Mitigating Employee Turnover and Enhancing Knowledge Retention at WYDOT: A Comprehensive Approach Using AI and Knowledge Management Systems

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1. Problem Statement

Employee turnover in state transportation agencies (STAs) is a significant challenge, with rates ranging from 6% to 30%. High turnover, particularly among employees with less than five years of service, is driven by factors such as inadequate supervision, dissatisfaction with organizational culture, and retirement, with compensation being a lesser concern (McRea et al., 2018). This issue is especially critical in smaller workgroups, where simultaneous vacancies can overburden remaining staff. Younger employees, particularly those under 35 years old or with less than eight years of service, present an even higher turnover risk, jeopardizing the retention of future leaders (Perkins et al., 2012).

The turnover of experienced personnel creates substantial knowledge gaps in STAs, which exacerbates operational challenges such as design quality and overburdened staff, as indicated by a recent survey and interviews, conducted by the Principal Investigator, of Wyoming Department of Transportation (WYDOT) personnel. Key challenges include employees' lack of awareness of necessary knowledge, time-consuming training of new hires, and concerns that Knowledge Management (KM) systems may stifle critical thinking. Additionally, disorganized resources and ineffective use of cloud-based services further hinder knowledge sharing. Capturing tacit knowledge—personal insights and undocumented expertise—remains difficult, especially with high turnover rates.

Turnover not only results in knowledge loss but also increases operational costs and burdens smaller workgroups, particularly during peak seasons. The difficulty in recruiting and retaining employees, along with supervisory issues and dissatisfaction with organizational culture, further complicates retention efforts. Effective KM practices are critical to capturing and sharing institutional knowledge, improving communication, and mitigating the negative impacts of turnover. These practices are essential to ensuring continuity, reducing costs, and maintaining efficiency across STAs (McRea et al., 2018; Perkins et al., 2012). Therefore, this project aims at determining the root causes of employee turnover and developing a KM system to help new WYDOT personnel become more efficient.

2. Preliminary Literature Review

KM and Knowledge Transfer (KT) refer to structured processes that facilitate the sharing, organizing, securing, and applying knowledge within organizations. These processes enable the effective distribution of knowledge among employees and stakeholders, ultimately contributing to organizational development. KM has become a critical component across various sectors because it enhances operational efficiency, improves decision-making, and fosters innovation (Mitton et al., 2007). The success of KM lies in its ability to harness the collaborative skills of an organization's workforce and partners. When managed effectively, these skills can significantly contribute to achieving institutional goals (Pond 2015). Research has demonstrated that KM positively influences organizational performance at multiple levels, directly and indirectly (Abuaddous et al., 2018).

The concept of KM gained prominence over the past decade as organizations recognized that their success depends not only on tangible assets but also on the intangible knowledge possessed by employees. Early KM efforts were primarily focused on capturing explicit knowledge—knowledge that could be easily documented, such as manuals, procedures, and reports (Mullin1996). However, this approach overlooked the importance of tacit knowledge, or the unwritten expertise held by employees. In response, new KM practices emerged, including mentoring, storytelling, and creating Communities of Practice (CoPs), where employees could share experiences and ideas (Pond 2015).

As KM matured, technological advancements became integral to its practice. In the early 2000s, many organizations adopted IT tools such as databases for knowledge storage and social media platforms to facilitate knowledge sharing (Burk 1999) These tools allowed organizations to manage vast amounts of information more efficiently, supporting decision-making and developing innovative solutions. KM practices also evolved to extend beyond internal organizational boundaries, focusing on exchanging knowledge across entire supply chain networks. This shift underscored the importance of inter-organizational collaboration for maintaining a competitive edge in the global economy (Kassaneh et al., 2021).

By the second decade of the 21st century, KM had expanded in scope, with organizations viewing knowledge as a valuable resource that required not only generation but also transformation and development. KM became a strategic tool for planning and emphasized promoting a knowledge-sharing culture as a foundation for sustainable improvement (Pond 2015). The realization emerged that effective KM systems must be supported by a culture that encourages knowledge sharing without fear of job insecurity (Mitton et al., 2007).

Today, KM is widely regarded as an essential tool for organizations seeking to promote innovation and efficiency. As KM continues to evolve, it must adapt to new technological advancements and challenges, ensuring that knowledge remains a key determinant of organizational success in a knowledge-driven economy (Mitton et al., 2007).

Despite its potential benefits, many organizations face challenges in effectively retrieving and utilizing their available knowledge. KM addresses this issue by ensuring that critical information is accessible at the right time to the right people, enhancing decision-making and organizational performance. For example, the Virginia Department of Transportation (VDOT) has integrated KM practices to manage both explicit knowledge, such as documented information, and tacit knowledge held by employees. This dual approach enables VDOT to maintain high operational standards and respond effectively to external changes (Pond 2015).

Similarly, the Federal Highway Administration (FHWA) emphasizes KM’s role in retaining organizational memory and supporting strategic goals. By implementing KM, FHWA mitigates the risk of knowledge loss due to staff turnover, ensuring that key knowledge is captured, shared, and leveraged to enhance organizational capacity (Burk 1999). Effective KM practices safeguard valuable knowledge and support the development of an organization’s overall capability (Mitton et al., 2007).

Several techniques have been developed to facilitate KM within organizations. One widely used method is the CoP. CoPs are groups of individuals from similar professional backgrounds who regularly meet to share and enhance their expertise. These communities encourage continuous learning and innovation by facilitating knowledge exchange among employees. For example, VDOT has utilized CoPs to improve staff communication and disseminate best practices and other useful knowledge-sharing tools (Pond 2015). Another valuable KM tool is knowledge mapping, which helps organizations identify who possesses specific knowledge and how that knowledge can be effectively transferred. Knowledge mapping fosters collaboration across departments by making it easier to recognize areas needing training or further knowledge codification (Moiseev et al., 2022). Organizational culture often presents knowledge-sharing barriers, such as concerns about job security, employee rivalry, and lack of trust. Some employees may fear that sharing their expertise will make them redundant, leading to job insecurity (Mitton et al., 2007). The absence of well-defined processes and appropriate technological tools for knowledge storage and distribution can also hinder KM efforts. For instance, while CoPs and knowledge mapping are effective, their success relies on strong organizational structures and leadership support (Moiseev et al., 2022).

