A Study on Synthesizing PDM and LMS in K-12 Environments

Meagan Hughes

Purdue University

Follow this and additional works at: https://docs.lib.purdue.edu/open_access_theses

Recommended Citation
https://docs.lib.purdue.edu/open_access_theses/1398

This document has been made available through Purdue e-Pubs, a service of the Purdue University Libraries. Please contact epubs@purdue.edu for additional information.
A STUDY ON SYNTHESIZING PDM AND LMS IN K-12 ENVIRONMENTS

by

Meagan Hughes

A Thesis
Submitted to the Faculty of Purdue University
In Partial Fulfillment of the Requirements for the degree of

Master of Science

Department of Computer Graphics Technology
West Lafayette, Indiana
May 2018
THE PURDUE UNIVERSITY GRADUATE SCHOOL
STATEMENT OF COMMITTEE APPROVAL

Dr. Nathan Hartman, Chair
Department of Computer Graphics Technology

Professor Nancy Rasche
Department of Computer Graphics Technology

Dr. Patrick Connolly
Department of Computer Graphics Technology

Approved by:

Dr. Bedrich Benes
Graduate Program Co-Chair

Dr. Colin M. Gray
Graduate Program Co-Chair
To everyone who has gotten me to where I am today
ACKNOWLEDGMENTS

First I would like to thank my advisor, Dr. Nathan Hartman, for the opportunities he has provided me throughout my time at Purdue. His support and guidance has gotten me to where I am today. Without him, this paper would not have been possible.

I would also like to thank my committee members Professor Nancy Rasche and Dr. Patrick Connolly for dedicating their time to be on my committee. I am grateful for the support and feedback they have provided me during the process of writing my thesis.

I am extremely thankful to my family and friends, who provided me with the emotional support that was needed for me to get through grad school. It was a roller coaster journey for me and their encouragement helped more than they know.

And lastly, I would like to thank everyone who helped me in my journey at Purdue.

Boiler Up!
TABLE OF CONTENTS

LIST OF TABLES.................................................................................................................. viii
LIST OF FIGURES .................................................................................................................. ix
GLOSSARY ............................................................................................................................ xi
LIST OF ABBREVIATIONS ..................................................................................................... xii
ABSTRACT ............................................................................................................................. xiii

CHAPTER 1.  INTRODUCTION ................................................................................................. 15
1.1 Statement of Purpose ...................................................................................................... 16
1.2 Research Question ......................................................................................................... 17
1.3 Problem Statement ........................................................................................................ 17
1.4 Scope ............................................................................................................................... 17
1.5 Significance ..................................................................................................................... 18
1.6 Assumptions ................................................................................................................... 19
1.7 Limitations ..................................................................................................................... 19
1.8 Delimitations .................................................................................................................. 20
1.9 Summary ....................................................................................................................... 20

CHAPTER 2.  LITERATURE REVIEW .................................................................................... 22
2.1 Introduction to PLM ...................................................................................................... 22
2.2 PDM ............................................................................................................................... 24
2.3 PLM Industries .............................................................................................................. 27
2.4 Fashion vs Education .................................................................................................... 30
2.5 Document Management in Education ........................................................................... 32
2.6 Popular Learning Management Systems ....................................................................... 33
2.7 PDM & LMS Association ............................................................................................ 35
  2.7.1 Core Function Association .................................................................................... 35
  2.7.2 Workflow Association ......................................................................................... 39
2.8 PLTW ............................................................................................................................. 42
2.9 Summary ....................................................................................................................... 43

CHAPTER 3.  METHODOLOGY ............................................................................................. 45
3.1 Research Framework .................................................................................................... 45
3.2 Sample.......................................................................................................................... 46
3.3 Sample Size..................................................................................................................... 46
3.4 Research Methodology ................................................................................................. 47
3.5 Data Sources & Collection Procedure ......................................................................... 49
3.6 Survey ............................................................................................................................ 49
3.7 Data Analysis .................................................................................................................. 50
3.8 Coding ............................................................................................................................ 51
3.9 Threats to Validity ......................................................................................................... 57
3.10 Test of Validity ............................................................................................................. 57
3.11 Researcher Bias ........................................................................................................... 58
3.12 Pilot Study ..................................................................................................................... 58
3.13 Protection of Human Subjects ..................................................................................... 59
3.14 Summary ....................................................................................................................... 59

CHAPTER 4. FINDINGS ........................................................................................................... 60
4.1 Introduction ..................................................................................................................... 60
4.2 Survey Data .................................................................................................................... 60
4.3 Survey Question Overview ........................................................................................... 61
  4.3.1 Individual School LMS Survey Questions ............................................................... 61
  4.3.2 Courses Survey Questions ..................................................................................... 72
  4.3.3 Document Management Survey Questions ........................................................... 78
4.4 Summary ......................................................................................................................... 85

CHAPTER 5. DISCUSSION AND CONCLUSION .................................................................. 86
5.1 Introduction .................................................................................................................... 86
5.2 Survey Discussion ......................................................................................................... 86
5.3 Sub-Research Questions ............................................................................................... 90
5.4 Results Derived ............................................................................................................. 93
5.5 Final PDM & LMS Association .................................................................................. 95
5.6 Future Work .................................................................................................................. 97
5.7 Conclusion ...................................................................................................................... 99

APPENDIX A. SURVEY ......................................................................................................... 101

APPENDIX B. EMAILS ......................................................................................................... 106
APPENDIX C. RESPONSES TO SURVEY QUESTIONS .............................................. 108
APPENDIX D: MEMOS AND CODING ................................................................. 122
REFERENCES .................................................................................................. 126
LIST OF TABLES

Table 1. Requirements for Product Data. (Stark, 2015). ................................................................. 24
Table 2. PDM Functions and Control Points. (Li, Chen, Yen, and Lin, 2013). ................................. 26
Table 3. Industries using Product Lifecycle Management. (Stark, 2015). ........................................ 28
Table 4. Research Design and Methodology Matrix ........................................................................... 48
Table 5. White Board Key Concepts .................................................................................................. 56
Table 6. Key Concepts from Coding ................................................................................................. 88
Table 7. Likes and Dislikes of Individual LMS and Courses. ............................................................. 89
LIST OF FIGURES

Figure 1. PLM grid. (Stark, 2015). .......................................................... 23
Figure 2. A Functional View of a PDM system. (Li, Chen, Yen, and Lin, 2013). .......... 25
Figure 3. Functionalities of various PLM systems. (Segonds et al, 2014). ................... 29
Figure 4. PLM Systems Diagram. (Zweave, 2017). ........................................... 31
Figure 5. PDM & LMS Core Functions .................................................................. 37
Figure 6. Initial Association between PDM Core Functions and LMS Core Functions .... 39
Figure 7. Example of Process Management and Workflow. (Li, Chen, Yen, and Lin, 2013) .... 40
Figure 8. Interface Tailored for Different Users. (Li, Chen, Yen, and Lin, 2013). .............. 40
Figure 9. Workflow within PDM System. (Mackay, 2014). ....................................... 41
Figure 10. Workflow within LMS. (Wickham, 2015). .............................................. 41
Figure 11. Reproduced Grounded Theory Coding Illustration. (Statistics How To, 2018) .... 52
Figure 12. Axial Coding Process Photo .............................................................. 53
Figure 13. Axial and Selective Coding Process Photo ............................................ 54
Figure 14. Final Phase of Coding of White Board .................................................. 55
Figure 15. Question 2: What is the LMS Used at Your School? ............................... 61
Figure 16. Question 3: What is the Overall Rating of the LMS? ............................... 62
Figure 17. Question 7: How Often Do You Use the LMS? ..................................... 66
Figure 18. Question 8: Do You Use the LMS to Distribute Grades? ......................... 67
Figure 19. Question 9: Do You Feel That Students Are Satisfied with the LMS? .......... 68
Figure 20. Question 10: Do You Have Students Work with a Software Outside of the LMS to Communicate? .......................................................... 69
Figure 21. Question 11: Do You Have Experience with Another LMS? ...................... 70
Figure 22. Question 12: Should Your School Switch to a New LMS? ......................... 72
Figure 23. Question 13: How Satisfied with Courses Are You? .............................. 73
Figure 24. Question 17: How Often Do You Use Courses? ..................................... 76
Figure 25. Question 18: Do You Feel the Students are Satisfied with Courses? .......... 77
Figure 26. Question 19: Do You Use a Software Other than the LMS to Communicate with Students? .............................................................................. 79
Figure 27. Question 20: Which Program Do You Use the Most to Communicate with Students? ................................................................. 80
Figure 28. Question 21: Have You Ever Used Interactive Change with Students? .................. 80
Figure 29. Question 21.2: Would Viewing Students’ Progress On Projects Be Beneficial to You? .................................................................................................. 81
Figure 30. Question 22: Do You Ever Have Difficulty with the Submission/Grading of Different File Formats? .................................................................................................................. 82
Figure 31. Question 23: Do You Re-use Material from the Previous Year? ....................... 83
Figure 32. Question 24: Which of the Following Do You Participant in When Editing Documents? .......................................................................................................................... 84
Figure 33. Final Association between PDM & LMS ............................................................ 95
GLOSSARY

Document management – “the use of a computer system to store, manage, and track electronic documents” (Almarashdeh, 2016)

Learning Management System – “a software application for the administration, documentation, tracking, reporting and delivery of educational courses or training programs” (PLTW, 2017)

Product Data Management – “the business function often within product lifecycle management (PLM) that is responsible for the management and publication of product data. In software engineering, this is known as version control” (Stark, 2015)

Product Lifecycle Management – “the process of managing the entire lifecycle of a product from inception, through engineering design and manufacture, to service and disposal of manufactured products” (Stark, 2015)

Project Lead the Way – “an American not-for-profit organization that develops STEM curricula for use by US elementary, middle, and high schools” (PLTW, 2017)
LIST OF ABBREVIATIONS

BOM – Bill of Material
LMS – Learning Management System
PDM – Product Data Management
PLM – Product Lifecycle Management
PLTW – Project Lead the Way
This thesis concentrates on combining PDM and LMS in K-12 environments. With PLM making a rise in nontraditional environments, there is a need for research in the education area. A directed look at document management in the “Project Lead the Way” classes at high schools across Indiana has been conducted with this study. The survey aims to find the issues that teachers encounter when using the learning management system both with the PLTW curriculum and the one that is currently in place at their individual schools. Using the issues reported from the data obtained from the survey, the possibility of using PDM tools/methods to resolve the issues found was examined.
CHAPTER 1. INTRODUCTION

Product Lifecycle Management (PLM) integrates people, processes, systems, data, and more throughout a company (Stark, 2015). It is the concept of managing a product from the beginning to the end. One of the most important steps to PLM is getting the data organized and under control. Companies can do this by implementing a Product Data Management (PDM) system. There are many benefits that companies can obtain from the implementation of a PDM system into their company. Time is saved, cost is reduced, and the company is more efficient overall (Stark, 2015). Without PLM, it is possible for companies to run into problems due to lack of organization and communication. The manufacturing industry is rapidly integrating PDM systems into their companies, and the benefits are evident.

Due to success in the manufacturing sector, PLM is now evolving into other areas. It is expanding to other industries with evidence of success. This is partly because PLM is a flexible concept, and it can be molded to meet a company’s needs (Stark, 2015). Different PDM models can be integrated to reach peak efficacy with each company’s uniqueness.

It is becoming apparent that PLM can be applied to many nontraditional environments with the rise in technology is every aspect of human life. Education is one of the possibilities that PLM can be applied to. Educational technology is a learning tool that, when integrated correctly, can be very beneficial (Rodi, Kohun, & DeLorenze, 2013). With technology being a huge part of the school system, a lot of data is being transferred across devices. This is where document management is becoming more relevant, and may need to have more effective options. Utilizing a PDM system within a school could be one of these options.

PDM systems have not been explored in the education area. As of right now, most schools are tackling document management with the implementation of a Learning Management System
LMSs are being used to manage data within education. They can be used to distribute assignments, run discussion boards, manage schedules, and help with overall communication. The increase of technology in education has led to the need for a well-organized LMS (Avgeriou, Papasalouros, Retalis, & Skordalakis, 2003).

1.1 Statement of Purpose

Product Lifecycle Management (PLM) is well known in the manufacturing industry, but it is starting to be used in other sectors. PLM is making a rise in different areas such as fashion and department stores (D'Amico, Giustiniano, Nenni, and Pirolo, 2013). Based on recent trends, PLM usage is going to expand and impact other nontraditional environments (Stark, 2015). This paper focuses on a nontraditional environment, one that PLM has no research toward: education. How can the education field take the methods applied to manufacturing and, in turn, help teachers and educators? Overall, can PLM help improve the education system?

The prospect of introducing a PDM system into education could revolutionize document management within the school system. Education is an extremely important part of our society. It is a complex system that is always being modified and improved. The impact that technology has had on education is groundbreaking. With the increased use of technology, there is an abundance of ways to manipulate document management among teachers (Rodi, Kohun, & DeLorenze, 2013). The way in which educators manage their documents needs be analyzed to find the issues they run into on a daily basis. The use of different software can impact how much time a teacher spends on work both in and out of the classroom. With the proper testing and research, this can be the first step in combining PLM with education.
1.2 **Research Question**

Would it be beneficial to combine PDM tools and methods to LMS in K-12 environments?

1.3 **Problem Statement**

There is an abundance of ways to manipulate document management among teachers with the increased use of technology. With the study based around PLTW teachers, an analysis on the issues discovered will help determine whether a PDM system can help with document management in the K-12 school system.

1.4 **Scope**

This research will focus on three sub-research questions in order to address the issues in document management within education:

1. How do PLTW teachers manage, manipulate, and organize files?
2. Can PDM tools/methods address the most common participant issues that were identified throughout the data collection process?
3. Is there a data management system that is best suited for the given environment?

Question one will be addressed by a survey to find out about teacher habits when it comes to document management. The survey will discover how teachers feel about the LMS that the PLTW curriculum uses along with the current LMS system implemented at their individual school. The survey will also look at how teachers manage revisions, update their files, and what software they use most often for daily tasks. The survey will provide information as to whether there is an issue in the way that schools handle document management. The survey will find the issues that teachers are running into with their LMS.
Question two will be answered through a comprehensive review of data management literature. The criteria that is collected from the survey will be compared to the attributes of a PDM system used within the manufacturing industry. Question three asks if there is a data management system that is best suited for the given environment. This will be answered using the knowledge of both the survey results and from what is collected during the review of literature. A data management system that stands out above the others in the results of the survey and literature would help determine this.

1.5 Significance

Education is an extremely important part of our society. It is hard to find a job with a high school diploma; most companies are now requiring a college degree (Rodi, Kohun, & DeLorenze, 2013). This is resulting in more people pursuing higher degrees. With the growing percentages of how many people are getting a higher degree, schools of all levels are growing and expanding at a rapid rate.

This also brings about the fact that technology is rising and developing at an increased rate (Rodi, Kohun, & DeLorenze, 2013). Companies are constantly generating new equipment that is supposed to make our lives easier. While people are using brand new, state-of-the-art technology, certain aspects that need attention are being set aside, such as basic document management (Rodi, Kohun, & DeLorenze, 2013).

Document management within a school classroom can be complicated and tricky. Part of the purpose of this study is to view the ways in which teachers manage, organize, and manipulate their documents. A study done in 2011 was based around faculty perceptions and use of Blackboard at Purdue (Little-Wiles & Naimi, 2011). The conclusion from the study was that while the faculty embraces the use of an LMS, there are many issues that need to be addressed. Results indicated
that faculty thought the LMS was unreliable, the LMS is frustrating and hinders productivity, along with the need for training to use the LMS to the best of its abilities.

With Purdue being a large institution with a high educational standard, the issues that arose in this study are troubling. If these problems are emerging at the university level, what is going on at the secondary level? Most Americans go through the education system, and document management needs to be at the utmost proficiency. Without proper document management, time is lost, money is wasted, and the academic advancements that the world is capable of could be hindered (Rodi, Kohun, & DeLorenze, 2013). By taking a look at what LMSs a majority of schools are using, it can be seen if there is a better way to manage data than what they are currently doing. Is it possible to use a PDM system to solve these problems?

1.6 Assumptions

The following are assumptions that were made during this research. These assumptions were beyond the researcher’s control but may have impacted the study:

- The information gathered from the surveys will be accurate.
- The participants’ cooperation and providing concise, definitive, and honest answers to the best of their abilities.
- At the end of data collection phase there would be an exhaustive list of information that will lead to interesting realizations.

1.7 Limitations

The following are limitations associated with this research. These limitations were beyond the researcher’s control but many have impacted the study:
This research is limited by the problems faced by the learning management systems under study.

This study is limited by the participants’ cooperation and willingness to complete the survey thoroughly, honestly, and to the best of their ability.

This study is limited to the number of responses of participants, as participants will be specially targeted, and the survey will be completely optional.

This research will provide recommendations based on the results of the survey.

Qualtrics Survey Software will be the only tool used to create the survey mechanism.

