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Fostering Cognitive Processes of Knowledge Integration through Exploratory Question-Posing

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Structure of this presentation

1. WHATs of the thesis

- The problem
- The solution
- Major Results
- Contributions

2. HOWs of the thesis

- Overall Research Design
- Design-Based Research Cycles
- Individual Studies
  - Study Design
  - Results

WHATs of this thesis

Introduction – What this thesis is about

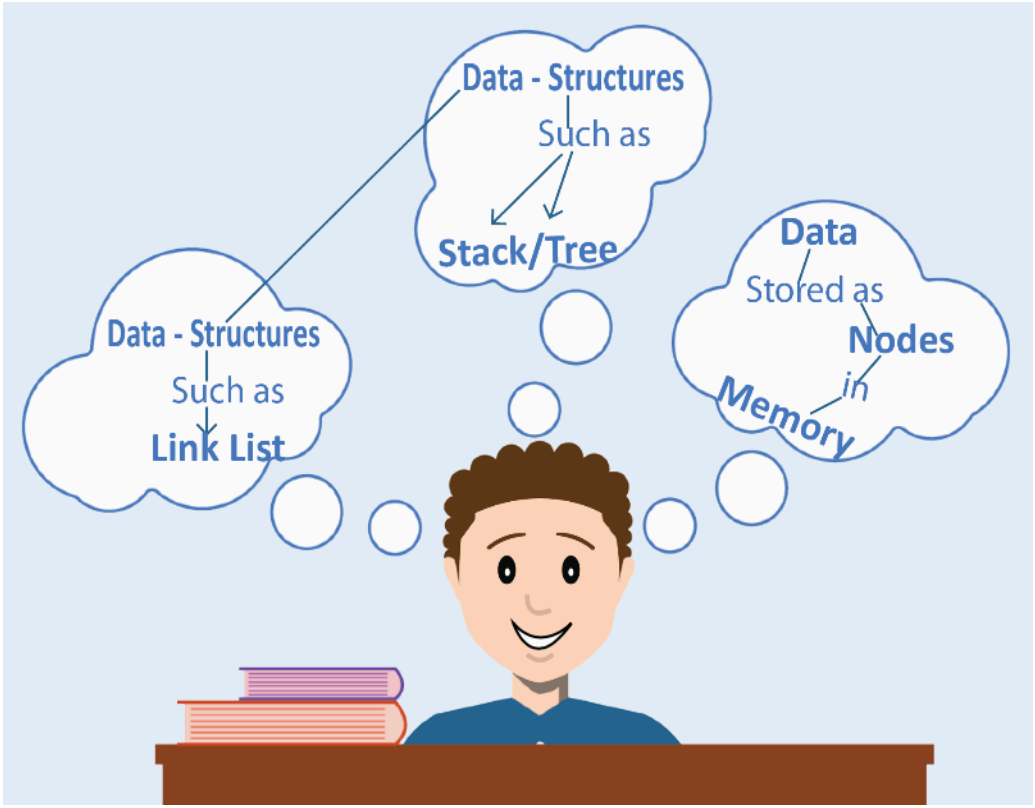
When students encounter new knowledge often it is fragmented and not well connected with their existing knowledge.

Introduction – What this thesis is about

- It is highly desirable that students integrate the knowledge pieces effectively.
- Explicitly targeting improvement of students' knowledge integration skill is needed.

Introduction – What this thesis is about

Towards better
knowledge integration skill



Introduction - What is knowledge integration

- The process by which learners sort out connections between new and existing ideas to reach more normative and coherent understanding in science (Liu, et al., 2008).

- This process of making links between knowledge pieces and forming arguments results in a more organized understanding of the concepts (Lee, et al., 2011).

Introduction - Why is it an important problem

- Knowledge fragmentation occurs frequently and in various age groups.
- For a learner who is new to a topic, the fragmentation occurs more.
- Novices has fragmented organization of knowledge and focus on superficial differences between their observations.

