IGLC 2021
LIMA, PERÚ - 29TH ANNUAL CONFERENCE
INTERNATIONAL GROUP FOR LEAN CONSTRUCTION

EXPLORING CONTROLLED EXPERIMENTAL SETTINGS FOR LEAN CONSTRUCION RESEARCH

Amila N. Wickramasekara
Vicente A. Gonzalez
Michael O'Sullivan
Cameron G. Walker
Mohammed A. Abdelmegid

AGENDA

- Introduction
- Research Method
- Literature Review
- Theoretical Framework to Support Serious Game-based Experimental Setting (SGES) in Lean Construction (LC) Research
- Conclusions

INTRODUCTION

- Nature of artifacts related to the current Lean Construction (LC) research

  Lean tools (i.e. LPS) + other technologies:
  Ex:
  - Computer simulation (Abdelmegid et al. 2019)
  - Building information modelling (Sacks et al. 2013)
  - Reliable commitment modelling (González et al. 2010)

- Such artifacts have not been tested with controlled experiments

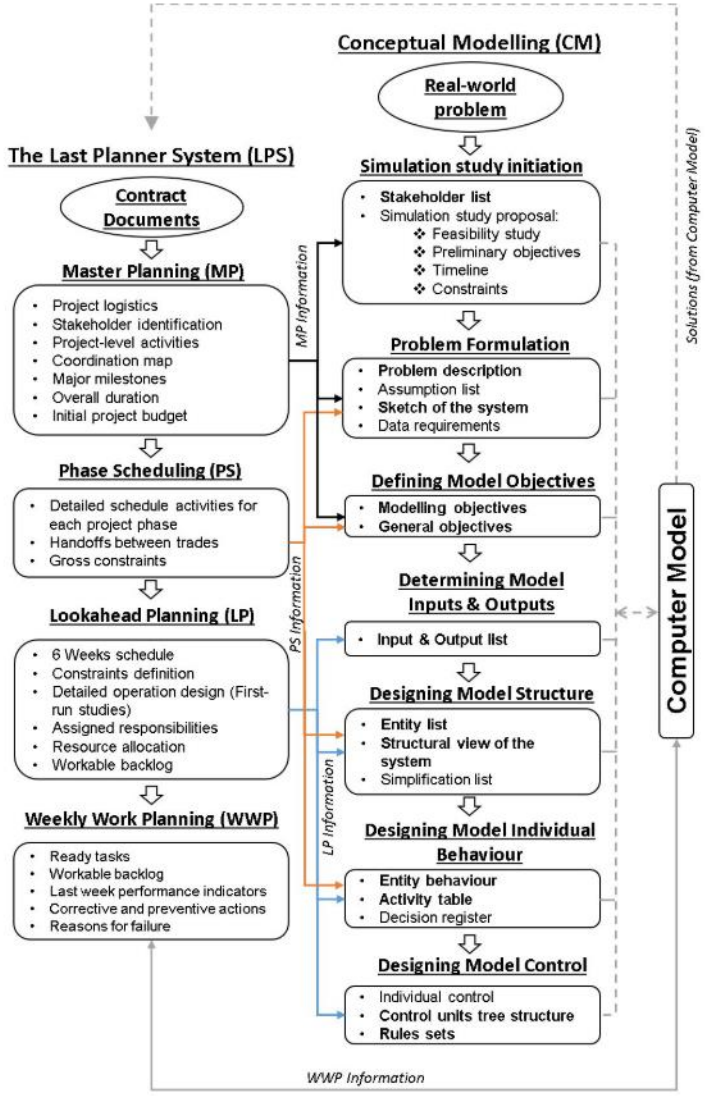


Figure 1. Ex: LPS with Computer Simulation, Abdelmegid et al. (2019)

INTRODUCTION

- Why controlled experiments?
  - To manipulate the variable(s) of interest
  - while controlling all other variables that exist in the experimental environment (Pelcin 1997)

- Effectiveness of such artifacts have been tested using controlled experiments with Serious Games in other domains
  Ex:
  - disaster preparedness (Feng et al. 2020)
  - IT education (Montes et al. 2021)
  - project management (Rumeser and Emsley 2019)

- But, controlled experiments have not been used in Lean Construction (LC) research with Serious Games

INTRODUCTION

- Why controlled experiment for LC research with serious games?
  - Construction operations are affected by many outside factors
    Ex: weather, work performance and supply fluctuations (AbouRizk et al. 2011)
  - Those factors influence on variable(s) of interest in research
  - It is challenging to develop controlled experiments in real construction projects
  - Consequently, hypothesis tests can not be performed accurately
  - But Serious Games can facilitate the development of controlled experimental environment

INTRODUCTION

- Our Proposal: Serious Game-based Experimental Settings (SGESs) for LC research
  - features of a real construction project can be presented,
  - controlled and
  - replicated (to a certain extent), in order to conduct controlled experiments

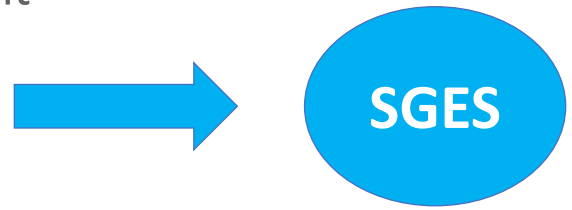
- Thereby, validity of Lean Construction (LC) research can be enhanced through accurate hypotheses testing

- Development of SGES with the following
  - Agile Project Management
  - Design Thinking
  - Lean Start-up
  - Design Science Research Methodology

RESEARCH METHOD

- Research Method – Literature Review
- Objective -
  - To emphasize the advantages of using

    Agile Project Management
    Design Thinking
    Lean Start-up
    Serious Games
    Design Science Research Methodology



- Database - Scopus
- Keywords -

  Agile
  Design Thinking
  Lean Start-up
  Serious Games
  Design Science Research Methodology
  Controlled Experiments

- Search criteria –

  Abstract, Title, Keywords

- Backward & forward snowballing

LITERATURE REVIEW – Agile Project Management

- 4 Values & 12 Principles (Beck et al. 2001)
  - individuals and interactions over processes and tools
  - working software over comprehensive documentation
  - customer collaboration over contract negotiation
  - responding to change over following a plan.