The research is to be limited to a survey instrument to collect data.

1.8 Delimitations

The following are delimitations associated with this research. These delimitations were beyond the researcher’s control but many have impacted the study:

This research will not provide an alternative learning management system design.

This research will not seek to implement solutions in the learning management systems under study.

This research will not create a new standard for learning management systems.

1.9 Summary

This research will explore the document management methods of teachers. This research intends to analyze the information taken from the study and find the positives and negatives associated with each LMS. Based on the issues identified, different LMSs will be able to be compared. The data collected on LMSs will also be compared to a typical PDM system, to see if the issues identified could be addressed with a PDM philosophy. This research shall not implement
potential solutions, but will identify a feasible option. A thorough literature review was done to establish the legitimacy, significance, and need for the research.
CHAPTER 2. LITERATURE REVIEW

In order to support the research question posed by this thesis, an extensive literature review has been conducted. This review focuses on Product Data Management (PDM) within Product Lifecycle Management (PLM), Learning Management Systems (LMS), and Document Management within the PLTW curriculum. LMS and document management are the areas of concern within education. The literature chosen demonstrates the existence of the problem and the value for solving it. PDM will frame the methodology for studying the problem. These three areas will compose the majority of the literature review. The intent is to demonstrate that there are problems identified within the use of the LMS systems used across the state of Indiana in K-12 environments, and the proper application of PDM tools and methods has the potential to solve them. With the correct application, we will be able to see how a PDM system can benefit a nontraditional PLM environment.

2.1 Introduction to PLM

Product Lifecycle Management (PLM) is the concept of effectively managing a product from the beginning of its development all the way through to its demise (Stark, 2015). In 2015, Stark defined PLM as “the business activity of managing, in the most effective way, a company’s products all the way across their lifecycles; from the very first idea for a product all the way through until it is retired and disposed of” (p.1). It integrates people, processes, systems, and data across enterprises within a company (Lee, Ma, Thimm, & Verstraeten, 2007). Being able to manage a company’s product across the entire lifecycle can lead to many benefits, including cuts in production time, lower expenses, increased profits, and overall better organization (Stark, 2015). McKendry, Whitfield, and Duffy (2015) state “PLM ensures that during the product’s lifecycle,
the information is properly structured and that any design changes are highlighted and effectively communicated, aiding improved decision making, decreased approval time, decreased rework and improved quality” (p. 3). Without PLM application, companies run the risk of being blindsided by problems outside of their visibility. With the proper implementation, PLM allows a company to control a product from beginning to end.

To give an overview of PLM, the following grid, Figure 1, gives an excellent example of all that is included in the lifecycle of a product. Imagine, Define, Realize, Support/Use, and Retire/Dispose are listed here as the five phases within the lifecycle. The vertical axis shows components that need to be managed. The grid helps show the depth of a company and where PLM can help.

Figure 1. PLM grid. (Stark, 2015).
2.2 PDM

In order to integrate PLM into a company, a critical step is to get the data organized and under control. One of the most important concepts of PLM is Product Data Management (PDM). A PDM system is used in PLM to organize data in a single, centralized software system (Stark, 2015). One of the key elements within PLM is to control the data. Without data organization, PLM implementation cannot begin to take effect.

PDM systems, according to Stark (2015), “provide support to the many activities of the lifecycle such as design, signoff, the sharing of data between multiple users, the tracking of engineering change orders, the management of design alternatives, and the control of product configurations” (p. 175). Access right management, vaults, document visualization, check-outs, check-ins, document versioning, states, and workflows are all significant functionalities found within a PDM system (Segonds, Mantelet, Maranzana, & Gaillard, 2014). With a PDM system, data can be accessed whenever, by whoever, and wherever it is needed (Stark, 2015).

Without the proper product data, time will be wasted, and work will need to be redone. Data also needs to be appropriately organized and maintained (Stark, 2015). A PDM system can prevent loss of data and disorganization. To achieve the optimal data management system, the data that is entered into the system must meet certain requirements. The requirements for product data that Stark (2015) has laid out in Table 1 below:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Attribute</th>
</tr>
</thead>
<tbody>
<tr>
<td>under control</td>
<td>reusable</td>
</tr>
<tr>
<td>high quality</td>
<td>lean</td>
</tr>
<tr>
<td>secure</td>
<td>complete</td>
</tr>
<tr>
<td>available when and where needed</td>
<td>accurate</td>
</tr>
<tr>
<td>seen as a strategic company asset</td>
<td>easy to find</td>
</tr>
</tbody>
</table>

Table 1. Requirements for Product Data. (Stark, 2015)
The way that data is transferred through a company can be depicted through a data model. Stark (2015) states, “A data model is a representation, usually a diagram, of the data in a particular environment” (p. 134). A data model is unique to each company depending on their objectives, circumstances, and basic needs. An example of a PDM system data model is shown below:

![Figure 2. A Functional View of a PDM system. (Li, Chen, Yen, and Lin, 2013).](image)

A PDM system has very important roles: to move, store, and control information (Li, Chen, Yen, & Lin, 2013). According to Li, Chen, Yen, & Lin (2013) the basic set of functions for an “ideal” PDM system are:

- An electronic vault of data repository
- A set of user functions
- A set of utility functions

While this list describes the ideal PDM system, in real life the PDM system will vary depending on the company’s needs. According to Stark, “The PDM application will manage all data defining and related to the product across the product lifecycle from initial idea to retirement.
It will provide controlled access to correct versions and configurations. It will enable tracking of product configurations.” (p. 154). In Table 2, Li, Chen, Yen, and Lin (2013) go more in depth in describing the functions and control points of a PDM system.

Table 2. PDM Functions and Control Points. (Li, Chen, Yen, and Lin, 2013).

<table>
<thead>
<tr>
<th>Functional group</th>
<th>Control points</th>
</tr>
</thead>
</table>
| Document management | • Secure data storage  
                      • Access control  
                      • Metadata management  
                      • Product data classification, linkage, and relationship  
                      • Electronic approvals check  
                      • Release management file status history preserve  |
| Engineering change management | • Workflow administration  
                            • Workflow routing control  
                            • Event triggers preserve  
                            • Workflow messaging and notification preserve  
                            • Task or product electronic sign-off check  |
| BOM management | • Product structure and maintenance  
                          • Parts classification, search and access authorizations  |
| Parts management | • Parts creation and maintenance  
                           • Parts classification, search and access authorizations  |
| System management | • User authorization  
                           • Data distribution management  
                           • Archive, backup, and restore management  
                           • External systems interface management  
                           • Third-party application integration  
                           • System security and monitoring  |

Table 2 is listed as a summary below. The PDM system core functionalities can be used for comparison later in the literature review. PDM system core functionalities are:

1. Document management: provide services for the storage and retrieval of product information.

2. Engineering change management: control the associated procedures for handling product data and providing a mechanism to operate the business with information.
3. BOM management: handle bills of material, product configuration, and associated versions and design variations.

4. Parts management: provide information on standard components and to facilitate the re-use of various designs.

5. System management: provide some utility tasks including user authorization management, system security control, data communication and database management.

While these functions are ideal, each company is very different. Functionalities will vary depending on the company’s needs. This is where a PDM system can be applied to other industries besides manufacturing.

2.3 PLM Industries

Before PLM, there was a gap in knowledge between different departments within a company. All departments (marketing, manufacturing, packaging, etc.) made decisions on their own (Stark, 2015). They did not check with each other before ordering a different part or installing a new software. This caused a lot of waste; in time, cost, materials, and other miscellaneous categories. There was no approach to get a product throughout the lifecycle with effective communication (Stark, 2015).

PLM is now the future of manufacturing companies (Stark, 2015). With the success in the manufacturing industry, PLM is now evolving. It is expanding to other areas with evidence of success. PLM is a flexible concept and can be molded to meet a company’s needs. Each business can have a different PDM model that works for their company specifically (Stark, 2015). Recent studies have shown that it is starting to work its way into nontraditional environments. Stark (2015) provides a list of industries that PLM has already affected in Table 3 below:
Table 3. Industries using Product Lifecycle Management. (Stark, 2015).

<table>
<thead>
<tr>
<th>Aerospace</th>
<th>Apparel</th>
<th>Automotive</th>
<th>Beverage</th>
<th>Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumer goods</td>
<td>Construction equipment</td>
<td>Defense</td>
<td>Electrical engineering</td>
<td>Electronics</td>
</tr>
<tr>
<td>Financial services</td>
<td>Food</td>
<td>Furniture</td>
<td>Life sciences</td>
<td>Machine tool</td>
</tr>
<tr>
<td>Machinery</td>
<td>Medical equipment</td>
<td>Mechanical engineering</td>
<td>Petrochemical</td>
<td>Pharmaceutical</td>
</tr>
<tr>
<td>Plastics</td>
<td>Plant engineering</td>
<td>Rubber</td>
<td>Shipbuilding</td>
<td>Shoe</td>
</tr>
<tr>
<td>Software</td>
<td>Transportation</td>
<td>Turbine</td>
<td>Utility</td>
<td>Watch</td>
</tr>
</tbody>
</table>

Before jumping to see how a PDM system can be applied to the education area, looking at one of the areas listed above in detail will help show how PLM is flexible and can be molded to meet different industries’ needs. Observing the research done with one of these areas will show how PLM can benefit a non-manufacturing environment. While there are many interesting areas listed in Table 3, one of the nontraditional areas that is currently making huge growth in PLM application is the fashion industry. PLM is being used as a tool to help create value in the fashion industry system, especially dealing with different approaches to market needs.

D’Amico, Giustiniano, Nenni, and Pirolo (2013) describe how there is a need for understanding the trend in market demand in the fashion world, “effective understanding of the trend in market demand in order to meet different customers’ expectations: the diffusion and the spread of multichannel sales networks affect the firms’ ability to handle heterogeneous buyers’ profiles with a customized offer” (p. 4). They also state that “all the components of a Product Lifecycle Management (PLM) system could help companies to address decisions on quality/price
perception and potential (new) adoptions and grant companies better conditions in terms of efficacy and efficiency of their competitive choices.” (p. 6)

In the fashion industry, PLM can be effective in all the different departments. Information must travel through the designer all the way to shipping. A PDM system helps predict future trends that the item will go through. D'Amico, Giustiniano, Nenni, & Pirolo (2013) state that PLM will help improve “the need to minimize the size of the inventory and the stock at risk, and to improve customers’ buying experience” (p. 3)

Looking further in depth to PLM in the fashion industry, the following graph, Figure 3, shows the functionalities of various PLM systems. This graph helps show how the typical PLM workflow can be adapted to fit a nontraditional environment, along with all the software used within the fashion industry.

Figure 3. Functionalities of various PLM systems. (Segonds et al, 2014).
As seen in the above figure, the fashion industry is very complex and PDM can be implemented to help bring structure to the system. When you look at how an apparel company runs, you can see where all the items start to intermingle. There is a lot to consider, like supply variability, supply variety, service from firm to retailer, and need to reduce the lead time (D'Amico, Giustiniano, Nenni, & Pirolo, 2013). Both cooperation and information sharing is vital in the fashion industry.

The fashion industry is applying PLM to their company in a unique way. They are taking PLM to a new level by blurring the boundaries of what a PDM system can be used for. Now that PLM in the fashion industry has been discussed, it has shown that PLM can be molded to fit the needs of different companies. It is making a huge statement in a nontraditional environment, and can be extremely beneficial when applied correctly. The next section of the literature review will take what has been found in the fashion industry and use it to observe the potential of PLM in another nontraditional environment: education.

2.4 Fashion vs Education

A PDM system can be applied to education in the same way that it is being applied to fashion. Both cooperation and information sharing are vital in both fashion and education. PDM can be implemented to help bring structure to the system. While fashion is still a manufacturing company, it is using a PDM system in a new way. D'Amico, Giustiniano, Nenni, & Pirolo (2013) state “a PLM system makes communication simpler for subjects working inside and outside the production chain and reduces the associated costs” (p. 4). The graphic below gives an example of how PLM solutions can be flexible and applied to a company to meet its needs.
Many fashion companies have teamed up with Adobe to create a connector to allow a PLM and Illustrator integration (Centric Software, 2016). This combination allows brands, retailers, and manufacturers to centralize all important information with a product. The PLM system allows the companies to access information directly through Illustrator (Centric Software, 2016). Ron Watson, VP Product Development of Centric Software stated in an interview: “Our goal is to make designers feel at home by bringing the essential elements of PLM, such as a BOM Builder for creating or modifying Bills of Material, into the familiar Adobe Illustrator workspace; the same workspace as flat and technical sketches, fabrics and colors.”

The Illustrator workspace is very familiar to many designers. Designers can share final sketches and other designs directly with PLM software. This allows for better collaboration with everyone involved (Centric Software, 2016).
With the integration of a PDM system and Illustrator workspace, the realm of possibilities has opened to the education sector. PDM systems have not been explored in education. Right now, most schools have implemented LMSs to their schools to handle document management. Perhaps a PDM system integrated into a popular LMS is the solution to teacher issues.

2.5 Document Management in Education

Technology is a new learning tool that, when integrated correctly, can be very beneficial (Buck, 2012). With new equipment becoming popular (e.g., virtual reality, augmented reality, smartboards) learning experiences can be enhanced and new opportunities can be created. With the increase in educational technology, technology is transforming the learning experience. All levels of education experience it. First graders use iPads with their lessons and middle school students are allowed to take their Microsoft Surfaces home. Public schools all seem to be moving toward 1-to-1 computing, which means the school provides the students with their own piece of technology to take home with them. At the post-secondary education level, college students can take their learning and research to the next level with online classes and all the available technology that their universities offer.

With technology being a huge part of the school system, mass amounts of data are being transferred across devices. Document management is becoming more pertinent, and needs to be paid close attention to. Document management is the use of a computer system to store, manage, and track electronic documents (Almarashdeh, 2016).

With the increase of technology in education, there has also been an increase in the need for Learning Management Systems (LMS). LMSs are being used to manage data within education. Some examples of Learning Management Systems are Blackboard, Moodle, and Canvas. They can be used to distribute assignments, run discussion boards, manage schedules, and communicate
Watson and Watson (2007) state “LMS is the framework that handles all aspects of the learning process” (p. 28). Implementing an LMS can lead to many different advantages including cost, actuality, multimedia elements, interaction, and evaluation (Hamade, 2012).

In 2012, Julian Buck wrote an article about the benefits of document management such as LMS in education:

It is important for educational institutions to put in place an IT infrastructure that can deliver significant cost and time efficiencies with the same number (or fewer) staff. Document management is one such technology that should be on both the Finance Director’s and IT director’s ‘wish list’. It can be rolled-out across all areas, from the management and storage of finance documents through to the electronic storage of student records, and with this technology typically delivering a payback within just six months, it provides a compelling proposition during a time of economic austerity. (p. 48)

Rodi, Kohun, and DeLorenze (2013) praise LMS as it “provides faculty the ability to manage the administrative portion of the course including the housing of PowerPoint presentations, worksheets, homework assignments, quizzes, class notes and additional materials” (p. 439).

2.6 Popular Learning Management Systems

Canvas is one of the most popular LMSs that over 3,000 school systems have in place (“Canvas”, 2016). It was launched in 2011 and created by the company called Infrastructure. Canvas boasts an easy-to-use interface and 24/7 support with the company itself. Canvas has won many Readers’ Choice Awards in 2017, making it one of the most popular LMS systems out there. A study done in 2016 shows that 89% of faculty and 91% of faculty from Virginia Tech had an overall positive experience with Canvas (“Canvas”, 2016). They also gave it highest marks in usability and portability.

Even though Canvas has very high reviews, there are still problems with the highest rated LMS. A recent study done in 2017 by Sanga found that there are many issues that teachers face on a daily basis with Canvas. Broken links, trouble with submissions, and issues with developing
course modules were all highlighted in the study (Sanga, 2017). Sanga goes on to mention that some of these issues can be resolved with proper training on the LMS, yet some are just issues that Canvas needs to address.

The LMS that Purdue University uses is called Blackboard Learn. Blackboard Learn is created by Blackboard, which is a company that provides education technology solutions for K-12, higher education, business, and government (Blackboard, 2018). With over 40,000 undergraduate and graduate students, document management is of the utmost importance.

In 2007, Watson and Watson discovered “The importance of understanding LMS as well as its related technologies lies in the role it will play in future approaches to instruction as the needs of today’s learners are not being met by current approaches” (p. 30).

According to research done in 2012 by Hamade, “Graduate students slightly favored the use of Blackboard for student participation in the discussions and submitting assignments, and for reasons beyond the functionalities of the system, such as for being specially made for teaching and learning, prestigious, and used in most American universities” (p. 598).

