MASTER THESIS

Critical success factors in implementing component content management systems from technical communicators' perspective

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Abstract

A component content management system (CCMS) is a package of integrated technologies that are used to collect, create, maintain, repurpose, and publish content at the component level. An increasing number of technical communication (TC) groups are adopting component content-management system (CCMS) to create and maintain their content at a component level. However, the CCMS adaptation could be a challenging task. All the promises and benefits that could be brought by a CCMS cannot be achieved if the system is not successfully implemented and adopted. On the contrary, a successful implementation can not only save time and effort but also solve or prevent challenges brought by the CCMS.

Antecedent studies have noticed the importance of CCMS implementation and given suggestion on how to implement a CCMS successfully. However, most of them consider the implementation as an integrated process and failed to identify the differences among the phases, and therefore the suggestions offered by them were mostly too general to enlighten the people who are interested in the CCMS implementation.

To explore how the CCMS implementation is conducted and generate suggestions on successful implementation, this study defined the CCMS implementation, identified the phases of it and explored the critical success factors (CSF) in different phases by interviewing technical communicators who have experience with CCMS implementation. 11 technical communicators from the Netherlands and China participated in the one-on-one semi-structured interviews.

By analyzing the data collected in the interviews, this study defined the CCMS implementation as the process starting with the system preparation and ending with the large-scale practice. The phases of CCMS implementation specified by this study include: system preparation, promotion, pilot practice, training, and large-scale practice. Different challenges, solutions, and benefits were found being related to different phases of CCMS implementation. Many challenges brought by CCMSs to organizations, including the difficult transition to topic-based writing, the metadata chaos, the poor usability of the CCMS, the negative attitude hold by people towards the changes, and the poor workflow and collaboration among different roles could be solved or prevented by conducting a good CCMS implementation. This study generated a detailed list of the CSFs in different phases of implementing a CCMS as a guidance for the people and organizations interested in CCMS implementation.

Keywords: component content management system, implementation, technical communicator, critical success factor

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1. Introduction

Imagine that you participate in a craft club and are asked to create a new craft work every week. The theme of last week was "father" and you made a wooden doll of a male with short hair and blue eyes. Then, you know the theme of this week is "mother" and you plan to make another wooden doll of a female with long hair and brown eyes. There are many similarities between the two dolls. What would you do? Would you find a new piece of wood and carve it? Is it possible for you to create a new doll by only adjusting the different parts, such as the hair and eyes? If the dolls are made from a whole piece of wood, it would be hard to make adjustment; but if the dolls consist of blocks, like LEGO, the adjustment is simple and easy. In technical communication, the traditional documentation writing which is linear and unstructured is like the one-piece doll and the structured writing is like the LEGO. Creating and maintaining content at a component level like LEGO blocks enables the same piece of content be reused in various places and speed up the pace of documentation.

An increasing number of technical communication (TC) groups are adopting component content-management system (CCMS) to create and maintain their content at a component level. Results of some independent surveys indicated that component content management (CCM) adoption has reached critical mass and will be a future trend as well. SDL's *Global Authoring Survey 2009* noted the increasing awareness and adoption of structured writing strategies based on XML, a markup language, and DITA, an XML-based standard, among global organizations. The *2012 technical communication benchmarking survey summary results* (Abel, 2013) showed that 14% of the over 500 companies surveyed plan to adopt CCM in the future.

The benefits could be brought by a CCMS make many technical communication groups eager to adopt a CCMS. However, the CCMS adaptation could be a double-edged sword. All the promises and benefits cannot be achieved if the system is not successfully implemented and adopted. Some antecedent studies (Dayton & Hopper, 2010; Zhang, 2016) found that the implementation of CCMSs impacted the follow-up work efficiency of CCMSs.

A successful implementation could not only save time and effort but also solve or prevent challenges brought by the CCMS. Zhang (2016) mentioned that the technical problems, the problem of collaboration, and the issue of negative attitudes and lack of content management strategies can all be solved fully or to a certain degree if the CCMS is properly implemented. Although it is useful to study the processes of implementing a CCMS in organizations, the research into CCMS implementation is scarce. Conducting studies on CCMS implementation could build up new knowledge or even theories about the implementation processes of CCMS, which might be applied to the implementation of other innovation or technology. In addition, knowledge of the practice of CCMS implementation could have great importance for the technical communicators who will participate or are participating in an implementation, the organizations that plan to or are conducting an implementation, and educational institutes that aim to help students become professional and competitive technical communicators.

Implementing a CCMS is a costly and complicated task and the transition for most organizations has been anything but smooth (Andersen, 2014). While Dayton and Hopper (2010) and Zhang (2016) have noticed the importance of CCMSs implementation, they did not discuss further how to conduct the implementation. Some trade publications (Shumate, 2015; Oberon Technologies, Inc., 2018) gave suggestions on how to implement a CCMS successfully, but most of them considered the implementation as an integrated process and failed to identify the differences among the phases of implementing CCMSs. However, the CCMs implementation is a complicated process which undergoes several phases and contains various aspects. The general suggestions given by previous studies were not enough to enlighten

the people who are interested in CCMS implementation. In addition, both the scholarly and trade publication overlooked the technical communicators' thoughts which may offer numerous insights.

To explore how the CCMS implementation is conducted and generate suggestions or guidance on conducting CCMS implementation in organizations, this study planned to answer the research question: *What are the critical success factors (CSF) in different phases of CCMS implementation from the perspective of technical communicators?* This study tries to firstly define CCMS implementation, identify the phases of it and then explore the specific activity or information that must be present in the identified phases for CCMS implementation to be successful.

Section 2 will introduce the concepts of CSF and CCMS in previous studies and reviewed antecedent studies that have investigated CCMS implementation. Section 3 will describe the methodology applied in this study. Section 4 will present the results. Finally, Section 5 will state the discussion, limitations, and conclusion of this study.

2. Literature review

2.1. Critical Success Factor (CSF)

Critical success factor, also called key success factor, refers to a specific activity, condition, or variable that is required for ensuring the success of a project or an organization. The concept of CSF is refined from the concept of "success factors" developed by Daniel in 1961. Rockart conducted a refinement in 1979 and defined the CSF approach as a method to help managers determine what information is the most relevant to them to attain goals successfully.

In the context of this study, CSF is defined as the specific activity or information that must be present for the CCMS implementation in organizations to be successful. In order to specify the CSFs in different phases of CCMS implementations in organizations, this study need to first identify the phases of CCMS implementation and then collect the challenges, measures and benefits recognized by technical communicators in different phases as the basis for CSF analysis.

2.2. Definition of CCMS

A typical content management system (CMS) is a technology that is used to create, manage, and publish content at a document level, with the core functions being indexing, search and retrieval, format management, and revision control.

A CCMS is a type of CMS that manages content at a component level rather than at the document level. A component is a chunk of structured content of any length that is independent and self-contained (Baker, 2019), which can be a single word, a series of paragraphs, an image, or a video. More specially, a CCMS is a technology that relies on markup languages, most often XML, to "store content" "as textual and graphical components"; these systems "mediate the workflow to collect, manage, and publish content" (Dayton & Hopper, 2010). In most cases, a CCMS is composed of authoring tools that support markup languages, database platforms that store and manage components, and publishing engines that create the final outputs. Zhang (2016) clarified the common basic parts of CCMSs and defined a CCMS as "a package of integrated technologies that are used to collect, create, maintain and publish content components, which include an XML technical authoring tool, database platforms that store components and sometimes images, and a publishing engine" (pp. 4-5).

This study applies Zhang's definition and modified it into "a package of integrated technologies that are used to collect, create, maintain, *repurpose*, and publish content components, which include an XML technical authoring tool, database platforms, and a publishing engine." A small change is made in the new definition. The "repurpose" is added as one the main functions of CCMSs, as many studies (Andersen & Batova, 2015; Clark, 2016) have emphasized that content reuse is one of the major goals of CCMSs.

2.3. Benefits and challenges of applying CCMS

Along with an increasing number of organizations adopting CCMSs, the field of technical communication witnessed a transition from traditional documentation writing to technical content management, which greatly accelerate the pace of documentation and encourage the reuse of content. In TC groups, the introduction of CCMS has led to changing working processes, a wider range of tasks, shifting roles of technical communicators, and some other changes on the organizational and individual level. Take technical communicators for example, after the adoption of CCMSs, they have to move towards the new approach and must "learn to write modular, component-based, context-independent content using a new breed of technical authoring tools" (Rockley, Manning & Cooper, 2010). These changes lead to both benefits and challenges that technical communicators and organizations experience in a CCMS-based working environment. Antecedent studies have identified some of these benefits and challenges, including the component-based writing, metadata, reuse of component, the separation of content and layout, publishing, workflow, usability and cost (Bailie & Huset, 2015; Zhang, 2016).

2.3.1. Benefits

In CCMSs, the approach of documentation is changed from a document-based one to a component-based one (Andersen, 2013). By breaking content into components, small pieces of self-contained information that is structured and reusable, CCMSs promote the components being "repurposed in multiple outputs for multiple audiences" (Andersen & Batova, 2015). Another benefit is about metadata, the data for components in a CCMS, which promises the search and management of all the components. By writing metadata for each component, information is stored in a CCMS in a structured and connected way, and members of the organization "could build on that shared knowledge and find information across the organization with the help of the embedded metadata" (Rockley et al., 2010). The reuse of components is the biggest benefit of CCMSs, which avoids inconsistency of the information and reduces the labor and cost of writing. In tradition working environment, the copy-and-paste form of content reuse is quite natural and widely used, but also "the most error-prone, inefficient and costly method of content reuse" (Abel, 2013). In CCMSs, the single-sourcing approach enables authors to edit the reused information in one place and update the changes to all the places where the edited component is used. CCMSs feature a separation of content and layout, which "allow for rapid reuse and repurposing of content" (Clark, 2007). Clark said that the separation of content and outlet enables information to be automatically altered to appear in different channels and devices. This also indicates that publishing in CCMSs enjoys more flexibility. The study conducted McCarthy, Grabill, Hart-Davidson, and McLeod (2011) showed that CCMSs simplify the workflow of documentation and own a great usability.

2.3.2. Challenges

CCMSs also bring many challenges. Abel (2013) pointed out that the transition to the new component-based approach is "not an easy change for many" traditional technical communicators. Another big challenge for these communicators is writing metadata (McCarthy et al., 2011). In McCarthy's study, they also noticed that many communicators did not understand the value and necessity of using metadata and they did not know how to tag metadata in an effective and efficient way. For the reuse of component, Clark (2002) said that the practices to make components as reusable as possible may result to creating

components that "aren't perfect fits for any contexts". As some communicators would still want to control the layout with the content rather than address them individually (McCarthy et al., 2011), the separation of outlet and content "can create philosophical and cognitive dissonance" (Clark, 2007) for these technical communicators. Johnson (2009) observed that "the more developed a content management system" is, "the more options it has", and technical communicators often struggle with the complicated technical operations and think that CCMSs have a bad usability. In addition, for many organizations, the cost of a CCMS may block them to implement one. Zhang (2016) observed the challenges of workflow and collaboration among different roles within and without documentation groups. Some interviewees in her study reflected that they need to involve other people in the organization in supplying information after adopting a CCMS, but the collaboration across the departments is not easy. It is worth noting that Zhang said that the above-mentioned challenges can be solved fully or to a certain degree if the CCMS is properly implemented.