To overcome these challenges, organizations must foster a culture that encourages knowledge sharing and ensures that employees feel secure in doing so. This requires the provision of suitable technological platforms and resources, as well as adequate training for employees to use these tools effectively. Clear KM processes, including responsibilities for knowledge acquisition, sharing, and utilization, must also be established to ensure the success of KM initiatives (Mitton et al., 2007).

2.1 Knowledge Management by State Highway Agencies

Several DOTs have developed frameworks to adopt KM and KT systems. These agencies are listed as follows:

1. **The Kentucky Transportation Cabinet (KYTC):** KYTC sponsored a study to address the issue of knowledge loss in public agencies due to retirements and staff changes. The study explores KM strategies and their implementation across DOTs. The study emphasizes the importance of preserving institutional knowledge, particularly in the face of employee turnover and outsourcing. It highlights the challenge of capturing tacit knowledge—personal insights that are difficult to document—and the necessity of retaining it to prevent valuable expertise from being lost. Case studies from DOTs in Alaska, California, Virginia,

Pennsylvania, Texas, Wisconsin, and Missouri illustrate diverse KM approaches such as CoP, succession planning, and technology-based KT. At KYTC, the study examines existing KM programs, including training initiatives and knowledge-sharing platforms. A survey of KYTC employees reveals information-seeking behaviors, highlighting areas for improvement in current KM efforts. The study concludes with practical recommendations for enhancing KM within public agencies. Key strategies include documenting the knowledge of retiring employees through interviews and videos, incentivizing knowledge-sharing, and fostering cross-departmental interactions to encourage collaboration. Succession planning for specialized positions is also emphasized, along with job rotation to help employees develop broader skills and reduce turnover. To further support knowledge continuity, the study suggests engaging retired workers on a project basis and holding exit interviews to capture departing employees' insights. Leadership training workshops and social network analysis tools are recommended to identify key knowledge holders and ensure critical information is retained. These strategies aim to build a resilient KM system that mitigates the effects of employee turnover and outsourcing. By implementing these approaches, public agencies can ensure that essential skills and knowledge are preserved, maintaining operational continuity as experienced employees transition out of the workforce (Gibson et al. 2018).

2. **The Vermont Agency of Transportation (VTrans)**: VTrans sponsored a study aimed at addressing concerns about employee turnover and knowledge loss at VTrans. Using a mixed-methods approach, the study involved focus groups, turnover analysis, and KM assessments to evaluate the agency's practices in these areas. Key findings revealed that retention challenges were particularly pronounced among younger employees and those with fewer than five years of service, who were more likely to leave the organization. The study identified recruitment difficulties, generational differences, and supervision quality as major contributors to turnover. While younger employees valued benefits, work-life balance, job security, and career growth, dissatisfaction with supervision and organizational culture emerged as primary reasons for considering departure.

Pay, although mentioned, was not the main factor driving turnover. Two pilot projects were introduced to mitigate these issues. The first was an exit questionnaire, which reinforced the finding that supervision and organizational culture, rather than pay, were the dominant reasons for employee departures. The second pilot, focused on KM, resulted in the creation of a Knowledge Exchange Tool and a workshop process aimed at documenting and sharing tacit knowledge within the organization. These efforts highlighted existing gaps in VTrans' KM practices, especially in capturing institutional knowledge that is often lost due to turnover (McRea et al. 2018).

The study provided actionable recommendations, including the formal implementation of the exit questionnaire, regular reviews of turnover and KM data, and improvements in supervision. It also suggested enhancing the use of SharePoint for knowledge organization, establishing a leadership group for KM, and designating a specific individual responsible for KM efforts. Despite the existence of KM practices, the study identified significant gaps, including a lack of systematic documentation for core processes and inadequate tools for knowledge sharing. Employees often relied on personal notes and peer communication rather than a structured KM system, which put institutional and historical knowledge at risk. Moreover, the study emphasized the need for improved organization of electronic resources and better mechanisms for documenting infrequently performed tasks. In conclusion, while VTrans has made some strides in employee retention and KM, the study emphasizes the need for more robust strategies to address turnover and ensure the preservation of institutional knowledge. Implementing these recommendations is crucial for the agency to retain valuable expertise and meet its long-term operational goals (McRea et al. 2018).

3. **Virginia Department of Transportation (VDOT)**: VDOT KM Strategy Document highlights the critical role of KM in supporting the complex operational framework of the organization. It draws a distinction between information and knowledge, stressing the importance of managing both effectively within VDOT. While Information Management (IM) is primarily concerned with the storage, retrieval,

and organization of data, KM focuses on fostering understanding, collaboration, and the practical application of knowledge, with an emphasis on human-centered processes.

VDOT's KM strategy encompasses several key initiatives, including CoPs, Knowledge Mapping, Lessons Learned Initiatives, Process Mapping, and Electronic Access. CoP facilitate the sharing of tacit knowledge among employees, thereby enhancing both organizational efficiency and effectiveness. Knowledge Mapping serves as a tool for identifying knowledge gaps, aiding in succession planning, and fostering professional networks. The Lessons Learned Initiative aims to capture and document insights from past experiences, thus informing and improving future practices. Process Mapping brings together subject matter experts to standardize and document procedures, promoting accountability and the dissemination of knowledge. Furthermore, Electronic Access, provided through the VDOT Research Library, ensures that employees have access to a comprehensive range of resources, including a modern catalog system and extensive databases (Hammer 2015). While VDOT's KM framework is comprehensive in its inclusion of key initiatives, it may fall short in addressing the dynamic and evolving nature of knowledge in large organizations. The reliance on static processes such as CoPs and Lessons Learned Initiatives, though valuable, may not fully capture or adapt to real-time shifts in knowledge needs and emerging technologies.