In 2011, there were studies done by Little-Wiles and Naimi (2011) at Purdue to see faculty’s opinions on the LMS system. The results of the study showed that most of the faculty use Blackboard at least once a week to help with their classes. The major tools that are being used the most are lecture notes, online quizzes, communication methods, and grades (Little-Wiles & Naimi, 2011). Faculty believe that with students being able to track their progress in their courses and the fact that all learning material is within the LMS, they are likely to do better in the class overall. The results of the surveys also found that students liked the communication tools within Blackboard, but faculty did not find much use for these tools (Little-Wiles & Naimi, 2011).
There were many interesting findings within this research. From the surveys, they gathered that there was hesitation by the faculty members to actually use the LMS (Little-Wiles & Naimi, 2011). Further in-depth research needs to be done to see the cause of the hesitation. Is it the LMS in general that teachers do not like, or are there certain aspects of Blackboard that keep teachers from using the full functions of it?

Another interesting topic that the research brought up was the focus on administrative and policy issues. Further research could be on “technical support, costs, upgradability, permissions and authorizations, and the upkeep of campus technology that could affect the efficacy and use of LMSs in instruction” (Little-Wiles & Naimi, 2011). As shown in previous studies, even the most popular LMSs have issues. Would the implementation of PDM tools/methods help with these issues?

2.7 PDM & LMS Association

Both PDM systems and LMSs deal with handling large amounts of data within a software application, just in different industries. Stark (2015) states “PLM is a digital paradigm. Under the PLM paradigm, products are managed across the lifecycle with digital computers, digital information and digital communication” (p. 17). A LMS is a software application for the documentation, tracking, reporting, delivery, and administration of educational courses or training programs (Avgeriou, Papasalouros, Retalis, & Skordalakis, 2003).

2.7.1 Core Function Association

If we look in depth at LMS core functionalities, we can see that a PDM system can be flexible to meet the needs of an LMS. Functionalities of a LMS can vary depending on the source. The
following functionalities were pulled from multiple sources to obtain the most common and most important core functions.

LMS core functionalities:

1. Managing users, courses, roles, and generating reports: helps uploading courses, assigning roles, and generating various reports. Track and manage the skills and abilities of an organization’s staff and compare them against their goals (Sharma, 2017).

2. Making a course calendar: helps with managing the course activities. Enables LMS users to view the available training programs or courses at one glance (Sharma, 2017).

3. Messaging and notifications: users and trainers can send reminders and notifications, including upcoming training and events (“Learning Management System”, 2017).

4. Assessments that can handle pre/post testing: exams with study guides and review.

5. Certification and display employees’ score and transcripts: helps in maintaining training records of the learners, performance of the individual, and providing certificates to those who have completed training successfully (Sharma, 2017).

6. Instructor-led course management: is time-saving and efficient, since it has a single, centralized tracking system (“Learning Management System”, 2017).

7. Administration: helps facilitating the ways and means of getting enrollment approval, individual and batch registration, verifying prerequisites, etc. (“Learning Management System”, 2017).
8. Competency management/ tracking and reporting: one can track and check the skills set of the team members and compare them against business goals. It provides a wide range of standard and custom summaries and detailed reports, so that the learner may view his average test scores, final test scores, single user report, company log-In record, summary of overall tests taken, etc. (Sharma, 2017).

The figure below extracts the core LMS functions listed above, and also shows the core PDM functions that were discussed in Section 2.2.

<table>
<thead>
<tr>
<th>PDM Core Functions</th>
<th>LMS Core Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Document management</td>
<td>Managing users, courses, roles, and generating reports</td>
</tr>
<tr>
<td>Engineering change management</td>
<td>Making a course calendar</td>
</tr>
<tr>
<td>BOM management</td>
<td>Messaging and notifications</td>
</tr>
<tr>
<td>Parts management</td>
<td>Assessments that can handle pre/post testing</td>
</tr>
<tr>
<td>System management</td>
<td>Certification and display students’ score and transcripts</td>
</tr>
<tr>
<td></td>
<td>Instructor-led course management</td>
</tr>
<tr>
<td></td>
<td>Administration</td>
</tr>
<tr>
<td></td>
<td>Competency management/tracking &amp; reporting</td>
</tr>
</tbody>
</table>

Figure 5. PDM & LMS Core Functions

If the core LMS functionalities are compared against the PDM, similarities between the core functions are evident. By using the definitions listed throughout this chapter for both the PDM Core Functions and the LMS Core Functions, the researcher created initial associations between the two.
The following statements are strictly from the researcher’s point of view and are created based on definitions from literature. If actually implemented, the associations could warrant change. The following statements are the initial associations that the researcher has employed:

- **Document management** includes secure data storage, access control, product data classification and electronic approval checks (Li, Chen, Yen, & Lin, 2013). These are important when dealing with assessments, exams, homework, etc.

- **Engineering change management** deals with workflows, administration, and electronic sign offs. There are many LMS functions that fall under this category such as messaging, management, and approvals.

- **Product structure management** can be found under Bill of Material (BOM) management. A BOM can perform the same function as a home for the students’ scores and transcripts. At the beginning of the year, teachers can create a list of all grades that will be included for the semester and update it accordingly.

- **Parts Management** deals with parts creation and maintenance. By creating a course calendar, a “part” or syllabus/project outline, can constructed and maintained.

- **System Management** includes data distribution, backup of data, user authorization, system security, etc. The LMS core function of Managing users, courses, roles, and generating reports can easily fall into this category.

The chart below has been created by the researcher in order to visualize how the LMS characteristics can be categorized to fit in with those of the PDM system:
The current state of the ideal LMS functions can be molded to meet PDM principles that are put in place in the manufacturing industry. The chart created to show the association between PDM Core Functions and LMS Core Functions helps to visualize this concept.

2.7.2 Workflow Association

Another area that can be compared between LMS and PDM system is workflows. Li, Chen, Yen, & Lin (2013) state “PDM/PLM system not only helps employees in each unit of the enterprise to manage their workflow and supervise the steps of the product development, but also collects, integrates, and keeps track of all product data to ensure it was effectively controlled.” (p. 742).

An example of an overall PLM workflow can be viewed below:
A PDM system has the capability to sort relevant information based on a user’s needs (Li, Chen, Yen, & Lin, 2013). Different data files from different users (admin, teachers, students, etc.) can be entered into the PDM system. Based on the workflow integrated into the PDM system, the data is restricted to who can view what data. With the restriction on who can see certain documents and data, grades can be distributed and viewed along with revisions, interactive change, etc.

Different industries will produce different file types that need to be managed, yet the structure of the way this data is managed is very similar. Both LMS and PDM system data can be traced through a workflow. The management of workflows is an important concept within a PDM system (Stark, 2015). An example of a workflow within a PDM system is shown in Figure 9 below:
Figure 9. Workflow within PDM System. (Mackay, 2014).

An example of how an LMS can be laid out in a workflow is shown in Figure 10 below:

Figure 10. Workflow within LMS. (Wickham, 2015).
Again, the management of workflows is an important concept within a PDM system (Stark, 2015). Many different file types need to be managed throughout both a PDM system and an LMS. A workflow shows the way in which the data is structured. Both LMS and PDM system data can be traced through a workflow. This brief depiction of the workflows that can take place within a PDM system and LMS help show that there is a clear connection between what each industry is trying to achieve: the effective flow of data.

2.8 PLTW

The focus group that has been selected for this study is Project Lead the Way (PLTW). PLTW is a national non-profit organization that engages K-12 students in pre-engineering curriculum (PLTW, 2017). The hands-on STEM program enables students to step into the role of being an engineer at a young age (PLTW, 2017). There are multiple classes in the PLTW curriculum that focus on different skill sets within engineering.

The reason for PLTW being the focus of this study is the fact the students work with a multitude of data files, including CAD files, Word documents, images, videos, coding languages, etc. (PLTW, 2017). This will allow the researcher to view the full spectrum of how teachers manage, organize, and communicate with students when given the different data files.

Math, science, social studies, and other classes that K-12 students go through do not have the multitude of data that is being presented in PLTW classrooms (PLTW, 2017). PLTW is unique to where the subjects are working with more than basic file formats, i.e. Microsoft Office. Talking to teachers that have experience with all the file formats will allow us to see which data is easiest to work with and which is most difficult. The intent is to take the information gathered and be able to generalize it to other subjects.
PLTW teachers also have experience with many different document management systems and can provide useful insight for this study. PLTW used to use an LMS on their own: Canvas. They used this separate for all the individual schools, which resulted in most PLTW teachers using two different LMSs at the same time. In the past year PLTW has switched from using an LMS to a delivery system called Courses.

Theresa Hall (PLTW Director of School Engagement) was able to give some information regarding the PLTW side of the story as to why they decided to change to Courses. From the beginning, PLTW didn’t want to be involved with LMSs, but it did seem to be the most convenient way to get course information to teachers. PLTW began to use Canvas, and they soon realized that schools were using another LMS other than Canvas. Teachers were then using two different LMSs, and it was just one more thing to log into and remember a password to.

PLTW also wanted to be able to really customize assessments, both summative and formative and that wasn’t possible with Canvas. PLTW started using Courses this past year, with the intent that teachers can now link out to Courses. It is also compatible with many LMSs across the country. The information received from Theresa gives an interesting perspective on what Courses is meant for.

2.9 Summary

Based on the information gathered from this literature review, there are many questions raised that need to be asked. Teachers should be asked about the current LMS system put in place, along with what they like and do not like, and if they should use another LMS that is not funded by the school. What are the pros and cons of using their LMS, and do they find it beneficial?
There is also a need to see how PDM methods/tools can be applied to the LMS. This can be achieved through research to see if there is an alternate LMS that is more suitable to the teachers based on their results of the questions that are asked of them.

There can also be research done to see if a PDM system can be used in place of the LMS. Is there a data management system that is secure to send grades? Is there a way to secure grades in a PLM system? According to Stark (2015), “PLM gives transparency about what’s happening over the product lifecycle. It offers managers visibility about what’s really happening with products and with product development, modification and retirement projects.” Is there software that allows students to work and teachers can monitor the progress? The results at the end of the study will be able to benefit the PLTW curriculum and give excellent feedback as to the thoughts of teachers.
CHAPTER 3. METHODOLOGY

This section introduces the research methods that were taken to acquire data for this study. The research framework and methodology will be given, along with the sampling technique that was used. Also, the data collection methods, how the data was analyzed, and any threats to validity will be given.

3.1 Research Framework

This study takes a qualitative approach with the intent to see the viewpoints of teachers when it comes to the current LMS system put into place in PLTW courses along with the LMS used at their school. The study also attempted to find if there is a better alternative to the LMS system using PDM tools/methods. The general outline of the research is as follows:

1. Determine teachers viewpoints on their current LMS.
2. Determine how PDM tools/methods can be applied to an LMS.
3. Determine if there is a data management system that is best suited for the given environment.

The overall goal is to answer the research question: Would it be beneficial to combine PDM tools/methods to LMS in K-12 environments? The first step in building this dataset is by analyzing what teachers think about the LMS that PLTW has put into place and the LMS at their individual school. This study used a survey instrument to gather the information. Based on the information received from the survey, both the positive and the negative sides of the different LMSs are observed. Using the information gathered, the researcher determines how PDM tools/methods can be applied to the LMS system, and if there is a data management system that is best suited for the given environment.
3.2 Sample

The sample is derived from a willing population of PLTW teachers. These teachers all have first-hand experience using their current LMS. The participants’ responses to the surveys are crucial in developing the framework for this study. Therefore, it is vital that these teachers have experience using their LMS.

The reason for PLTW being the focus of this study is the fact that PLTW curriculum works with a multitude of data files, including but not limited to: CAD files, Word documents, images, videos, coding languages, etc. This allows us to see the full spectrum of how teachers and students communicate when given the different data files, something that would not be possible when observing other subjects like math, science, social studies, etc.

The design strategy involves purposeful sampling. A mixed methods approach was taken with both Maximum Variance and Snowball (Chain) Sampling used to gain participants. Teachers were first chosen based on recommendations from information rich resources. The researcher then made sure that the participants selected were coming from different sizes of schools. The study made sure to gather information from small, medium, and large size high schools.

3.3 Sample Size

A survey instrument was used to gather opinions of Project Lead the Way teachers. Throughout research and literature, there are many different opinions on what the proper sample size should be. Patton (2014) states: "There are no rules for sample size in qualitative inquiry. Sample size depends on what you want to know, the purpose of the inquiry, what's at stake, what will be useful, what will have credibility, and what can be done with the available time and resources" (p. 311). Sandelowski (1995) says, “A sample size of 10 may be judged adequate for certain kinds of homogeneous or critical case sampling” (p.179). Ruemler (2016) used a similar
technique to Sandelowski’s by using a sample size of ten. While this number works for some research, Ruemler states that the low sample size was one of the possible reasons for inconclusive results. Aravind (2017) also conducted a similar study to Sandelwoski’s and Rumeler’s. With a minimum sample size of seventeen, Aravind’s research was a success in gathering the appropriate information needed to form conclusions. After reviewing literature, a minimum of fifteen teachers was decided for this research. With the use of open-ended questions, the information collected from a minimum of fifteen teachers would provide the information needed to draw conclusions. Seventeen participants were recorded at the end of the data collection phase.

Lincoln and Guba (1985) recommend sample selection “to the point of redundancy…In purposeful sampling the size of the sample is determined by informational considerations. If the purpose is to maximize information, the sampling is terminated when no new information is forthcoming from new sampled units; thus redundancy is the primary criterion” (p. 202). For this study, seventeen participants completely saturated the data. The minimum sample size was reached and the survey was closed at seventeen participants.

3.4 Research Methodology

A qualitative approach was used in this study to determine if it would be beneficial to apply PDM methods/tools to an LMS. The research methodology aimed to answer the research question: Would it be beneficial to combine PDM tools/methods to LMS in K-12 environments? The overall design and methodology that was put in place can be seen in Table 4. The table was employed by Aravind (2017) to lay out and organize qualitative research.
Table 4. Research Design and Methodology Matrix

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Would it be beneficial to combine PDM tools/methods to LMS in K-12 environments?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goals</td>
<td>Determine if the issues that teachers run into with their LMS can be resolved by the use of PDM tools/methods.</td>
</tr>
<tr>
<td>Data Collection Methods</td>
<td>Survey</td>
</tr>
<tr>
<td>Sampling Technique</td>
<td>Purposeful sampling technique: Snowball (Chain) Sampling Maximum Variance</td>
</tr>
</tbody>
</table>
| Analysis Method   | 1. Frequency Charts/Graphs  
|                   | 2. Memos  
|                   | 3. Coding |
| Possible Outcomes | 1. PDM tools/methods can help resolve the issues that teachers run into with their LMS.  
|                   | 2. PDM tools/methods cannot help resolve the issues that teachers run into with their LMS.  
|                   | 3. It cannot be determined if PDM tools/methods can help resolve the issues that teachers run into with their LMS. |
| Validity Threats  | 1. Interpretive Validity  
|                   | 2. Theoretical Validity |
| Methods to negate Validity Threats | 1. Interpretive  
|                                      | a) Use of open-ended questions to obtain descriptive data  
|                                      | b) Ensure data is grounded during analyzation  
|                                      | 2. Theoretical  
|                                      | a) Researcher bias awareness  
|                                      | b) Thinking reflexively throughout study |

There are many benefits to using tables to design qualitative research (Maxwell, 2012). Aravind (2017) states “The reason for developing the above matrix is to highlight the connection that exists between the research questions and the methods employed in the study”. A survey was used in this study to gather data about the issues that PLTW teachers run into when using different LMSs. Frequency charts/graphs, memos, and coding were all used to analyze the survey data. Detailed descriptions of both the data collection process and the data analysis process are provided in the next sections.
3.5 **Data Sources & Collection Procedure**

The research participation invitation was sent through email to teachers within the PLTW community. The data collection instrument that was employed in the study is the survey. A brief description of the research, a PDF of the online informed consent, the survey link, and an invitation to participate was included in the email. Before the participants were allowed to begin the survey, they were asked to confirm that they had read the informed consent and agreed with its contents. Confidentiality of responses will be maintained. Participation was voluntary, and all participants were able to withdraw from the study at any time.

3.6 **Survey**

To obtain the required information for the research question, a survey was administered to the selected teachers of PLTW. The survey was validated through a pilot study. The survey was administered through Qualtrics. The Qualtrics link was shared through the research invitation emails. The survey included 38 questions total. The survey was comprised both of open-ended questions and multiple choice questions. There were 26 core questions with 12 sub-questions. The sub-questions were not displayed for everyone to answer. The purpose of the sub-questions was to gather more details based on the answer given in the core questions. Most sub-questions had open-ended answers. This helped with the gathering of more detailed information. The full survey can be found in Appendix A.

The survey questions developed for the teachers covered a multitude of topics. Where teachers store files, if they are happy with the current LMS, and if other software is used to communicate with students, are all example questions that will be found on the survey. The survey questions were created based on the research question and the sub-research questions defined in the scope of the study.
The first question that was asked dealt with the online consent form that was sent to them in the invitation email. They must have checked the ‘Agree’ option if they wished to continue on to the survey. If they chose ‘Disagree’ they would be redirected to the end of the survey automatically. By clicking ‘Agree’ they were agreeing with everything stated in the Online Consent form approved by IRB along with approval from their school officials to participate in the study.