2.4. Earlier research work on CCMS implementation

2.4.1. Aspects of Implementation

The implementation of CCMSs is a complicated process that include many aspects. Zhang (2016) listed some major aspects according to the interview, including technical support, training and learning, conversion and migration of documents, content modeling, layout and template design, usability implementation, fitting a CCMS into whole organization, and redesign of functionality of a CCMS, roles and workflow. Zhang's study also indicated that the aspects may has different timelines. Some may start from the beginning of the implementation and still last after the implementation, such as offering technical support and training, and other may be conducted at a later stage of the implementation, such as converting existing documents with other formats into XML-based components and migrating them into the CCMS.

2.4.2. Definition of Implementation

There is no standard definition of CCMS implementation in antecedent studies. Andersen (2014) applied Rogers' Diffusion of Innovation Theory (1962) which described implementation as putting the innovation to use if it has been adopted. In the 5-stage framework provided by the theory, before the implementation stage, preliminary researches had been done in the knowledge stage to explore CCMSs, and decisions about adopting the new CCMS had been made in the persuasion and decision stage; after the implementation stage, the group would confirm whether to continue or discontinue use by weighing the advantages and disadvantages. Coggio (2015) divided the development of a CCMS into three stages: early investigation, active development, and launch. The launch stage is similar to the implementation stage in Diffusion of Innovation Theory. Compared with Andersen's study, Coggio offered more details when describing the implementation. For example, it set two end points of the stage, one being the time when the CCMS is used to produce more than 95% of the content in the Technical Communication department, and the other being the time when every member of the department respond that they fully accept the system. In Coggio's case study, the implementation started when two technical communicators began using the system for a small-scale deliverable. To investigate the different way of defining CCMS implementation, this first sub-question of this study is as follow:

SQ1: How do technical communicators define CCMS implementation in organizations?

2.4.3. Phases of Implementation

The implementation of a CCMS cannot be completed in one go. According to Dayton and Hopper's survey (2010), most of the technical communication groups completed the implementation within a year,

with the mean being 7.9 months and the median being 6 months, while some groups experienced very long implementation times over 2 years. The implementation is a long process with several phases.

Only a few scholarly and trade publications described the phases of CCMS implementation with detailed and concrete information. In the case study conducted by Coggio (2015), the implementation went through five phases: pre-training, small-scale practice, system refinement, large-scale practice, expansion in the number of languages and document types. Based on the experience of successfully implementing a CCMS in her team, Shumate (2011) suggested that the implementation was broken into four phases: preparation, training, pilot implementation, large-scale practice. Both Coggio and Shumate analyzed the phases from the perspective of technical communication groups. The guide given by Oberon Technologies, Inc. (2018) planned the implementation as five phases: analysis and infrastructure setup, deploy core pilot, extensions and integrations, system refinement, full deployment. Oberon Technologies, Inc. analyzed the phases from the perspective of solution suppliers and emphasized the importance of system infrastructure, extensions and integrations. More studies need to be conducted to explore further on the phases of CCMS implementation in organizations. Therefore, the second sub-question of this study is as follows:

SQ2: What are the phases of CCMS implementation in organizations?

2.4.4. Suggestions on Implementation

To help other organizations implement a CCMS successfully, some CCMS vendors and technical communication groups which have completed the implementation gave their suggestions or shared the lessons they learned on CCMS implementation. Many of these suggestions emphasized the importance of expectation management, training, communication, planning, and pilot projects (Andersen, 2014; Batova, 2019, 2018, 2017; Shumate, 2015; Oberon Technologies, Inc., 2018; Pennington, 2007; Tjong, 2017; Vasont Systems, 2020). Some resources highlighted the need to apply a phased approach (Shumate, 2015; Oberon Technologies, Inc., 2018), but did not state clearly what should be done or what could be done in each phase to promote the implementation. Most of these suggestions were quite general and could not be connected to a specific phase, as the implementation of CCMSs was considered as an integrated process, which failed to discuss the differences among the phases of implementing CCMSs. More studies need to be conducted to explore what should be emphasized in different phases of CCMS implementation.

2.4.5. Roles of Technical Communicators

In the implementation of CCMSs, what role technical communicators play and should play deserves discussion. Coggio (2015) explored the technical communicators' influences on the decision of adopting CCMSs and found that the pro-innovation bias, the lack of adequate vocabulary for communication, and the rhetorical sensitivity influenced the adoption of a CCMS among technical communicators. Since the study mainly focused on the technical communicators' influences on the decision of adopting CCMSs, only a few words from technical communicators about the reasons why they adopted the technology were collected, and only a little attention was attached to their understandings of implementing CCMSs. Batova and Andersen (2017) listed the important skills that can help technical communicators survive and achieve success in CCMS-based working environments, but did not mention whether there is a priority among them in different phases of implementing CCMSs.

Although some antecedent studies have explored the role of technical communicators in the implementation of CCMSs, most of them analyzed the problem from the organization's or the industry's perspective, which overlooked technical communicators' thoughts. As technical communicators may largely influence on the implementation of CCMSs, more studies need to be conducted to explore their

thoughts on implementing CCMSs which may provide insights into what aspects should be emphasized in different phases and throw light on how to promote the implementation of CCMSs in organizations. Therefore, the third, fourth, and fifth sub-question of this study are as follows:

SQ3: What challenges are recognized by technical communicators in different phases of CCMS implementation in organizations?

SQ4: What measures are taken by technical communicators to overcome the challenges in different phases of CCMS implementation in organizations?

SQ5: What benefits are recognized by technical communicators in different phases of CCMS implementation in organizations?

3. Methodology

In order to gain comprehensive and in-depth insights into the research question, this study applies the qualitative method of semi-structured interviews with the technical communicators who have experience with CCMS implementation. 11 interviewees participated in this study. This study was approved by the Ethics Committee of the Faculty of Behavioural, Management and Social Sciences at the University of Twente.

3.1. Data collection

3.1.1. Participants

This study invited 11 technical communicators, including 3 Dutch and 8 Chinese, to participate in the one-on-one semi-structured interviews. LinkedIn was used to search and contact potential participants. The 3 interviews with Dutch were conducted in English and the 8 interviews with Chinese were conducted in Chinese. All the interviews were conducted online via video conference.

The 11 interviewees included 3 consultants from CCMS suppliers (1 of them were also CCMS engineer and used to be a technical author and 1 of them used to be an information architect) and 7 technical authors (2 of them were also system administrators and information architects, 2 of them were also team managers, 1 of them were also a release manager) who worked in a TC group applying a CCMS, and 1 E-learning designer who worked in a TC group but did not use the CCMS to create content. All of the 11 interviewees have participated in or are experiencing CCMS implementation in their organizations.

None of the interviewees came from the same company. In the 3 consultants, 2 were from software resellers and 1 was from a solution provider. Apart from the 3 consultants, the 8 interviewees came from 8 companies, including 1 small, 3 medium, and 4 large companies. These companies included software companies (1 interviewees), hardware companies (4 interviewees), information service companies (2 interviewees) and livestock management company (1 interviewee). Half of these companies had only one technical communication group that worked at the same site, and the other half had several technical communication teams that worked at different sites. Half of these companies used Microsoft Word to create content before their CCMS implementation, and the other half created documentation in XML but did not follow the standard of DITA before applying the CCMS. Only 2 of these companies had used a CMS before the implementation of CCMS.

3.1.2. Interview questions

To gain comprehensive and in-depth insights into the research question as well as the sub-questions, the semi-structured interview was designed to be composed of some predetermined questions as conversation starters and interview frameworks, and some follow-up questions which were asked spontaneously to obtain more in-depth understanding of the feedback.

The predetermined questions were written down as interview question lists (see Appendix A) before the interviews. There were two variants of interview question lists which were written in two languages, English and Chinese. This study composed two versions of interview question lists: a version for consultants from CCMS suppliers and a version for other technical communicators working with a CCMS. There was a slight difference between the two versions. The interview question list for technical communicators was comprised of four sections: team condition, CCMS implementation, critical success factors, and evaluation and suggestion; the version for consultants did not include the section of team condition, because the background information of CCMS suppliers was not the focus of this study.

The section of team condition aims to investigate the conditions of the TC team and the organization that the interviewee belongs to. The section of CCMS implementation aims to investigate the interviewees' understandings of the overall CCMS implementation process, including their definition, their engagement and the phases they identified. The section of critical success factors aims to explore the interviewee's thoughts of CCMS implementation in different phases, including the challenges that they faced, the solutions to these challenges, and the benefits of preventing potential challenges, which could be refined into critical success factors. The section of evaluation and suggestion aims to collect the interviewee's suggestions on CCMS implementation.

Both versions of interview question lists were written in English and Chinese. In order to ensure the quality of the content and structure of the English and Chinese versions, this study conducted a back-translation procedure. The author firstly designed the English version for technical communicators and then took it as a basis to design the English version for consultants. After that, these two English lists were translated into Chinese by the author, a native speaker of Chinese. Then, the Chinese lists were back-translated by a professional Chinese-English translator. This study found that the back-translated lists and the English lists were comparable to each other.

Follow-up questions were asked spontaneously to gain more comprehensive insights into the issues. For example, when a technical author identified "converting other manuals" as one phase of CCMS implementation, some questions like "Did you convert all the manuals or just some of them into the CCMS?" and "Was the conversion automatically or manually?" were asked to obtain more information.

3.1.3. Procedure

The participants were sent an introduction of this study (see Appendix B) and an informed consent form (see Appendix C) via E-mail once they agreed to accept the interview. The introduction of this study aims to enable participants to have a basic understanding of this study, including the context, topic, values, and method of this study. The informed consent form aims to inform participants some basic information about the upcoming interview, including the purpose, the time needed, the request of recording, the privacy issues, and the interviewee's rights. The interviewee was asked to read the form carefully before the interview. All of the interviewees agreed to the form. 3 interviewees sent a signed informed consent form back via E-mail before the interview and 8 interviewees showed their agreement through a recorded oral consent prior to the interview. The 11 interviews were recorded by electronic devices according to the consent given by interviewees. The average length of the interviews was about 60.4 minutes, with the

longest interview being 81.1 minutes and the shortest one being 47.5 minutes. In case of any mechanical failure, 2 recording devices were used to record audios and 1 screen recorder software to record videos in every interview. During the interview, some notes were taken to mark the key information.

3.2. Data processing

3.2.1. Transcribe the recorded audios

The recorded audios were transcribed manually in a word-by-word manner. When some parts of the audios were not clear enough for transcription, sometimes due to a sudden noise or device problems, the recorded videos of online interviews were used as an assistant to identify the information delivered by the audios. 3 transcripts were in English and 8 transcripts were in Chinese. After a careful manual check, the transcripts were ready for the coding process.

3.2.2. Code the transcripts

The coding process was conducted in the software ATLAS.ti which is a powerful tool for the qualitative analysis of large bodies of unstructured data and enables the user locate, code, and annotate in data material. The design of the coding process is based on the study of Hruschka et, al. (2004).