- Scrum – tools (Rodríguez et al. 2012)
  - product backlog
  - sprint
  - sprint planning
  - sprint review meeting
  - sprint retrospective meeting

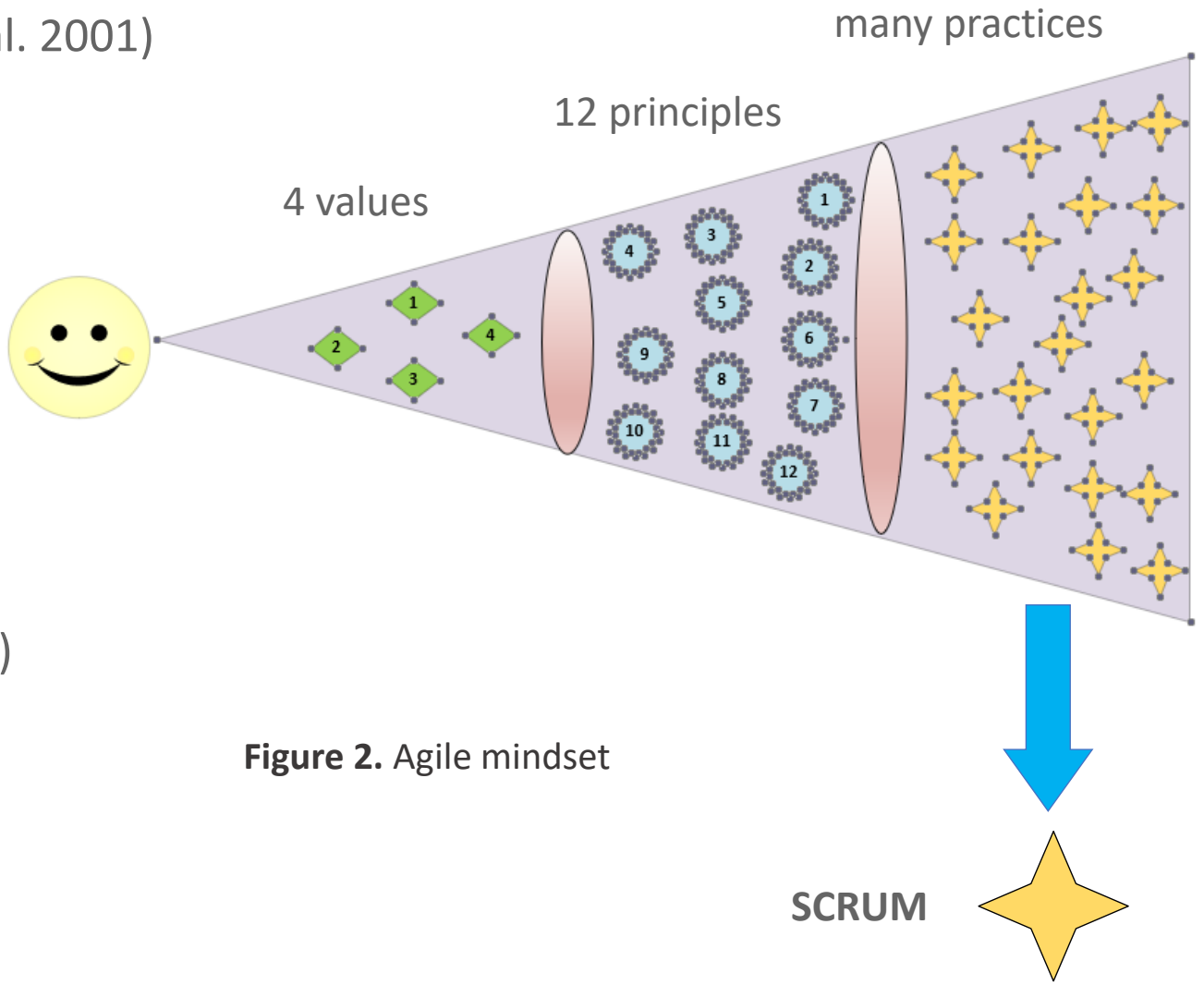


Figure 2. Agile mindset

LITERATURE REVIEW – Design Thinking

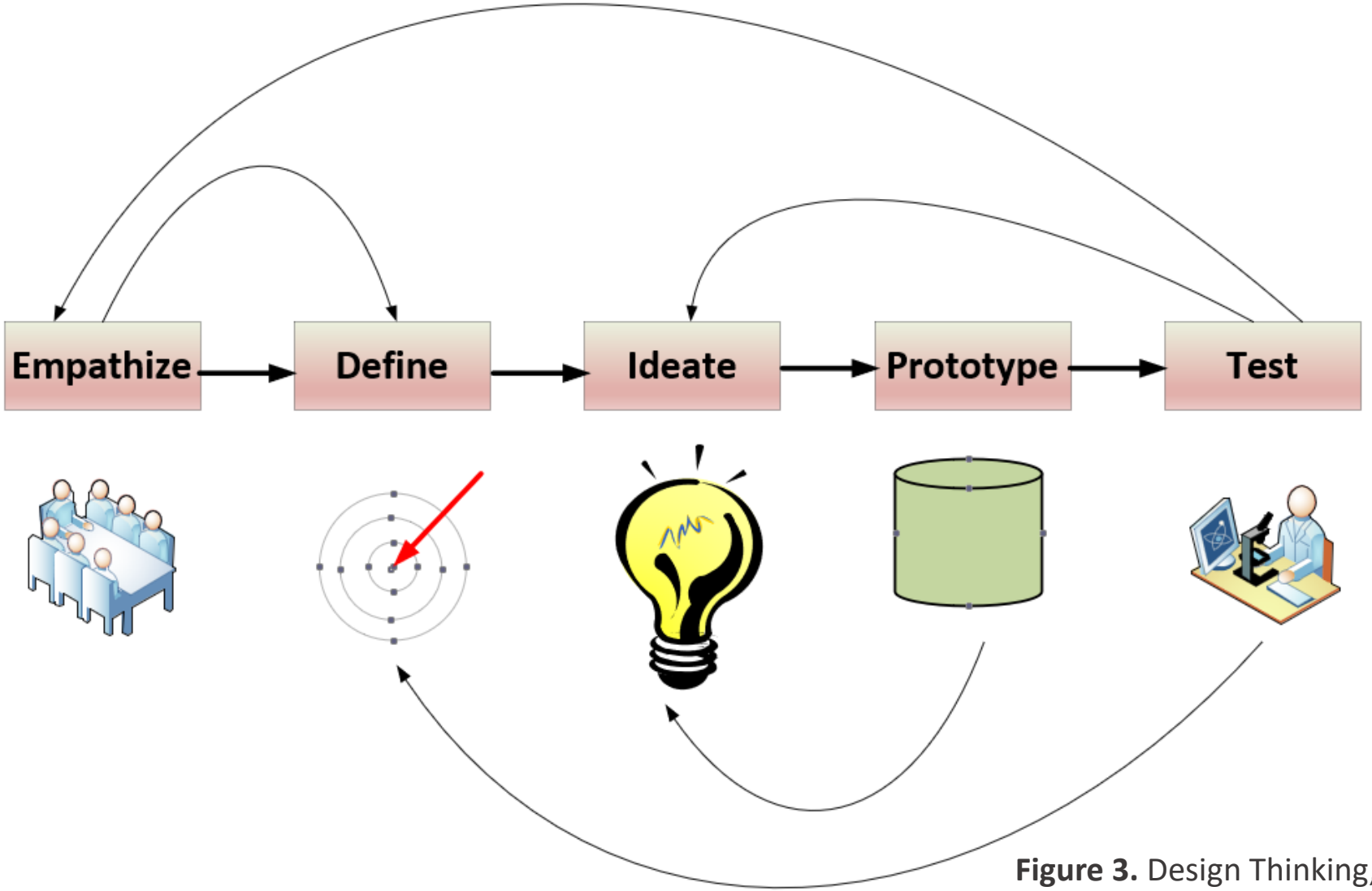


Figure 3. Design Thinking, (Plattner et al. 2011)