No demographic information was collected during the study. With the purposeful sampling method that was selected, all subjects were qualified to take the survey without needing to meet any criteria that would eliminate them from the study.

The open-ended questions of the survey were analyzed through coding and memos. The coding process is described in further depth in Section 3.8. Memos were written up by the researcher during and after the data collection and were a key element in the conclusions of the study.

3.7 Data Analysis

The data collected throughout the surveys was thoroughly analyzed using thematic analysis until the emergent theories became prevalent. Braun and Clarke (2006) state, "Thematic analysis is a method for identifying, analyzing, and reporting patterns (themes) within data" (p. 79). These results determined the next step of the study, which was to address the issues that arose throughout the data collection process.

Frequency charts/graphs, coding, and memos were used to analyze the data. The data collected through Purdue Qualtrics was exported into an excel document, where the information was organized and analyzed. Multiple choice questions were analyzed using frequency charts/graphs. The next chapter presents the charts for visual interpretation.
Open ended questions were analyzed using coding methods. Saldaña (2015) describes coding as “a researcher-generated construct that symbolizes or ‘translates’ data and thus attributes interpreted meaning to each individual datum for later purposes of pattern detection, categorization, assertion or proposition development, theory building, and other analytic processes” (p. 4). Since the research used a grounded theory approach, specific coding methods were selected to support this. Section 3.8 goes into depth with the coding methods used.

After analysis was completed, graphs and charts were created and included for visualization purposes. The issues that are prevalent in the surveys are the main sources for conducting the final conclusions of the research. It will be seen if PDM tools/methods can be used to fix these issues that are in the current LMS system, and if there is a data management system that is best suited for the K-12 learning environment.

3.8 Coding

Open coding, axial coding, and selective coding were used to analyze the data. Using these three types of coding ensured that the data be grounded in theory. The three methods of coding were used together with data collection. Throughout the coding process, constant comparison of the data was imperative to maximize the similarities and differences of information. The figure below illustrates the use of the coding methods:
Throughout the coding and analyzation process, reflexivity was practiced. The researcher remained aware that looking at the data from a certain viewpoint could create a blinder that would invalidate the research. No data was ignored or thrown away along with other steps taken which are stated in Section 3.10.

The first coding method used after data collection was Open (Initial) Coding. Saldaña (2015) defines Initial Coding as “a first cycle, open-ended approach to coding the data with some recommended general guidelines” (p. 115). Each survey was analyzed individually. The open ended questions were looked at specifically. Open coding is a combination of both In Vivo and Process coding (Saldaña, 2015). Using open coding techniques, snippets of words/phrases were taken from the surveys. Memos were also created by the researcher as surveys were analyzed and codes were created. Guba and Lincoln (1994) state: “The aim of the memo writing is, primarily, to uncover the properties of the category” (p. 342). This part of the coding was done on a computer with Microsoft Word.

The second cycle of coding that was employed is Axial Coding. This is where the data is assembled in new ways after the Open Coding Process (Saldona, 2015). After all initial codes were created, they were then formed into basic categories. This step was completed by printing
out all words/phrases and cutting them up into strips. The strips were then placed on colored pieces of paper depending on which category it belonged in. A photo documenting this phase of the process is shown below:

![Axial Coding Process Photo](image)

Figure 12. Axial Coding Process Photo.

The original coding categories were divided into 2 large categories: Teacher Specific Behaviors and LMS Reviews. Each were broken down into 9 and 16 subcategories respectively. As depicted in the picture above, the original codes and memos were all lumped into each category without any sort of organization. The researcher then went back through the codes and memos of each category, and started creating groups within the sub-categories. This is where data was reorganized and split into different categories and subcategories as new information emerged. In this stage of analysis, similarities were synthesized to make room for the new data (Saldaña, 2015).

The codes and categories were then transferred to a white board. A logic diagram was created on the white board that showed which parts correspond with others. Analytical memos continued
to be created throughout this process. The photo below depicts the organization of the codes within the pieces of paper, along with the way in which memos were created throughout this phase of the process.

![Axial and Selective Coding Process Photo](image)

**Figure 13. Axial and Selective Coding Process Photo**

After Axial Coding, Selective (Theoretical) Coding was employed. This is where categories were refined and integrated into a theoretical framework (Saldona, 2015). Saldona states that “a Theoretical Code functions like an umbrella that covers and accounts for all other codes and categories formulated thus far in grounded theory analysis” (p. 250). As the researcher observed the data, it became apparent that two key themes were appearing. After the initial coding papers had been taken off, more memos were created in their places. Two different colored markers were used to divide the two emerging themes. The photo below shows the last step performed on the white board. The sentences written in black indicate the memos and insights from the initial
categories and subcategories. The sentences written in green indicate the memos and insights written after the colored paper were removed.

![Figure 14. Final Phase of Coding of White Board](image)

The key concepts were taken from the above photo and written in the table below for better organization and easier reading. The final concepts included 2 main categories. Category 1: Document Management, had 11 subcategories associated with it. Category 2: LMS Reviews, had 5 subcategories associated with it.
## Table 5. White Board Key Concepts

<table>
<thead>
<tr>
<th>Category 1: Document Management</th>
<th>Category 2: LMS Reviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>There are many different ways to communicate with students in today’s society through technology. While many are used, there are still a few that stand out above the others: google docs, email, and website are top contenders.</td>
<td>Canvas is the LMS that has the most experience from PLTW teachers. It has a lot of positive attributes, but still has negative connotations.</td>
</tr>
<tr>
<td>When asked in open-question format, communication is mostly done through the LMS and email. There are many different file formats that have trouble with submission/grading. Goes from Microsoft Office docs to CAD files. Teachers have found alternative submission methods such as converting to PDF.</td>
<td>Courses is the PLTW delivery system that was just switched to this year. The only positive that came from it is the curriculum accessibility. The negatives included no edit capability, no assignment upload capability, limited downloads, can’t save work, training useless.</td>
</tr>
<tr>
<td>There is no prevalent destination to save files. Teachers do whatever is easiest for them/what they have been taught at some point. Same with saving document destination, no prevalent location to keep documents that are reused each year.</td>
<td>Among all the other LMS mentioned, teachers are looking for cost efficient solutions that are user friendly, have quiz/test capabilities, integration abilities, and customization abilities.</td>
</tr>
<tr>
<td>Based on data collected, teachers must use multiple software/websites/LMS in order to complete what they want accomplished. It is possible to have different software/websites/LMS to distribute assignments, communicate with students, complete assignments, submit work, grade work, and distribute grades.</td>
<td>Students play a role in the success of an LMS.</td>
</tr>
<tr>
<td>Many different software programs are used throughout the school system.</td>
<td>Even if the teacher side of the software is top notch, if the students can’t access it easily or it is not easy for them to figure out, the LMS is then deemed useless.</td>
</tr>
<tr>
<td>Although not many teachers have experience with interactive exchange, it would be beneficial!</td>
<td></td>
</tr>
<tr>
<td>The ability to interface with other software was always a plus listed under the LMS. If all info is located in one software, there is no need to have to interface with other software.</td>
<td></td>
</tr>
<tr>
<td>There are many options in which teachers can choose to communicate with students. If there was a central software that enabled communication along with everything else, all would be more efficient.</td>
<td></td>
</tr>
<tr>
<td>A centralized software that can keep all documents related to course on would be beneficial. Right now documents are saved/stored in all sorts of places.</td>
<td></td>
</tr>
<tr>
<td>The difficulty of submission/grading of different file formats deals with all the different software that is used at a school. It is possible for assignment completion, submission, grading, distributing grades to be different. This leads to teachers not able to grade in-depth and students not getting full feedback.</td>
<td></td>
</tr>
</tbody>
</table>

The coding process resulted in the finding of both a key assertion and a theory grounded in the data. Chapters 4 and 5 discuss this more in depth. More photos documenting the coding process can be found in Appendix D.
3.9 Threats to Validity

The threats to validity for this research are:

- Interpretive validity
- Theoretic validity
- Researcher bias
- Participants provide inaccurate or false information
- Participants not completing the survey completely
- Participants lack experience or knowledge with the current LMS
- Not obtaining enough participants
- Tacit knowledge

3.10 Test of Validity

Many threats to validity were apparent before the research was conducted. Ensuring that these threats did not affect the study was crucial. Patton (2001) states: “The validity, meaningfulness, and insights generated from qualitative theory have more to do with the information richness of the cases selected and the observational/analytical capabilities of the researcher than with sample size” (p. 245).

There were two major threats to validity that were identified in this study. The first major threat to validity in this research is interpretation. This is the threat of imposing one’s own meaning on the data, instead of understanding what the individuals intend the data to mean (Saldaña, 2015). In order to achieve interpretation validity, open-ended questions allowed the participants to give descriptive answers, thus reducing confusion when analyzing data. Maxwell (1992) states that
when interpreting data, it should be “grounded in the language of the people studied and rely as much as possible on their own words and concepts.” (p. 289)

The other major threat to validity in this research is theoretical. This is when the researcher has a specific viewpoint that they think the data will support (Maxwell, 1992). In order to avoid compromising theoretical validity, the researcher needs to ensure they do not ignore data or force data to match the theory that they believe (Saldaña, 2015). Researcher bias was taken into consideration beforehand and throughout the research process. Section 3.11 offers a statement from the researcher and was regarded throughout the data analyzation process. This, along with reflexive thinking, was how theoretical validity was ensured during this study.

3.11 Researcher Bias

With my experience in education, there are problems when it comes to the use of learning management systems in schools. Also, with my background working with PLM, the two can be combined in some way to make document management in the education sector more efficient.

3.12 Pilot Study

To ensure the validity of the survey instrument, a pilot study was conducted. The survey was first distributed to two professors at Purdue to achieve face validity. After the feedback from the professors had been integrated, the survey was distributed to five experts/teachers to complete and confirm the resourcefulness of the questions. According to Connelly (2008), literature suggests that a pilot study sample should be 10% of the sample projected for the larger parent study. The survey instrument was distributed one at a time. All feedback was taken into consideration. Those who participated in the pilot study were not asked to participate in the final study.
The survey was also validated by asking the same question twice, in two different ways, spaced apart in the survey. If the answers matched up, the survey was considered valid. If the answers did not match up, the survey was discarded.

3.13 Protection of Human Subjects

Institutional Review Board (IRB) approval was obtained through Purdue University’s Human Research Protection Program. This ensured that all research was conducted ethically. An online consent form was included in the invitation email. Before beginning the survey, participants had to agree to the statement of reading through the consent form. If they selected “Disagree”, they were redirected to the end of the survey and were not able to participate in the research.

3.14 Summary

This section provided the information that the researcher followed in order to answer the research question that was introduced in Chapter 1. The population and sample includes teachers involved with the PLTW curriculum. With the data that was collected from the surveys, the information was analyzed and summarized. Threats to validity were also given. The outcomes of this research are discussed in Chapter 4.
CHAPTER 4. FINDINGS

4.1 Introduction

This chapter presents the findings that were collected during the data collection phase of the study. The survey data that was gathered, synthesized, and analyzed is discussed in the following sections. The resulting data helped to develop insights in order to answer the research question. Along with the data collected, graphs and charts are incorporated to illustrate the resulting information.

4.2 Survey Data

Qualtrics was used to collect the survey data. A survey link was sent to all participants through email. The email included an informed consent along with information about the research. The email that was used to invite subjects to participate in the research is located in Appendix B. The survey link was active for two weeks, during which a reminder email was sent out.

The data collection phase was over once the survey was closed. Overall, 40 respondents were sent out. 19 surveys were returned which results in a 47.5% response rate. The surveys were briefly analyzed within Qualtrics for validation. 2 surveys were excluded for being partially completed. The reason for exclusion was that most of the responses were left unanswered and they provided inadequate information that was not beneficial toward the goals of this research. The remaining 17 surveys were exported out of Qualtrics. The data from these 17 surveys was used to perform analysis and come to conclusions on the findings of this research.
4.3 Survey Question Overview

The survey questions were broken up into three main categories: Individual School LMS Questions, Courses Questions, and Document Management Survey Questions.

4.3.1 Individual School LMS Survey Questions

The first question that was asked was about whether the participant had read the informed consent. If ‘Agree’ was chosen, the participant was taken to Question 2. If ‘Disagree’ was chose, the participant was directed to the end of the survey. If this happened the survey was discarded as no information was collected.

The second question was to find out which LMS is used at the participant’s school (not in the PLTW courses). The results showed that a majority of schools use Canvas. 10/17 schools, or 58.8%, utilize Canvas over the multitude of options there are. Google Classroom was the other LMS that is used by multiple schools. 3/17 schools, or 13.7%, use Google Classroom. Synergy, Schoology, Moodle, and itsLearning were all mentioned once.

![Figure 15. Question 2: What is the LMS Used at Your School?](image-url)
Question 3 asked about the overall rating of the LMS that is used in the individual schools. Nine of the participants stated that they were only somewhat satisfied with their school’s LMS. With this being the majority response, this indicates that there is room for improvement with the individual LMSs. There was one teacher that was somewhat dissatisfied with their LMS and one teacher that stated he/she was neither satisfied nor dissatisfied. No one was extremely dissatisfied. Only six out of the seventeen teachers were extremely satisfied with their school’s LMS. This indicates that 64.7% of teachers are not completely satisfied with their LMS. A majority of teachers feel that there is room for improvement when it comes to their LMS. Canvas was the only LMS to be rated as “Extremely Satisfied”.

![What is the overall rating of the LMS?](chart.png)

**Figure 16. Question 3: What is the Overall Rating of the LMS?**

The next question is a sub-question of Question 3. The question displayed after Question 3 was different to each participant depending on what they had selected previously. For example, if the participant selected ‘Extremely satisfied’, the next question would be: You said you were extremely satisfied with the LMS, please explain your response. The purpose of this question was
to get further information as to why the participant selected the response that they did on question three. This gave great insight into what the participant’s initial response to their LMS was, without directing them with a more specific question. A text box was provided for their response in order to collect the descriptive data.

Question 3.1 was the first in a series of questions that provided the pluses and minuses of the LMS at the individual schools. Question 3.1, along with questions 4, 5, and 6, were all categorized similarly in the coding process. The feedback from these questions helped determine what teachers do and do not like with their current LMS.

All answers from this question can be found in Appendix C. Some quotes that highlight a majority of positive responses from Question 3.1 include:

- “Very versatile in function. Allows instructor to create, monitor, and assess student performance in several ways.”
- “It has great capability and flexibility in use.”
- “Canvas provides many great features to help teachers with assessment and manage curriculum to instruct students. The ability to use many external Internet-based tools is a huge aspect of our 1:1 computing environment at our school”
- “I feel that having Canvas has helped provide organization and better teaching through 21st Century teaching practices.”

Some quotes that highlight a majority of negative responses from Question 3.1 include:

- “I feel that there should be more user friendly options and overall”
- “We previously used My Big Campus, and I felt the user interface and student experience was better.”
• “Overall satisfied with Google classroom, would like to see some additional features and controls with it.”

• “I have previously used Canvas, I prefer that platform.”

• “I do not use the LMS system much in my classes. I use it for a starting point and link out of it to Google resources.”

Question 4 was also open ended response with a text box for the participant to type in. The question asked what the teachers liked about their LMS. All answers from this question can be found in Appendix C. The following quotes highlight the results:

• “Strong analytical tools, wide array of question types for assessments. Good mobile app.”

• “Easy to navigate, pretty easy to structure.”

• “Being able to do most tasks through it rather than having to quiz separately”

• “I really enjoy the ability to customize pages and develop a unique curriculum that is engaging to students and promotes learning.”

Question 5 was set up the same way as Question 4. Instead of asking about the likes of the LMS, the dislikes were examined. All answers from this question can be found in Appendix C. The highlights include:

• “Not user friendly as it should be.”

• “The user interface is not good and the learning curve for people who are not tech wizards is rough. It does not integrate with our student management system (Harmony) so we cannot have the grades from itsLearning go directly into Harmony. This therefore requires a good deal of manual data entry.”

• “The fact that it is unorganized and difficult to find materials.”

• “A secondary software (Flubaroo) is needed for grading.”
• “Limited functions. Not able to submit and grade assignments. We now have to use Google Classroom”

• “Need easier ability to transfer grades from one platform to another.”

• “It is more steps to take than a simple share with Google docs.”

Question 6 was the last question that requested open ended answers when it comes to the LMS that is used at the individual’s school. The teachers were asked what they would like to see added or changed. All answers from this question can be found in Appendix C. The following quotes highlight the majority of answers:

• “Better file management.”

• “Better user interface, early learner platform, and integration with Harmony.”

• “If it had a survey feature, that would really make a difference. To survey, you have to go out and use another vendor. Having that integrated so that data could be collected and used, would be great.”

• “An option for students to save work on LMS and submit”

• “Automatic grading transfer to Skyward.”

• “I would prefer not to use it.”

