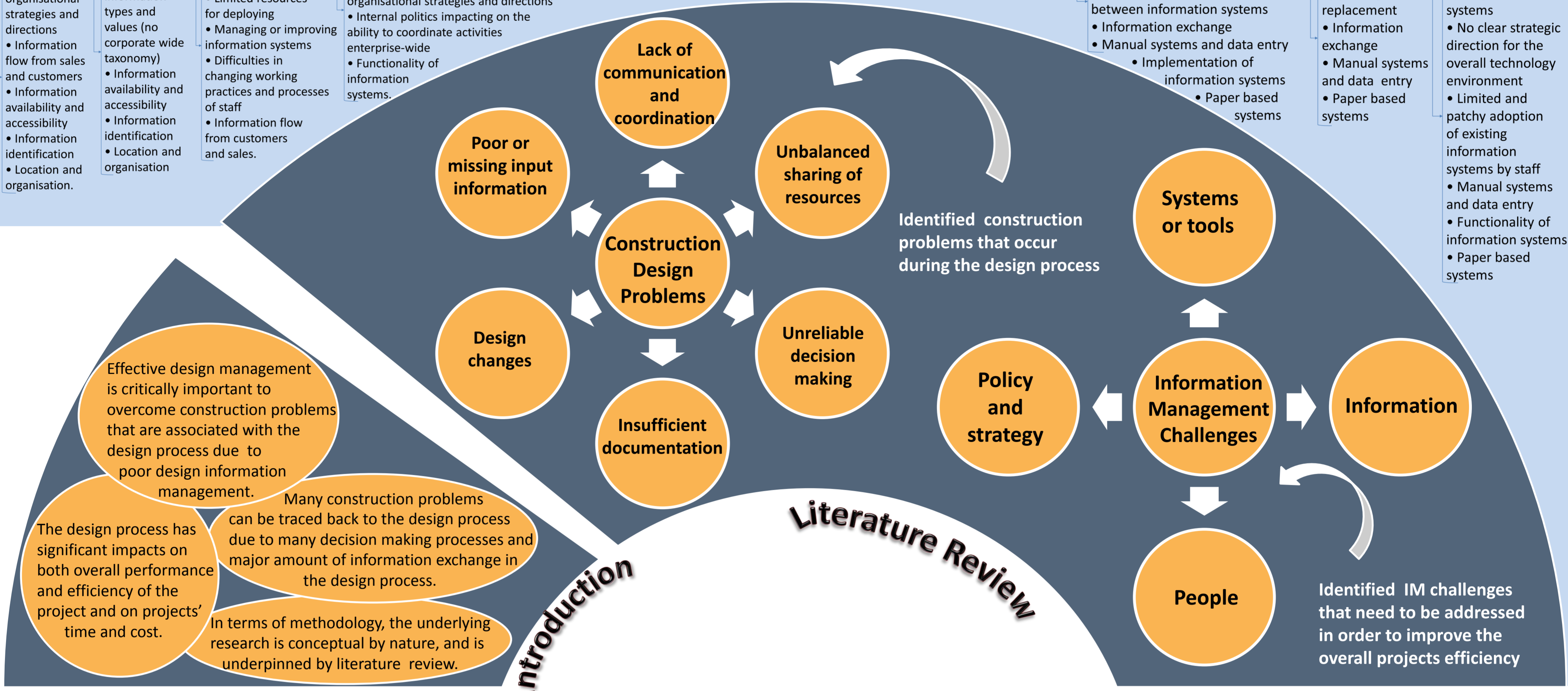


- People**
 - a) Lack of communication and coordination
 - Lack of integration or coordination between information systems
 - Large number of diverse business needs and issues to be addressed
 - Manual systems and data entry
 - Information flow from customers and sales
 - Information availability and accessibility
 - Implementation of information systems
 - Information completeness and accuracy
 - Paper based systems
 - b) Insufficient documentation
 - Large number of diverse business needs and issues to be addressed
 - Information availability and accessibility
 - Information completeness and accuracy
 - Information duplication
 - Paper based systems
 - c) Unbalanced sharing of resources
 - Little recognition and support of information management by senior management
 - Difficulties in changing working practices and processes of staff
 - Manual systems and data entry
 - Information flow from customers and sales
 - Information completeness and accuracy
 - Information duplication.
 - e) Unreliable decision making
 - No clear strategic direction for the overall technology environment
 - Limited and patchy adoption of existing information systems by staff
 - Large number of diverse business needs and issues to be addressed
 - Internal politics impacting on the ability to coordinate activities enterprise-wide
 - Information completeness and accuracy
 - Information duplication.
- Information**
 - a) Lack of communication and coordination
 - Lack of integration or coordination between information systems
 - Limited resources for deploying
 - Managing or improving information systems.
 - b) Insufficient documentation
 - Lack of clarity around broader organisational strategies and directions
 - Difficulties in changing working practices and processes of staff
 - c) Unbalanced sharing of resources
 - Difficulties in changing working practices and processes of staff
 - Information exchange
 - d) Poor or missing input information
 - Functionality of information systems
 - Information and availability and accessibility
 - e) Unreliable decision making
 - Information identification and location
 - Information and organisation accessibility
 - f) Design changes
 - Paper based systems
 - Large number of diverse business needs and issues to be addressed
- Policy and Strategy**
 - a) Lack of communication and coordination
 - Lack of clarity around broader organisational strategies and directions
 - Information flow from sales and customers
 - Information availability and accessibility
 - Information identification and organisation.
 - b) Insufficient documentation
 - Lack of enterprise-wide definitions for information types and values (no corporate wide taxonomy)