In the first step, the transcripts were read carefully and segmented manually into smaller pieces based on the content of the text. The information contained in every segment needed to be independent, complete and relevant. The segments were marked as quotations in ATLAS.ti. Every time a quotation was marked, an English note explaining the theme of the segment and highlighting the key information within the segment was added at the same time. After the first round of segmentation, two rounds of checks were conducted to make the segmentation optimal.

In the second step, an initial codebook was created based on the notes of the themes. During the segmentation, a set of themes was proposed. These themes were examined based on their relevance to the research question and the sub-questions. The refined themes were divided into 2 groups, phase and CSF, which were identified as the code group. The code group "phase" referred to the phases of CCMS implementation that interviewees identified, and it was further categorized into 5 upper-level codes: system preparation, promotion, pilot practice, training, large-scale practice. The code group "CSF" referred to the activity or information that interviewees mentioned when discussing different phases of CCMS implementation, and it was further categorized into 3 upper-level codes: challenge, solution, benefit. The "challenge" marked the information about the challenges that interviewees confronted with; the "solution" marked the information about the solutions that interviewees took to overcome challenges; the "benefit" marked the information about the measures that interviewees evaluated able to prevent potential challenges. Some upper-level codes were further divided into lower-level codes. For example, the "system preparation" was categorized into 5 lower-level codes: conduct information analysis, make a content model, make an information model, specify outputs, conduct delivery test. In the codebook, a short comment was added on every code to explain its definition. Both the codebook and comment were written in English.

In the third step, the segments were coded according to the initial codebook. Segments were tagged with one or more codes in ATLAS.ti. In most cases, a segment was tagged with at least two codes, one from the "phase" code group and the other from the "CSF" code group.

In the fourth step, the reliability of the initial codebook was assessed by a second coder. 30% of the total interviews were selected randomly from the 11 interviews. The segmented transcripts of the 3 selected interviews and the initial codebook of the upper-level codes was given to the second coder. The second

coder was proficient in both English and Chinese. In ATLAS.ti, the second coder could see the segments marked as quotations by the author and the upper-level codes. The second coder tagged the segment with codes based on personal understanding. Cohen's kappa was applied to assess the reliability, and the Cohen's kappa value was 0.74.

In the fifth step, the second coder and the author discussed their problems and confusions on tagging codes, code definitions, and codebook modification. The code "pre-training" was modified to "promotion" for highlighting the distinction between it and "training".

3.2.3. Translate the segments being quoted

Since the translation of all Chinese transcript would result in a large work burden and be not necessary, the author only translated the Chinese segments being quoted by the thesis into English. To assess the quality and accuracy of the author's translation, a Chinese-English translator conducted back-translation on these quotations.

4. Results

The results of this study were reported in three areas: definition of CCMS implementation, phases of CCMS implementation, and the challenges, solutions, and benefits in every phases.

4.1. Definition of CCMS implementation

The interviews asked several questions designed to investigate the interviewees' definition of CCMS implementation. To drive interviewees to offer more detailed answers, the interviews asked them to mark the beginning and the end of CCMS implementation. There were 9 interviewees, including 3 consultants from CCMS suppliers and 6 technical authors from technical communication groups sharing their insights. Not all interviewees responded to this question, because 2 of them participated in the CCMS implementation in their companies midway and could not specify what the starting point was.

Table 1 presents the results of the question regarding the starting point and end point of CCMS implementation. According to the table, the delivery of CCMS is the milestone recognized by both CCMS suppliers and TC groups. As can be seen, while the CCMS suppliers marked it as the end point, the TC groups marked it as the starting point. There is a gap between CCMS suppliers and TC groups in terms of defining CCMS implementation.

Table 1. *Starting Point and End Point of CCMS Implementation*

Interviewees	Starting Point	Number of Interviewees	End Point	Number of Interviewees
Consultants from CCMS suppliers	Selection of the CCMS	3	Delivery of the CCMS	3
Technical authors from TC groups	The first task of creating content in the CCMS	3	Creating different content in the CCMS	3
	Delivery of the CCMS	1	Smooth workflow	2
	At least one person can handle all things	1	Every team member can handle all things	2
	Draw a blueprint	1		

As can be seen in Table 1, people in different roles had different understandings of CCMS implementation. All the CCMS suppliers shared a similar definition and defined the CCMS implementation from the angle of system. In their view, once their solution was selected by their customers, the implementation started, and the end point of the implementation was the delivery of the system. By contrast, the technical authors in TC groups described the CCMS implementation from different angles. Half of the technical authors gave a definition from the angle of task. They thought the implementation started with "the first task of creating content in a more structured way with the CCMS" (TA2) and the end point was to create and publish different documentation types with the CCMS. The other half of the technical authors explained the implementation from the angle of system or capability. From the angle of system, the implementation started when "the CCMS was installed and deployed in the organization, getting the environment ready (for the implementation)" (TA7) and ended when "the workflow was smooth" (TA2) and the system was optimally running. The angle of capability focused on the technical authors' ability to create and maintain content in the CCMS. Since the successful installment and deployment of CCMS is the precondition of either creating the first content in the CCMS or checking the capability to handle all things with the CCMS, for most technical authors, the delivery of CCMS could be regarded as a milestone that marked the beginning of CCMS implementation no matter which angle they have approached it from. Only one technical author marked the activity of drawing a blueprint for documentation as the starting point, and this activity was conducted before the delivery of CCMS.

One interviewee noticed and pointed out the different definitions of CCMS implementation by people in different roles. As the interviewee said: "People in different roles have different understandings of (CCMS) implementation. For an IT professional, the implementation refers to the process from system acquisition to system delivery. For our technical writing team, the implementation starts with information architecture" (TA8).

It is remarkable that although most technical communicators in TC groups didn't include the activities before system delivery in the process of CCMS implementation, they all emphasized the importance of early preparation during the interviews.

4.2. Phases of CCMS implementation

The interviews asked several questions about the phases of CCMS implementation that were identified by the interviewees. All the interviewees shared their insights about the different phases in the process of CCMS implementation based on their experience and understanding. Table 2 lists the phases of CCMS implementation identified by the interviewees. According to the table, there were five phases of CCMS implementation, but not all the phases were pointed out by all the interviewees.

Table 2. *Phases of CCMS Implementation*

Phases	Number of Interviewees	Explanation
System preparation	11	Refine the needs of TC groups and prepare a CCMS that meet the needs
Promotion	8	Promote the CCMS to TC groups and make them accept it
Pilot practice	8	Create, manage, and publish the first content with the CCMS
Training	11	Train on topic-based writing and the CCMS
Large-scale practice	9	Migrate old content or create new content in the CCMS

Only system preparation and training were identified by all the interviewees. Large-scale practice was pointed out by 9 interviewees, including 2 CCMS consultants and 7 technical authors. Both promotion and pilot practice were identified by 8 interviewees, including 2 CCMS consultants and 6 technical authors.

A technical author did not share insights into promotion, pilot practice and large-scale practice, because the self-developed CCMS was too difficult to use and the organization stopped the implementation midway. There was a CCMS consultant who also failed to identify these three phases, as the consultant only focused on CCMS suppliers' scope of work, especially the system preparation.

4.2.1. System preparation

System preparation refers to the phase of preparing the CCMS that meets the needs of TC groups. Both CCMS suppliers and TC groups (mostly the project team of the TC group) participated in this phase. Most of the TC groups identified system preparation as an integrated phase and did not include it into the implementation, while the CCMS suppliers often broke this phase into several sub-phases. Table 3 lists the sub-phases of system preparation recognized by the interviewees from the perspective of CCMS suppliers and TC groups.

Table 3. *Sub-phases of System Preparation*

Interviewees	Sub-phases	Explanations	Sample quotations
Consultants from CCMS suppliers	Conduct information analysis	To refine TC group's needs for information	"… phase is information analysis, what is the sort of information that you are going to make, who are the users for this information, the user groups whether they are engineers internally or end-users externally so they need different approach." (C1)
	Make a content model	To design a model in terms of DITA to satisfy TC groups' needs on content.	"… phase is to make a content model. We try to find the best model in terms of mostly DITA, what are the elements you need to create what you want." (C1)
	Make an information model	To design a model that explain how information interact between different protocols.	"The information model explains what are going to be sent to what protocol and how do they interact." (C1)
	Specify outputs	To refine TC groups' needs and requirements on outputs.	"Then you basically have everything, you may need to specify the output better. There is a sort of rules, like the marketing department would design the logo, the colors, the foot you need, so they often already have a style guide." (C1)
	Conduct delivery tests	To test the system before the delivery.	"When the system is implemented, you do the test, FAT (Factory Acceptance Test) and SAT (Site Acceptance Test)." (C1)

Technical authors from TC groups	Draw a blueprint	To clarify TC group's needs for information	"The first step was to draw a blueprint of information needs, to clarity our needs by pictures …" (TA5)
	Internal review blueprint	To review the blueprint internally	"… then the company conducted internal reviews on the blueprint; the blueprint was sent to the technical consultant of the CCMS supplier once it was approved." (TA5)
	External analyze blueprint	To evaluate the feasibility of the blueprint	"… (the technical consultant) analyzed the blueprint, to see if there were technical barriers to realize these needs; whether these needs can be met was reviewed by the research and development (R&D) consultant." (TA5)
	Test system	To test the system provided by the CCMS supplier	"Then deployed the platform and tools. Once they were deployed, the company conducted internal tests on the feasibility of the set of tools and the compatibility of the tools with other platforms." (TA5)

It is worth noting that the sub-phases defined by CCMS suppliers and TC groups, to a large extent, match each other. The combination of "conduct information analysis" and "specify outputs" is equivalent to the combination of "draw a blueprint" and "internally review blueprint". "Make a content model" is comparable to "externally analyze blueprint" and "conduct delivery test" is similar to "test system". The only sub-phase identified by CCMS suppliers that could not find a match is "make an information model", since this sub-phase is not an essential step for all TC groups and companies. Whether a TC group needs an information model or not depends on how complicated the ICT infrastructure and the organization are. There is also a slight difference between "conduct delivery test" and "test system". Normally, the delivery tests defined by CCMS suppliers include two types, Factory Acceptance Test (FAT) and Site Acceptance Test (SAT). FAT is an internal test conducted by CCMS suppliers to check the system itself, while SAT is conducted by CCMS suppliers and TC groups together to see whether the system works well at the TC group's site after system installation. "Test system" defined by TC groups only refers to conduct the SAT.