LITERATURE REVIEW – Lean Start-up

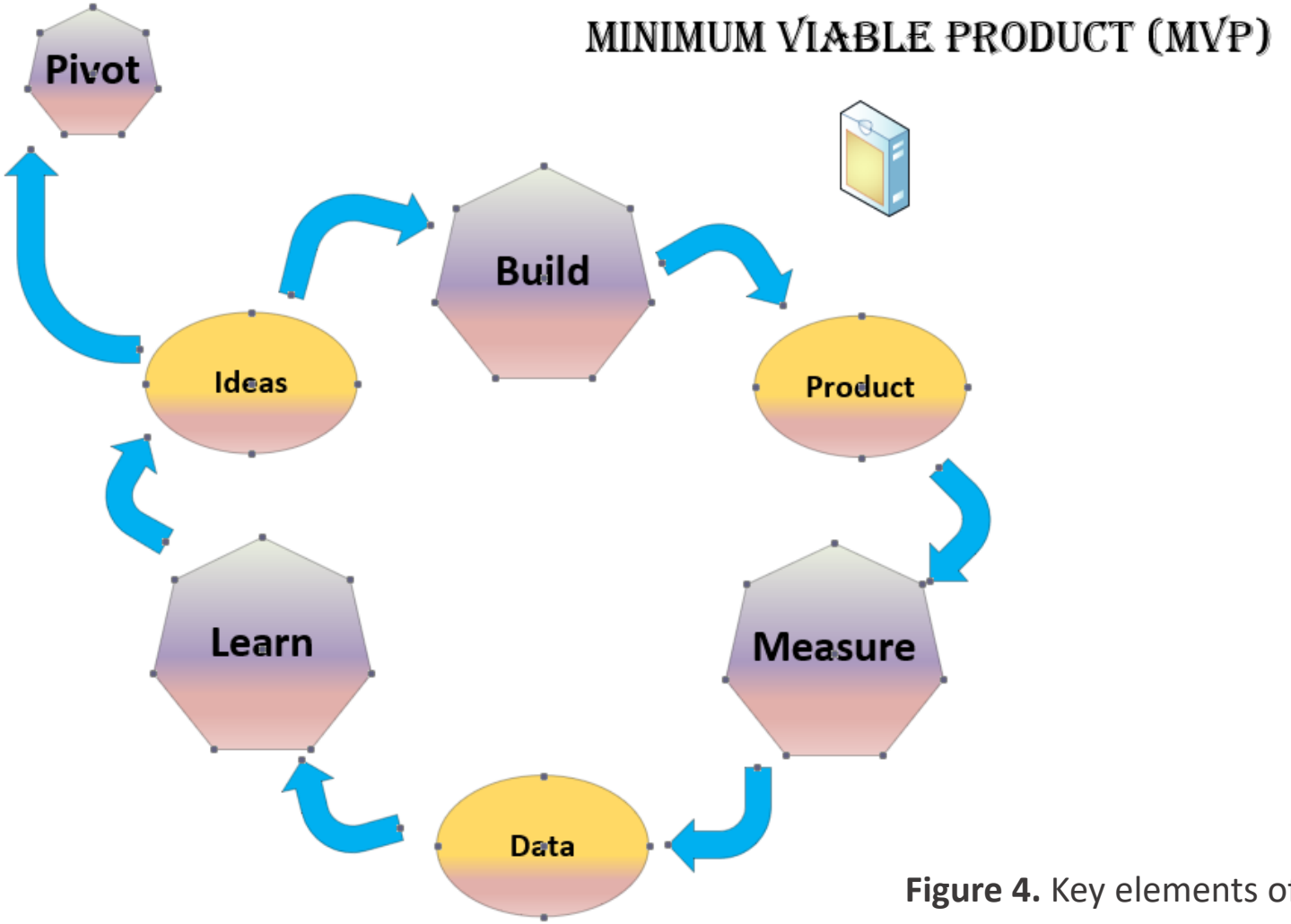


Figure 4. Key elements of Lean Start-up, (Ries 2011)

LITERATURE REVIEW – Serious Games (SGs)

- Definition – Serious Games
  "games in which education (in its various forms) is the primary goal, rather than entertainment". (Michael and Chen 2006)

- Serious Games provide the opportunity to learn something without the cost of real-world consequences or errors.

- Serious Games have been used as an assessment tool in different fields,
  (i.e. education, health etc.)