2.2 Using Chatbots to Support Knowledge Management

Chatbots have proven to be valuable tools for KM across various industries, offering significant benefits in data collection, interaction, and decision-making. As artificial intelligence (AI) and natural language processing (NLP) technologies evolve, chatbots are gaining prominence in sectors like construction, project management, and corporate training. This section explores the application of chatbots in automating processes, facilitating real-time communication, and managing structured data.

In the educational sector, Al-Emran et al. (2023) examined the factors influencing the use of AI-based chatbots for knowledge sharing. They found that performance expectancy, defined as the perceived improvement in task quality due to chatbot usage, positively impacted users' intentions to adopt chatbots for KM. However, concerns about data privacy and misinformation remain barriers to broader adoption. The study also highlighted the enhanced effectiveness of chatbots in managing and sharing knowledge within educational institutions (Al-Emran et al., 2023).

Chatbots are also contributing to improving project management by streamlining workflows and KT among team members. Felicetti et al. (2024) highlighted the use of generative chatbots to assist project managers in organizing and distributing knowledge. These chatbots aid in task allocation, resource optimization, and time estimation, underscoring their importance in KM. Factors influencing chatbot adoption include innovation attitude, peer influence, and task-technology fit. Real-time communication through chatbots leads to better decision-making, driven by data (Felicetti et al., 2024).

In the construction industry, chatbots play a crucial role in reporting and data management. Cho and Lee (2019) introduced a construction daily report management system using chatbots, enabling contractors to communicate with subcontractors via platforms like Kik or Slack, integrated with NLP. The chatbot processes unstructured conversations and organizes them into structured reports, detailing labor, equipment, and work progress. This automation enhances KM by ensuring accurate, up-to-date records, which reduces manual data entry and errors. Consequently, project managers can focus on higher-level decision-making tasks (Cho & Lee, 2019).

Chatbots are also proving valuable in the exchange and extraction of knowledge across systems. Arsovski et al. (2019) proposed a method for transforming knowledge from rule-based chatbots into neural conversational agents. This approach automates the process of structuring unstructured data from conversations, reducing the time required to manually build knowledge bases. Such systems are particularly beneficial for large organizations with extensive knowledge resources (Arsovski et al., 2019).

Finally, chatbots enhance knowledge-sharing experiences in corporate training by providing instant feedback and automating learning processes. Bodea et al. (2021) explored the use of chatbots in project management training, emphasizing their role in promoting sustainable education. By offering learner-centric experiences, chatbots enable employees to access training materials at their convenience, facilitating continuous professional development (Bodea et al., 2021).

3. Objectives

Three objectives of this research are listed as follows:

1. Determine root causes of employee turnover across different WYDOT divisions/groups.

To measure the completion of this objective, surveys, exit interviews, and focus group discussions should be conducted with current and former employees (if applicable), with the goal of identifying common themes related to turnover. The percentage of surveyed employees providing insights into reasons for leaving or staying will serve as an indicator. Statistical analysis of employee turnover data, correlating factors such as job satisfaction, management support, salary, and workload, will help identify at statistically significant factors contributing to turnover. Additionally, reviewing existing human resources reports and organizational climate surveys will be essential, with the completion of a summary report highlighting key root causes of turnover, categorized by division or group.

2. Develop recommendations to reduce the rate of employee turnover.

To measure the completion of this objective, a list of actionable recommendations with supporting evidence or case studies will be developed based on the identified root causes. These recommendations should be validated and refined by engaging key stakeholders, such as managers, human resources, and employees, through workshops or surveys, with the aim of gaining approval of the proposed recommendations. A detailed implementation plan that outlines the necessary resources and expected outcomes will also be developed.

3. Develop a knowledge management and transfer plan to mitigate the impact of the departure of experienced personnel.

For the third objective, the focus will be on developing a comprehensive framework to capture tacit knowledge, particularly the insights and experiences of departing personnel, through mentorship programs, peer learning, and knowledge-sharing sessions. The effectiveness of this framework will be measured by its implementation across WYDOT, and the success will be indicated by the level of engagement in these knowledge-sharing activities, as well as feedback from employees on how well critical knowledge has been retained and transferred. A pilot program in a selected division will help assess the practicality of this framework, with feedback gathered through surveys or interviews indicating how well the framework captures tacit knowledge.

Simultaneously, a chatbot will be developed to facilitate the transfer of explicit knowledge stored in WYDOT's databases. This chatbot will ensure that formal procedures, guidelines, technical manuals, and other structured information are easily accessible to employees. The completion of this measure will be indicated by the successful development and deployment of the chatbot, as well as feedback from users on its ease of use and effectiveness in accessing stored knowledge. To assess the effectiveness of the framework for tacit knowledge and the chatbot for explicit KT within the available timeframe, we will collect immediate feedback from users shortly after implementation. Surveys and interviews will be conducted to evaluate the ease of KT, both tacit and explicit, and the usefulness of the chatbot. Indicators of success will include positive user feedback on the accessibility of information and the perceived improvement in knowledge-sharing practices.

4. Benefits

There are four main benefits to WYDOT because of this research listed as follows:

1. Improved Employee Retention

By identifying the root causes of employee turnover and developing targeted recommendations, WYDOT can take proactive steps to retain its workforce. This will not only reduce the costs associated with recruiting and training new employees but also ensure that valuable institutional knowledge stays within the organization. Retaining experienced personnel will lead to better project outcomes and more efficient operations, ultimately saving time and resources.

2. Enhancing Knowledge Retention and Efficiency with a Knowledge Management System and Chatbot

By developing a framework to capture explicit and tacit knowledge and a chatbot for accessing explicit knowledge stored in WYDOT's databases, critical information will be preserved and made more accessible across all levels of the organization. This ensures that important knowledge does not leave when employees do, making it easier for employees to solve problems and reducing dependency on specific individuals. The result is a more resilient workforce that can maintain high performance even during staff transitions.

Additionally, the chatbot will streamline access to necessary procedures, technical details, and guidelines, significantly reducing the time employees spend searching for information. This system will enhance overall operational efficiency, allowing for faster decision-making and quicker problem resolution. Employees will spend less time reinventing solutions that already exist, leading to more consistent project delivery.