4.2.2. Promotion

In the promotion phase, the CCMS was promoted to members of TC groups or even other departments in order to make them aware of the importance and urgency of CCMS adoption and encourage them to accept the CCMS and get ready for the follow-up tasks. The content of the promotion was mainly about the concept, background and value of the system. Figure 1 presents the topics mentioned by interviewees when they share their insights into the content of promotion.
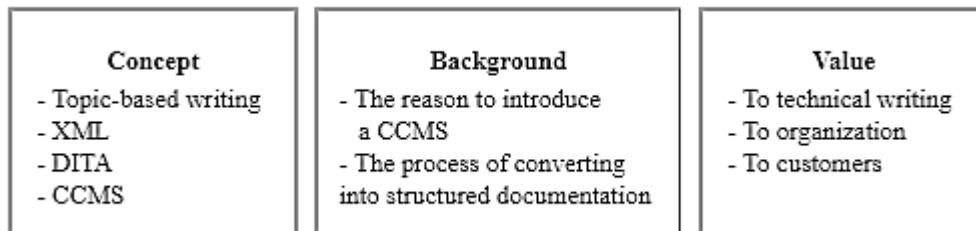

Figure 1. Content of Promotion

Different TC groups included different contents in the promotion based on their own situation. Some TC groups were used to a CMS and could see the advantages of a CCMS, and therefore there was less introduction about CCMS and the reasons to adopt a CCMS. In Europe, as an interviewee said, "there are many companies aware of what topic-based writing is, they have all heard of it and have some concepts" (C1), and thus the introduction of topic-based writing was not necessary for these companies. Both CCMS suppliers and TC groups participated in the promotion and could play the leading role. But if the TC groups had no idea what CCMS and topic-based writing are, the CCMS suppliers should take the lead.

4.2.3. Pilot practice

Pilot practice refers to the phase of conducting the first project of creating, managing, and publishing content with the CCMS. In this phase, TC groups were the protagonist and the project teams often played a leading role. When TC groups confronted difficulties and asked for help, CCMS suppliers would intervene and try to find solutions. Most of the TC groups split this phase into six sub-phases. Table 4 lists the sub-phases of pilot practice identified by interviewees from the perspective of TC groups.

Table 4. *Sub-phases of Pilot Practice*

Sub-phases	Explanations	Sample quotations
Select	To select one manual or the manuals of one product as the object of the pilot practice.	"To select which product as the object of the pilot is related to the product's form, for example, software or hardware, the frequency of publication and updates, such as updating every two weeks, once a month, or once a year, and so on." (TA7)
Analyze	To analyze the content and structure of the selected object.	"Analyze the content and structure of the documents, and think about how to migrate the content from the old platform to the new platform, including the reuse and splitting of documents." (TA7)
Plan	To make a plan for the pilot practice.	"In the planning phase, the project manager would confirm the product development cycle with the product development team, (for example,) whether a version would be delivered in two weeks or two months. This plan would affect the release of documents." (TA7)
Prepare	To make the content ready for conversation.	"When we started, we decided to roughly distinguish the types of topics, such as marking a topic as a concept, and then it was imported directly into the system as a concept." (TA6)
Convert	To import the content into the system and convert it.	"The next step is conversion, in which tools can be used." (TA7)
Post-convert	To check the content and correct the errors.	"At this time, we still needed to read the manuals one by one and correct all the errors, including the misuse of links and tags." (TA6)

TC groups usually regarded the pilot practice as a small-scale test. It was a chance to uncover problems with CCMS not discovered during the system preparation and to adjust the system before it was put into

use on a large scale. Another objective of the pilot practice was to set an example that people could follow once they started to create content with the system. During the pilot practice, TC groups defined roles and responsibilities, set up the workflow, and designed rules and regulations. Based on the needs, some TC groups also created their own training materials, such as the user manual for the system, when they conducted the pilot practice.

Some interviewees highlighted the relationship between preparing and post-converting. When the interviewees (TA6 and TA7) roughly measured the workload in different sub-phases, both preparing and post-converting account for 35%, the biggest workload, while the proportion of analyzing, planning, and converting were 15%, 20%, and 5% respectively. Preparing and post-converting both aim to improve the content quality and the interaction between them is noticeable. The standard of the preparation has a significant influence on the workload of the post conversion. A poor preparation would result a long-time post-conversion, as there would be many errors after the conversion. In addition, the sum of time spent on the two sub-phases is relatively constant, which depends largely on how structured and standard the old contents are. The closer the pattern and writing style of the old documents are to DITA standard, the less workload of preparation and post-conversion would be.

It is interesting to note that the sub-phases could be classified into two stages based on their participants. The content selection, content analysis and project plan are identified as the early stage, while content preparation, conversion and post-conversion are categorized as the later stage. At the early stage, the participants were in various roles, including information architects (IA), technical writers (TW), TC team managers, and project managers of CCMS implementation. Sometimes, members from other departments, such as marketing, R&D, and sales, also contributed to the activities at the early stage. To engage almost all the stakeholders of technical communication into the pilot practice at the early stage could help to make an optimum plan. At the later stage, the participants were mainly technical authors, who followed the plan and completed the preparation, conversion and post-conversion. In most cases, tasks were identified at the early stage and then were conducted at the later stage. For example, TC groups recognized the importance of content splitting when analyzed the content, and actually divided the content into different topics at the content preparation.

Remarkably, the implementation of the pilot practice varied from TC groups. For the TC groups with a large number of employees, the project team of CCMS implementation or the TC team of the selected manual or product were placed in change of the pilot practice. For the TC groups that have more than one sites responsible for documentation, the pilot practice was mostly launched by the site with the most knowledgeable and experienced members.

4.2.4. Training

In the training phase, both CCMS suppliers and TC groups, generally the experienced members in the groups, could take the responsibility of training other people. As an interviewee said, the training sessions were composed of two parts, "one is about standard structured writing and the other is about the operation of the system" (C2). Through the training on how to write and how to operate, employees of TC groups learned to write content in a topic-based way and manage content with the CCMS. According to the interviewees, the training on topic-based writing was mostly conducted before the training on system operation. The training could be conducted in different ways. Figure 2 presents the types of training methods applied in the organizations of the interviewees.
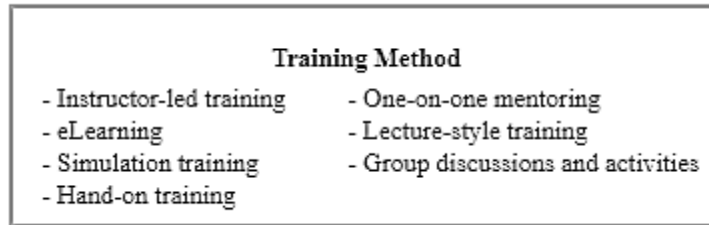
Figure 2. Types of Training Methods

Intriguingly, the form of training depended on the topic, purpose, and target group of training. When the target group was a large employee population, one-on-one mentoring and groups discussions would not be applied as they were time-consuming. One-on-one mentoring was efficient when there were only a few employees but they varied in knowledge, skills, and abilities, since they may need individualized training. For large-scale training on system operation, simulation training and eLearning were effective, as they allowed employees to progress consistently and at their own pace.

4.2.5. Large-scale practice

In the large-scale practice phase, TC groups got used to the CCMS and successfully migrated old content or created new content with the system. At the beginning of large-scale practice, TC groups needed to decide whether to convert old content to the new system or to directly create new content in the new system. The decision depended largely on the quality of old content and the capacity of TC groups. As one interviewee said: "If they really have rubbish content, if it's really bad, then I suggest that they just start by making their new content in the new system" (C1). If the content varied in quality or there were not enough human resources to re-write all the old content, converting partial content to the CCMS was an alternative. In most cases, TC groups would not convert all the old content and the selection of the content to be converted depended mainly on the use of content. The manuals of the products that are still in use and have many updates were often re-written in the CCMS. The practice of converting old content or creating new content was similar to the pilot practice, which could be further divided into six sub-phases: select, analyze, plan, prepare, convert, and post-convert.
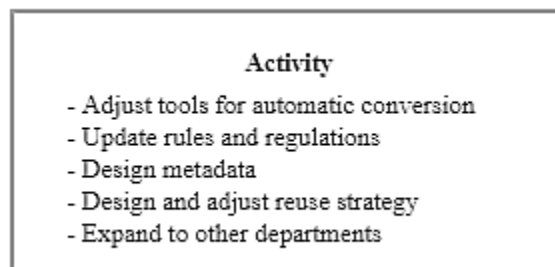
Figure 3. Activities in Large-scale Practice

Figure 3 presents the different activities done by TC groups during the large-scale practice. According to the interviewees' observation, in the large-scale practice, TC groups adjusted tools for automatic conversion, updated rules and regulations, and designed metadata to manage the rapid increasing data and content in the CCMS. Designing and adjusting the reuse strategy was an important task in this phase. Based on the needs, some TC groups also encouraged or required employees from other department to contribute to the documentation with CCMS. For example, the engineers from the R&D department could directly import some data, such as parameters and specifications, into the platform and participate in

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technical reviews in the platform after they learned how to use the CCMS. The pattern of cooperation with other departments were established in the pilot practice and became mature in the process of large-scale practice.

4.3. Challenges, solutions, and benefits

The interviews asked interviewees to figure out and describe the challenges they faced, the solutions they found to these challenges, and the benefits of preventing potential challenges in different phases of CCMS implementation. All interviewees shared their insights about the challenges, solutions, and benefits in different phases. This section will first introduce the interviewees' feedback on the challenges, solutions, and benefits in each phase, and then discuss the categories of these challenges, solutions, and benefits.

4.3.1. Challenges, solutions, and benefits in the system preparation phase

Table 5 presents the interviewees' insights into the challenges, solutions, and benefits in the phase of system preparation.

Table 5. *Challenges, Solutions, and Benefits Identified in System Preparation*

Types		Explanations	Sample quotations
Challenges	Needs	It's difficult for people to identify the needs.	"It was a pain point, many customers [TC groups] in China do not have the ability, which will cause a disconnection. They cannot specify the needs at the early stage, and later come up with many ideas and ask CCMS suppliers to solve, which will cause trouble." (C2)
	System adjustment & customization	People have no idea about how to make the system meets the needs.	"The challenge is that often they are not so much aware of what a CCMS is actually and how it works. The CCMS is new and strange to them, so that may be confusing." (C1)
	Expectation	People are overwhelmed by the expectations on the system.	"When we were drawing the blueprint, we imagined that this (CCMS) would be very perfect and idealized, mainly because we didn't know it very well." (TA5)
Solutions	Role of CCMS suppliers	CCMS suppliers play a constructive and leading role.	"The supplier is also responsible to have good discussions, not only sell a product. The supplier should play a constructive role in the conversation." (C1)
	Project team	A well-organized project team lays a solid foundation.	"Information architects (IA) are important. If the TC group doesn't have an IA, be sure to develop and train an IA." (C3)
	Positioning	Understanding the position of CCMS helps to manage expectations.	"The position of DITA authoring tool is an authoring tool and the position of CMS is the combination of database and publishing engine, and therefore, it is not

			possible to use CCMS to complete both the review work and the translation work." (TA5)
Benefits	Interactive workshops	Workshops improves the communication between TC groups and CCMS suppliers.	"We had 6 workshops, about the value chain from the distributors and manager, the information needs analysis, content model, information process, and project management." (TA2)
	Involvement of all stakeholders	Inviting various roles and stakeholders to participate in is beneficial.	"Both IA and TW were involved, because different roles analyze it from different perspectives." (TA5)
	Communication with all TC sites or teams	The communication enables the project team understand the needs for information.	"We talk with all the production sites on how do they create documentation and what types of documents do they have." (TA1)
	No DITA specification	DITA specification is better conducted at a later stage.	"DITA can be specialized. But it's risky to pursue a specialization based on business practices at the beginning, because at first (the TC group) may not know enough about content and classification is a very difficult thing to do." (C3)
	More resources in delivery tests	The more people participate in the delivery tests, the more system problems could be discovered.	"Invest as much effort as possible in the acceptance tests, no matter for the system or stylesheets. Because the problems a person can find are limited, we should ask all to test and find more problems." (TA3)

During the system preparation, the challenges were mainly about what the needs are, how to make a CCMS meet the needs, and how to ensure the needs to be real and feasible.

