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Research on the Development and Application of Science and Technology Project Management Platform Based on Data Visualization

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Abstract: *The difficultness of S&T project management activity is relatively increasing significantly and the vast and multidimensional datasets from the projects far exceed the acceptable use limits of conventional management tools. Information overload and fragmentation result in slow decision-making and delayed responses to risks, which is a major obstacle to improve the effectiveness of science and technology innovation. Data visualization technology with its technical core being graphic representation of abstract information represents a new opportunity for science and technology project management. It is no longer just an information display technology, it is now a primary method used to mine the information value of data and enhance cognitive efficiency. Developing a project management platform with integrated advanced visualization technologies may be urgently needed to provide real-time understanding and dynamic interaction of complex project data to optimize resource allocation, speed up project development, and augment scientific decision-making, that is of great practical significance to improving the competitiveness of national science and technology.*

Keywords: *Data Visualization; Science and Technology Project Management Platform; Development; Application*

1. Introduction

The basic mission of science and technology projects is to promote frontier exploration and industrial upgrading, and effective management is closely related to the effectiveness of innovation. However, the management of science and technology projects typically is facing serious challenges: cumbersome reports bury key indicators, information silos of scattered and heterogeneous data sources, barriers to collaboration from multiple parties, and decisions made inevitably creeping from backward and one-sided information. Data visualization technology solves the above dilemmas by offering a disruptive alternative thanks to its strong information compression and intuitive presentation capabilities. It converts the abstract and complex status of the project, resource flow and risk signals into visual language that is perceivable to the user, thus reducing cognitive load and enabling sharing and agreeing consensus. Exploring and constructing a science and technology projects management platform with a deep integration of data visualization is an inevitable pathway to address the complexities of management, unleash the value of data and ensure the science decision-making is agile, addressing an important way to optimize the science and technology innovation ecosystem.

2. Theoretical Foundations of Data Visualization and Technology Project Management

2.1 Definition and Characteristics of Data Visualization

Data visualization is fundamentally about the technical work of transposing complex and abstract data information to visual graphical symbols that illuminate patterns, trends, and anomalies that lie behind numbers. The key to this technology includes the exercise of the nature of the human visual system as a powerful pattern recognition machine, consequently mapping multi-dimensional project indicators (for example, progress, cost, risk, etc.) to intuitive visual elements (for example, shapes, locations, colors, etc.). When project managers are faced with enormous amounts of project data, they do not have to struggle over de-coding raw forms or report after report, but rather can note important status and identify potential problems almost immediately [1]. Visualization is a natural method of providing meaning from complex information quickly, converting static data points into interactive

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dynamic graphics, and allows users to focus on details or focus on general (big picture) project status. Its design best practices rely on a representation of real-time project dynamics and reveal the underlying connections in data, and thus penetrate the fog of information for managers to make better, and more timely and accurate judgments.

2.2 Advantages and Roles of Data Visualization in Management

Visualization tools bring substantial cognitive efficiency gains to technology project management. When faced with the complexity of project information, graphical representations can penetrate the surface of the data and reveal early signals of schedule deviations, resource allocation conflicts, or potential risks. As a result, communication barriers within the team are greatly reduced, and members from different professional backgrounds rely on a shared visual language to quickly understand the project's overall picture and the relevance of their respective tasks, so that the goals of collaboration become clearer and more recognizable. Decision-making is supported by dynamically updated charts and graphs instead of lagging textual reports, so that resource allocation adjustments or risk response strategies can be based on a precise grasp of the real-time status. The value of project data no longer sleeps in the database, but is activated as the key basis for driving actions, helping managers quickly locate the core issues in complex situations. Visualization has the natural qualities of cohesion and focus, making the process of promoting science and technology projects more transparent and controllable, making it possible to shift from passive response to active guidance, and shortening the path from insight to action [2].

