the scope, select, solve and sustain methodology as a way to organize the reporting of the results. The final chapter now brings together the results and discussion to conclude the work.

Generating a Body of Knowledge from the Multi-Criteria Knowledge Management Approach to Lean School Safety

Body of knowledge is a concept and term used to describe the complete set of concepts and related activities within a domain. It is therefore useful to summarise this chapter by identifying and describing the body of knowledge created by this research in terms of how it relates to the multi-criteria knowledge management system for lean school safety. The key domain of this body of knowledge is accident prevention for the students at the case study school. In this sense, the remit of the body of knowledge is bounded by the research objective, which provides a new lean thinking knowledge management approach to school safety. In this research, the body of knowledge is created by combining lean thinking with knowledge management to create a new approach to reducing issues of school safety and where the body of knowledge is continuously improved and expanded as well as being combined with best practice, which can subsequently be shared and therefore continuously improved.

Knowledge management is a philosophy of managing the experiences of knowledge workers, which in this research were the staff and teachers in a school. Managing these workers in the context of the school safety body of knowledge helps to prevent accidents, reduce risk management costs and facilitate stakeholder satisfaction. Staff and teachers' school safety experiences were taken into the body of knowledge via knowledge sharing. This then allowed for analysis and management using KM methods and following the concept of lean thinking. This body of knowledge then allowed creation of a multi-criteria knowledge management system for lean school safety. The research revealed that the body of knowledge in this work is made up of sets of school safety knowledge management, the use of lean thinking applied to school safety processes and the combination of using lean thinking together with knowledge sharing. The body of knowledge highlights the new concept of using lean thinking within knowledge management, especially in terms of enhancing school safety. Lean is traditionally within the domain of industrial sectors, but in this research, the evidence indicates that lean thinking can also be utilised in the education sector. In summary, the key bodies of knowledge

in this research relate to managing school safety with lean, and can be outlined as follows:

- Lean thinking could help in managing school safety by reducing costs, enhancing satisfaction of parents, staff and teachers, and finally, assisting the school administrators.
- Lean thinking could be combined with other knowledge management methods, which could also be applied to school safety, and could become a critical tool for school administrators.
- Knowledge sharing is a key tool in gathering knowledge workers' experiences to help in preventing school accidents. Knowledge workers' experiences represent valuable intellectual capital, which could bring value-added benefits to the organization when captured and utilized with KM.
- The experience of teachers and staff is essential in preventing student accidents, as they have direct experience which can be utilized to handle problems.
- Managing school safety needs cooperation from all stakeholders. Any knowledge or processes implemented should come from the consensus of everyone involved and not from the administrators alone.
- School stakeholders' knowledge is also essential for school safety knowledge management as the different knowledge perspectives could reflect hidden knowledge and add to the best practice of the school.