One significant challenge in the system preparation was that TC groups were overwhelmed by expectations. TC groups were likely to expect a system that could solve all the problems they faced and meet all the needs they identified, especially when they were not familiar with what CCMS is. However, the fact is that some needs specified by TC groups could not be met due to technical barriers. Furthermore, it is impossible to conduct all the tasks with the CCMS, as the system has its focuses and limitations. Failing to manage expectation during the system preparation could result negative attitudes towards the newly developed system.

The prominent reason of the challenges that TC groups met in the system preparation was the TC groups' lack of knowledge and experience in various aspects. TC groups did not have the confidence and ability to complete the tasks during the phase of system preparation. For example, three interviewees (C2, TA1, TA8) said that selecting applicable topics, elements and tags to make an efficient content model was challenging for the group, as they had not built a comprehensive understanding of topic-based writing at that time. For another example, one interviewee (C1) said that it was difficult for the TC group to design

the information model alone, because members in the group were unfamiliar with the ITC infrastructure and protocols.

There were some solutions to the challenges in the phase of system preparation. First, CCMS suppliers should play a constructive role in the conversation with TC groups and assist TC groups to prepare an ideal CCMS, if TC groups lacked knowledge and experience. By introducing concepts or asking questions, CCMS suppliers helped TC groups generate a clear understanding, which paved the way for efficient communication between TC groups and CCMS suppliers. Second, a well-organized project team should be established to lay a solid foundation for the system preparation. The project team of CCMS implementation in TC groups was mostly composed of managers, information architects (IA), and technical writers (TW). An experienced information architect (IA) was necessary for a good project team, as the IA could play a vital role in conducting information analysis, designing content models, and refining needs. An internal IA would be better than an external one, as the internal IA would be more familiar with the customers and their demands. Third, TC groups should understand the position of CCMS during the system preparation, which could help them manage their expectations.

The interviewees identified many benefits that were able to prevent potential challenges or improve the system preparation. Involving various roles and stakeholders to participate in the system preparation is a significant benefit. First, the participation of different roles could promote TC groups to have a more comprehensive understanding of the implementation, as different roles consider the matter from different perspectives. Second, the communication between TC groups and CCMS suppliers could be more efficient if different stakeholders were involved. For example, IT departments was familiar with ICT infrastructure and could discuss with the suppliers about the information model. Third, inviting colleagues from other departments to participate in the system preparation and keeping them informed and updated could encourage them to accept the new system.

4.3.2. Challenge, solution, and benefit in the promotion phase

Table 6 presents the interviewees' insights about the challenge, solution and benefit in the phase of promotion.

Table 6. *Challenge, Solution, and Benefit Identified in Promotion*

Types		Explanations	Sample quotations
Challenge	Motivation	It's difficult to arouse people's desire to use the CCMS.	"… in the promotion, how to encourage the (TC) teams of the various product lines within the company to participate in requires a good approach. (We need to find) a good approach to arouse their desire to use the CCMS." (TA8)
Solution	Benefits	Informing people of the specific benefits the CCMS could bring to them is inspiring.	"… we informed our colleagues … what are the advantages. That's very important. It inspired them about the situation, so that was very positive … for example, with the product update, it's easy to update the documentation." (TA2)
Benefit	Case sharing	Inviting external organizations to share	"… external people were invited to share cases of the conversion to structured

| | | their experience is beneficial. | writing, making people know what problems may be encountered in the process and what benefits can be brought to the team." (TA3) |

The objectives of the promotion were to not only help TC groups learn about the CCMS, but also to encourage them to hold a positive attitude towards the system and motivate them to accept it. However, arousing people's willingness and desire to use the CCMS was a challenging task. People could be accustomed to and satisfied with the old way of documentation, such as linear writing with Microsoft Word, and thought it unnecessary to convert to topic-based writing and adopt a CCMS.

The solution to the challenge was to inform people of the benefits that could be brought by the CCMS to their work. When introducing the advantages of the system and topic-based writing, TC groups need to enable people to see the relevance between CCMS adoption and their work. Different roles obtained different benefits from the transition. Making people see the specific benefits that CCMS could bring to them was more effective than listing the general advantages of the system.

The interviewees said that inviting external people to share their experience of CCMS implementation and adoption was beneficial to the promotion. During the case sharing, the external organizations introduced the problems they encountered, the benefits they identified, and the feedback they received from their customers. As an interviewee (TA2) said, colleagues thought the case sharing by external organizations were more convincing than the presentations given by the internal people.

4.3.3. Challenges, solutions, and benefits in the pilot practice phase

Table 7 presents the interviewees' insights about the challenges, solutions, and benefits in the phase of pilot practice.

Table 7. *Challenges, Solutions, and Benefits Identified in Pilot Practice*

Types		Explanations	Sample quotations
Challenges	Bad usability & system failures	A CCMS is hard to use or with many failures, which may influence the process of work.	"Because we really used the tool for documentation once it was deployed to the computers, if the tool encountered some problems, it would actually interrupt the day-to-day work and affect the progress of content delivery." (TA5)
	Collaboration among different roles	The way of collaboration is changed in a CCMS-based working environment.	"We hoped the product development engineers could review content or directly import some data, such as parameters and specifications, into the platform, but they thought these were additional workload and burden, as they needed to learn this platform which was very complicated." (TA7)

	Goal-setting	It's difficult to measure improvement and set goals.	"This requirement cannot be quantified. There is no clear way to judge whether the goal is achieved or not. It is difficult to explain, if the manager questioned whether it [the conversion to topic-based writing] has improved the quality of content." (C3)
Solutions	FAT	CCMS suppliers conducts FAT to reduce failure rate.	"But first you need to test it for yourself to find is there a thing that you just forget. It is stupid that you implement the system at your end-user's site and then find 'Oh, I forgot this'." (C1)
	Plan B	Design an alternative plan to ensure delivery on time.	"During the pilot practice, there must be an alternative plan. In the event of system problems, there is still another solution to ensure the normal development and delivery of manuals." (TA5)
	Flexible workflow	Setting up a flexible workflow at the beginning and adjust it in a later phase.	"So, I suggest that you set up workflows and permissions first, which can be flexible at this point, so that people can use the system first." (C3)
	Role-based user manual	The role-based user manual created by TC groups helps people know how to work with the system.	"… manuals that are written based on roles. People in different roles have different divisions of labor, and they work in different modules in the system." (C2)
	Library of conversion examples	People can learn about the standard of content conversion by checking examples in the library.	"… a library of conversion examples, showing what the original manual was like and what it would be like after being converted into structured content. Such examples of content conversion were archived as a library …" (TA5)
Benefits	Enough resources at the early stage	Invest enough time and resources in the early stage is beneficial.	"I recommend that the time allocated to the early stage must be sufficient, so as to reduce the workload of the later stage." (TA6)
	Consideration for the proficiency	Take the proficiency of TC groups into consideration when selecting product and making plan.	"… when the employee maturity is not high, TC groups could take the product with a longer cycle as the object of the pilot practice, so that they have enough time to complete. But in reality, (the product with a cycle of) two weeks have a stronger demand for DITA, because DITA is more suitable for fast-pace response. Of

| | Competitive analysis | Learning from competitors helps TC groups to analyze content. | course, it's a big test of employee maturity." (TA7)

"In the phase of analyzing the content and structure of the selected manual, if (the TC group) cannot find the direction, it can conduct competitive analysis and look how peers or competitors design the architecture and outputs. These are often shared and communicated." (TA7) |
| --- | --- | --- | --- |

The difficult collaboration among different roles was the most significant challenge in the phase of pilot practice. The collaboration among different departments was changed in a CCMS-based working environment, and it could be challenging for people outside TC groups to adapt it. There were three reasons for the difficult collaboration among different departments. First, employees outside the TC group needed to learn CCMS, which could be an additional burden. Second, an account was needed for people to sign in and contribute to the documentation with CCMS, but some people could not access to an account. For example, in addition to the internal engineers from the R&D department, the external customers invited by the market development department could also participate in the review process. However, the external customers could not log into the system to review the content. Third, employees from other departments preferred to use other tools instead of a CCMS. Different departments had different needs and priorities and using a CCMS might not be the best choice for them. The way of communication was also altered during the pilot practice, which could lead to difficult collaboration among different roles. For example, in a CCMS-based working environment, once the content was ready, it could be sent to the translation agency automatically rather than by mailing or texting. The content being sent to the translation agency could be a component instead of a full document, which might confuse the translators at the beginning.

Another prominent challenge in the pilot practice was the poor usability of the CCMS. The system was found difficult to use or with many failures when TC groups conduct the pilot practice. The poor usability could result from the poor system preparation. TC groups failed to specify real needs and establish an efficient communication with CCMS suppliers, and therefore the system offered by suppliers could not meet the needs or even conflicted with the real demands. The other reason was that CCMS suppliers did not ensure the quality of the system before delivering it to TC groups. Ideally, CCMS suppliers should conduct both FAT and SAT before the system deployment. However, some suppliers delivered the system to TC groups without a FAT, and TC groups did not discover the problems with the system until they used it for a period time, since the system was new to them at the beginning. In these cases, it was very easy for TC groups to meet many system failures or even a system crash.

The interviewees specified goal-setting as a challenge in the pilot practice. One interviewee (C3) thought that it was difficult to set goals for content conversion, because there was no concrete way to measure how the content quality was improved after converting from a linear way to a topic-based way. The interviewee thought that the value of documentation was about neither the format nor the reuse of content, but depended on to what extent the content meets the needs, and therefore only converting content from Microsoft Word to DITA was not enough. TC groups found it difficult to raise an accepted standard describing clearly to what extent should the content be converted, and to set goals for content conversion based on the standard.

An important solution to enhance the collaboration among different roles was to create role-based user manuals. These user manuals were mostly created by TC groups based on real data and real products in the organizations. TC groups could start to write their own user manual for the CCMS which introduced tasks and the corresponding operations in detail during the pilot practice. Different from the on-line offered by the CCMS supplier which was in big pieces, the user manual created by the TC group was more detailed and task-oriented. To better help colleagues in different roles know how to work with CCMS and collaborate with each other, the user manuals could be written based on roles. The role-based manuals could guide people only through what they should do, rather than introducing all the tasks and processes of documentation.

Aside from good system preparation to reduce the rate of system failure, TC groups should prepare an alternative plan for documentation. During the pilot practice, TC groups conducted the first project of creating, managing, and publishing content with the CCMS, and system failures could lead to reworkings or delayed deliveries of content. The alternative plan being prepared in advance could help TC groups be least impacted by system failures or crashes and ensure the progress of work.

To help people understand the standard of content conversion comprehensively, TC groups could start to build a library of conversion examples in the pilot practice and keep update it. The conversion examples were mostly compiled by experienced technical authors based on real content. By visiting the library and checking the examples, people could get a clear idea to what extent should the content be converted. As an interviewee said, "With an example which is similar (to the current task), people are less likely to go beyond the scope, as there are less room for creation" (TA3).