The chatbot will further improve ease of access by providing real-time retrieval of critical information. Instead of relying on lengthy document searches or specific individuals for answers, employees can quickly find what they need through a user-friendly interface. This not only reduces the time spent on information retrieval but also ensures that vital knowledge is always available, even in the absence of experienced personnel. This combination of preserved knowledge, operational efficiency, and easy access promotes better decision-making, faster problem-solving, and a more self-sufficient workforce.

5. Applicable Questions

The implementation of the chatbot will involve some potential barriers, including the running costs and integration with existing systems. The initial development and operational costs of the chatbot will be covered by the project budget, with maintenance and website integration later transferred to WYDOT IT for long-term management. To ensure cost-efficiency, scalable hosting solutions (e.g., Amazon Web Services or Micorsoft Azure) will be explored, and a maintenance plan will be developed in collaboration with WYDOT IT. A key decision will be whether to integrate the chatbot into the existing WYDOT website for better user accessibility or to host it on an independent domain for more flexibility. Additionally, concerns may arise regarding personnel sharing tacit knowledge, as some employees might hesitate due to fears of job security or lack of recognition. These concerns will be addressed by ensuring confidentiality, offering recognition for knowledge sharing, and fostering a culture that encourages collaboration.

The expected period for full development and implementation is 9-12 months, including the pilot phase, feedback collection, and system-wide rollout. However, uncontrollable factors, such as technological limitations or unforeseen integration challenges, may cause delays. To mitigate these risks, the chatbot will be piloted in a controlled environment first, with contingency plans for technical support. While the project does not involve the production of confidential data, concerns regarding the sharing of tacit knowledge will be addressed by ensuring that the knowledge-sharing platform maintains employee privacy and confidentiality where necessary.

6. Statement of Work

6.1 Overview of Research Tasks

This research will involve several key tasks to address employee turnover and improve KM within WYDOT. First, an extensive literature review will be conducted on employee turnover and KM. Then, surveys and structured interviews will be administered to identify the root causes of employee turnover across WYDOT divisions, followed by an analysis of exit interview data to assess its effectiveness and suggest improvements. Based on these findings, targeted recommendations to reduce turnover will be developed. Simultaneously, we will create a framework using large language models (LLMs) to support KM and transfer, concluding with implementing and piloting an AI-based chatbot to facilitate knowledge sharing.

6.2 Description of Tasks

Task 1 – Conduct an extensive literature review on employee turnover

The literature review will employ a systematic review methodology to ensure comprehensive and unbiased coverage of existing research on employee turnover. This method involves defining explicit inclusion and exclusion criteria to select relevant studies, including empirical research, theoretical frameworks, and industry reports. Databases such as ROSAP, Scopus, and Web of Science will be searched using structured queries and Boolean operators to gather pertinent articles. Each study will be assessed for quality using established criteria, such as the PRISMA guidelines, which emphasize transparency and reproducibility. Data will be extracted and synthesized using thematic analysis to identify patterns and gaps in the literature. The review will culminate in a synthesis report that integrates findings from multiple studies to provide a nuanced understanding of turnover dynamics and strategies for retention.

Task 2 – Conduct questionnaire surveys and interviews to investigate causes of employee turnover across WYDOT division and groups

This task will involve designing and administering structured questionnaire surveys and in-depth interviews to systematically investigate the underlying causes of employee turnover across various WYDOT divisions and groups. The research will adopt a mixed-methods approach to ensure comprehensive data collection and analysis.

Survey Design and Distribution: A structured questionnaire will be developed to gather quantitative data on factors contributing to employee turnover. The survey will be designed to include closed-ended questions with Likert scale responses, as well as a limited number of open-ended questions to capture additional qualitative insights. Key variables will include job satisfaction, workplace culture, compensation, management support, workload, and opportunities for career advancement. The survey will be distributed to current employees across all WYDOT divisions and groups, as well as former employees who have voluntarily left the organization within the last two years.

Structured Interviews: To complement the survey data, a series of structured interviews will be conducted with both current and former employees from diverse roles within WYDOT. The interviews will follow a predefined set of questions, allowing for consistency across respondents while providing opportunities for probing deeper into specific issues. The interviews will focus on exploring the nuanced, context-specific factors that may contribute to employee turnover, such as interdepartmental collaboration challenges, work-life balance concerns, and perceptions of leadership.

Data Collection and Sampling: A representative sample of employees will be selected to participate in both the questionnaire surveys and the structured interviews, ensuring proportional representation from all WYDOT divisions and groups. Stratified random sampling will be employed to account for differences in turnover rates, roles, and tenure within the department, ensuring that the data collected is reflective of the entire organization.

Data Analysis: Quantitative data from the surveys will be analyzed using statistical methods, including regression analysis, to identify key factors correlated with employee turnover. Qualitative data from the interviews will be coded and analyzed thematically to identify common patterns, trends, and underlying causes that may not emerge from the survey responses alone. The integration of both datasets will provide a comprehensive understanding of turnover drivers, allowing for more robust and actionable recommendations.

The results from this task will directly inform the development of targeted interventions to reduce turnover and retain institutional knowledge within WYDOT.

Task 3 – Analyze exit interview data to determine their efficacy and suggest improvements

This task will involve the collection and analysis of exit interview data from the WYDOT Human Resources (HR) department to evaluate the effectiveness of the current exit interview process in identifying key factors contributing to employee turnover. The aim is to determine whether the current process is sufficient or requires improvements to better capture insights that could inform retention strategies.

Data Collection: Exit interview data from the last five years will be obtained from WYDOT HR. This data will include both qualitative and quantitative responses provided by employees during their exit interviews. We will ensure that data is anonymized to protect the confidentiality of former employees.

Data Analysis: The qualitative data from the exit interviews will be analyzed using thematic analysis. This method involves systematically coding and categorizing responses to identify recurring patterns, themes, and underlying causes of turnover. Key themes, such as dissatisfaction with management, lack of career development opportunities, or work-life balance issues, will be extracted and categorized according to their frequency and significance.