2.3 International experience in advanced data visualization techniques

The international leading team integrates the data-driven concept into the whole management process, and the visualization system naturally carries the function of decision support instead of recording after the fact. Dynamic rendering engine and distributed computing architecture support instant response to massive project data, and complex correlation analysis is completed in a nearly senseless state with interaction delay. Interaction design philosophy emphasizes the priority of user's cognitive habits, and high-frequency operation paths are refined into minimal gestures or voice commands through rigorous behavioral analysis. Standardized component libraries allow development teams to reuse massively validated visualization patterns, avoiding the internal consumption of resources caused by duplicated development of basic diagrams. Open protocols led by industry consortiums ensure that core metrics definitions and visual coding rules remain consistent across different platforms, eliminating the need for additional adaptation costs for cross-organizational collaboration. The open source ecosystem continues to contribute battle-tested security protection modules and privacy computing frameworks, and the professional community has formed a technology dividend sharing mechanism. Behind these practices is a systematic coupling of technology, standards and collaboration culture, and visualization has truly become an extension of managers' intuition rather than an additional tool, and its experience kernel deserves in-depth analysis.

3. Problems and Challenges in the Development of Science and Technology Project Management Platform

3.1 Insufficient Data Integration and Standardization

Science and technology project data are often scattered in the respective systems of different departments, with a variety of formats that make it difficult to have direct conversations, and a lack of unified standardization of basic information that makes the meaning of key fields ambiguous. If the platform wants to converge this information to depict the whole picture of the project, it is firstly hindered by the reality of huge differences in data sources, with inconsistent names, non-uniform units, and raw data of varying granularity piling up to form an insurmountable integration gap. The lag in standardization further exacerbates the difficulty of analysis. Indicators with similar meanings may be given different definitions in different parts of the process, and the process of data cleansing and conversion consumes a lot of energy, but it is still difficult to ensure the reliability and comparability of the results. As a result, the real reflection of the project status becomes fragmented, and it is difficult for managers to obtain accurate and consistent data to support cross-project comparison or trend judgment, and a large amount of valuable information lies dormant in each other's fragmented silos, which cannot be effectively linked, and the timeliness and accuracy of decision-making are deeply burdened by it.

The underlying defects of data integration become the primary bottleneck of the platform's visualization performance, restricting the transformation efficiency from data to insights [3].

3.2 Visualization and Interaction Efficiency Needs to be Improved

Users' tolerance for slow or unwieldy visualizations often will be expended before the user actually sees a dynamic charts, graphs loading in a slow manner or slower than expected will immediately impair the ability to view key information. When an interaction design does not respond to the primary aspects of real-world management scenarios, users often feel lost in redundant menus and complex controls and quite frankly, it will take so much time and effort to find the right data or view dimensions, that they will end up frustrated. Poorly constructed operating logic will waste even more time having users spend extra effort trying to learn the rules for engagement of the interface rather than engaging the subject area and in the process, the potential efficiency that the tool was suppose to eventually lead to will suffer hidden costs. Having not been optimized for high-frequency operation pathways complicates even simple tasks by making users have to click through several surfaces to check on progress or take the pulse on risk in terms of interrupting the continuous thought pattern contextually. When gaps in interaction experience arise users will progressively lose trust in operating visualization tools, regardless of how high level the bleeding edge data presentation might be - interaction bottlenecks will mean that they will not convert to real management performance , and the technological advantage will eventually be collapsed in planning for action through sloppy operating processes affecting users' intent and longevity to engage with the platform at a deeper level.

3.3 Insufficient Support of Policies and Industry Standards

The policy framework is ambiguous in defining the scope of data collection and sharing mechanism, and the platform developer lacks authoritative guidelines to clarify the definition boundary of core indicators and interaction norms. The lag in the construction of industry standards makes it difficult for the visualization modules built by different organizations to be interoperable, and the logical structure and data caliber of the same project presented in different systems differ significantly. In cross-departmental collaboration, each party follows its own internal rules, and the platform is forced to be compatible with multiple data specifications, which increases the complexity of the underlying architecture. In the absence of standards, development teams need to repeatedly coordinate data interfaces and presentation logic, and a large amount of resources are consumed in basic adaptation rather than functional deepening. Users face re-learning costs when switching between platforms, and the construction of a unified management view is substantially hindered by the lack of standards coordination. The weak industry consensus makes it difficult to promote advanced visualization practices on a large scale, and platform development is caught in the inefficient cycle of repetitive wheel building. The lack of support at the policy and standards level has become a key resistance that restricts the healthy development of the platform ecosystem.