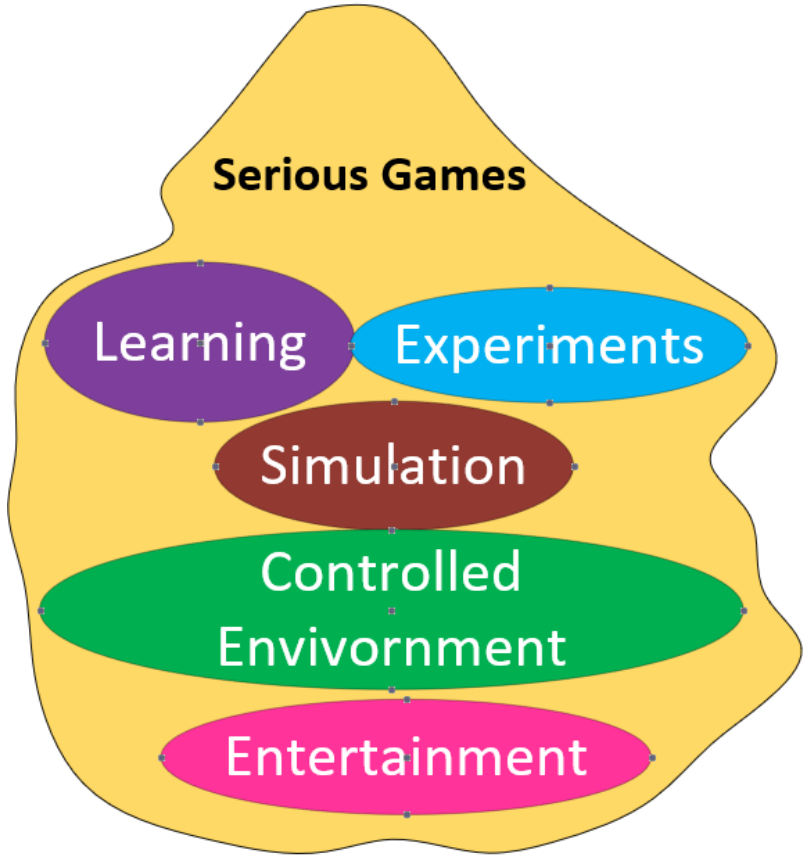


Figure 5. Overview of Serious Games

LITERATURE REVIEW –
Design Science Research Methodology

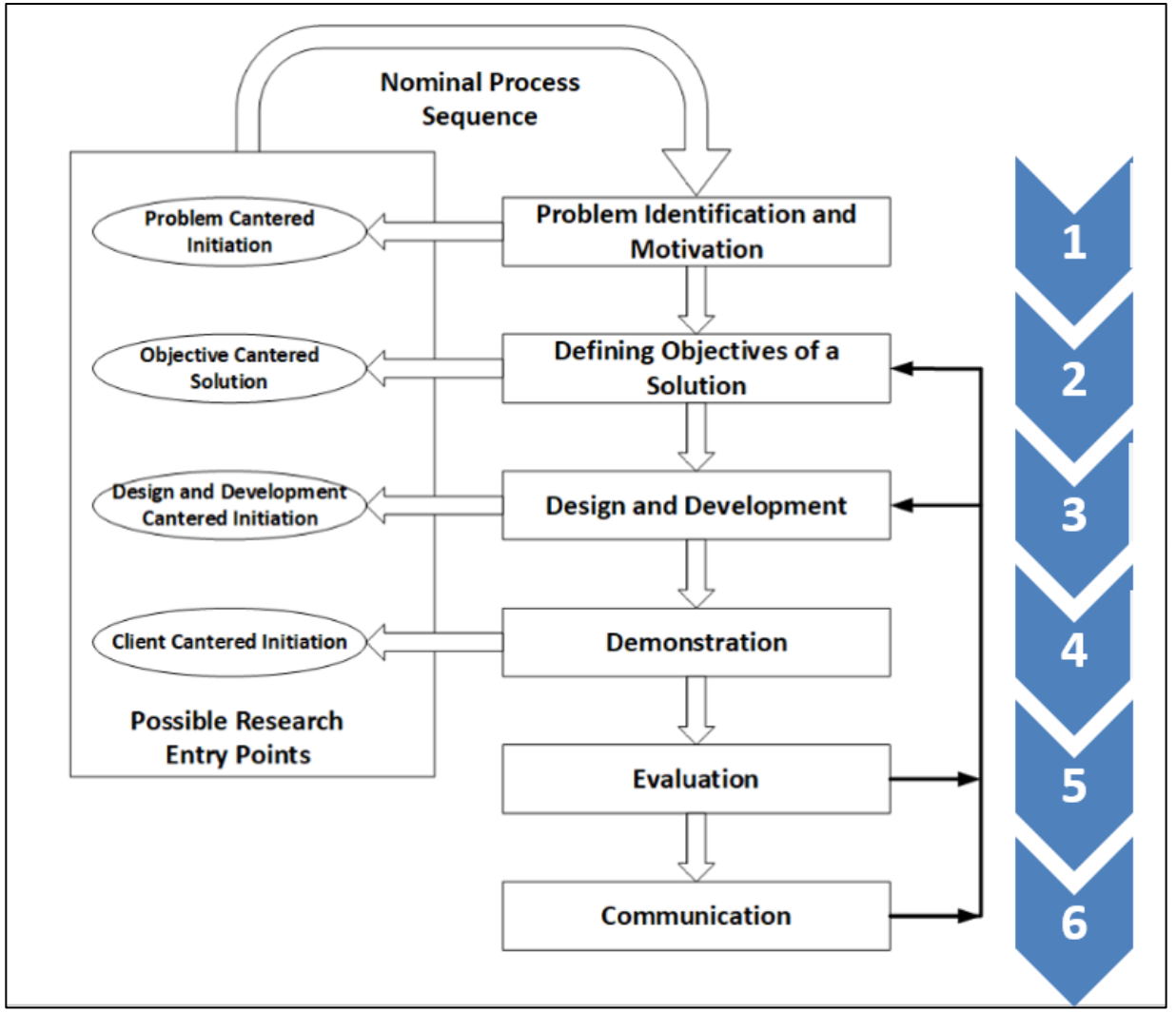


Figure 6. Design Science Research Methodology, (Peffers et al. 2007)

LITERATURE REVIEW – APM with Design Thinking

- Key feature –This model enrich the planning of product development through user-centred ideas of Design Thinking in the beginning of the process

- It results in a better understanding of the requirements of the software to be built.

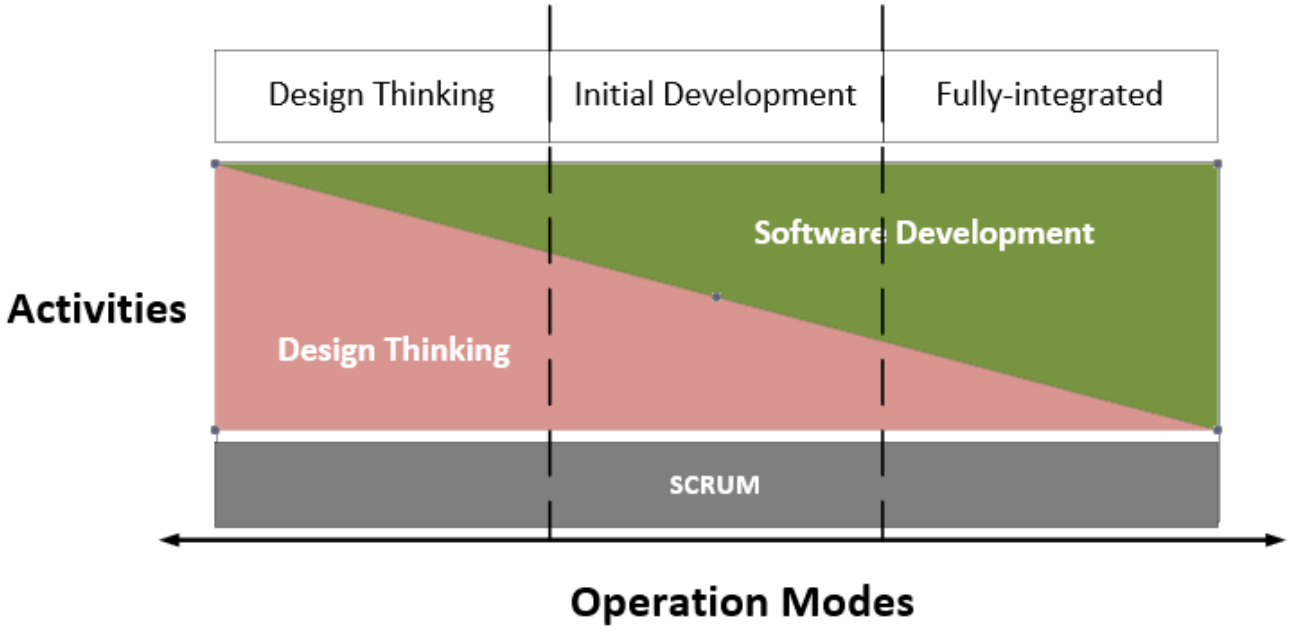


Figure 7. DT@Scrum, (Hager et al. 2015)

LITERATURE REVIEW –
Design Thinking, APM with Lean Start-up

- Hildenbrand and Meyer (2012)
  - Design Thinking – Initiation
  - Agile & Lean – Development Process
- Grossman-Kahn and Rosensweig (2012)
  - Nordstorm model
  - Scalability of the approach – among cross functional teams
- Paula and Araújo (2016)
  - Improved version of Nordstorm
- Dobrigkeit and Paula (2017)
  - InnoDev model – Flexible for different business settings