It is important for TC groups to invest enough time and human resources in the early stage of the pilot practice, which consist of content selection, content analysis and project plan, and take all the stakeholders into consideration, as the outcome of the early stage was the basis of the later stage. Without a well-designed information architecture and project plan, the content conversion would be hard to conduct and the content quality would be difficult to ensure.

4.3.4. Challenge, solution, and benefits in the training phase

Table 8 presents the interviewees' insights about the challenge, solution, and benefits in the phase of training.

Table 8. *Challenge, Solution, and Benefits Identified in Training*

Types		Explanations	Sample quotations
Challenge	Training effect	It's difficult to ensure the training effect among different people.	"To do the implementation on other sites, we have to train the people, especially the people who are not used to the CCMS. After you train them a few days, you have to fly back home and you have to help them digitally." (TA1)
Solution	Form of training	Different forms of training are fit for different conditions.	"So, we regularly hold Q&A, training, sharing, case summary … to sum up the experience and learn from each other, making the whole team mature." (TA7)

Benefit	Training materials	Prepare suitable materials for the training sessions.	"Then, we trained on how to use (the system). The idea that could be followed was 'the less cost and effort, the better' … So, I suggest that when training on the workflow, everyone just focus on what they have to do." (C3)
	Sandbox	The sandbox enables people to learn by practicing.	"In the CCMS, we also had a sandbox, a copy of the CCMS, where they could try and play the system without harming the actual system." (TA1)

TC groups and CCMS suppliers organized a series of activities to train people on how to create topic-based content with CCMS. However, the training effect could be largely influenced by the trainees' level of knowledge. The interviewees noticed that some people with knowledge of CMS or structured writing found the training easy and accepted the new way of working quickly, while some people who used to work with Microsoft Word found the training complicated and difficult. It was a challenging task to guarantee the training effect among users with different backgrounds, especially those who were not used to CCMS.

To help people with different levels of knowledge learn efficiently and effectively, TC groups or CCMS suppliers need to carefully select the form of training. Compared with lecture-style training, one-on-one mentoring or eLearning could be more suitable for people with varied knowledge and abilities, as they could personalize their training content and learning progress. Group discussions and activities encouraged different people to exchange ideas and share experiences, which could help members in the group become mature quickly. Different training materials and tools could be created and applied to ensure the effect of training.

4.3.5. Challenges, solutions, and benefits in the large-scale practice phase

Table 9 presents the interviewees' insights about the challenges, solutions, and benefit in the phase of large-scale practice.

Table 9. *Challenges, Solutions, and Benefit Identified in Large-scale Practice*

Types		Explanations	Sample quotations
Challenges	Consistency	It's difficult to do topic-based writing in a consistent way.	"When the system is growing, you saw people started creating their own topics. You had to take care that it was still in line with the first thing set up. People all want to inventing their own things." (TA1)
	Data management	It's difficult to manage the increasing data and content, such as illustrations.	"Because the content in CCMS is component-based, the amount of content and data that needs to be managed is greatly increased." (C3)
	Conversion of old content	It's difficult to design and conduct the content conversion.	"Our plan was to re-write them in the CCMS. But there were only two people at that time, so it took a lot of time to re-

			write them in the CCMS. The capacity of people was always a problem." (TA2)
	Reuse strategy	It's difficult to design the reuse strategy.	"Reuse is difficult to design. Most of the time, designing reuse strategy belongs to the customer's [TC groups] part, because it depends on who is gonna reuse things." (C1)
	Process standardization	People don't adhere to the standardized process.	"Although the (standard) process was in place, someone would not follow it." (C3)
Solutions	Rules & standards	Set up rules and standards to regulate people's behavior.	"Yes, if you want to see good metadata filled, like it is obligatory … they have to fill that in; otherwise, they could not store the illustrations in the database. So, if it is really necessary, you need to make it obligatory." (TA1)
	Simplified process	A simplified standard process encourages people to follow it.	"Therefore, we must think clearly when designing the management process. First, the management process should be concise. Second, the number of management nodes should be decreased, because the amount of data has multiplied." (C3)
Benefit	Tools	Tools can be used to aid people to execute the rules and standards.	"… hope to use tools to help people better enforce the rules. At present, we have some rules. However, to follow these rules, people need to learn them and keep them in mind. We want to use tools which could remind of or prohibit actions not complied with the rules. This may be more reliable than people." (TA7)

When an increasing number of people start to work with the CCMS, how to ensure the consistency in writing was recognized as a prominent challenge for TC groups. During the large-scale practice, more and more people gradually got used to writing in a topic-based way with the CCMS. However, different people had different understanding of topic-based writing. And therefore, it was difficult to align the content created by different people, if there was not unified rules or standards to regulate the topic-based writing. If TC groups had set up some rules and standards, conveying them to different people could also be difficult. The other challenge caused by the increasing number of users was the difficult management of the rapidly growing data. Many TC groups found it difficult to manage different types of data, such as illustrations and videos, in an efficient way.

No matter how TC groups decided to convert old content to the new platform, manually or automatically, the conversion of old content in the large-scale practice was challenging. When the conversion was done by technical authors manually, the lack of human resources was identified as a challenge by the interviewees. When tools were used to convert old content automatically, the interviewees found that the

poor quality of old content could cause a lot of problems. In the automatic conversion, the quality of the outputs largely depended on the quality of the inputs. The tools could not produce high-quality content if the old content was in poor quality.

Another prominent challenge in the large-scale practice identified by the interviewees was about process standardization. A standard process, together with a set of rules and regulations, was gradually established and became mature during the large-scale practice. However, as an interviewee (C3) noticed, there was always someone who did not follow the standard process. The interviewee said:

> "*Although the (standard) process was in place, someone would not follow it. What should you do if people don't perform the actions specified in the process? The (standard) process was designed for everyone to work collaboratively and to comply with, why did not someone follow it? ... In this case, quality control needs to be added throughout the process. There is a problem: if the process is too complex, there will be actions that do not follow the process.*" (C3)

Rules and standards need to be set up to regulate people's writing and operation, which could improve both the consistency in writing and the management of data. TC groups could start to design rules and standards during the pilot practice, and keep updating them in large-scale practice. The standard of topic-based writing guided people to create content in the same way, and the rules of operation led people to perform the necessary actions. These necessary actions could be designed to improve the data management. For example, as an interviewee (TA1) said, to better manage the illustrations in the CCMS, people were required to fill in the metadata on illustrations correctly when they import the illustrations into the database, and to clean up the database by deleting illustrations not used anywhere throughout the system when they complete the documentation. Setting up rules and standard early established a solid foundation for the large-scale practice. After the rules and standards were established, TC groups could design and use tools to aid people to execute these rules and standards in the documentation with CCMS.

Another important solution mentioned by the interviewees is to simplify the standard process, which could not only reduce administration costs but also encourage people to follow the standard process of documentation. An over-complex standard process could confuse the people and make them unwilling to follow it. People were likely to find a shortcut or omit some procedures when facing an over-complex standard, and the nonstandard process of documentation might negatively influence the quality of the created content.

4.3.6. Categories of Challenges, solutions, and benefits

As Table 10 shows, the challenges identified by the interviewees in different phases of CCMS implementation could be categorized into six groups: attitudes, writing style, ability, collaboration, system, and time.

Table 10. *Challenges in Different Phases of CCMS Implementation*

Categories	Explanations	Phases
Attitudes	People hold negative attitude towards the transition to CCMS.	
Expectation	People are overwhelmed by the expectations on the system.	System preparation
Motivation	It's difficult to arouse people's desire to use the CCMS.	Promotion
Writing style	People cannot convert from linear writing to topic-based writing.	

Goal-setting	It's difficult to measure improvement of content quality and set goals.	Pilot practice
Training effect	It's difficult to ensure the training effect among different people.	Training
Consistency	It's difficult to do topic-based writing in a consistent way.	Large-scale practice
Conversion of old content	It's difficult to design and conduct the content conversion.	Large-scale practice
Reuse strategy	It's difficult to design the reuse strategy.	Large-scale practice
Ability	People are unable to conduct the implementation.	
Needs	It's difficult for people to identify the needs.	System preparation
System adjustment & customization	People have no idea about how to make the system meets the needs.	System preparation
Collaboration	People cannot collaborate well with others during the implementation.	
Collaboration among different roles	The way of collaboration is changed in a CCMS-based working environment.	Pilot practice
Process standardization	People don't adhere to the standardized process.	Large-scale practice
System	There is something wrong with the system.	
Bad usability & system failures	A CCMS is hard to use or with many failures, which may influence the process of work.	Pilot practice
Data management	It's difficult to manage the increasing data and content, such as illustrations.	Large-scale practice
Time	People cannot find available time for CCMS implementation.	

Some challenge categories, such as negative attitudes, difficult conversion of writing style, and the lack of time, could trouble TC groups in the whole process of CCMS implementation, from system preparation to large-scale practice.

During the implementation, some people were found unwilling to accept the system, and the reluctance was mainly caused by four reasons. First, the system could not meet the needs specified by TC groups due to technical barriers. In this case, CCMS suppliers often offered alternative solutions, but TC groups might feel reluctant and inconvenient. Second, in most cases, people were unable to experience the benefits of topic-based writing and CCMS at the beginning of the implementation, which might result a skeptical attitude towards the transition. Third, the CCMS was complicated and some people found it difficult to learn the system. These people preferred to keep using the old system rather than adopting a new system. Fourth, the implementation was additional workload which required people to spend extra time and energy to complete. People often made extra efforts but did not receive extra reward, as the implementation was also regarded as a part of their work.

Converting from linear writing to topic-based writing was a challenge that troubled technical authors in all the phases of CCMS implementation. The conversion on the way of writing actually referred to the

conversion on the way of thinking, which was very difficult for technical authors. Writing topic-based content correctly could also be challenging for TC groups.

Time was always needed in every phase of CCMS implementation. Finding available time for the implementation was another prominent challenge. There were three reasons for this challenge. First, TC groups needed to continue their normal work while they implemented a CCMS, and therefore they would be busier during the CCMS implementation. Second, the CCMS implementation costed a lot of time. For example, converting the old content to the new platform was regarded to be a time-consuming process, especially when the conversion was conducted manually and the capacity of the TC group was limited. Third, the lack of knowledge and experience resulted a longer implementation, as TC groups needed to acquire these knowledges first before they take action. In addition, the TC groups lacking knowledge and experience were more likely to list vague needs at the beginning, and to keep changing ideas and demands during the later phases, which could also make the implementation longer.

As Table 11 demonstrates, the solutions and benefits identified by the interviewees in different phases of CCMS implementation could be categorized into three groups: support, participation, and management. While the measures and materials being applied to help people learn about the topic-based writing and the system were regarded a type of "support", the activities related to the communication and interaction between different roles and departments were grouped together as "participation". The last group, "management", covered the solutions and benefits that promote the management of expectation, operation, progress, resources, and risks.