 - Information availability and accessibility
 - Information identification and organisation.
 - c) Unbalanced sharing of resources
 - Little recognition and support of information management by senior management
 - Limited resources for deploying
 - Managing or improving information systems
 - Difficulties in changing working practices and processes of staff
 - Information flow from customers and sales.
 - e) Unreliable decision making
 - No clear strategic direction for the overall technology environment
 - Large number of diverse business needs and issues to be addressed
 - Lack of clarity around broader organisational strategies and directions
 - Internal politics impacting on the ability to coordinate activities enterprise-wide
 - Functionality of information systems.
- Systems or Tools**
 - a) Lack of communication and coordination
 - Large number of disparate information management systems
 - Lack of integration or coordination between information systems
 - Information exchange
 - Manual systems and data entry
 - Implementation of information systems
 - Paper based systems
 - b) Insufficient documentation
 - Range of legacy systems requiring upgrading or replacement
 - Information exchange
 - Manual systems and data entry
 - Paper based systems
 - e) Unreliable decision making
 - Direct competition between information management systems
 - No clear strategic direction for the overall technology environment
 - Limited and patchy adoption of existing information systems by staff
 - Manual systems and data entry
 - Functionality of information systems
 - Paper based systems

The IM challenges and their relation to the construction design problems



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HOW BIM-LEAN INTEGRATION ENHANCES THE INFORMATION MANAGEMENT PROCESS IN THE CONSTRUCTION DESIGN

Conclusion

- Some of the key challenges within the construction design have been highlighted in this paper such as lack of communication and coordination, poor or missing input information, design changes.
- This paper identified some of the key IM challenges within the design process which have been summarised into four main categories of systems or tools, information, people, and policy and strategy.
- These challenges have been linked to the construction design problems and it is believed by the authors that by improving those, the IM will be accordingly improved.
- BIM and Lean would enhance IM. It is believed that the integration of BIM functionalities (i.e. visualisation) with Lean principles (i.e. reduce variability) enable better IM improvement during the design process.
- BIM and Lean interaction would benefit IM in terms of reducing construction design problems associated with the IM problems.