Among all the LMS mentioned, teachers are looking for cost efficient solutions that are user-friendly, have quiz/test capabilities, integration abilities, and customization abilities. Students play a role in the success of an LMS. Even if the teacher side of the software is top notch, if the students can’t access it easily or it is not easy for them to figure out, the LMS is then deemed useless.

Question 7 aim was to see how often a teacher uses their school’s LMS. Zero participants responded with ‘Never’. 12/17 participants responded with Daily or Constantly. The LMS is an important tool that is used at least daily with 70.6% of the teachers.
Figure 17. Question 7: How Often Do You Use the LMS?

Question 8 was a simple ‘Yes’ or ‘No’ question: Do you use the LMS to distribute grades? The goal of this question was to find out whether the LMS was used for multiple tasks or if the teachers had to utilize a separate software in order to get grades to their students. While questions 3-6 gave us insight to this problem without probing, Question 8 backs the data that was discovered in the open ended answers. 53% of the teachers answered ‘No’. Over half of the teachers stated that they must use a separate software to distribute grades.
The next question was a sub question of Question 8. If the teacher answered ‘Yes’ to Question 8, they automatically skipped ahead to Question 9. If the teacher answered ‘No’ to Question 8, they were asked a sub question: What software do you use?

The answer had a low response rate, with only 3 teachers answering with grade distributing software. Two teachers responded with Skyward and one teacher responded with PowerSchool. The reason for a low response rate dealt with confusion to the question. Most teachers answered this question with what software is used in their classroom by the students instead of what software is used to distribute grades. The question was asked more for curiosity on the researcher’s side than gathering vital data, so no harm was done with the unclear question.

Question 9 provided the participants with a sliding bar to rate what they felt their students’ satisfaction with the LMS was. Zero was listed as the lowest rating and 10 as the highest. The graph below shows the answers of each individual. The numbers along the left hand side portray...
the rating that was selected and the numbers along the bottom show how many participants selected that number. 16 teachers responded.

![Bar Chart](image)

**Figure 19. Question 9: Do You Feel That Students Are Satisfied with the LMS?**

The next question is a sub question of Question 9. If the participant responded with anything less than a 10 (which is deemed extremely satisfied) the following question would be asked: You stated that the students are not extremely satisfied with the LMS, please explain your response. If the participant responded with a 10 (extremely satisfied) they would be automatically directed to Question 10. A text box response was used for Question 9.1. The purpose of this question was to get descriptive information as to why the students were not completely satisfied with the LMS. The students’ perspective of an LMS can be important when it comes to the success of an LMS. All answers from this question can be found in Appendix C. The highlights of a majority of the answers include:

- “They do not know how to use all the different functions that different teachers use.”
• “Too busy and cluttered. Not user friendly on the student side.”
• “I think they use it because they have to. If they had a choice, they might use something else.”
• “Can't save work. One more thing for them to remember, login/password”
• “Some love it and some do not. Part of it is each teacher uses it differently.”

Question 10 asked if the teachers have students work with a software outside of the LMS to communicate. This was the question that dealt with validity of the survey. The same question is asked later in a different way with sub questions to find out more about the ways in which teachers and students communicate. The results of Question 10 revealed that 76% of teachers and students use a software outside of the LMS to communicate. The results of this question will be discussed in greater depth later.

Figure 20. Question 10: Do You Have Students Work with a Software Outside of the LMS to Communicate?

Question 11 is looking to find the experience that teachers have with an LMS outside of the one that is being used at their school currently. The question, do you have experience with another
LMS, revealed 82% of teachers having experience with multiple LMSs. This helps with getting more detailed information on what a teacher looks for in an LMS.

![Pie chart showing percentage of teachers with experience with another LMS](image)

**Figure 21. Question 11: Do You Have Experience with Another LMS?**

The next two questions are sub questions of Question 11. If the participant responded with ‘Yes’, they have had experience with another LMS, they were directed to Question 11.1. If the participant responded with No, they were directed to Question 12. Question 11.1 asked which LMS did they have experience with. A text box was provided in which to put the answer so that participants had freedom to write as much as they wanted.

Moodle, Blackboard, Google Classroom, My Big Campus, and Canvas were all listed, some multiple times. All answers from this question are listed in Appendix C. Question 11.2 was displayed next. The question asked about their opinions on the LMS(s) that they answered in the previous question. All answers from this question can be found in Appendix C also.

The teachers were given complete freedom with how they answered, and it was interesting to see that cost was a factor multiple times:
• “Backboard is the best on the market, but very expensive.”

• “Canvas is an industry leader, but it was expensive and had some of the same learning curve issues”

A majority of the answers revealed mixed reviews on the LMSs:

• “I like it but the options are limited.”

• “All have pluses and minuses.”

• “It's very easy to use but limited in it's capabilities.”

• “The Canvas Speedgrader is so much more efficient and saves so much more time for teachers to grade.”

While most answers were mixed reviews, there were many participants that did not like the other LMS options at all. The highlights include:

• “Very horrible product and would rather never use it again.”

• “Avoid it whenever possible.”

During the coding process, Questions 11.1 and 11.2 ended up being categorized alongside Questions 3-6. All these questions dealt with different LMSs and their pros and cons. With the data obtained from these questions, what teachers are looking for in an LMS is identified.

Question 12 asked if the school should switch to a new LMS, in the teacher’s opinion. 71% state No, they do not think the school should switch to new LMS. 23% stated that they have No Opinion on the matter, and 6% stated Yes. A majority of teachers stated that they do not think the school should switch to a new LMS.
The next question was a sub question of Question 12. If the participants answered ‘Yes’ to Question 12, they were directed to Question 12.1. If the participants answered ‘No’ or ‘No Opinion’, they were directed to Question 13. Only 1 participant stated that he/she thought their school should switch to a new LMS. Question 12.1 asked if they had an LMS in mind. The participant responded with “Google”.

4.3.2 Courses Survey Questions

Question 13 begins a series of questions that deal with Courses, the current delivery system that is used in the PLTW classes. The questions in this section are very similar to the previous section. The first question of this section is: how satisfied with the current delivery system (Courses) that is used in PLTW classes are you? One teacher responded with ‘Extremely satisfied’. 4/17 teachers responded ‘Somewhat satisfied’. One teacher selected ‘Neither satisfied nor dissatisfied’. 6/17 responded ‘Somewhat dissatisfied’ and 5/17 replied ‘Extremely dissatisfied’. 94.1% of the
teachers are not completely satisfied with Courses, with 64.7% of teachers ranking Courses somewhere in the dissatisfied range.

Figure 23. Question 13: How Satisfied with Courses Are You?

The next question is a sub-question of Question 13. The question displayed after Question 13 was different to each participant depending on what they had selected previously. For example, if they participant selected ‘Extremely satisfied’, the next question would be: You said you were extremely satisfied with Courses, please explain your response. The purpose of this question was to get further information as to why the participant selected the response that they did on Question 13. This gave great insight into what the participant’s initial response to Courses was, without directing them with a more specific question. A text box was provided for their response in order to collect the descriptive data.

Question 13.1 was the first in a series of questions that provided the pluses and minuses of Courses. Question 13.1, along with questions 14, 15, and 16, were all categorized similarly in the
coding process. The feedback from these questions helped determine what teachers do and do not like with Courses.

All answers from this question can be found in Appendix C. Some quotes that highlight a majority of positive responses from Question 13.1 include:

- “It is doing what it is designed to do, which is to provide curriculum content to a diverse group of districts and learners that do not use the same LMS.”
- "As simply a delivery tool it does the job. I can point a student there and they can get everything they need. Since I use Google the delivery works for me."

Some quotes that highlight a majority of negative responses from Question 13.1 include:

- “I feel that the process is very archaic and lacks features of very useful tools.”
- “It seems like you have to sift through a bunch of things you don’t need to find what you are looking for.”
- “Compared to the version from the past couple of years the new system is NOT user friendly, very frustrating for student and instructor.”
- “I really feel as though Courses has taken away a lot of tools that were once available for PLTW teachers.”
- “I liked being able to tweak the documents to fit my needs and situations.”

Question 14 was also open ended response with a text box for the participant to type in. The question asked what the teachers liked about Courses. All answers from this question can be found in Appendix C. The following quotes highlight the results:

- “Easy to Navigate”
- “Love the built in powerpoints!”
- “The fact that it has our curriculum.”
• "Navigation bar on the left."

• "not much"

• "Courses provides a simpler interface and curriculum delivery tool for teachers that aren't technology savvy, but it does take away from teachers who like to use the LMS but may not be able to work in a 1:1 environment."

Question 15 was set up the same way as Question 14. Instead of asking about the likes of Courses, the dislikes were examined. All answers from this question can be found in Appendix C. The highlights include:

• "NOT user friendly."

• "It is very basic and difficult to import into Canvas and have students complete work digitally."

• "PLTW is really good at putting in pointless information and grammar errors and can't change these through the new platform"

• "I can not edit items."

Question 16 was the last question that requested open ended answers when it comes to Courses. The teachers were asked what they would like to see added or changed. All answers from this question can be found in Appendix C. The following quotes highlight the majority of answers:

• "Quiz functionality."

• "More teacher functionality and user customization."

• "Students should be able to submit assignments on the site without leaving and submitting on Canvas for grading."
• “I would like for it to be more functional where students can submit work, download Word instructions for use offline (high poverty school = kids without home internet to complete activities).”
• “Google Suite compatible.”

Giving teachers the option of open-ended questions let them vent about what they did not like about the program. The only positive that came from it is the curriculum accessibility. The negatives included no edit capability, no assignment upload capability, limited downloads, can’t save work, training useless.

Question 17’s aim was to see how often a teacher uses Courses. 10/17 participants stated that they use Courses ‘Two to three days a week’ or less. Only 41.2% of teachers use Courses ‘Daily’ or ‘Constantly’.

Figure 24. Question 17: How Often Do You Use Courses?

Question 18 provided the participants with a sliding bar to rate what they felt their students’ satisfaction with Courses was. Zero was listed as the lowest rating and 10 as the highest. The graph
below shows the answers of each individual. The numbers along the left hand side portray the rating that was selected and the numbers along the bottom show how many participants selected that number. 14 teachers responded.

![Bar Chart: Do you feel the students are satisfied with Courses?](image)

**Figure 25. Question 18: Do You Feel the Students are Satisfied with Courses?**

The next question is a sub question of Question 18. If the participant responded with anything less than a 10 (which is deemed extremely satisfied) the following question would be asked: You stated that the students are not extremely satisfied with the LMS, please explain your response. If the participant responded with a 10 (extremely satisfied) they would be automatically directed to Question 19. A text box response was used for Question 18.1. The purpose of this question was to get descriptive information as to why the students were not completely satisfied with Courses. All answers from this question can be found in Appendix C. The highlights of majority answers include:

- “The students use itsLearning, the school LMS, and have not been introduced to Courses.”
- “NOT user friendly.”
- "My students do not use the PLTW platform, only Canvas”
- “We do not particularly use this LMS, because I find using Canvas is much better than trying to use different LMS's for my classes”
- “It would be simpler for them if it lined up with the Google stuff better.”

4.3.3 Document Management Survey Questions

The third part of the survey’s goal is to ask document management questions that will help answer the research question. The questions are meant to gather data about communication, document management, and storage of files.

Question 19 asks if there is another software other than the LMS incorporated in the school to communicate with students in use. Teachers were given choices and were able to select as many options as they wanted. They were also give an ‘Other’ option, followed by a textbox. They could type in an answer if it was not in the given list. Many different options were given and are listed in the chart below. The two that stood out the most however, were Google Docs and email. Both received 13/17 participants.
Figure 26. Question 19: Do You Use a Software Other than the LMS to Communicate with Students?

Question 20 was an open-ended question. The question asked teachers which program they used to communicate most with students. While this question is similar to Question 19, the use of an open ended response allows the researcher to see which program is most important to the teacher. The answers revealed many different results. This shows that there are many different ways to communicate, and most do not use the LMS for this reason.
Question 20 asked which program teachers use the most to communicate with students. The bar chart shows the distribution of responses:

- Schoology - message: 3
- Google Classroom: 4
- Google Drive: 3
- Remind.com: 2
- Skyward: 1
- E-mail: 4
- Outlook: 1
- Canvas discuss board: 3

Figure 27. Question 20: Which Program Do You Use the Most to Communicate with Students?

Question 21 asked if the teachers have ever used interactive change with students. 100% of participants replied with no.

Figure 28. Question 21: Have You Ever Used Interactive Change with Students?
Question 21.1 was a sub question to Question 21. If the participants responded with ‘Yes’, they would be directed to the following question: Do you find interactive change beneficial to view students' progress on projects? Since no participants answered ‘Yes’, this question was not used. Question 21.2 was also a sub question to Question 21. If the participants responded with ‘No’, they would be directed to the following question: Would viewing students' progress on projects be beneficial to you? 75% of participants responded with ‘Yes’, and only 25% with ‘No’. The graph below shows the distributions. The researcher asked this question to see how often interactive change was used in schools today. As it turns out, it is not used at all.

![Pie chart showing the distribution of responses to Question 21.2](image)

Figure 29. Question 21.2: Would Viewing Students’ Progress On Projects Be Beneficial to You?

Question 22 asked if teachers ever have difficulty with the submission/grading of different file formats. 62% of teachers responded with ‘Yes’ and 38% responded with ‘No’. Over half of the teachers in PLTW classes have trouble with the submission/grading of different file formats.
Figure 30. Question 22: Do You Ever Have Difficulty with the Submission/Grading of Different File Formats?

Question 22.1 is a sub question of Question 22. If they participant answered ‘No’ to Question 22, they were directed to Question 23. If the participant responded ‘Yes’ to Question 22, they were directed to Question 22.1. Question 22.1 asked about which file types specifically the teachers had trouble grading/submitting. There were many different answers, the highlights are included below:

- “Any Microsoft extension being graded using Canvas, which opens as a Google Doc, etc.”
- “Revit and Inventor files I have graded as submitted pdfs. It is typically easier to annotate hard copies”
- “I try to limit submissions to PDF format to avoid issues.”
- “Autodesk file”

Question 23 asked teachers if they re-use material from the previous year. The response was 100% ‘Yes’.
The next two questions are sub questions of Question 23. If the response to Question 23 was ‘Yes’, they were directed to Question 23.1: Where is it stored? A text box was provided for the response. Many different answers were given, which shows that there is no prevalent place to store documents. The highlights include:

- “Many are stored on the cloud.”
- “Google drive”
- “Canvas”
- “Online”
- “A number of places, primarily on dropbox.”
- “On my teacher drive at school.”
- “On a school home drive and on a stand alone PLTW dedicated laptop.”
If the response to Question 23 was ‘No’, they would be directed to Question 23.2: Would you re-use material if there was a place designated to keep it? Since none of the respondents answered ‘No’, this question was not used.

Question 24 asked: When editing documents, which of the following do you participate in? There were multiple choices given and participants could choose as many options as they wanted. All three choices were used multiple times, however ‘Save files directly to cloud’ was chosen the most with 11 respondents. The figure below shows the distributions.

![Bar chart showing the distribution of choices for Question 24](image)

**Figure 32. Question 24: Which of the Following Do You Participate in When Editing Documents?**

Question 25 asked if there were any other comments they would like the researcher to know. The answers were included in the coding, but no significant answers were given. All answers from Question 25 can be found in Appendix C.

The survey was completed with Question 26, asking if anyone would be willing to participate in a 10 minute phone interview. If ‘Yes’ was selected, the participant would be directed
to enter their email address in order to be contacted later. If ‘No’ was selected, they would be directed to the end of the survey. The goal of the phone interview was to gather more data if needed. The data obtained from the survey provided the researcher with plenty of data, so the phone interview was not needed.

4.4 Summary

This chapter presented the data that was collected and analyzed for this research. First the survey data was introduced and a brief reminder of the coding methods followed were reviewed. The survey responses were analyzed and displayed. Tables and charts were included for visual support. Quotes were included with the open-ended questions to help highlight the results found during the coding process. The next chapter uses these findings for discussion and conclusion.
CHAPTER 5. DISCUSSION AND CONCLUSION

5.1 Introduction

This chapter utilizes the findings presented in the previous chapter. The survey responses are discussed and summarized. Insights from the researcher are given along with suggestions as to what the best solution based on data collected is. The data that was analyzed in this research is used to build conclusions. Future work is also presented.

5.2 Survey Discussion

The survey had a total of 17 respondents that represented the PLTW teacher community. The minimum number of participants was met for a successful qualitative study. All 17 of the respondents completed the survey in full; however, some participants did not answer all of the open-ended questions presented. If all questions had been answered, it would have given an opportunity for the researcher to collect unique insights. However, with the information that was collected, data was completely saturated and patterns were evident. By closely observing the data and following the steps provided through literature, a theory emerged that is completely grounded, along with a key assertion. These will be discussed in Section 5.4.

The information collected clearly lays out problems that teachers run into while trying to use technology in a school system. The purpose of this phase of the research was to find out if there were issues or not, and data was collected from the surveys to satisfy that answer.