3.4 Inadequate Multi-Role Collaboration Mechanisms

The platform design fails to fully consider the different roles of researchers, financial specialists, outsourcing units and other different roles in the distribution of rights and access to information at the level of different needs, the key nodes lack of smooth collaboration interface. The R&D personnel are buried in the technical attack, but it is difficult to perceive the signals of customer demand change or budget adjustment in real time, and the financial team is often caught in the tug-of-war of repeated confirmations due to the technical terminology understanding bias when reviewing the progress. There are obvious faults in the chain of information transfer, upstream task delays or changes can not be automatically triggered by the downstream responsible party's early warning prompts, and the collaborative process in the key interfaces appear in the management vacuum. Fuzzy boundaries of authority cause some members to be at a loss when faced with requests for operations beyond their scope of responsibility, and it is difficult to respond in a timely manner to those who really need to intervene due to the lack of information transparency. Collaboration barriers make cross-functional communication evolve into inefficient meetings and email exchanges, and the team's energy is consumed in coordination rather than value creation. The coherence and agility of the overall promotion of the project are weakened, and the synergistic potential that the platform is supposed to have is far from being unleashed.

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3.5 Security and Privacy Protection Issues

The core technical parameters and sensitive business data aggregated on the platform face severe external threats and internal control risks, and unencrypted transmission or improper storage may expose key R&D secrets to potential leakage. Failure to accurately match the principle of minimal authorization for different roles in the design of the privilege system may result in ordinary members having access to core data that is beyond their scope of responsibility, and improperly set operating privileges may further magnify the possibility of misuse or malicious tampering. In the absence of fine-grained access control mechanisms for cross-border data flow or third-party collaboration scenarios, partners may have access to project details beyond the agreed boundaries. Weak security audit function makes it difficult to trace abnormal access behavior, and there is a lack of effective watermark tracking and operation trace when sensitive data is exported or transferred. The lagging nature of protection measures and the rapid evolution of attack methods form a continuous tension, and the foundation of users' trust in the platform for storing critical information is eroded, and security shortcomings substantially hinder the in-depth release of data value and the willingness of cross-organizational collaboration.

4. Countermeasure Suggestions for the Development of Science and Technology Project Management Platforms

4.1 Strengthening Data Infrastructure Construction

The top-level design of data architecture must prioritize the establishment of a unified core metadata standard and specification system, which paves a solid foundation for cross-system and cross-stage data flow. Governance rules need to clarify the attribution of responsibility and quality verification process at the source of data collection to eliminate cognitive confusion caused by homonym or synonym, which can guarantee the accuracy and consistency of the underlying data. The technical support level should deploy flexible and scalable data center capabilities to efficiently clean, convert and integrate multi-dimensional heterogeneous data sources from experimental records, financial systems, progress tracking and so on. The infrastructure should have built-in full-cycle data lineage tracing mechanism and status monitoring functions, so that abnormal fluctuations or quality decline can be recognized and intervened in a timely manner. The technical department should continue to invest in optimizing the performance of data storage and computing resources, which can support real-time processing and efficient access to massive amounts of project data, and provide a stable and reliable data supply for upper-level visualization and analysis. The transformation of data from isolated fragments to organic integration is the prerequisite foundation for releasing its in-depth value to serve management decision-making, and is also the underlying lifeline for building credible visualization insights [4].

4.2 Optimizing Visual Interaction Design

The interaction logic should deeply fit the actual workflow of research managers from macro-control to micro-exploration, and high-frequency operations such as progress tracking or risk screening should be designed to avoid multi-layer jumps. The response speed of visualization components must be prioritized to ensure that the loading efficiency of the underlying rendering engine on dynamic charts directly affects the timeliness of obtaining key information. The user interface needs to be clearly divided between the core indicator area and the auxiliary analysis area, and the color coding and visual hierarchy should follow the cognitive rules to reduce the interpretation burden. The positional arrangement of operation controls should be in line with the natural trajectory of visual movement, and commonly used filtering, drilling down or comparison functions should be placed in the hot zone within easy reach. The interaction feedback mechanism should be immediate and clear, and the visual elements should have a coherent transition to avoid cognitive disconnection after a state change or operation trigger. Customization capabilities allow users to save frequently used view combinations based on their own focus, reducing repetitive configuration time. Smooth and natural interaction experience allows managers to focus on the essence of the problem rather than the tool itself, so that the process of transforming data insights into management actions is smoother and more efficient, and the technology really serves decision-making rather than creating obstacles.