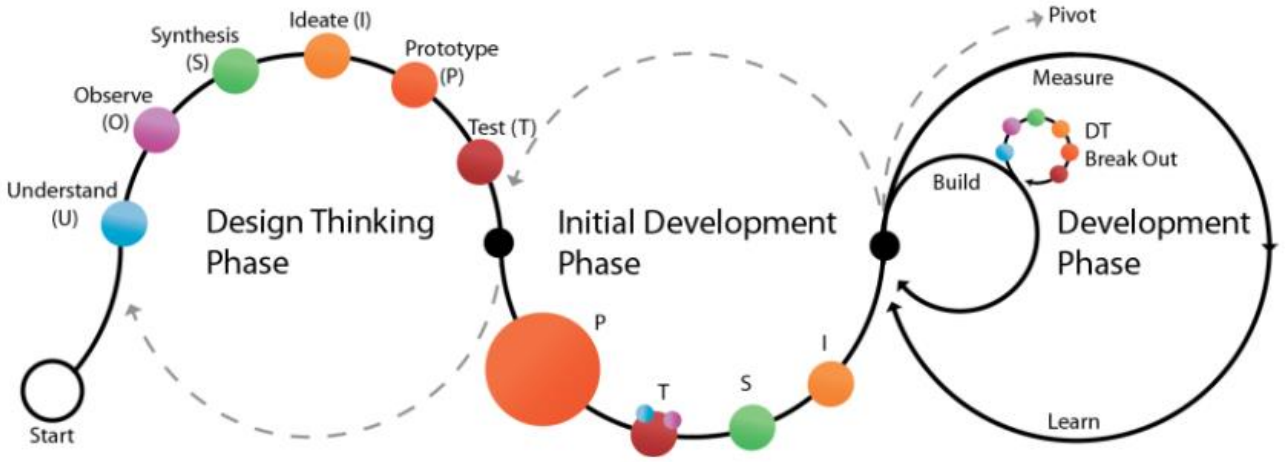


Figure 8. InnoDev, (Dobrigkeit and Paula 2017)

THEORETICAL FRAMEWORK TO SUPPORT SGES IN LC RESEARCH

- A novel methodology for experimenting LC artifacts - Advantages
  - Engagement of construction practitioners
  - Solving real-world problems
  - Controlled experiment
  - Effective testing of hypotheses
  - Contribution to the knowledge

- Elements of the framework
  - Design Science Research Methodology
  - Design Thinking
  - Lean Start-up
  - Agile Project Management
  - Serious Games