Evaluation of Exit Interview Process: In parallel with data analysis, the effectiveness of the exit interview process will be evaluated. This evaluation will include assessing the structure of the interview questions, the depth and breadth of information collected, and the overall consistency of the process. We will investigate whether the current exit interview process provides actionable insights into turnover or if important factors are being overlooked.

Recommendations for Improvement: Based on our findings, we will provide detailed recommendations on how to improve the exit interview process. These may include revising the interview questions to capture more comprehensive information, implementing structured interviews, or integrating additional qualitative techniques to elicit deeper insights. Suggestions will be aimed at ensuring the exit interviews effectively capture both explicit and tacit knowledge related to employee departures, which can then inform retention strategies.

The outcome of this task will provide a thorough understanding of the efficacy of WYDOT's exit interview process and actionable recommendations to enhance its ability to uncover key drivers of employee turnover.

Task 4 – Develop Recommendations to reduce employee turnover rates

This task will focus on formulating targeted recommendations to reduce employee turnover rates at WYDOT, based on the findings from exit interviews, questionnaire surveys, structured interviews, and data analysis. The goal is to address the key drivers of turnover identified through earlier research tasks and propose actionable strategies tailored to WYDOT's specific organizational structure and workforce dynamics.

Data-Driven Approach: The recommendations will be developed by synthesizing insights from the thematic analysis of exit interviews, survey results, and structured interviews conducted with current and former employees across different divisions and groups. These insights will reveal patterns related to job satisfaction, management practices, compensation, work-life balance, career development opportunities, and organizational culture, all of which will inform the development of strategies to address these factors.

Customizing Solutions to Divisions and Groups: Recognizing the diverse needs of different WYDOT divisions and groups, the recommendations will be tailored to the unique challenges faced by various departments (e.g., Engineering, Maintenance, Construction). For instance, solutions for improving retention in field operations may differ from those needed in administrative or technical divisions. We will categorize recommendations by division where appropriate to ensure they are practical and relevant.

The recommendations will provide a clear, actionable roadmap for WYDOT to implement retention strategies that are both practical and grounded in data, ultimately contributing to a more stable and satisfied workforce.

Task 5 – Conduct an extensive literature review on knowledge management and transfer

This task involves conducting a comprehensive literature review to explore best practices, technological advancements, and innovative strategies for KM and transfer, particularly within the context of transportation agencies. The review will cover efforts undertaken by other state DOTs, as well as initiatives from Canadian and European counterparts. Special attention will be given to emerging technologies, such as chatbots and artificial intelligence, that facilitate knowledge sharing and retention.

Review of DOT KM Efforts: We will begin by examining KM strategies adopted by other state DOTs. This will include analyzing published reports, case studies, and academic literature on initiatives aimed at preserving institutional knowledge and improving KT processes. Specific examples of successful programs or tools that have proven effective in reducing knowledge loss during employee transitions will be identified, providing relevant benchmarks for WYDOT.

International Perspectives: The review will expand to cover KM efforts by Canadian and European transportation agencies. These counterparts often adopt innovative approaches, driven by different regulatory, cultural, and technological environments. We will investigate how these organizations have addressed challenges related to tacit knowledge capture, and KT within large agencies.

Technological Innovations: A significant portion of the review will focus on the latest technological efforts used to enhance KM. We will analyze the growing use of chatbots as tools for facilitating the transfer of explicit knowledge, particularly in government and infrastructure sectors. This will include a review of their integration with internal databases, as well as their role in providing employees with easy access to technical documentation, procedures, and institutional knowledge.

Artificial Intelligence in KM: The literature review will also explore the role of artificial intelligence (AI) in supporting KM and transfer. We will review the latest developments in AI, including generative AI models, and assess how these technologies can enhance both explicit and tacit knowledge capture and transfer. The review will include case studies of organizations that have successfully implemented AI-driven systems for knowledge retention, exploring how AI can be used to automate processes, provide personalized knowledge recommendations, and support decision-making.

Tools for Tacit Knowledge Capture and Transfer: Lastly, the review will delve into various tools and methodologies designed to capture and transfer tacit knowledge—often the most difficult and valuable type of organizational knowledge. We will explore techniques such as mentorship programs, peer-to-peer learning platforms, storytelling, and AI-driven knowledge extraction methods, evaluating their effectiveness in different organizational contexts.

The outcome of this literature review will provide a robust foundation of KM and transfer practices that can be adapted and applied to WYDOT, with a particular focus on using cutting-edge technologies like AI and chatbots to preserve institutional knowledge and improve accessibility for current and future employees.

Task 6 – Develop a framework to utilize large language models to support KM and transfer

This task involves developing a comprehensive framework that leverages large language models (LLMs) to support KM and KT within WYDOT. The framework will focus on capturing explicit knowledge and building a user-friendly system that facilitates knowledge retention and accessibility across different WYDOT groups and divisions.

Capturing Explicit Knowledge: The first phase of the framework will focus on collecting and organizing explicit knowledge. We will start by feeding publicly available WYDOT documents, such as standard specifications, guidelines, and technical manuals into the KM system. This will involve digitizing and structuring these documents to make them easily accessible and searchable within the system. Next, we will collaborate with specific WYDOT groups to capture their unique explicit knowledge. This includes collecting technical documentation, procedures, and standards that are not publicly available but critical for internal operations. We will ensure that the KM system can accommodate and organize this information in a way that allows for efficient retrieval and use.

Building an AI Tool for Capturing Tacit Knowledge: In addition to managing explicit knowledge, the framework will focus on building a user-friendly AI tool designed to capture tacit knowledge—the personal insights, experiences, and undocumented practices that are often critical for effective operations. The AI tool will use NLP algorithms to facilitate conversational knowledge capture, allowing employees to input their insights or expertise in a way that can be structured and retained for future use. This system will encourage knowledge sharing through interactive dialogue or interview-like formats that are easy for employees to use.

Textualizing Flowcharts and Figures: As part of the effort to fully capture WYDOT's explicit knowledge, we will develop methods to transform non-textual data, such as flowcharts, diagrams, and figures, into text-based formats that can be integrated into the LLM-driven system. This will include generating descriptions and annotations for visual content, ensuring it is accessible within the KM system and can be used with text-based information. This process will involve collaboration with WYDOT subject matter experts to ensure that the context and meaning of these visual aids are accurately preserved when transformed into text.