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4.3 Improving Policies and Industry Standards

Policymakers need to clearly define the ownership, sharing boundaries and security responsibilities of core data of science and technology projects, and provide a compliant and operable legal framework for cross-agency data flow. The industry alliance should take the lead in building a widely recognized visual symbol system and interaction protocol, and unify the visual coding rules for key indicators such as progress status and risk level. The standard system should cover technical details such as data interface specifications, permission model definitions and audit log formats, which can ensure seamless integration and mutual recognition of data across different platform modules. Regulators can promote the establishment of a third-party certification mechanism to grant an interoperability logo to management platforms that comply with the standard specifications, so as to incentivize developers to proactively follow the unified framework. Standards documentation needs to be dynamically updated to incorporate emerging technology practices and evolving industry management needs. Consensus rule framework significantly reduces collaboration friction, developers do not need to repeatedly solve basic compatibility issues, user experience remains consistent when switching between different platforms, and policies and standards jointly pave the institutional track to promote the visualization platform ecosystem from fragmentation to synergy.

4.4 Promoting Multi-Actor Collaboration

The platform architecture needs to build a multi-role collaborative space with task flow as the core, where researchers, financial specialists and outsourcing units can obtain differentiated data views and operation entrances according to their permissions in a unified interface. Task status changes or risk warnings should automatically trigger cross-functional alert mechanisms, and the budget control module should synchronize resource consumption analysis when R&D engineers submit milestone results. The responsibility matrix should be clearly embedded in the collaboration process, and the operation authority and information visibility of each link should accurately match the roles and responsibilities, so as to avoid overstepping the authority to intervene or responsibility vacuum. Collaboration nodes are preset with standardized information exchange templates, and technical parameter updates and funding approvals are transmitted semantically and without loss through structured fields. The platform mechanism drives the information from passive request to active push, the project secretary no longer spends a lot of time manually coordinating progress synchronization meetings, and cross-role collaboration is transformed into an organic operation based on real-time data linkage, releasing the team's potential to focus on core value creation [5].

4.5 Safeguarding Data Security and Privacy

The encryption system needs to run through the whole chain of data storage, transmission and application, and the core R&D parameters and commercially sensitive information can only enter the shared environment after being processed by high-strength algorithms. The permission model must strictly follow the principle of minimization of authorization and dynamic adjustment, and the experimenter only has access to the raw data of the module he is responsible for, and the financial commissioner automatically triggers dynamic desensitization of the key technical details when checking the cost details. Access control mechanism needs to support fine-grained policy configuration, third-party collaborators to obtain temporary privileges when the system automatically blocks the project information outside the agreed scope. The security audit function should completely record the data flow and operation traces, and the multi-factor verification process is triggered in real time by abnormal login or multi-frequency sensitive operations. Data export behavior is forced to load tamper-proof digital watermarks and operator identification, which combines with regular penetration testing and vulnerability scanning to form a closed loop of active defense. When the technical protection and management system form a deep bite, the security line of defense is transformed into a trust asset that supports cross-organizational collaboration, and users dare to entrust key data to the platform for in-depth mining and analysis, so that a dynamic balance is achieved between data value release and security and control.

5. Conclusion

The value of a technology project management platform that incorporates data visualization goes far beyond the tool level. It builds a new project management language - transforming abstract progress, resource games and potential risks into visual narratives that can be perceived intuitively. This transformation effectively breaks the information overload dilemma, and makes the whole picture and subtle dynamics of complex projects clearly presented. In the face of insufficient data integration, interaction efficiency bottlenecks and security concerns and other challenges, the only way to fully release the platform's potential is to systematically consolidate the underlying data governance, meticulously sculpt the user-centered interaction experience, actively promote the construction of cross-domain standards, break down the barriers to multi-role collaboration, and build a solid data security defense. When decision makers can “see” the pulse of the project and team members share the same dynamic panorama, the management will be upgraded from passive response to active foresight and precise control. The future platform will be smarter and more integrated, becoming the nerve center of science and technology innovation, allowing data to truly serve innovation, and driving science and technology project management to a new stage of greater efficiency, transparency and resilience.

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