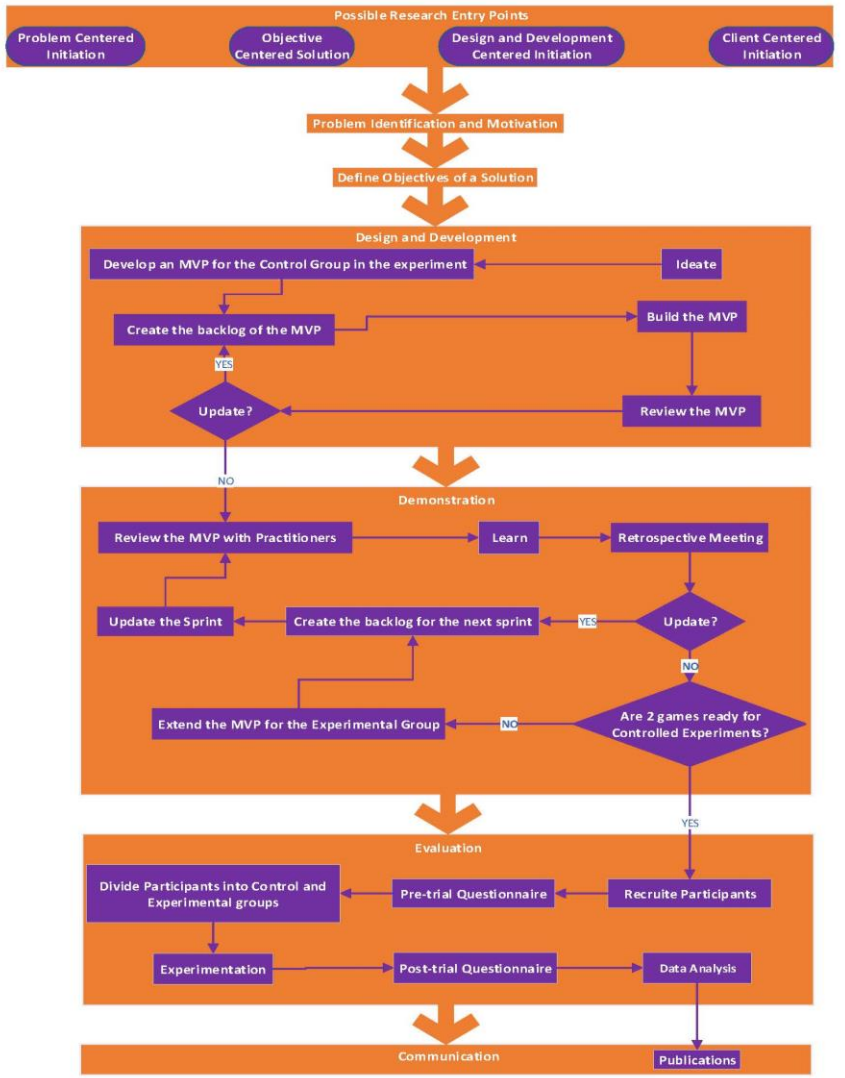


Figure 9. SGES – Theoretical Framework

THEORETICAL FRAMEWORK TO SUPPORT SGES IN LC RESEARCH

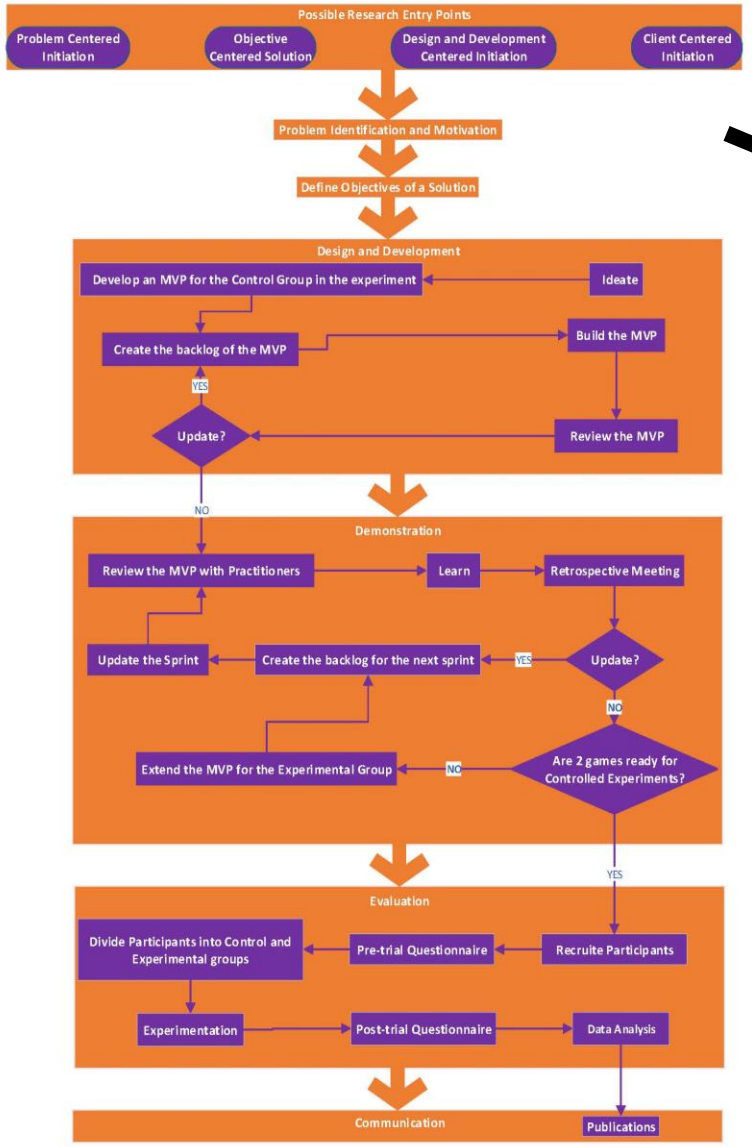


Figure 10. SGES – The first two stages

THEORETICAL FRAMEWORK TO SUPPORT SGES IN LC RESEARCH

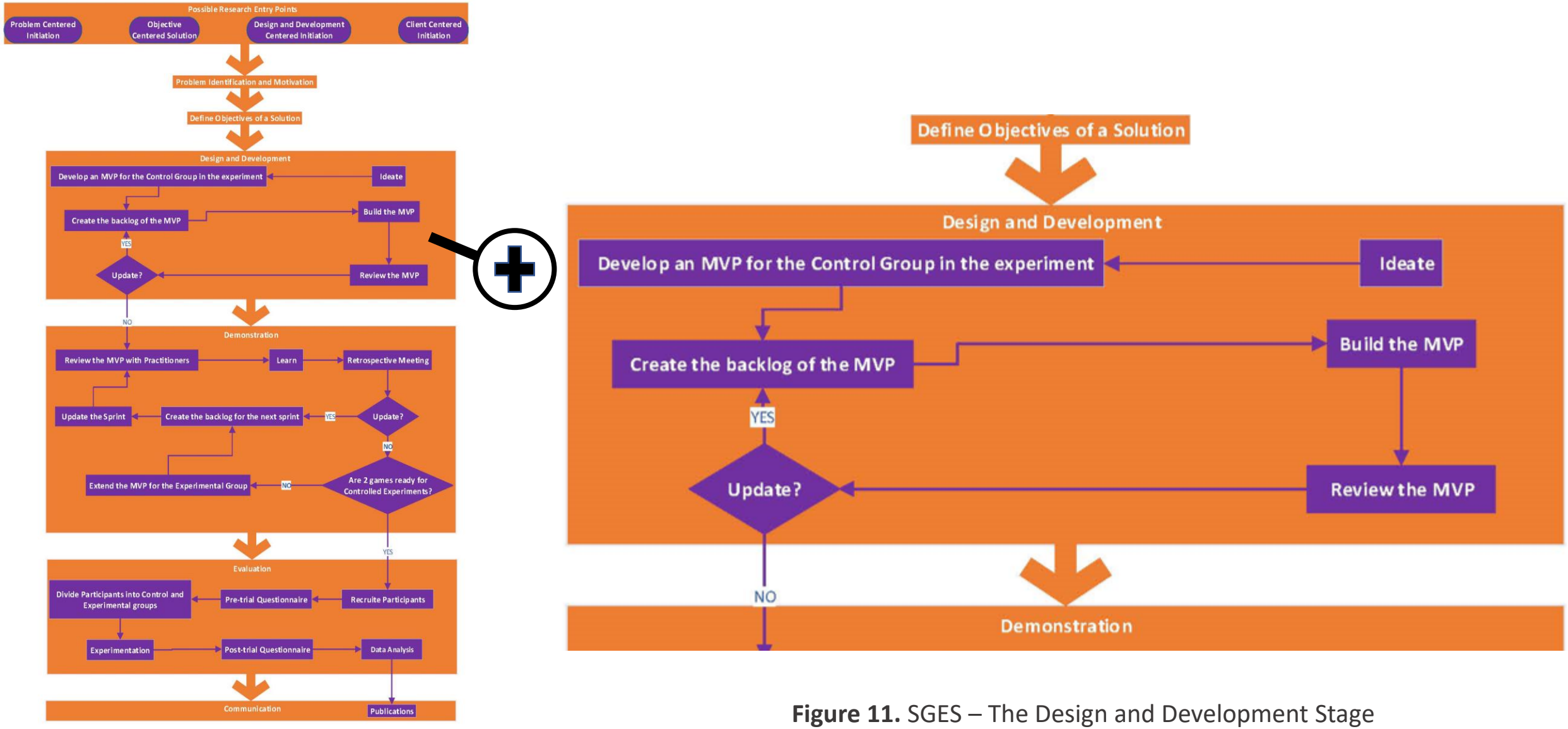
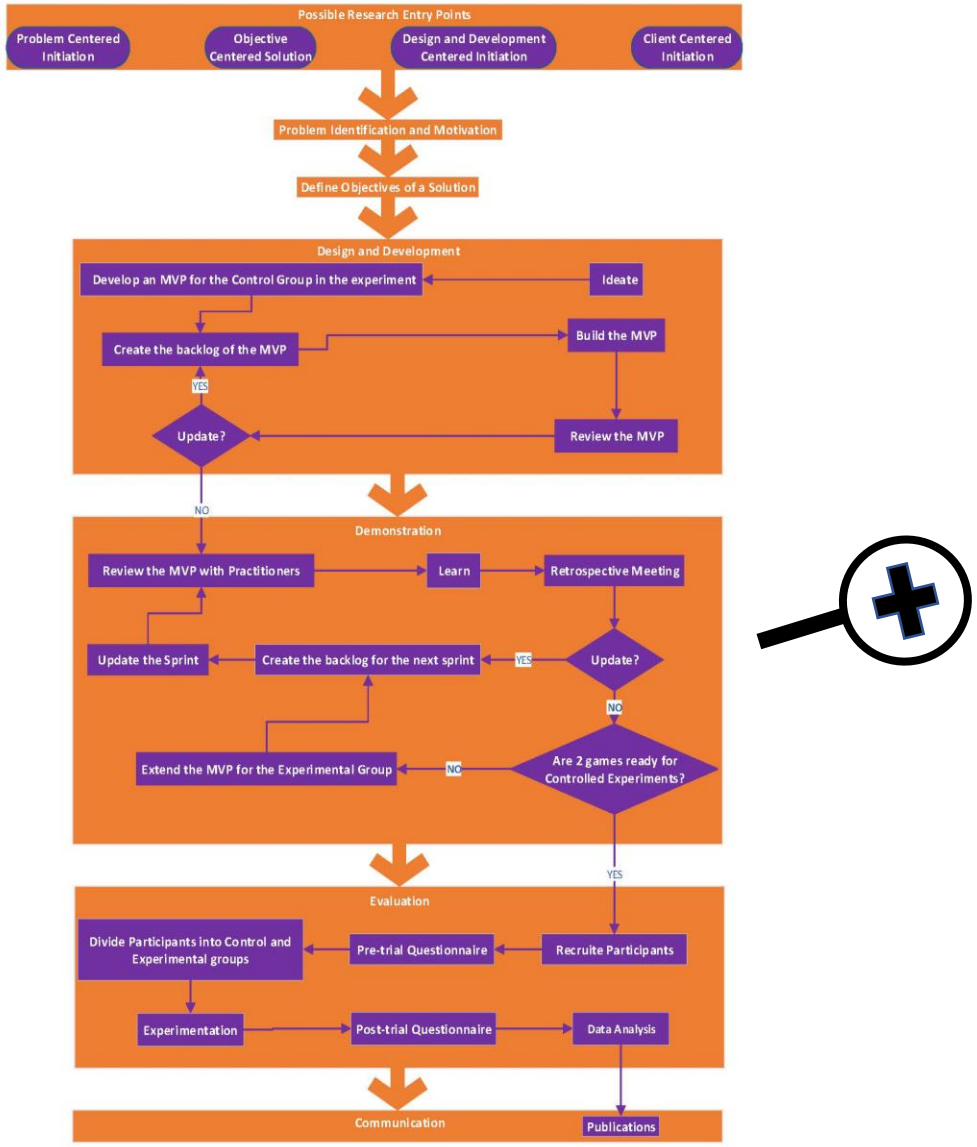