Integration and Usability: The final step of this task will focus on integrating explicit knowledge into a cohesive system supported by LLM. The AI-based tool will provide an intuitive, user-friendly interface that allows employees to query the system, retrieve information, and input knowledge seamlessly. We will emphasize creating a system that is accessible to all levels of WYDOT staff, from field engineers to administrative personnel, ensuring that the KM system becomes an essential tool in daily operations.

The outcome of this task will be a robust framework that uses LLM to support the effective management and transfer of both explicit and tacit knowledge, significantly improving WYDOT's ability to retain institutional knowledge and facilitate knowledge-sharing across the organization.

Task 7 – Implement a ChatBot model (KNOWWY) to facilitate knowledge management and transfer

This task focuses on developing and implementing the **Knowledge Network of Wyoming (KNOWWY)** chatbot, a tool designed to enhance KM and KT across WYDOT by leveraging advanced LLMs. KNOWWY will allow WYDOT employees to interact with and retrieve knowledge from internal documents, databases, and other resources in a user-friendly and efficient manner.

Example Implementation Using ChatGPT:

As a starting point, we have developed an initial prototype using OpenAI's ChatGPT, demonstrating how LLMs can facilitate KM. Figure 1 depicts the pseudocode of the example implementation. The prototype involves extracting text from documents (such as PDF files) and allowing users to ask questions related to the content. Using Python code, the model retrieves specific sections of the document and responds in real time, enabling seamless interaction with knowledge stored in WYDOT documents such as standard specifications, technical manuals, and procedural guides.

```
1. LOAD necessary libraries and environment variables.

2. RETRIEVE API key from environment.

3. DEFINE function to extract text from a PDF file:
   - Check if the file exists.
   - Extract text from specified pages.

4. DEFINE function to send user prompts to OpenAI:
   - Send a question to the GPT model and retrieve a response.

5. DEFINE function for chatbot interaction:
   - Prompt the user for questions about the PDF.
   - Send the questions to OpenAI with PDF context and return the answers.

6. In the MAIN function:
   - Load a PDF file and extract its text.
   - Start a chatbot conversation based on the PDF content.

END
```

Figure 1. Pseudocode of example implementation

Here’s an example of the code used for this prototype:

- **Text extraction:** Extracts relevant content from PDF files.
- **Chat interface:** Allows users to ask questions based on the document, with responses generated by the GPT model.
- **API integration:** Uses OpenAI’s API to interface with ChatGPT and return useful responses based on the input provided.

This example demonstrates one possible solution, but as part of this task, we will explore additional LLM options and identify the most **cost-efficient** and scalable solution for WYDOT's long-term use. Figure 2 shows the implementation of the example code.

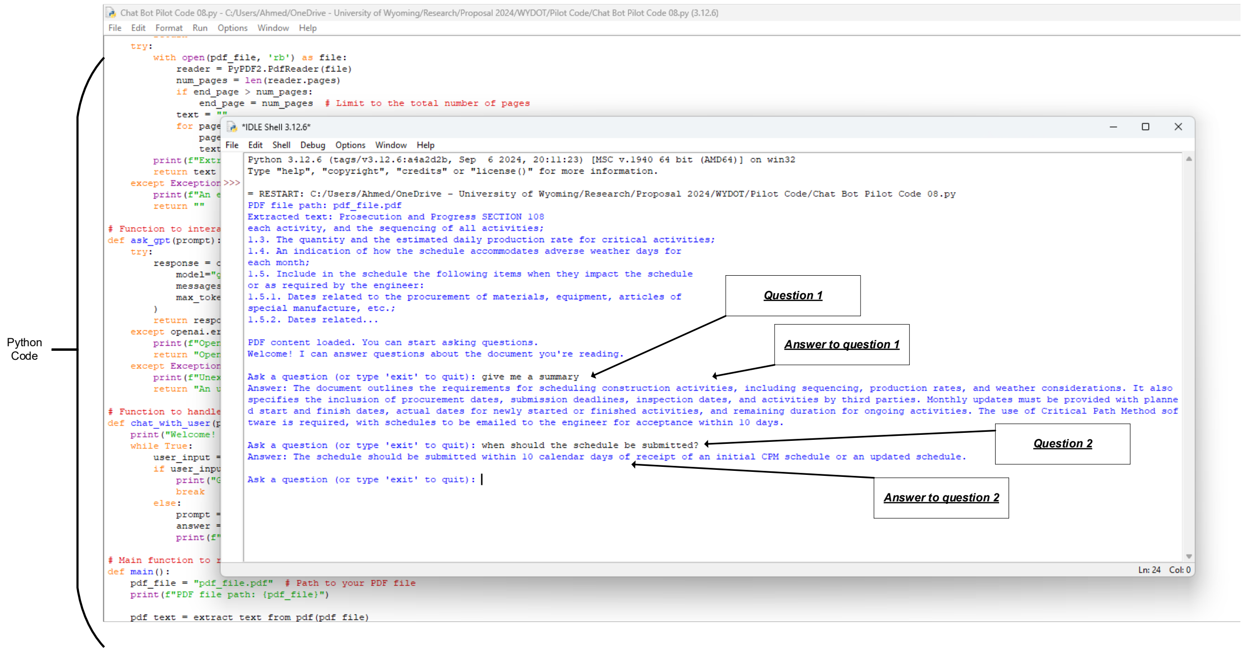

Figure 2. Example of code implementation

Exploration of Alternative LLM Models:

To ensure that KNOWWY is cost-effective and scalable, we will explore several other LLM models and platforms, comparing their capabilities, costs, and ease of integration. Examples of LLM models that will be considered include:

1. **Google's Pathways Language Model (PaLM):**
   This is a powerful LLM from Google designed to handle various language tasks. Palm has performed well in question-answering, summarization, and document interaction tasks, making it a potential candidate for KNOWWY. As part of this task, the cost and ease of integration with existing infrastructure will be evaluated.