The following statistics are the highlights of the data from the multiple choice questions of the survey. These items are important because they sum up important statistics that were collected
from the multiple choice questions. These bullet points were included in the coding analysis process along with the open ended answers:

- 10/17 schools, or 58.8%, utilize Canvas over the multitude of options there are.
- 64.7% of teachers are not completely satisfied with their LMS.
- The LMS is an important tool that is used at least daily with 70.6% of the teachers.
- Over half of the teachers stated that they must use a separate software to distribute grades.
- 76% of teachers and students use a software outside of the LMS to communicate.
- A majority of teachers stated that they do not think the school should switch to a new LMS.
- 94.1% of the teachers are not completely satisfied with Courses.
- 10/17 participants stated that they use Courses ‘Two to three days a week’ or less.
- Email most used for communication with Google Docs and Canvas listed next.
- Interactive change is never used by teachers. 75% report it would be beneficial.
- Over half of the teachers in PLTW classes have trouble with the submission/grading of different file formats: CAD files, Microsoft Office, Mac to Windows translation.
- All teachers re-use material from the previous year.

By obtaining the above data and including them with the coding methods employed, the mixed methods approach of both open and close ended questions helped with validation of the results. The following table was listed Section 3.8 when the coding methods were being discussed. These were the key concepts that were taken from the white board in the final steps of the analysis process. These concepts are important as they shape the conclusions that were derived. The statistic information that was obtained from the multiple choice answers was also included in the coding process so that no information was left out.
There are many different ways to communicate with students in today’s society through technology. While many are used, there are still a few that stand out above the others: google docs, email, and website are top contenders.

When asked in open-question format, communication is mostly done through the LMS and email. There are many different file formats that have trouble with submission/grading. Goes from Microsoft Office docs to CAD files. Teachers have found alternative submission methods such as converting to PDF.

Courses is the PLTW delivery system that was just switched to this year. The only positive that came from it is the curriculum accessibility. The negatives included no edit capability, no assignment upload capability, limited downloads, can’t save work, training useless.

There is no prevalent destination to save files. Teachers do whatever is easiest for them/what they have been taught at some point. Same with saving document destination, no prevalent location to keep documents that are reused each year.

Students play a role in the success of an LMS. Many different software programs are used throughout the school system.

Although not many teachers have experience with interactive exchange, it would be beneficial!

The ability to interface with other software was always a plus listed under the LMS. If all info is located in one software, there is no need to have to interface with other software.

There are many options in which teachers can choose to communicate with students. If there was a central software that enabled communication along with everything else, all would be more efficient.

A centralized software that can keep all documents related to course on would be beneficial. Right now documents are saved/stored in all sorts of places.

The difficulty of submission/grading of different file formats deals with all the different software that is used at a school. It is possible for assignment completion, submission, grading, distributing grades to be different. This leads to teachers not able to grade in-depth and students not getting full feedback.

The key concepts are divided into two categories: Document Management and LMS Reviews. The key concepts from the Document Management section came from 8 subcategories. The subcategories included:
The key concepts from the LMS Reviews section came from 6 subcategories. The table below highlights the positives and negatives from the individual school LMS, Courses, and the student satisfaction comments.

Table 7. Likes and Dislikes of Individual LMS and Courses.

<table>
<thead>
<tr>
<th>Individual School LMS Positives</th>
<th>Individual School LMS Negatives</th>
<th>Individual School LMS Student Satisfaction</th>
<th>Courses Positives</th>
<th>Courses Negatives</th>
<th>Courses Student Satisfaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface with other software</td>
<td>Not user friendly</td>
<td>Not user friendly</td>
<td>Curriculum Accessibility</td>
<td>No Edit Capability</td>
<td>Confusing</td>
</tr>
<tr>
<td>Cost Efficient</td>
<td>Must use other software for tasks</td>
<td>Too busy and cluttered</td>
<td></td>
<td>No Assignment Upload Capability</td>
<td>School LMS is better</td>
</tr>
<tr>
<td>User friendly</td>
<td>Limited Customization Options</td>
<td>Students use it because they have to</td>
<td></td>
<td>Can’t Save Work</td>
<td>Not user friendly</td>
</tr>
<tr>
<td>Quiz/Test Capability</td>
<td>Time Consuming</td>
<td>One more login/password for students to remember</td>
<td></td>
<td>Training Useless</td>
<td>Use for testing only</td>
</tr>
<tr>
<td>Customization</td>
<td>Need Training</td>
<td>Students do well once they are familiar with it</td>
<td></td>
<td>Limited Downloads</td>
<td>Students do not use Courses</td>
</tr>
<tr>
<td>Grade System</td>
<td>Expensive</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
As stated at the beginning of this section, the information collected clearly lays out problems that teachers run into while trying to use technology in a school system. The information that was concluded from the survey results, along with the information collected from the review of literature, can now be used to answer the sub-research questions. The answering of the sub-research questions will aid in the final conclusions and will ultimately answer the main research question: Would it be beneficial to combine PDM tools and methods to LMS in K-12 environments?

5.3 Sub-Research Questions

The above insights are the highlights of what data was collected. There is clear evidence that there are problems within document management in a school system. The purpose of this phase of the research was to find out if there were issues or not, and it has been discovered that there are. This corresponds with previous studies that have stated that there can be improvements with LMSs.

As mentioned in Chapter 1, there were three sub-research questions that the survey aimed to answer to help identify if PDM tools/methods can be beneficial in the education area. The first sub-question was: how do teachers manage, manipulate, and organize files? The bullet points below are taken from the key concepts obtained from the analyzation phase of the data. These points are important because they show the popular habits that teachers follow when it comes to data management:

- Communication is mostly done through the LMS and email.
- There are many different file formats that have trouble with submission/grading. Goes from Microsoft Office docs to CAD files. Teachers have found alternative submission methods such as converting to PDF.
• There is no prevalent destination to save files. Teachers do whatever is easiest for them/what they have been taught at some point. Same with saving document destination, no prevalent location to keep documents that are reused each year.

• Based on data collected, teachers must use multiple software/websites/LMS in order to complete what they want accomplished. It is possible to have different software/websites/LMS to distribute assignments, communicate with students, complete assignments, submit work, grade work, and distribute grades.

• Although not many teachers have experience with interactive exchange, it would be beneficial.

• The ability to interface with other software was always a plus listed under the LMS.

• The difficulty of submission/grading of different file formats deals with all the different software that is used at a school. It is possible for assignment completion, submission, grading, distributing grades to be different. This leads to teachers not able to grade in-depth and students not getting full feedback.

The second sub-research question that this study aimed to answer is: can PDM tools/methods address the most common participant issues that were identified throughout the data collection process? The most common participant issues include:

• Not user friendly

• Must use other software for tasks

• Limited customization options

• Time consuming

• Training useless

• Expensive
- Can’t save work

As a reminder, PDM is used to organize data in a single, centralized software system (Stark, 2015). One of the main problems that teachers have with an LMS is the use of multiple software on a daily basis for basic tasks. If the data collected is looked at, there is repeated talk about using different LMS/applications/websites to get a simple task done. The concept of having all information stored in a ‘single, centralized software system’ would be beneficial for teachers. With a PDM system, data can be accessed whenever, by whoever, and wherever it is needed (Stark, 2015). Higher administration would also be able to access student work, progress, and how the class is doing as a whole. A PDM system has very important roles: to move, store, and control information (Li, Chen, Yen, & Lin, 2013). The secured data management system that PDM offers would allow secure grade distribution along with private feedback.

The third, and final, sub-research question that this study aimed to answer was: is there a data management system that is best suited for the given environment? Based on results from the surveys, there is not an LMS that teachers are completely satisfied with. Canvas is the LMS that is utilized most at the K-12 level and has the most experience from PLTW teachers. It has a lot of positive attributes, but still has negative connotations. Google Classroom also has a lot of positive feedback. It also has some factors that Canvas does not, such as cost efficient. Based on what is currently available to teachers, and survey feedback, Canvas or Google Classroom are the two data management systems that are best suited for K-12 environments. However, both LMSs have room for improvement.
5.4 Results Derived

There were many insights that were derived from data analysis that helped answer the sub-research questions along with the main research question. The following insights made the greatest impression on the researcher and will be useful in the conclusions of the study.

The greatest insight that was collected from data was that teachers must use multiple software/websites/LMS in order to complete what they want accomplished. For example, it is possible to have a different software to distribute the assignment, communicate with students, submit the assignment, grade the assignment, and also distribute grades. Diving deeper into this insight, the different software that is used in each of these different stages, along with the pros and cons of each, have been recorded throughout this paper. From the pros and cons, the researcher was able to gather what teachers look for most from their LMS and what they wish could be added or changed.

Another insight is that teachers have trouble with the submission/grading of certain document formats. The greatest being 3D CAD models. As a reminder, PLTW teachers work with pre-engineering curriculum. PLTW works with a multitude of data files, including CAD files, Word documents, images, videos, coding languages, etc. Because of the inability to transfer this type of data, teachers have students save the file in a PDF version, which compromises the depth of grading, and in turn, the ability for the teacher to give good feedback and positive criticism.

There is no prevalent destination to save files and to keep documents for future use. Teachers do whatever is easiest for them or what they have learned at some point. This results in document management specific to the teacher and unknown to the school administration.

Another interesting insight is that students play a role in the success of an LMS. The poverty level of the school, whether the students are tech-savvy or not, how lazy the students are, these all affect whether an LMS is used efficiently or not. For example, if a student does not have internet
at home, an LMS that can be accessed online only and nothing can be downloaded from it, the student is most likely not going to use that LMS to its fullest capabilities.

Most of the data that was obtained from the study supports the key assertion and theory obtained. However, there were a few results from the survey that do not support the findings that this paper presents. Question 12, for example, had a unique outcome. The results from the question state that a majority of teachers do not want to switch to a new LMS. There can be many different explanations for this, all of which would need further exploration to find why teachers are not completely satisfied with their LMS yet are not willing to switch to a new one. A possibility could be that the teachers do not know of a different LMS out there that they would rather use. While the results of Question 12 were not in favor of the study, this does not invalidate the rest of the findings that this research presents.

All the insights gathered were beneficial for the study and helped reach the final conclusions that sum up the research. With the data collected and thoroughly analyzed, both a key assertion and a theory were developed. According to Saldaña (2015), a key assertion is “a summative and data-supported statement about the particulars of a research study” (p. 282). The key assertion found is: The main attributes that teachers are looking for in an LMS are user friendly, quiz/test capabilities, integration abilities, and customization options.

The key assertion is very important to the study as it lists what teachers want in an LMS. The key assertion is also the backbone to the theory developed: With the proper training, a centralized, core software used throughout the school on a cloud system that allows teachers to communicate, submit assignments, grade, distribute grades, view progress, and store files would eliminate a majority of issues that teachers run into with their LMS.
5.5 Final PDM & LMS Association

In Chapter 2, the research proposed a figure to demonstrate the association between the PDM and LMS core functions. After completing the study, the LMS core functions that were listed are all still at the utmost importance for a successful LMS. The figure below has been rearranged in order to allow better visualization between the two. The order that the functions are listed do not depict the importance of the function. The LMS Core Functions were reordered from the original table simply for better clarity. The PDM core functions on the right are flexible concepts that can be molded to meet the needs of an LMS.

<table>
<thead>
<tr>
<th>PDM Core Functions</th>
<th>Association between PDM &amp; LMS</th>
<th>LMS Core Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Document management</td>
<td></td>
<td>Assessments that can handle pre/post testing</td>
</tr>
<tr>
<td>Engineering change management</td>
<td></td>
<td>Messaging and notifications</td>
</tr>
<tr>
<td>BOM management</td>
<td></td>
<td>Instructor-led course management</td>
</tr>
<tr>
<td>Parts management</td>
<td></td>
<td>Competency management/tracking &amp; reporting</td>
</tr>
<tr>
<td>System management</td>
<td></td>
<td>Administration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Certification and display students' score and transcripts</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Making a course calendar</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Managing users, courses, roles, and generating reports</td>
</tr>
</tbody>
</table>

Figure 33. Final Association between PDM & LMS

The following statements are strictly from the researcher’s point of view. They are created based on definitions from literature. The associations could be changed if a PDM system is actually implemented into a school as its data management system. The following statements are the final associations that the researcher has:
- Document management includes secure data storage, access control, product data classification and electronic approval checks which in turn can be used when dealing with assessments, exams, homework, etc.

- Engineering change management deals with workflows, administration, and electronic sign offs. Messaging, course management, competency tracking, and administration rights are all necessary within an LMS and can fit within engineering change management.

- A BOM can perform the same function as a home for the students’ scores and transcripts. At the beginning of the year, teachers can create a list of all grades that will be included for the semester and update it accordingly.

- Parts Management deals with parts creation and maintenance. A syllabus, project outline, or assignment could also be classified as a “part”, and by creating a course calendar, these can be constructed and maintained.

- System Management includes data distribution, backup of data, user authorization, system security, etc. The LMS core function of Managing users, courses, roles, and generating reports can easily fall into this category.

In Chapter 2, there was a discussion about the way a PDM system has been implemented into Adobe Illustrator to help with designers in the fashion industry. The same concept can be applied here. Some of the issues that were brought up by teachers have already been solved by the popular LMSs (i.e. Canvas, Google Classroom). For example, Canvas is user friendly, highly customizable, and easy to learn. Implementing a PDM system into Canvas can solve a majority of the rest of the issues. The teachers would be able to work in an LMS they are familiar with while working with all of their documents in a centralized system.
The association between PDM core functions and LMS core functions have also been looked at. Looking at the connections listed in Figure 33, it is a reminder that a PDM system can be flexible and molded to meet the needs of the LMS. The PDM system can provide assessments, messaging, notifications, a course calendar, administration rights, assignment submission, grading distribution, and possibly much more. Having a PDM system implemented into an LMS such as Canvas, would eliminate the multitude of software that teachers must work with today to get the needs of their class met.

A possible goal of this research was to see if a PDM system can be used in place of an LMS. In order to answer this question, and based on results collected, a PDM system would have to be completely customized, created, implemented, and tested to see if it would be a viable solution. With the information currently available in literature, the question is unable to be answered at this time and is out of scope for this particular study.

Based on the results from the data and the extensive research that the researcher has gone through, the researcher suggests the following conclusion: implementing a PDM system into a high rated LMS (i.e. Canvas, Google Classroom), could solve the issues that teachers are having.

5.6 Future Work

This study looked at the possibility of using PDM tools and methods to benefit document management in education. This concept has never been looked at before and no studies have been done on it. This study acts as a starting point for further research.

There are many ways in which this research can be taken in the future. It would be interesting to come up with this solution is physical form. A PDM system is already a flexible concept and is easily implemented to fit a company’s needs. With the right set of coding skills, it would not be
difficult to alter change the names of the PDM tools and change them to their associations shown in Figure 33. This could be the first step in testing the trustworthiness of the figure created by the researcher. The figure at the moment is created merely from information obtained from literature. As of now, the conclusion that was reached by the researcher is only speculation, as time constraints would not allow to take the research further.

After the solution from this research has been created in physical form, and a fully-tested figure showing the associations between PDM and LMS core functionalities has been put in place, the next step this research could take would be to implement the physical form into a real-life situation. Using the physical form that contains associations between PDM and LMS, it can be implemented into a popular LMS, such as Canvas or Google Classroom, and tested to see if the results of this study are accurate. Using the example from Adobe Illustrator, the integration between the PDM system and the popular LMS would keep teachers feeling comfortable in an environment they are used to. It would also bring in the features of a PDM system, where all documents can be stored and managed from a centralized system. Not only teachers would be able to easily keep track of their files, but administration could see where classes stand when it comes to grades, progress, etc.

On a completely different note, future work could also be done to see if there are administrative reasons as to why teachers are not completely satisfied with their current LMS. It is possible that the LMS wasn’t implemented correctly into the school by administration, therefore it is not being used to the best of its capabilities. A common response in the survey data was that teachers wish they could have received proper training on the LMS. If proper training was put in place for the LMSs that are currently in the school, would there even be a need to switch away from the popular LMSs out there now?
Another interesting future step would be to get the students viewpoints on the LMS. This study hinted on the subject by asking teachers what the students’ perceptions on the individual school’s LMS and Courses. It would be interesting to ask students the same/similar questions to get their full viewpoint. One of the insights to this study was that students play a role in the success of an LMS. The poverty level of the school, whether the students are tech-savvy or not, how lazy the students are, these all affect whether an LMS is used efficiently or not. Getting the opinions of students could help confirm the results of the study or suggest more ways of improvement.

The final recommendation for future work would be to look at the use of PDM tools and methods with other nontraditional environments. Education is just one area that could benefit from the use of PDM systems. There could be many other areas out there that could also benefit that are outside of the manufacturing sector, they just haven’t been discovered yet. Talking to different professions about their daily tasks, it is found that technology plays a huge role in everyone’s workday. Lawyers, photographers, nurses, many different careers have data being transferred across multiple devices and stored in different places. Different software is being used for different tasks. While PLM and PDM are only dominant in the manufacturing section right now, hopefully this research shows the possibilities that can be achieved with a little creativity and flexibility.