Figure 11. SGES – The Design and Development Stage

THEORETICAL FRAMEWORK TO SUPPORT SGES IN LC RESEARCH



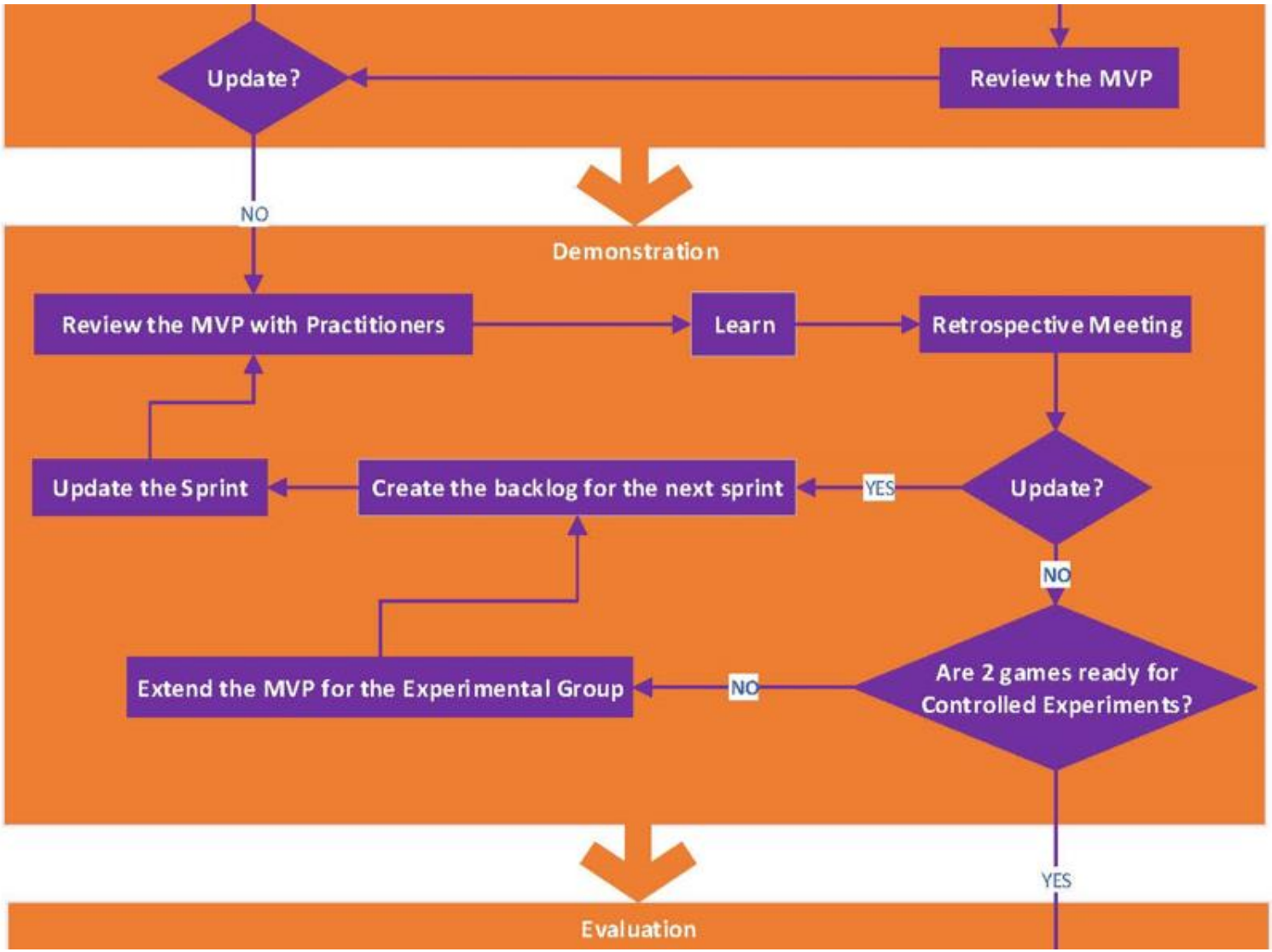
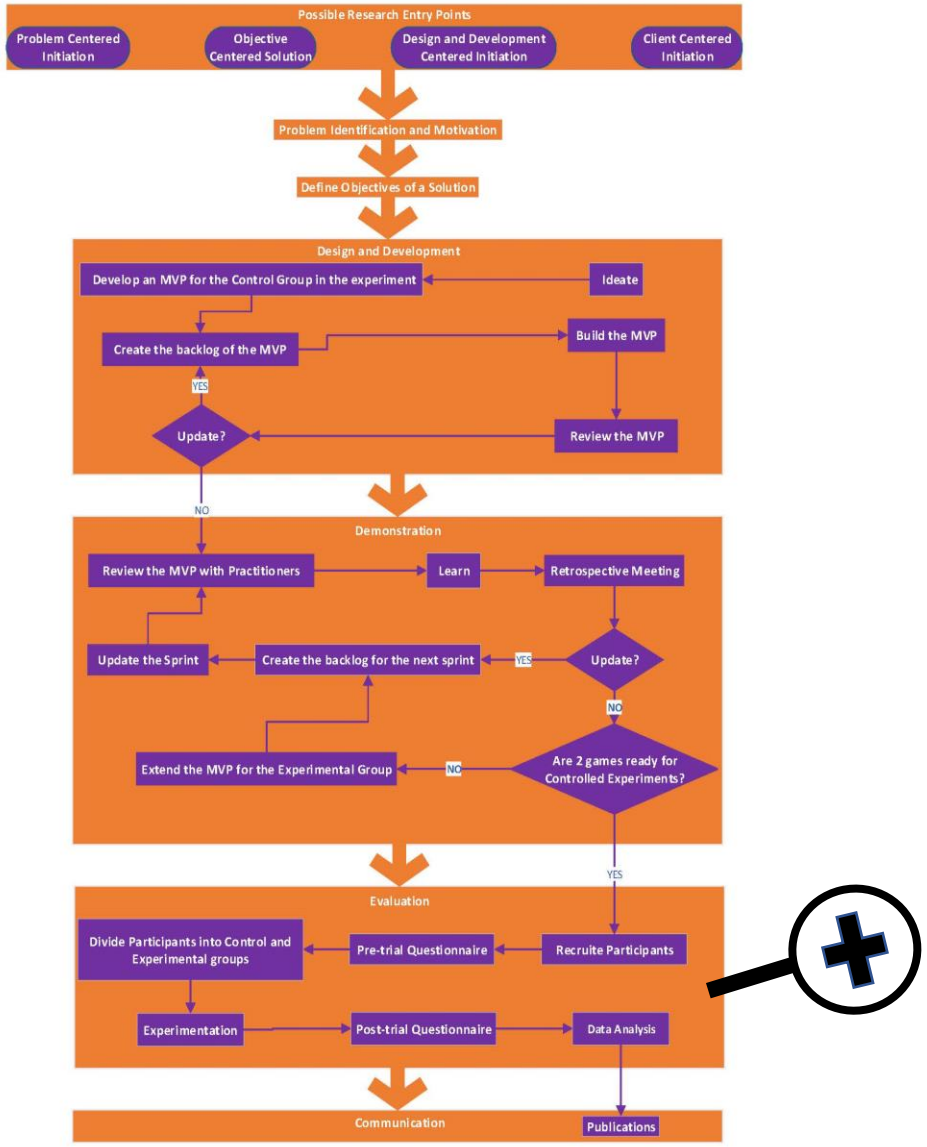