2. **Meta's Large Language Model Meta AI (LLaMA):**
   LLaMA is another competitive language model that offers high performance for tasks like text generation and summarization. As an open-source model, it may present more cost-efficient options, especially for organizations that require control over the data and processing environment.

3. **Open-Source Alternatives (e.g., GPT-J or GPT-NeoX):**
   These models are available for organizations looking to avoid the ongoing costs associated with cloud-based LLM APIs. By hosting an open-source LLM on WYDOT's internal servers, KNOWWY could become a highly cost-effective tool, which will require more hardware and maintenance investment.

Cost Efficiency Analysis:
As part of this task, we will conduct a detailed analysis of the costs associated with each LLM model, including upfront implementation and long-term operational expenses. This analysis will consider API usage fees, data storage, server hosting, and the technical support required to maintain the chatbot system. Our goal is to ensure that KNOWWY not only provides high-quality KT capabilities but does so cost-effectively and aligns with WYDOT's budgetary constraints.

Functionality Beyond Text Interaction:
In addition to interacting with textual content from documents, KNOWWY will be designed to handle more complex data types, such as flowcharts and figures. We will develop methods to extract and convert visual information into text-based data so that the chatbot can generate helpful responses, even when the original knowledge is stored in non-text formats. This feature will expand the chatbot's ability to handle a wider range of internal documents and resources.

Usability and Integration:
A key aspect of KNOWWY will be its user-friendly interface, ensuring that WYDOT employees from all divisions can easily access and retrieve relevant knowledge. The chatbot will be integrated with WYDOT's existing IT infrastructure, either as part of the internal website or through an independent domain, depending on WYDOT's needs and preferences. The decision on integration will also consider accessibility, security, and long-term maintenance requirements, which will be coordinated with WYDOT IT. The successful implementation of the KNOWWY chatbot will result in a powerful, AI-driven tool that enhances KM and transfer within WYDOT. Critical information will be easily accessible to all employees while ensuring the system remains scalable and cost-efficient.

<u>Task 8 – Conduct a pilot study to test and validate the ChatBot (KNOWWY) model</u>

In this task, we will conduct a pilot study to test and validate the KNOWWY chatbot model by deploying it for experimental use among select WYDOT employees. The pilot study aims to assess the functionality, usability, and accuracy of the chatbot in real-world scenarios, ensuring that it effectively facilitates KM and KT within WYDOT.

Deployment and Experimental Use:

The chatbot will be deployed in a controlled environment, allowing WYDOT employees from various divisions and roles to interact with it and access knowledge related to standard procedures, technical manuals, and internal documents. The employees will be encouraged to use the chatbot to retrieve information and answer queries related to their daily tasks.

Feedback Collection:

Throughout the pilot, we will formally collect feedback from the participating employees using structured surveys. The feedback will evaluate the chatbot's user interface, ease of use, response accuracy, and usefulness in facilitating knowledge access. We will also gather suggestions for improvements, allowing us to refine and optimize the system based on user experiences.

Accuracy Testing:

In addition to gathering user feedback, we will rigorously test the chatbot's accuracy by manually verifying the percentage of correct answers provided by KNOWWY. This will involve setting up a series of test queries across different knowledge areas and comparing the chatbot's responses with verified answers. The accuracy of the responses will be measured as a percentage, ensuring the chatbot can deliver reliable and precise information.

Validation Metrics:

The validation process will include the following key metrics:

- **Percentage of correct answers:** This will be calculated by comparing the chatbot's responses to a manually validated set of correct answers, providing an objective measure of its performance.

- **User satisfaction scores:** Based on employee feedback, we will assess how well the chatbot performs in terms of usability, response speed, and accuracy.

<u>Task 9 – Write a technical report and summarize the findings</u>

In this task, we will compile the results of the entire project into a comprehensive technical report. The report will summarize key findings from each phase, including:

- **Employee Turnover Analysis:** Detailed results from the structured questionnaire surveys and interviews and the exit interview data analysis will be provided. This includes identifying the root causes of turnover, evaluating the efficacy of current exit interviews, and providing actionable recommendations to reduce employee turnover rates across WYDOT divisions and groups.
- **KNOWWY Chatbot Development and Pilot Testing:** The report will present the outcomes of the KNOWWY chatbot development, including user feedback from the pilot study, accuracy metrics (such as the percentage of correct answers), and overall system performance. Key insights from the chatbot's validation phase and recommendations for future improvements will also be included.

7. Work Plan and Implementation

7.1 Deliverables

The main deliverables of this project include a comprehensive employee turnover Report, which analyzes the root causes of turnover, evaluates the current exit interview process, and provides targeted recommendations to reduce employee turnover across WYDOT. Another key deliverable is the KNOWWY Chatbot, a functional chatbot designed for KM and KT, capturing explicit knowledge and tested through a pilot study. Finally, the project will conclude with a Final Technical Report, summarizing all findings and offering actionable recommendations for the broader deployment of the KNOWWY chatbot and strategies to improve employee retention.

7.2 Progress Reports

We will submit quarterly progress reports to the research center for review and feedback. Each progress report will summarize the progress and findings of the project work tasks.

7.3 Final Report

A final report will be submitted by the end of the project, including all findings, results, and recommendations.

7.4 Project Closeout

A copy of the final report and project deliverables will be presented to the WYDOT research center by the end of the project's schedule.

8. Schedule

This project is expected to be 24 months, from January 2025 to December 2026. Figure 3 shows the expected start and finish dates for each task.