5.7 Conclusion

To summarize, there were three sub-research questions that were used to frame the survey instrument and gather data to which the main research question would be answered. The three sub-research questions are as follows:

1. How do teachers manage, manipulate, and organize files?

2. Can PDM tools/methods address the most common participant issues that were identified throughout the data collection process?
3. Is there a data management system that is best suited for the given environment?

The sub-research questions were answered in Section 5.3. The data gathered to answer these questions assisted in answering the main research question: Would it be beneficial to combine PDM tools/methods to LMS in K-12 environments?

Based on the results from the data and the extensive research that the researcher has gone through, the researcher suggests the following conclusion: implementing a PDM system into a high rated LMS (i.e. Canvas, Google Classroom), could solve the issues that teachers are having.

In conclusion, based on the information obtained from teachers in the PLTW community, **PDM tools/methods can be used to improve LMSs in the K-12 environment.** This research provides many facts that back this answer including all insights that has been discussed in this chapter. Though the research was not able to develop or implement a solution to the findings, the information gathered proved that the two areas can be combined in some way. With no prior research conducted on the combination of PLM and education, the data presented through this study is intended to act as a knowledge base to support future research.
The survey questions developed for the teachers are as follows:

1. I have read the informed consent that was included in the email I received. I consent to participate in this research project.
   Agree
   Disagree
2. What is the Learning Management System (LMS) put in place at your school?
3. What is the overall rating of the LMS?
   Extremely Satisfied
   Somewhat Satisfied
   Neither satisfied nor dissatisfied
   Somewhat Unsatisfied
   Extremely Unsatisfied
   3.1 You said you were extremely satisfied with the LMS, please explain your response:
4. What do you like about the LMS?
5. What do you dislike about the LMS?
6. What would like to see added or changed?
7. Do you use the LMS to distribute grades?
   Yes
   No
   7.1 What software do you use?
8. How often do you use the LMS?
   - Constantly
   - Daily
   - Two to Three Days a Week
   - Weekly
   - Monthly Never

9. Do you feel the students are satisfied with the LMS?
   Slide the dot to rate the student's satisfaction. 0-10

   9.1 You stated that the students are not extremely satisfied with the LMS, please explain your response:

10. Do you have students work with a software outside of the LMS to communicate?
   - Yes
   - No

11. Do you have experience with another LMS?
   - Yes
   - No

   11.1 Which LMS?

   11.2 What are your opinions on it?

12. Should your school switch to a different LMS?
   - Yes
   - No Opinion
   - No

   12.1 Do you have an LMS in mind?
13. How satisfied with the current delivery system (Courses) that is used in PLTW classes are you?
   - Extremely Satisfied
   - Somewhat Satisfied
   - Neutral
   - Somewhat Unsatisfied
   - Extremely Unsatisfied

13.1 You said you were *extremely satisfied* with Courses, please explain your answer.

14. What do you like about Courses?

15. What do you dislike about Courses?

16. What would like to see added or changed?

17. How often do you use Courses?
   - Constantly
   - Daily
   - Two to Three Days a Week
   - Weekly
   - Monthly Never

18. Do you feel the students are satisfied with Courses?
   Slide the dot to rate the student's satisfaction. 0-10

18.1 You stated that the students are not extremely satisfied with Courses, please explain your response:
19. Do you use a software other than the LMS incorporated in the school to communicate with students? Check all that apply:
   - Email
   - Website
   - Google Docs
   - Tablet/Phone App
   - Other….

20. Which program do you use the most to communicate with students?

21. Have you ever used interactive change with students?
   - Yes
   - No

   21.1 Do you find interactive change beneficial to view students’ progress on projects?
   - Yes
   - No

   21.2 Would viewing students' progress on projects be beneficial to you?
   - Yes
   - No

22. Is there ever any difficulty with the submission/grading of different file formats?
   - Yes
   - No

   22.1 Which file types specifically?

23. Do you re-use material from the previous year?
   - Yes
No

23.1. Where is it stored?

23.2 Would you re-use material if there was a place designated to keep it?
   Yes
   No

24. When editing documents, which of the following do you participate in?
   Save multiple copies of file
   Save files directly to cloud
   Save files directly to computer

25. Are there any other comments you would like the researcher to know?

26. Would you be willing to participate in a 10-minute phone interview?
   Yes
   No
Appendix B. Emails

Intro Email for Survey

Dear Project Lead The Way Teacher:

I am requesting your assistance in completing my thesis research through Purdue University. Attached to the bottom of this email is a web link to a survey related to PLTW teachers’ perceptions on learning management systems (LMS). The survey should take no more than 10 minutes to complete.

The survey contains a series of open ended questions about the LMS that is being used through PLTW along with the LMS that is used at your school. Please complete the survey as soon as possible. All responses will be anonymous.

This research, directed through Purdue University, concentrates on combining PDM and LMS in K-12 environments. A directed look at document management in the “Project Lead the Way” classes at high schools is being conducted with this study. The survey aims to find the issues that teachers encounter when using the learning management system (LMS) both with the PLTW curriculum and the one that is currently in place at their individual schools. Using the issues reported from the data obtained from the survey, we will then examine the possibility of using a PDM system to resolve the issues found. You are being asked to participate in this study because you, as a PLTW teacher, will provide useful insight into the happenings of LMSs in different learning environments.

The online consent form is attached to this email (Online Consent.pdf). Please note, if you participate in this research, you are also indicating that you have permission from your school administration to provide anonymous information to Purdue University.

If you have any questions, concerns, or suggestions, please email me at hughes72@purdue.edu. If you have any questions about this research project in general, you can contact the PI for the project: Dr. Nathan Hartman at (765)496-6104 or nhartman@purdue.edu. If you have questions about your rights while taking part in the study or have concerns about the treatment of research participants, please call the Human Research Protection Program at (765) 494-5942, email (irb@purdue.edu) or write to: Human Research Protection Program at Purdue University, Ernest C. Young Hall, Room 1032, 155 S. Grant St., West Lafayette, IN 47907-2114.

Thank you in advance for assisting with this research project.

Professionally,

Meagan Hughes
PLM Center of Excellence
Graduate Research Assistant
Purdue University

Please take the survey here: (insert survey link)
Reminder Email for Survey

Dear Project Lead The Way Teacher:

Many of you have received and taken my survey – Thank you!! Please delete this email if you have helped. For those who have not had a chance to do so, I am requesting your assistance in completing my thesis research through Purdue University. Attached to the bottom of this email is a web link to a survey related to PLTW teachers’ perceptions on learning management systems (LMS). The survey should take no more than 10 minutes to complete.

The survey contains a series of open ended questions about the LMS that is being used through PLTW along with the LMS that is used at your school. Please complete the survey as soon as possible. All responses will be anonymous.

This research, directed through Purdue University, concentrates on combining PDM and LMS in K-12 environments. A directed look at document management in the “Project Lead the Way” classes at high schools is being conducted with this study. The survey aims to find the issues that teachers encounter when using the learning management system (LMS) both with the PLTW curriculum and the one that is currently in place at their individual schools. Using the issues reported from the data obtained from the survey, we will then examine the possibility of using a PDM system to resolve the issues found. You are being asked to participate in this study because you, as a PLTW teacher, will provide useful insight into the happenings of LMSs in different learning environments.

The online consent form is attached to this email (Online Consent.pdf). Please note, if you participate in this research, you are also indicating that you have permission from your school administration to provide anonymous information to Purdue University.

If you have any questions, concerns, or suggestions, please email me at hughes72@purdue.edu. If you have any questions about this research project in general, you can contact the PI for the project: Dr. Nathan Hartman at (76)496-6104 or nhartman@purdue.edu. If you have questions about your rights while taking part in the study or have concerns about the treatment of research participants, please call the Human Research Protection Program at (765) 494-5942, email (irb@purdue.edu) or write to: Human Research Protection Program at Purdue University, Ernest C. Young Hall, Room 1032, 155 S. Grant St., West Lafayette, IN 47907-2114.

Thank you in advance for assisting with this research project.

Professionally,

Meagan Hughes
PLM Center of Excellence
Graduate Research Assistant
Purdue University

Please take the survey here: (insert survey link)
# APPENDIX C. RESPONSES TO SURVEY QUESTIONS

<table>
<thead>
<tr>
<th>Participant</th>
<th>Question 2</th>
<th>Question 3.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Canvas</td>
<td>It provides me with many different capabilities to instruct my students.</td>
<td></td>
</tr>
<tr>
<td>2 Canvas</td>
<td>Navigation is easy for students and is teacher friendly.</td>
<td></td>
</tr>
<tr>
<td>3 Canvas</td>
<td>There are a lot of working parts in canvas that make it helpful. One area that needs improvement is in the quiz section of Canvas.</td>
<td></td>
</tr>
<tr>
<td>4 Canvas</td>
<td>I feel that there should be more user friendly options and overall</td>
<td></td>
</tr>
<tr>
<td>5 itsLearning</td>
<td>We previously used My Big Campus, and I felt the user interface and student experience was better.</td>
<td></td>
</tr>
<tr>
<td>6 PLTW.org</td>
<td>The system is very unorganized and incomplete</td>
<td></td>
</tr>
<tr>
<td>7 Google Classroom, or Moodle, plus whatever</td>
<td>If this is referring to the PLTW LMS then I am not completely satisfied. In order to protect the property of Project Lead the Way you can no longer print many of the activities which is problematic. I was certified to teach PLTW prior to the adoption of the LMS. I went to a training that was useless on how to use the LMS. The speaker was from the company that developed it but had no idea how PLTW was using it. I think the LMS platform has been changed since then as well.</td>
<td></td>
</tr>
<tr>
<td>8 Schoology</td>
<td>There are some items that need to be worked into this system, to make it more user friendly.</td>
<td></td>
</tr>
<tr>
<td>9 For students to see course requirements and assignments</td>
<td>It is difficult to navigate and get assignments off of it this year. In the past, there were documents that were easier to access and distribute to the students.</td>
<td></td>
</tr>
<tr>
<td>10 Canvas</td>
<td>Very versatile in function. Allows instructor to create, monitor, and assess student performance in several ways.</td>
<td></td>
</tr>
<tr>
<td>11 Teacher chosen. Google Classroom</td>
<td>Overall satisfied with Google classroom, would like to see some additional features and controls with it.</td>
<td></td>
</tr>
<tr>
<td>12 Canvas</td>
<td>I am very familiar with it due to using it for PLTW for the past several years (my school just adopted it this year). It has great capability and flexibility in use.</td>
<td></td>
</tr>
<tr>
<td>13 Canvas by Instructure</td>
<td>Canvas provides many great features to help teachers with assessment and manage curriculum to instruct students. The quizzes feature is probably one of the best aspects of Canvas as it provides automatic grading and</td>
<td></td>
</tr>
</tbody>
</table>
collect statistics on student performance. The ability to use many external Internet-based tools is a huge aspect of our 1:1 computing environment at our school. I have nearly all of my curriculum uploaded into my Canvas courses and use it for a guide for students. Students are able to see what we have learned and are going to learn, so the material is always there for them to reference. I feel that having Canvas has helped provide organization and better teaching through 21st Century teaching practices.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Question 4</th>
<th>Question 5</th>
<th>Question 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Assignments</td>
<td>Sometimes it can be difficult locating certain files.</td>
<td>Better file management.</td>
</tr>
<tr>
<td>2</td>
<td>The creation of modules and file storage</td>
<td>Building tests and quizzes</td>
<td>Revise the test construction portion.</td>
</tr>
<tr>
<td>3</td>
<td>The capabilities that is provides outside of the quiz option.</td>
<td>I dislike the quiz making options. I like that you can create a quiz and send it out to your classes but the ease and functions in the quiz generator could be improved.</td>
<td>Be able to add questions from other quizzes without worrying about the question banks.</td>
</tr>
<tr>
<td>4</td>
<td>Speed Grader and Canvas PTP PowerTeacher Sync</td>
<td>Not user friendly as it should be.</td>
<td>Cross linking courses and allowing that to be an easier process. If you put a file into anywhere on Canvas, it, along with any course content, should be able to seamlessly move across Canvas, no matter which it came from-instead of having</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td><strong>5</strong></td>
<td><strong>Strong analytical tools, wide array of question types for assessments. Good mobile app. Lots of options.</strong></td>
<td><strong>The user interface is not good and the learning curve for people who are not tech wizards is rough. It does not integrate with our student management system (Harmony) so we cannot have the grades from itsLearning go directly into Harmony. This therefor requires a good deal of manual data entry.</strong></td>
<td><strong>Better user interface, early learner platform, and integration with Harmony.</strong></td>
</tr>
<tr>
<td><strong>6</strong></td>
<td><strong>Neither like or dislike</strong></td>
<td><strong>The fact that it is unorganized and difficult to find materials.</strong></td>
<td><strong>Better organization, the ability to download assignments from the system.</strong></td>
</tr>
<tr>
<td><strong>7</strong></td>
<td><strong>Students can access the complete curriculum.</strong></td>
<td><strong>Activities being filled out only on the LMS. This doesn't seem to work well.</strong></td>
<td><strong>Activities should be printable so students can work on the hands on portion without the need of an electronic device.</strong></td>
</tr>
<tr>
<td><strong>8</strong></td>
<td><strong>Easy to navigate, pretty easy to structure.</strong></td>
<td><strong>It is slow at times (network related probably), and it does time out when you have &quot;too many requests&quot; in 15 seconds.</strong>&lt;br&gt;&lt;br&gt;You cannot search or organize messages that are incoming/outgoing.&lt;br&gt;&lt;br&gt;Identifying items as &quot;test bank questions&quot; is an individual process, would be nice to be able to do bulk (take a quiz, put all questions into a common test bank for that quiz). Moving files into/out of courses is cumbersome. Again, single process, rather</td>
<td><strong>If it had a survey feature, that would really make a difference. To survey, you have to go out and use another vendor. Having that integrated so that data could be collected and used, would be great.</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Curriculum is easy to get to and organized</td>
<td>Can't print assignments easily</td>
<td>An option for students to save work on LMS and submit</td>
</tr>
<tr>
<td>10</td>
<td>See above</td>
<td>Grade book function is not user friendly in it's display format.</td>
<td>Grade book format.</td>
</tr>
<tr>
<td>11</td>
<td>Ease of use and accessible across many platforms.</td>
<td>No grading option built in. A secondary software (Flubaroo) is needed for grading.</td>
<td>Automatic grading transfer to Skyward.</td>
</tr>
<tr>
<td>12</td>
<td>Being able to do most tasks through it rather than having to quiz seperately</td>
<td>It does so much that I simply haven't learned to do everything yet. It's a bit clunky when you want to add pictures to quizzes, etc.</td>
<td>Make it easier to embed images.</td>
</tr>
<tr>
<td>13</td>
<td>I really enjoy the ability to customize pages and develop a unique curriculum that is engaging to students and promotes learning.</td>
<td>While I really enjoy the customization aspect of Canvas, but sometimes the amount of time it takes to develop content can be very time consuming.</td>
<td>The issue with Canvas that I have is the adding of images and links can sometimes be very cumbersome as you scroll to the bottom of the page. The menu along the right side of the screen doesn't follow along as you scroll down and you continually have to scroll back up, click to insert a image or link, and then scroll back down to see the content that was inserted.</td>
</tr>
<tr>
<td>14</td>
<td>Ease of entering grades, we can import test scores from Illuminate</td>
<td>Limited functions. Not able to submit and grade assignments. We now have to use Google Classroom</td>
<td>See above dislike</td>
</tr>
<tr>
<td>15</td>
<td>Canvas is very user friendly</td>
<td>Easier ability to transfer grades from one platform to another.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>It has a lot of &quot;things&quot; that you can do within it.</td>
<td>It is more steps to take than a simple share with Google docs.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I would prefer not to use it. I would rather see Google add a little more to their system.</td>
<td></td>
</tr>
</tbody>
</table>

| 17 | Students are already familiar with how to use Google Classroom. | It does not provide me with analytics and data points that I could use to assess learning if I used a more robust system. |
|   |   | Ways to assess students with in line rubrics. The ability to break out individual competencies. |