Figure 12 SGES – The Demonstrate Stage

THEORETICAL FRAMEWORK TO SUPPORT SGES IN LC RESEARCH



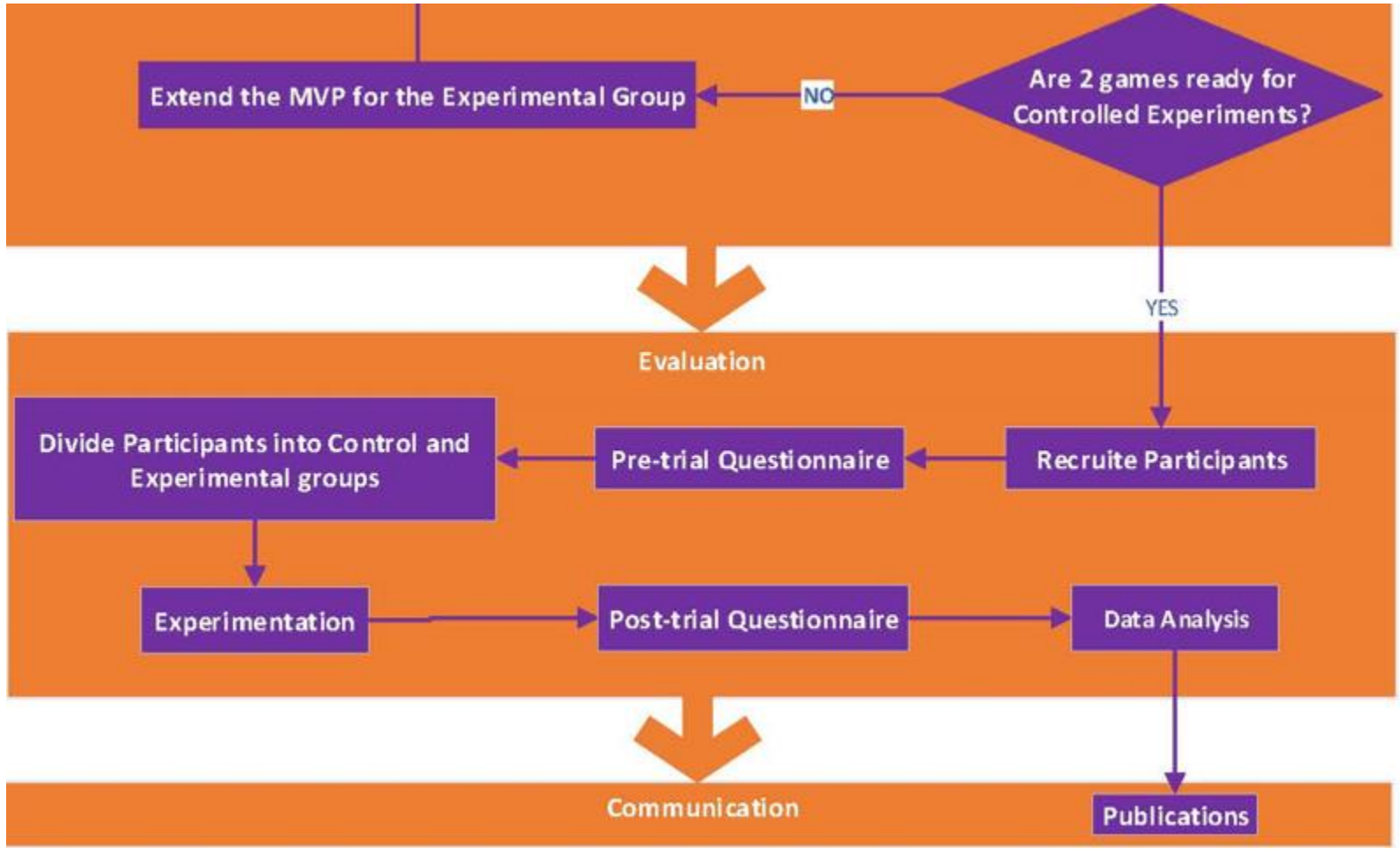


Figure 13. SGES – The Evaluation and Communication Stages

CONCLUSIONS

- 7 Research questions for further development of the framework
  - How can game design elements, game dynamics and game mechanics be determined to develop useful serious games for experiments?
  - How can participants be chosen for such experiments?
  - How can the group sizes be quantified for the control and experimental groups?
  - How can participants be allocated to control and experimental groups?
  - What types of data should be gathered during the experiment?
  - What methods can be used to collect data during the experiments?
  - What analytical techniques can be used to test research hypotheses?

THANK YOU!

Amila N. Wickramasekara
(awic135@aucklanduni.ac.nz)
PhD student
Department of Civil and Environmental Engineering
The University of Auckland, New Zealand