Research Findings

Lean Principles	BIM functionalities	Information Management Challenges / Construction Design Problems																							
		1. Systems or Tools						2. Information						3. People						4. Policy and Strategy					
		a	b	c	d	e	f	a	b	c	d	e	f	a	b	c	d	e	f	a	b	c	d	e	f
Reduce Variability	Visualisation	Indirect	Indirect	N/A	N/A	N/A	Direct	Direct	Direct	Direct	Direct	Direct	Direct	Direct	Direct	Direct	Direct	Direct	Direct	Direct	Direct	Direct	Direct	Direct	
Reduce cycle time																									
Increase flexibility																									
Use Visual Management																									
Verify and Validate																									
Reduce Variability	4D scheduling and construction sequence planning	Direct	Direct	N/A	N/A	N/A	Indirect	Direct	Direct	Direct	Direct	Direct	Direct	Indirect	Indirect	N/A	N/A	Direct	Indirect	Indirect	Indirect	N/A	N/A		
Reduce cycle time																									
Increase flexibility																									
Use Visual Management																									
Standardise																									
Reduce Variability	Collaboration and Communication	Direct	Indirect	N/A	N/A	N/A	Direct	Indirect	Direct	Direct	Direct	Direct	Direct	Indirect	Indirect	N/A	N/A	Direct	Indirect	Indirect	Indirect	N/A	N/A		
Reduce cycle time																									
Increase flexibility																									
Use Visual Management																									
Verify and Validate																									
Standardise																									
Reduce Variability	Clash Detection	Direct	Indirect	N/A	N/A	N/A	Direct	Direct	Direct	Direct	Direct	Direct	Direct	Indirect	Indirect	N/A	N/A	Indirect	Indirect	Indirect	Indirect	N/A	N/A		
Reduce cycle time																									
Verify and Validate																									

Lean Principles	BIM functionalities	1. Systems or Tools						2. Information	3. People	4. Policy and Strategy
		a	b	c	d	e	f			
Reduce Variability	Visualisation	Indirect	Indirect	N/A	N/A	N/A	Direct	Indirect	Direct	
Reduce cycle time										
Increase flexibility										
Use Visual Management										
Verify and Validate										
Reduce Variability	4D scheduling and construction sequence planning	Direct	Direct	N/A	N/A	N/A	Indirect	Direct	Indirect	
Reduce cycle time										
Increase flexibility										

4D scheduling and construction sequence planning

- Time and cost scheduling, and thus design could be identified in an earlier stage and would help to overcome the identified construction design problems such as missing information
- Information within the 4D scheduling provides an overall image of projects' current situation
- Project participants using 4D scheduling would be vital in recognising current conditions of the projects and the need to outline with necessary changes that could be required
- 4D scheduling supports the participants in identifying the necessary schedules required and the relevant data that will be needed in relation to material and cost information.
- It helps to avoid inconsistencies related to the provided documentation, unnecessary design changes, and avoid poor information input.
- It would improve the schedule planning reliability which will enhance the current deficiencies of communication and coordination within the projects

Clash detection

- Clash detection enables identifying clashes between systems and objects.
- These improved systems and strategies allow people to take more reliable decision making.
- Clash detection improves richness of the information exchange.
- It avoids future design changes and unreliable decision making.
- Human errors could also be identified through clash detection.

Visualisation

- All the shared information can be visualised by project participant in a collaborative environment.
- Design problems can be directly improved through identified design error or issues in the design stage.
- Visual management is linked closely to standardisation.
- Design problems due to lack of standardised systems would be improved directly and indirectly.
- As BIM and Lean provide effective work strategies the construction design problems will be resolved by improving information management

Collaboration

- Effective collaboration and communication among project participants enables creating accurate information.
- Integrated tools and systems improves the reliable decision making process
- Collaboration enables project participants to share information at the same time and adjust any changes.
- Clear understanding of the project strategy and requirements through better communication and improve coordination
- Effective information exchange among all the project team collaboratively enhances preparing sufficient documentation in the design process