<table>
<thead>
<tr>
<th>Participant</th>
<th>Question 8.1</th>
<th>Question 9.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>They do not know how to use all the different functions that different teaches use.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Too busy and cluttered. Not user friendly on the student side.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>I think they use it because they have to. If they had a choice, they might use something else.</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Unorganized, inability to download assignments</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Same issues as previously listed in regards to activities.</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Skyward</td>
<td>For the same reasons I expressed earlier.</td>
</tr>
<tr>
<td>9</td>
<td>Powerschool. It does interface with Schoology, but grading in Schoology for my classes, can also be cumbersome.</td>
<td>Can't save work. One more thing for them to remember, login/password</td>
</tr>
<tr>
<td>10</td>
<td>Inventor, Revit, AutoCAD, Inventor HSM, CNC Base</td>
<td>If not set up properly on the instructor end, the LMS is not always the easiest to navigate.</td>
</tr>
<tr>
<td>11</td>
<td>Computer is a Mac running boot camp for Windows programs. Standard office, or</td>
<td>I did not say that.</td>
</tr>
<tr>
<td></td>
<td>office emulators, Inventor, RobotC</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>----------------------------------</td>
<td>---</td>
</tr>
<tr>
<td>12</td>
<td>Skyward</td>
<td>Only because many of them are still learning to use it and they are not all very tech savvy. Some have a difficult time adjusting to a digital platform for learning but do well once they are familiar with it.</td>
</tr>
<tr>
<td>13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td></td>
<td>Some love it and some do not. Part of it is each teacher uses it differently. We are a Google school so it makes it easier to use that.</td>
</tr>
<tr>
<td>17</td>
<td>Autodesk, Google Suite, Microsoft Suite, Adobe Suite, SketchUp,</td>
<td>They don't have any other point of comparison to have an opinion.</td>
</tr>
<tr>
<td>Participant</td>
<td>Question 11.1</td>
<td>Question 11.2</td>
</tr>
<tr>
<td>-------------</td>
<td>---------------</td>
<td>---------------</td>
</tr>
<tr>
<td>1</td>
<td>Moodle &amp; Blackboard</td>
<td>Moodle is not a very strong LMS. Backboard is the best on the market, but very expensive.</td>
</tr>
<tr>
<td>2</td>
<td>Blackboard</td>
<td>I believe the test building is much easier for the teacher. Beyond that, Canvas is a much better LMS.</td>
</tr>
<tr>
<td>3</td>
<td>Google Classroom</td>
<td>I like it but the options are limited.</td>
</tr>
<tr>
<td>4</td>
<td>Project Lead the Way Inkling</td>
<td>Very horrible product and would rather never use it again.</td>
</tr>
<tr>
<td>5</td>
<td>My Big Campus, Canvas, Inkling</td>
<td>My Big Campus was great, but it was discontinued. Canvas is an industry leader, but it was expensive and had some of the same learning curve issues. Inkling has a very nice looking user interface, but it is hard to find what you need and is slow.</td>
</tr>
<tr>
<td>6</td>
<td>Moodle, not exactly and LMS. Some experience with Blackboard, not much.</td>
<td>The LMS is not an issue it is the protocols that PLTW has set.</td>
</tr>
<tr>
<td>7</td>
<td>All have pluses and minuses.</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Blackboard Moodle Canvas</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>PLTW LMS</td>
<td>Avoid it whenever possible.</td>
</tr>
<tr>
<td>12</td>
<td>Google Classrooms</td>
<td>It's very easy to use but limited in it's capabilities.</td>
</tr>
<tr>
<td>13</td>
<td>The LMS we used before Canvas was called My Big Campus and it was provided by Lightspeed Systems.</td>
<td>I personally did not enjoy My Big Campus as it did not allow for a lot of customization and had a very stylized appearance like Facebook. Students used it more for chatting and personal conversations rather than for assignments. It also had a lot of features that didn't allow for very friendly usage such as being able to organize resources and the grading feature wasn't very conducive for teachers as they had to download attachments, put comments in the file, save it, and then upload the file back in order to provide feedback. The Canvas Speedgrader is so much more efficient and saves so much more time for teachers to grade.</td>
</tr>
<tr>
<td>14</td>
<td>Canvas</td>
<td>It was very powerful once we were able to learn it.</td>
</tr>
<tr>
<td>15</td>
<td>Blackboard</td>
<td>Canvas &gt; Blackboard</td>
</tr>
<tr>
<td>Participant</td>
<td>Question 12.1</td>
<td>Question 13.1</td>
</tr>
<tr>
<td>-------------</td>
<td>---------------</td>
<td>---------------</td>
</tr>
<tr>
<td>1</td>
<td>Courses misses a lot of capabilities that Canvas provided the teachers with.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>PLTW has placed constraints on docx activities. This takes away from traditional freedoms for teachers.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>It has a great flow to it but the lacking of downloads and embedded PowerPoints are not helpful. This has been corrected on some lessons.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>I feel that the process is very archaic and lacks features of very useful tools. For example, if a student submits an activity (ie fill out blanks on the activity), I feel that teachers should be able to see it, just as on Canvas once a user's content was submitted for review.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Courses (Inkling.com) is much harder to find what you need in a speedy fashion than the older compiled html curriculum files were. It seems like you have to sift though a bunch of things you don't need to find what you are looking for.</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>The courses are taking away too many hands on activities. They are being replaced with worksheets, too many kids feel that its too much like a physics class and did not want to do so many worksheets, they wanted hands on projects.</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Same answer as given previously. I answered in regards to the LMS PLTW is using. Curriculum available to students is great. The inability to print activities and worksheets are problematic.</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Cannot easily download files, especially answer keys. No quiz/test feature. Too much fluff - easier to have files on our own LMS. Too many steps to walk through to get something.</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>I use part of the curriculum. Not all is worth getting to. Some just seems like busy work, I focus on main topics and elaborate on them. A lot of info to cover with students in a short time frame.</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Compared to the version from the past couple of years the new system is NOT user friendly, very frustrating for student and instructor.</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>See answers below</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>It is very basic and difficult to import into Canvas and have students complete work digitally.</td>
<td></td>
</tr>
</tbody>
</table>
13. I really feel as though Courses has taken away a lot of tools that were once available for PLTW teachers. Courses has a great interface for those working with iPads and e-readers, but it doesn't provide many resources for teachers who are using it in a 1:1 environment.

14. I liked being able to tweak the documents to fit my needs and situations.

15. Cant download or modify PLTW's documents from new platform

16. Google
As simply a delivery tool it does the job. I can point a student there and they can get everything they need. Since I use Google the delivery works for me. I wish all of the documents were compatible with Google docs and could be edited. I do change things from time to time and that has been harder.

17. It is doing what it is designed to do, which is to provide curriculum content to a diverse group of districts and learners that do not use the same LMS.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Question 14</th>
<th>Question 15</th>
<th>Question 16</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Easy to Navigate</td>
<td>No quiz functionality. No assignment upload capabilities.</td>
<td>Quiz functionality. Assignment upload capabilities.</td>
</tr>
<tr>
<td>2</td>
<td>The curriculum is concise and easy to locate in Inkling.</td>
<td>Ease of use. Standards, scope and sequence and teacher notes are very accessible.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>The flow of it and accessibility. Also the ability for PLTW to correct throughout the year.</td>
<td>The inability to create fillable worksheets or &quot;quizzes&quot;. Also the ability to edit projects for students that have IEPs.</td>
<td>&quot;worksheet&quot; option</td>
</tr>
<tr>
<td>4</td>
<td>Love the built in powerpoints!</td>
<td>Should not show all the course work and allow students to work ahead. This should be an option on the teacher's side to turn a module on or a particular activity.</td>
<td>More teacher functionality and user customization. Students should be able to submit assignments on the site without leaving and submitting on Canvas for grading.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Aesthetic, ability to download entire course content</td>
<td>See above</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>The older curriculum was far better than the current offerings</td>
<td>Too many worksheets not enough worksheets.</td>
<td>Bring back the hands on activities, smaller schools have trouble getting kids as it is, this will eventually cause a lot of schools to switch to the non PLTW courses.</td>
</tr>
<tr>
<td>7</td>
<td>Students have access to the curriculum.</td>
<td>I need training on using it.</td>
<td>Printable worksheets and activities.</td>
</tr>
<tr>
<td>8</td>
<td>The fact that it has our curriculum.</td>
<td>Same as above answer.</td>
<td>Fixes to above answer.</td>
</tr>
<tr>
<td>9</td>
<td>Outline and Objectives</td>
<td>Sometimes to complex for the students. If I made it as hard as the curriculum, students would not take the course because it is an elective.</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Navigation bar on the left.</td>
<td>NOT user friendly.</td>
<td>Blend the navigation bar with the delivery system from a couple of years ago, or simply switch back to the old delivery method.</td>
</tr>
<tr>
<td>11</td>
<td>All curriculum is accessible across various platforms.</td>
<td>No editing control. No summative or formative grading assessments. Difficulty and time consuming to register students. Limited downloads and only in certain formats.</td>
<td>Editing, downloading, assessments.</td>
</tr>
<tr>
<td>12</td>
<td>not much</td>
<td>It is very basic and difficult to import into Canvas and have students complete work digitally.</td>
<td>I would like for it to be more functional where students can submit work, download Word instructions for use offline (high poverty school = kids without home internet to complete activities).</td>
</tr>
<tr>
<td>13</td>
<td>Courses provides a simpler interface and curriculum delivery tool for teachers that aren’t technology savvy, but it does take away from teachers who like to use the LMS but may not be able to work in a 1:1 environment.</td>
<td>I really feel as though Courses has taken away a lot of tools that were once available for PLTW teachers. I also do not like how we don’t access to the curriculum documents and aren’t able to print very easily or provide hard copies of work to students.</td>
<td>I would like to see the documents added back into the curriculum for easier access for teachers to print and distribute materials when needed. I think it also makes it difficult to add to documents or add to some language in the document to help students. This is especially helpful when trying to help students with understanding building codes or explaining difficult concepts.</td>
</tr>
<tr>
<td>14</td>
<td>Easy to find lessons.</td>
<td>Not being able to edit documents and PPTs when I find errors.</td>
<td>Being able to edit. I understand the reasoning behind not be able to do this as the integrity of the curriculum has been compromised in the past.</td>
</tr>
<tr>
<td>15</td>
<td>The ability to go in chronological order</td>
<td>PLTW is really good at putting in pointless information and grammar errors and can’t change these through the new platform</td>
<td>Ability to download and modify</td>
</tr>
<tr>
<td>16</td>
<td>Simple</td>
<td>I can not edit items.</td>
<td>Google Suite compatible.</td>
</tr>
<tr>
<td>17</td>
<td>Interactive components and graphics</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Participant</th>
<th>Question 18.1</th>
<th>Question 20</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>Canvas discuss board.</td>
</tr>
<tr>
<td>2</td>
<td>Not sure about this. Students really don't have a frame of reference to compare against.</td>
<td>Outlook</td>
</tr>
<tr>
<td>3</td>
<td>They get confused with some of the links and the empty boxes that you think you are typing into.</td>
<td>Canvas, Remind, Email</td>
</tr>
<tr>
<td>4</td>
<td>See other comments</td>
<td>Canvas</td>
</tr>
<tr>
<td>5</td>
<td>The students use itsLearning, the school LMS, and have not been introduced to Courses. The</td>
<td>Remind.com</td>
</tr>
</tbody>
</table>
reason for this is to have some form of consistency for the students between classes.

<table>
<thead>
<tr>
<th></th>
<th>Google Drive</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Same as previously mentioned.</td>
</tr>
<tr>
<td>7</td>
<td>google drive/email</td>
</tr>
<tr>
<td>8</td>
<td>Schoology - message.</td>
</tr>
<tr>
<td>9</td>
<td>Students are lazy and don't want to navigate to find information. Google Classroom. It was chosen by the district because of cost. We assign assignments through there and provide announcements.</td>
</tr>
<tr>
<td>10</td>
<td>NOT user friendly.</td>
</tr>
<tr>
<td>11</td>
<td>They typically use the PLTW LMS for testing only. Google Classroom, Email and Skyward about equally.</td>
</tr>
<tr>
<td>12</td>
<td>My students do not use the PLTW platform, only Canvas. Remind</td>
</tr>
<tr>
<td>13</td>
<td>We do not particularly use this LMS, because I find using Canvas is much better than trying to use different LMS's for my classes. I mainly use Canvas to communicate with students and a little bit with Google Docs, but I use the Google integration tool within Canvas to complete a lot of assignments.</td>
</tr>
<tr>
<td>14</td>
<td>Email</td>
</tr>
<tr>
<td>15</td>
<td>Google Docs</td>
</tr>
<tr>
<td>16</td>
<td>They do not seem to care much either way. It would be simpler for them if it lined up with the Google stuff better. Google Classroom</td>
</tr>
<tr>
<td>17</td>
<td>Courses is not a LMS. It's a curriculum delivery system like an e-reader. This isn't a valid question.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Participant</th>
<th>Question 22.1</th>
<th>Question 23.1</th>
<th>Question 25</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Students that have made something on a Mac. Many are stored on the cloud.</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>docx</td>
<td>Google drive</td>
<td>Speed Grader in Canvas could use some work.</td>
</tr>
<tr>
<td>3</td>
<td>Canvas or one drive</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Any Microsoft extension being graded using Canvas, which opens as a Google Doc, etc.</td>
<td>Online</td>
<td>No</td>
</tr>
<tr>
<td>5</td>
<td>A number of places, primarily on dropbox.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Google Drive or PLTW LMS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Revit and Inventor files I have graded as submitted pdfs. It is typically easier to annotate hard copies.</td>
<td>Google Drive</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>N/A - not sure what the previous question was asking me.</td>
<td>On my teacher drive at school.</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Microsoft Office products with Google classroom</td>
<td>Google Drive or local H Drive</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>I try to limit submissions to PDF format to avoid issues.</td>
<td>Hard drive and cloud.</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>There were times students only had Word Pad or other programs at home and would use that to complete work and I couldn't open it at home. We just went 1:1 in the last month so hopefully that will no longer be an issue.</td>
<td>My Google Drive, Dropbox, or on school computer.</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>I store all materials in my Canvas courses and then they get copied from year to year. I also store them within my school issued Google Drive storage.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>PowerPoint and Excel</td>
<td>On a school home drive and on a stand alone PLTW dedicated laptop.</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Google Drive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Autodesk files</td>
<td>In my Google Drive</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX D: MEMOS AND CODING

Coding: Initial Categories

Transferred to White Board and Codes Synthesized
Further Analysis/Memos

Key for Final Analysis Phase
Key Concepts Grouped
### Key Concepts Groups (taken from white board)

<table>
<thead>
<tr>
<th>Category 1: Document Management</th>
<th>Category 2: LMS Reviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>There are many different ways to communicate with students in today’s society through technology. While many are used, there are still a few that stand out above the others: google docs, email, and website are top contenders.</td>
<td>Canvas is the LMS that has the most experience from PLTW teachers. It has a lot of positive attributes, but still has negative connotations.</td>
</tr>
<tr>
<td>When asked in open-question format, communication is mostly done through the LMS and email. There are many different file formats that have trouble with submission/grading. Goes from Microsoft Office docs to CAD files. Teachers have found alternative submission methods such as converting to PDF.</td>
<td>Courses is the PLTW delivery system that was just switched to this year. The only positive that came from it is the curriculum accessibility. The negatives included no edit capability, no assignment upload capability, limited downloads, can’t save work, training useless.</td>
</tr>
<tr>
<td>There is no prevalent destination to save files. Teachers do whatever is easiest for them/what they have been taught at some point. Same with saving document destination, no prevalent location to keep documents that are reused each year.</td>
<td>Among all the other LMS mentioned, teachers are looking for cost efficient solutions that are user friendly, have quiz/test capabilities, integration abilities, and customization abilities.</td>
</tr>
<tr>
<td>Based on data collected, teachers must use multiple software/websites/LMS in order to complete what they want accomplished. It is possible to have different software/websites/LMS to distribute assignments, communicate with students, complete assignments, submit work, grade work, and distribute grades.</td>
<td>Students play a role in the success of an LMS.</td>
</tr>
<tr>
<td>Many different software programs are used throughout the school system.</td>
<td>Even if the teacher side of the software is top notch, if the students can’t access it easily or it is not easy for them to figure out, the LMS is then deemed useless.</td>
</tr>
<tr>
<td>Although not many teachers have experience with interactive exchange, it would be beneficial!</td>
<td></td>
</tr>
<tr>
<td>The ability to interface with other software was always a plus listed under the LMS. If all info is located in one software, there is no need to have to interface with other software.</td>
<td></td>
</tr>
<tr>
<td>There are many options in which teachers can choose to communicate with students. If there was a central software that enabled communication along with everything else, all would be more efficient.</td>
<td></td>
</tr>
<tr>
<td>A centralized software that can keep all documents related to course on would be beneficial. Right now documents are saved/stored in all sorts of places.</td>
<td></td>
</tr>
<tr>
<td>The difficulty of submission/grading of different file formats deals with all the different software that is used at a school. It is possible for assignment completion, submission, grading, distributing grades to be different. This leads to teachers not able to grade in-depth and students not getting full feedback.</td>
<td></td>
</tr>
</tbody>
</table>
REFERENCES


Aravind, A. D. (2017). A study on understanding the creation of component maintenance manual using model-based definition (M.S.). Purdue University, Indiana.


Ruemler, S. P. (2016). Analyzing the opinion of industry professionals on model-based definition datasets to determine the most efficient method (M.S.). Purdue University, Indiana. Retrieved from https://search-proquest-com.ezproxy.lib.purdue.edu/docview/1855159130/abstract/63269C842B949FCPQ/1