Table 11. *Solutions and Benefits in Different Phases of CCMS Implementation*

Categories	Solutions	Phases	Benefits	Phases
Support	Benefits	Promotion	Interactive workshops	System preparation
	FAT	Pilot practice	Case sharing	Promotion
	Role-based user manual	Pilot practice	Competitive analysis	Pilot practice
	Library of conversion examples	Pilot practice	Training materials	Training
	Form of training	Training	Sandbox	Training
Participation	Role of CCMS suppliers	System preparation	Involvement of all stakeholders	System preparation
	Project team	System preparation	Communication with all TC sites or teams	System preparation
	Flexible workflow	Pilot practice		
Management	Positioning	System preparation	No DITA specification	System preparation
	Plan B	Pilot practice	More resources in delivery tests	System preparation
	Rules & standards	Large-scale practice	Enough resources at the early stage	Pilot practice
	Simplified process	Large-scale practice	Consideration for the proficiency	Pilot practice
			Tools	Large-scale practice

4.4. CSFs in Different Phases

The interviews asked interviewees to list the specific activity or information that they think must be present in different phases of CCMS implementation. Some interviewees answered the questions directly and listed the CSFs they identified, the other interviewees combined their answer with the feedback on the challenges, solutions, or benefits they identified. Table 12 lists the CSFs in different phases of CCMS implementation mentioned by the interviewees.

Table 12. *Critical Success Factors in Different Phases of CCMS Implementation*

Phase	Critical Success Factors	
	Activity	Information
System preparation	Organize interactive workshops; Invite various roles and stakeholders to participate in; Keep other departments informed and updated; Seek help from CCMS suppliers	
Conduct information analysis	Set up a project team; Specify core needs; Communicate with all TC sites or teams	Position and scope of CCMS; Existing documentation
Make a content model		DITA standard
Make an information model		ICT infrastructure
Specify outputs	Design stylesheets	Existing templates and style guides
Conduct delivery tests	Conduct FAT; Conduct SAT; Invite many people to participate in	
Promotion	Invite external organizations to share experience	Concept, background and value of CCMS and topic-based writing; Specific benefits could be brought by CCMS
Pilot practice	Set up a flexible workflow; Set up rules and regulations; Design metadata; Create role-based user manuals; Establish a library of conversion examples; Invest enough resources at the early stage	
Select	Consider the employee proficiency and maturity	Frequency of publication and updates; Product life cycles
Analyze	Design information architecture; Conduct competitive analysis	
Plan	Consider the employee proficiency and maturity; Design an alternative plan	Resources, budget and workload; Product development cycles

Prepare	Create a task list	Pattern of mapping between formats
Convert	Design or use tools for automatic conversion	
Post-convert	Adjust tools for automatic conversion	
Training	Select proper forms of training; Prepare suitable training materials; Apply a sandbox	Knowledge of CCMS operation; Knowledge of topic-based writing; Knowledge of metadata
Large-scale practice	Adjust the workflow; Update rules and regulations; Update the user manuals and library Adjust metadata; Design and adjust reuse strategy; Make decisions on the conversion of old content; Adjust tools for automatic conversion; Design or use tools to aid the execution of rules and regulations	

It is worth noting that there is a relationship between the features of organizations and the phases of CCMS implementation as well as the CSFs in each phase, by comparing the companies that the interviewees came from and the interviewees' insights on the phases of CCMS implementation.

The size and organization of TC groups had a large effect on the CCMS implementation, especially the execution of promotion, pilot practice, and training. First, how the promotion and training sessions were conducted depended partially on the size and organization of TC groups. For the TC groups with a large number of employees or several teams working at different sites, the promotion and training sessions were conducted step by step and site by site. When the promotion and training sessions were organized in batches, the executors of the early small-scale activities often came from CCMS suppliers and the later large-scale promotion and training were often conducted by the internal employees from TC groups. For the TC groups which was small and with all the members working at the same site, the promotion and training sessions were often conducted in one go. Second, the form of promotion and training was also influenced by the size of TC groups. For example, one-on-one mentoring was not suitable for the TC groups with a large employee population. Third, during the pilot project, the participators of the project depended partially on the size and organization of TC groups. The project team or the TC team of the selected object was usually responsible for the pilot practice in large TC groups. Conversely, all members participated in the pilot practice in small TC groups. For TC groups that had many documentation sites, the most knowledgeable and experienced site often launched the pilot practice.

The previous way of documentation greatly influenced the CCMS implementation. First, the content of the promotion and training sessions were designed on the basis of the previous way of documentation. For example, if the company was already used to structured writing before the implementation, knowledge about structured writing could be not or less introduced in the promotion and training. Second, which party, CCMS suppliers or TC groups, played a leading role in the promotion and training was also influenced by how the documentation was created in the past. If the TC group had never been exposed to content management and structured writing, the CCMS supplier was more likely to take the lead in the promotion and training. Third, because the difficulty level of topic-based writing perceived by the people

was largely influenced by the previous way of documentation they applied, more time needed to be allocated to and more efforts needed to be made in the promotion and training, if the TC group used to write linear and unstructured content with Microsoft Word. Fourth, in the pilot practice and large-scale practice, the workload of preparing old content for conversion depended on the previous way of documentation. The way of documentation depended on the quality of old content to some extent, with the quality referring to how structured the content was and how similar the structure was to the DITA standard. For TC groups used to write linear and unstructured content, more efforts needed to be made to prepare the old content, such as splitting, marking, or even rewriting content. Fifth, the priority of the preparation was also influenced by the way of documentation. For TC groups used to write structured content in XML, the priority was to find the one-to-one mapping between the previous format and the target format. For TC groups used to write unstructured content, the priority was to change the unstructured content into structured one.

5. Discussion and Conclusion

5.1. Discussion

This study investigated the definition of CCMS implementation from the perspective of technical communicators. It was found that technical authors' definitions in this study align with the definition in previous studies to some extent. In Coggio's case study, the implementation started when two technical communicators had the ability and began using the system for a small-scare deliverable, and ended when every member of the TC department fully accepted the system and produced over 95% of the content in the department with the system. Coggio's definition was similar to the opinions of technical authors who give definition from the angle of capability and task. Andersen (2014) described the implementation from the perspective of the decision-making unit in the TC groups and her definition of the starting point and end point was comparable to the CCMS suppliers' definitions in this study. The gap between TC groups' and CCMS suppliers' definitions of CCMS implementation was marked by the system delivery. While TC groups marked the delivery as the starting point, CCMS suppliers marked it as the end point. The reasons for the gap could be the different goals of the two parties and their different level of participation in activities before and after the system delivery.

To bridge the gap, this study suggests to integrate the definitions from TC groups with those from CCMS suppliers and mark the beginning of CCMS implementation as the selection of CCMS. And therefore, CCMS implementation in this study refers to the process starting with the system preparation and ending with the large-scale practice.

It is important for TC groups to realize that CCMS implementation starts earlier than they think and attach enough importance to the system preparation. First, the system preparation requires the involvement of both TC groups and CCMS suppliers. It is impossible for CCMS suppliers to prepare a system that meets the specific needs of TC groups without knowing what the needs are. To set up a system that functions well, TC groups need to participate in the system preparation and exchange ideas about the system with CCMS suppliers. Second, the system preparation is the foundation for the follow-up activities about CCMS implementation. An early and good system preparation could prevent potential problems, such as the poor usability of the system in real practice. Other phases of CCMS implementation are closely related to the phase of system preparation. Third, to make a good system preparation, TC groups need to be aware of and highlight the importance of early preparation before the delivery of CCMS. Enough time, money and human resources need to be allocated to the system preparation.

In this study, CCMS implementation undergoes five phases: system preparation, promotion, pilot practice, training, and large-scale practice. By a comparison between this study and antecedent studies, it can be found that because this study thought the system refinement in fact a kind of activity or task, which could be conducted at any time when TC groups created new ideas and demands in the process of the CCMS implementation or even after, this study did not mark system refinement as a phase as Coggio (2015) did. And unlike the phases identified by Shumate (2011), this study further divided the "preparation" mentioned by Shumate into "system preparation" and "promotion", which focus on the physical preparation and mental preparation respectively. While the phase of system preparation paid attention to the design, adjustment and customization of CCMS, the phase of promotion attached importance to the introduction of concept, background and value of CCMS which could encourage people to accept and welcome the system.

The splitting of "system preparation" and "promotion" is beneficial. First, the importance of the two phases could be different. While the system preparation was regarded as a compulsory phase in CCMS implementation, the promotion was an optional step. For TC groups that had already been familiar with CCMS and topic-based writing, the promotion could be unnecessary. Second, the preparation for the two phases could be different. During the system preparation, TC groups mainly needed to specify and refine their needs, with the focus being internal information. However, in the promotion, TC groups needed to prepare promotion materials about CCMS, with the focus being external knowledge. Third, the way of communication could be different in the two phases. In the system preparation, CCMS suppliers and TC groups (mostly the project team of CCMS implementation in the TC group) communicated with each other to prepare a system. The communication between the two parties was two-way. TC groups conveyed their ideas to CCMS suppliers, and the suppliers adjusted the system based on these ideas, and such interaction was in cycle even after the system was successfully delivered. In the promotion, CCMS suppliers or the project team promoted the system to members of TC groups or even other departments. The communication was more likely to be one-way. The promoters introduced the concept, background and value of the system to the audiences. Different methods need to be applied to improve the communication in different ways.

This study collected the challenges, solutions and benefits that technical communicators identified in different phases of CCMS implementation. Some of the challenges mentioned in this study, such as difficult conversion of writing style, metadata, poor usability, negative attitudes, and poor workflow and collaboration among different roles, were pointed out by antecedent studies (Abel, 2013; McCarthy et al., 2011; Johnson, 2009; Zhang, 2016) when they analyzed the challenges brought by CCMS. This study found that measures can be taken during the CCMS implementation to solve or prevent these challenges.

One prominent challenge brought by the adoption of CCMS was the difficult conversion of writing style (Able, 2013), which was also marked as a challenge category in the CCMS implementation by technical communicators in this study. There are two main reasons for the difficult conversion of writing style among technical communicators. First, the conversion of writing style actually refers to the conversion of the way of thinking, which cannot be completed without practice both mentally and physically. To reduce the difficulty level of the conversion perceived, people need to acquire knowledge and experience of topic-based writing. Second, the attitudes towards the conversion influences the willingness to accept topic-based writing to some extent. According to the theory of planned behavior (Ajzen, 1991, p.179-211), technical communicators who are willing to practice topic-based writing and believe that they can complete the conversion are more likely to overcome the difficulty. Therefore, to tackle the challenge of converting writing approach, the promotion and training need to be well designed and organized in the CCMS implementation to make technical communicators mentally and physically ready for writing

content in a topic-based way. The content, forms, and materials of the promotion and training need to be selected and prepared carefully. The well-organized promotion and training sessions could also tackle the challenges about metadata mentioned by McCarthy et al. (2011). The solutions and benefits that belong to the "support" group in this study could also be applied to solve the challenge about difficult conversion.