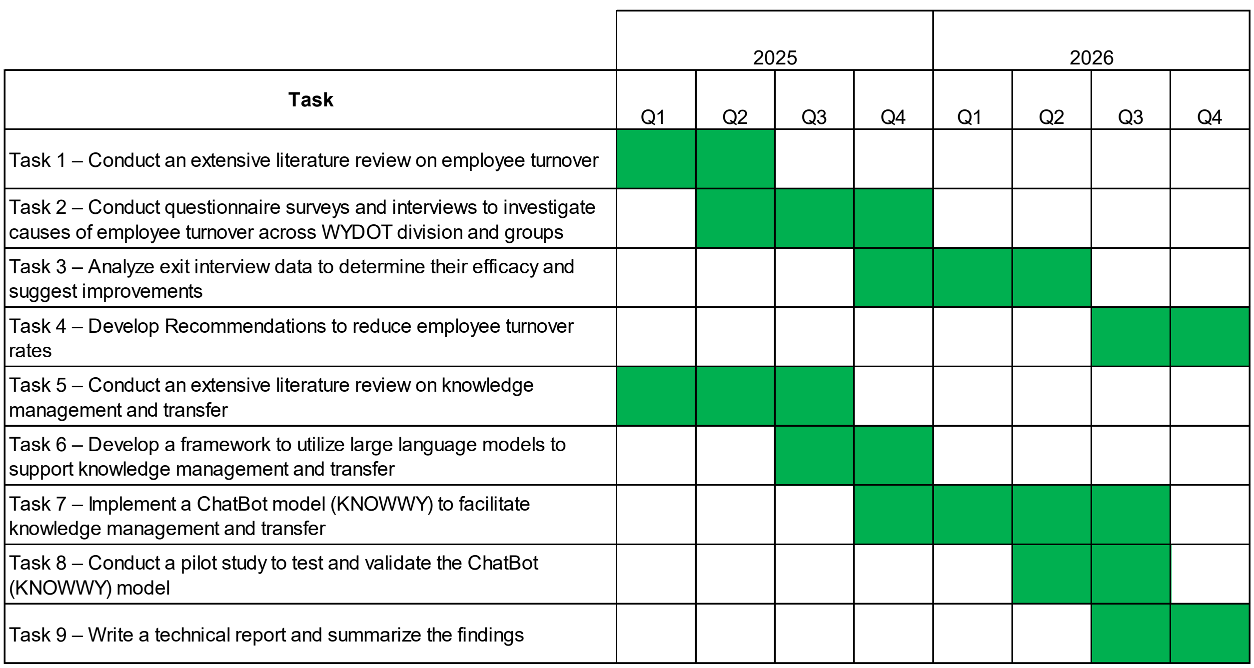

Figure 3. Project schedule

9. Budget and Justification

The total budget requested for this project is $216,515. Table 1 shows a detailed breakdown of the budget.

Table 1. Budget breakdown

Category	Year 1	Year 2	Total	Justification
Salary				
PI (Abdelaty)	$15,999.00	$16,318.98	$32,317.98	Three months of summer salary to lead and supervise research tasks
Graduate Student (PhD)	$29,100.00	$30,264.00	$59,364.00	Graduate student salary to work on tasks 5 to 9
Graduate Student (MSc)	$21,000.00	$21,840.00	$42,840.00	Graduate student salary to work on tasks 1 to 4 and 9
Consultant fees	$5,000.00	$5,000.00	$10,000.00	Consulting fees to oversee Chatbot development and domain hosting
Fringe				
PI (Abdelaty) 38.7%	$6,192.00	$6,315.00	$12,507.00	Fringe rate for PI
Graduate student 3.3%	$1,653.00	$1,719.00	$3,372.00	Fringe rate for graduate students
Travel	$3,000.00	$3,000.00	$6,000.00	Travel to present research outcomes at conferences
Publications/Editing services	$250.00	$250.00	$500.00	Editing fees for final report and research publications
Student tuition and fees	$23,365.00	$24,299.60	$47,664.60	Student tuition and fees
Open AI and application development	-	$9,000.00	$9,000.00	Estimated budget to process about 2000 pages of data and approximately 5000 user queries
Total direct	$105,559.00	$118,006.58	$223,565.58	
Indirect rate 20%	$21,111.80	$23,601.32	44,713.12	20% indirect cost
Total cost	**$126,670.80**	**$141,607.90**	**$268,278.70**	

10. Technology Transfer

The research team will disseminate the results of this research project through technical papers and presentations in academic venues. The results will also be shared with WYDOT personnel throughout the implementation of the research tasks.

11. Data Management Plan

Data collected from WYDOT will be stored in electronic form on the University of Wyoming computers and servers. In some cases, the team might need to collect non-digital data stored in paper forms. In these cases, the team will digitize the data in paper form for further analysis. Data will be stored for the duration of the projects, and the research team will store a backup of the data with approval from WYDOT.

12. Personnel

Dr. Abdelaty earned his PhD in Civil Engineering from Iowa State University with a concentration in Construction Engineering. His PhD focuses on infrastructure asset management and practices such as supporting decision-making systems using data-driven algorithms. He started his academic career in 2017 at Southern Illinois University-Edwardsville. He then transitioned to the University of Wyoming in 2020 as an assistant professor in the Department of Civil and Architectural Engineering and Construction Management. Dr. Abdelaty served as the PI for a project funded by the Mountains Plains Consortium to evaluate schedule delays in transportation projects. He is currently serving as PI for three other projects focusing on developing tools and methods to mitigate design errors and omissions for WYDOT, using AI to develop to enhance the engineer's estimate for transportation projects, and digitization of outdoor recreational trails.

Dr. Abdelaty also worked as the lead graduate research assistant for three research projects funded by the Iowa Department of Transportation and one funded by the Midwest Transportation Center. Through his research and funded research projects, Dr. Abdelaty gained experience in infrastructure asset management, preconstruction services, conceptual estimating, and life-cycle cost analysis. Dr. Abdelaty developed a conceptual estimating tool for the Iowa Department of Transportation to estimate bridge design projects' costs and engineering hours. The tool uses historical bid data and associated bridge design attributes to determine a conceptual estimate of the number of engineering hours and consultant fees to design the bridge using case-based reasoning, neural networks, and regression analysis. Dr. Abdelaty used Excel to develop the estimating tool, which enabled it to be practice-ready. Similarly, Dr. Abdelaty used the same methodology to develop another conceptual estimating model for a general contractor in Missouri. The tool allows the contractor to develop quick rough order of magnitude estimates using their historical data. Dr. Abdelaty possesses significant experience in developing tools that are ready for implementation to be used by local transportation agencies and contractors. Dr. Abdelaty has published more than 30 journals, conference papers, and technical reports.

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