Another challenge often mentioned by previous studies on CCMS adoption is the negative attitudes that people hold towards the transition. This study found that the negative attitudes could result from the poor usability of the system, the lack of goals or ambiguous goals on the conversion, the over-complex documentation process, the doubts on the benefits that could be brought by CCMS, the difficult system operation, and the additional burden caused by the implementation. The measures to tackle or prevent the challenge of negative attitudes could be categorized into two types. The first type is to enable the system to not only meet the needs of TC groups but also be easy and simple to operate. To achieve this goal, a good system preparation is essential. The other type is to encourage technical communicators accept the new system. Making technical communicators aware of the benefits that CCMS can bring to them and their organizations during the promotion could play an important role. Offering sufficient materials and support during the training could also motivate technical communicators to accept and practice the system. The second type of solutions is supported by the technology acceptance theory (Davis, Bagozzi, & Warshaw, 1989).

Poor usability of the CCMS was identified as a significant challenge that technical communicators confronted during the CCMS implementation, which could influence the progress of work, lead to negative attitudes, or even impede the transition. Aside from the complicated technical operations of the developed CCMS mentioned by Johnson (2009), the failure to specify core needs, the poor communication with CCMS suppliers on the system adjustment, the over expectation, and the lack of FAT in the phase of system preparation could result a CCMS with poor usability. And therefore, a good system preparation is the precondition of good usability and user experience. To prevent the challenge of poor usability, technical communicators need to attach enough importance to and allocate enough resources to the system preparation during the CCMS implementation.

This study explored the CSFs in different phases of CCMS implementation by analyzing the technical communicators' feedback. Unlike the general suggestions on CCMS implementation given by previous studies (Andersen, 2014; Shumate, 2015; Oberon Technologies, Inc., 2018; Vasont Systems, 2020), this study created a detailed list of the specific activity or information that must be present in different phases for the CCMS implementation to be successful, which reveals many important points that were ignored by previous scholarly and trade publications. Take the communication during the system preparation for example, technical communicators needed to communicate with CCMS suppliers about their needs for information and the feedback on the system, to communicate with other TC groups about the types and process of documentation, and to communicate with other departments about the up-to-date progress of CCMS implementation. Such details about communication during CCMS implementation was never mentioned by antecedent studies, as they mostly analyzed the process from the organization's or the industry's perspective, which overlooked technical communicators' thoughts. The detailed list of the CSFs in this study was created based on the thoughts of the experienced technical communicators, and could help more technical communicators have a clear and comprehensive understanding of the CCMS implementation.

5.2. Limitations

Several limitations must be taken into account when interpreting the findings of this study. First, the number of participants could be larger. This study first planned to interview over 25 technical

communicators with experience of CCMS implantation at the stage of conceptualization. However, due to the impact of COVID-19 pandemic, it became more difficult to access to potential participants. Possible participants could only be contacted online via LinkedIn or the network of the author's friends and teachers. And therefore, 11 technical communicators were invited to participate in the interviews. More insights into the CSFs in phases of CCMS implementation could be found, if more people could participate in the study.

Second, this study noticed that there are some differences between Chinese technical communicators and Dutch technical communicators. However, because the number of the participants was small and the proportion of the two groups was not balanced, this study did not explore further the differences between them. Future research could invite a similar proportion of Chinese and Dutch technical communicators to explore whether the cultures in the two counties have an influence on the CCMS implementation.

Third, the proportion of the technical authors who participated in the CCMS implementation but did not belong to the project team could be larger. In this study, 5 out of the 8 technical authors played a role in the project team. As a member of the project team, these technical authors usually worked as an executor in many phases and analyzed the CSFs from the perspective of executors, which might be different from the perspective of the technical authors being managed by them. In addition, the members of project teams were mostly more knowledgeable and experienced than other technical authors in the TC groups, and therefore they might be unable to discover some problems that normal technical authors met during the CCMS implementation. Inviting more normal technical authors to participate in the interview may bring more insights.

5.3. Conclusion

This study investigated the definition of CCMS implementation, identified the phases of it, and collected the challenges, solutions, and benefits in the identified phases to explore the CSFs in different phases of CCMS implementation from the perspective of technical communicators.

This study found that there is a gap between TC groups' and CCMS suppliers' definitions of CCMS implementation, which was not clearly mentioned by previous studies. To bridge the gap and improve the implementation, this study integrated the different definitions from the two parties, and referred the CCMS implementation to the process starting with the system preparation and ending with the large-scale practice. This study emphasized that it is important for TC groups to realize that CCMS implementation starts earlier than they think and to attach enough importance to the system preparation.

This study specified five phases of CCMS implementation: system preparation, promotion, pilot practice, training, and large-scale practice. Unlike antecedent studies, this study suggested TC groups to split the preparation work into two parts as "system preparation" and "promotion", which focus on the physical preparation and mental preparation respectively. The 5-phase model of CCMS implementation, "system preparation - promotion - pilot practice - training - large-scale practice", might be applied to the implementation of other innovation and technology.

In this study, various challenges, solutions, and benefits were specified by the interviewees in every phase of CCMS implementation. The challenges found in different phases of CCMS implementation could be categorized into six groups: attitudes, writing style, ability, collaboration, system, and time. The most prominent challenge categories were negative attitudes, different conversion of writing style, and the lack of time, as they could trouble TC groups in the whole process of CCMS implementation, from system preparation to large-scale practice. And the solutions and benefits identified in different phases of CCMS implementation could be categorized into three groups: support, participation, and management.

This study found that many challenges brought by CCMSs to the organizations, including the negative attitude towards the changes, the difficult transition to the topic-based writing, the mess in metadata, the bad usability of the CCMS, and the poor workflow and collaboration among different roles could be solved or prevented by conducting a good CCMS implementation.

To conduct a good CCMS implementation, this study first suggested TC groups to take the features of their companies into consideration when they design the implementation in phases, as the features of companies, especially the size and organization of TC groups and the previous way of documentation, have an influence on the phases of CCMS implementation.

Second, this study generated a detailed list of the CSFs in different phases of CCMS implementation, which specifies what activity or information must be present to conduct a good CCMS implementation. The list of the CSFs was created based on the thoughts of the experienced technical communicators. It revealed many important points that were ignored by previous scholarly and trade publications, and built up new knowledge about CCMS implementation. The list could help more technical communicators have a clear and comprehensive understanding of the implementation, and offer guidance to the organizations that plan to adopt or implement a CCMS. The CSFs in different phases of CCMS implementation could also inspire educational institutes to design and conduct courses or trainings to develop their students as professional and competitive technical communicators who are knowledgeable and experienced about CCMS implementation.

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Appendices

Appendix A: Interview Question Lists

Interview Questions for Technical Communicators

Part 1 Team Condition

1. Could you introduce the organization of your team?
2. Could you describe the workflow in your team to create and maintain contents?
   - What procedures are performed?
   - What tools are used?
3. What role does a CCMS play in the workflow?

Part 2 CCMS Implementation

4. Could you describe the process of implementing a CCMS in your team?
   - How would you describe the phases you identified?

   Notes: outline the phases and check it with the interviewee through an interpreting question.

5. How do you define CCMS implementation?
   - What marks the beginning and the end of the implementation?
6. How did you engage in the CCMS implementation?

Part 3 Benefits & Challenges

   Notes: match the answers to one or more specific phases mentioned in Part 1.

7. What challenges did you confront with in different phases?
8. How did you overcome the challenges?
9. What benefits did you discover in different phases?
10. *[for manager]* What measures did you take to prevent potential challenges in different phases?

   [for technical writer] What support did you receive to prevent challenges in different phases?

Part 4 Evaluation & Suggestion

11. Could you evaluate the CCMS implementation in your team?
12. What specific activity or information that you think must be present in different phases for a successful CCMS implementation?

   Notes: match the answers to one or more specific phases mentioned in Part 1.

13. *[for manager]* If you get a second chance, how would you improve the CCMS implementation?

   [for technical writer] What suggestions would you make to improve the CCMS implementation?

Interview Questions for CCMS Suppliers

Part 1 CCMS Implementation

1. How would you describe the process of implementing a CCMS?

   - How would you describe the phases you identified?

   Notes: outline the phases and check it with the interviewee through an interpreting question.

2. How do you define CCMS implementation?

   - What marks the beginning and the end of the implementation?

3. How did you engage in the CCMS implementation?

Part 2 Benefits & Challenges

   Notes: match the answers to one or more specific phases mentioned in Part 1.

4. What challenges did your customers confront with in different phases?

5. How did your customers overcome the challenges?

6. What measures could be taken to prevent potential challenges in different phases?

7. What support did you provide to your customers in different phases?

Part 3 Evaluation & Suggestion

8. What specific activity or information that you think must be present in different phases for a successful CCMS implementation?

   Notes: match the answers to one or more specific phases mentioned in Part 1.

9. What suggestions would you make to for organizations to improve the CCMS implementation?

Appendix B: Introduction of Study

Context

More and more organizations adopt a CCMS to create, store, and repurpose content. It has been widely proved that the adoption of CCMSs leads to both benefits and challenges for technical communicators and organizations. Antecedent studies found that the implementation of CCMSs have impacts on the follow-up work efficiency of CCMSs, and some challenges can be solved fully or to a certain degree if the CCMS is properly implemented. However, these studies considered the implementation of CCMSs as an integrated process and failed to discuss the differences among the phases of implementing CCMSs. In addition, most of these studies analyzed the problem from the organization's or the industry's perspective and overlooked technical communicators' thoughts, feelings and understandings which may offer numerous insights.

Topic

Critical success factors in different phases of implementing a component content management system in organizations from technical communicators' perspective.

(To explore the specific activity or information that must be present in different phases for the CCMS implementation to be successful.)

Values

- Identify the phases of CCMS implementation in organizations.
- Specify the challenges and benefits that technical communicators recognized in different phases of CCMS implementation.
- Investigate the measures that could be taken to overcome (potential) challenges in different phases of CCMS implementation.
- Explore technical communicators' thoughts, feelings, and understandings of CCMS implementation.
- Generate some suggestions or a guidance on conducting CCMS implementation in organizations.

Method

Online interviews with over 20 professionals from the field of technical communication. Participants are supposed to play a role in the implementation of CCMSs. The interview will last 40-60 minutes.

Appendix C: Informed Consent Form for Interview Participants

Please read the following information carefully. You can request a copy for future reference.

Purpose

The interview is for a Master thesis research. The research aims to explore the critical success factors in different phases of CCMSs implementation in organizations from the perspective of technical communicators. You need to answer questions asked by the researcher during the interview. The interview will be recorded.

Time involvement

The interview will last 40-60 minutes.

Risks

No risk.

Anonymity and privacy

Any data generated from the interviews will be kept completely anonymous when presented in the thesis or future publication. Your personally information and the recording will not be presented to third parties without your permission.

Participant's rights

The participation is voluntary. You can refuse to answer questions and have the right to withdraw from the research at any time, without having to give a reason.

If you have questions about your rights as an interview participant, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee of the Faculty of Behavioural, Management and Social Sciences at the University of Twente by ethicscommittee-bms@utwente.nl.

The findings of this research will be shared with all the participants.

If you agree with the above-stated conditions and are willing to participate in the interview, please sign below. By signing the form, you confirm that you meet the following conditions:

- You have read the above consent form, understood it and agree to it.
- You are willing to participate in the above-mentioned interview.

Yongjia Dong, University of Twente   _____   _____

Researcher name   Signature   Date