DiSessa, 2008, Izsak, 2005, Wagner, 2006, Gillespie et al., 2004, Chi et al., 1981

Introduction - What does knowledge integration entail

Cognitive Processes of KI

KI Instructional patterns should support following cognitive processes (Linn, 2011):

- Elicit or generate ideas from repertoire of ideas.
- Add new ideas to help distinguish or link ideas.
- Distinguish ideas.
- Sort out ideas by promoting, demoting, merging, and reorganizing.

Introduction - What does knowledge integration entail

Student should be able to (Linn, 2011):

- **Elicit prior knowledge** that may be related to the new knowledge.
- **Focus on the new knowledge.**
- **Distinguish ideas** - identify conflicts, inconsistencies and gaps.
- Sort out ideas by promoting, demoting, merging, and reorganizing.

Introduction - What does knowledge integration entail

Student should be able to*:

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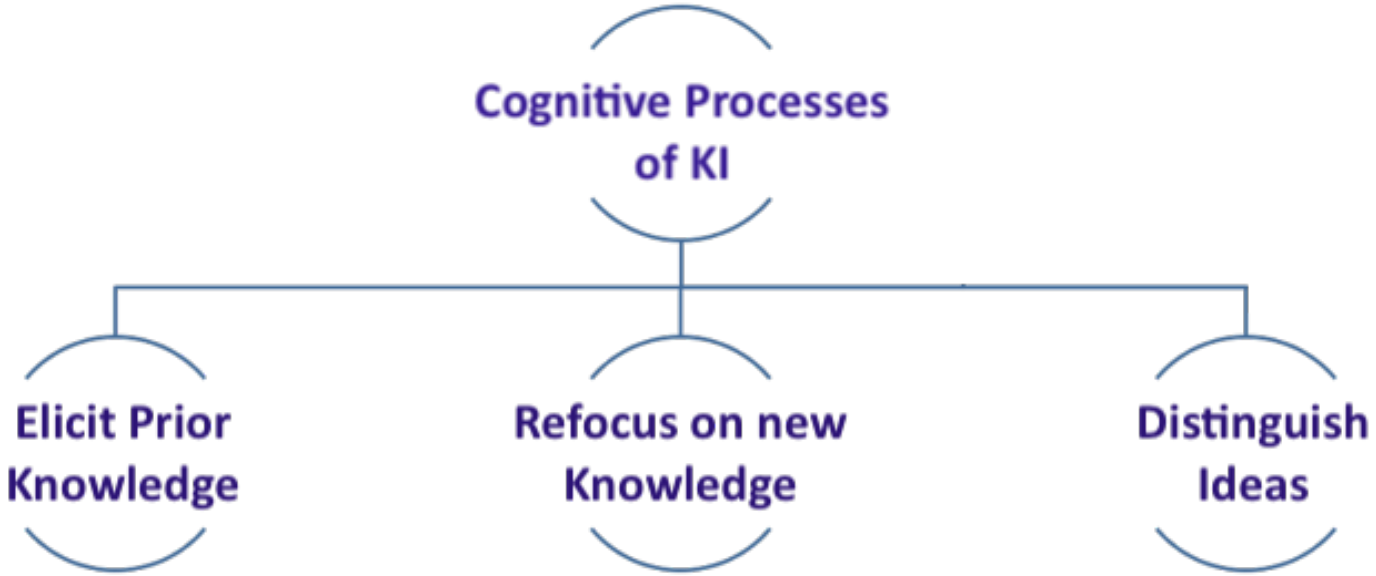
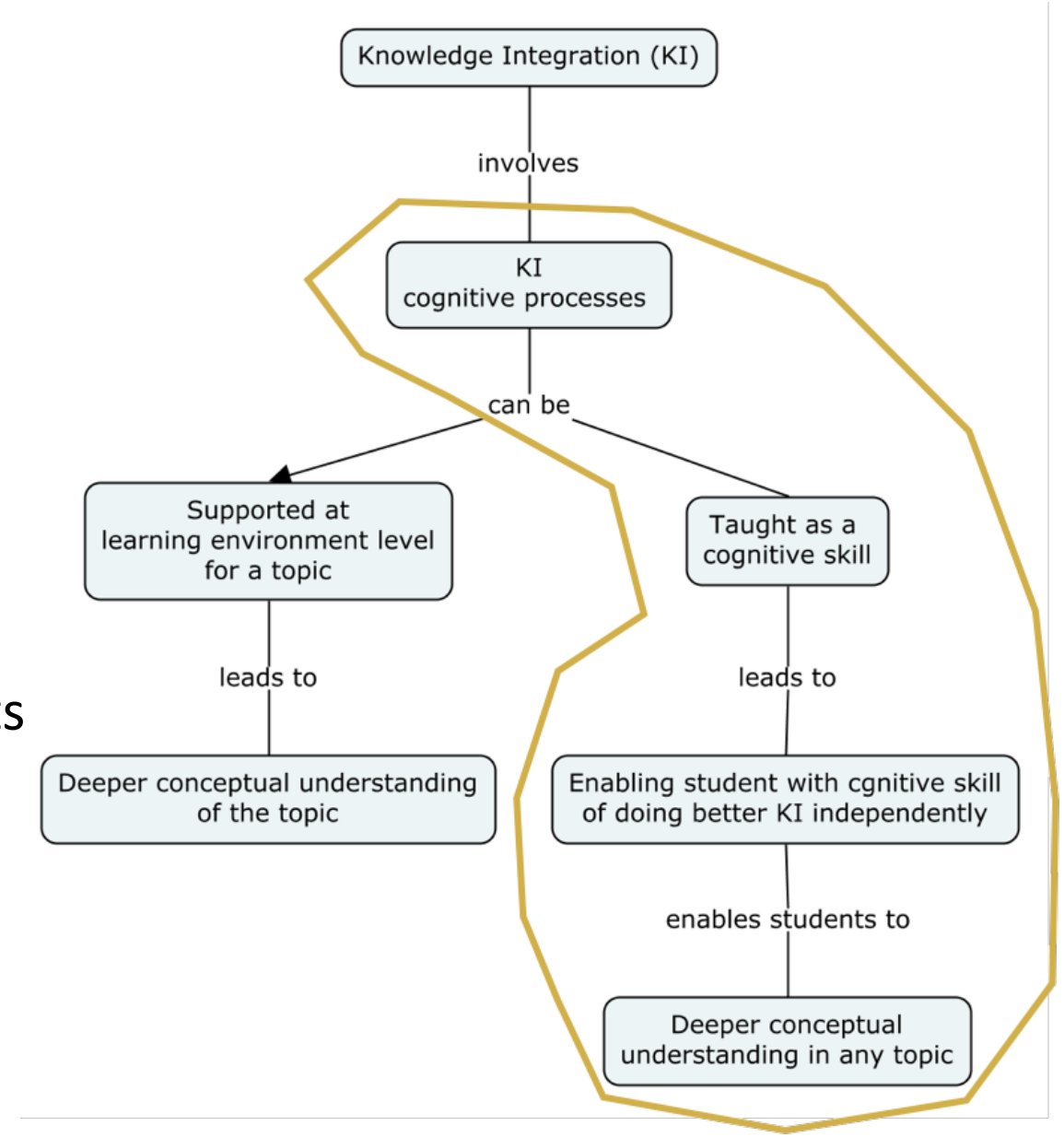


*M. C. Linn and B.-S. Eylon, 2011.

Gap - Supporting Knowledge Integration

Instructional supports for KI



Improving Cognitive Processes of KI

Broad Ph.D. Problem

- Designing and evaluating a technology enhanced learning environment (TELE) to improve students cognitive processes associated with knowledge integration.

Potential Solution approaches

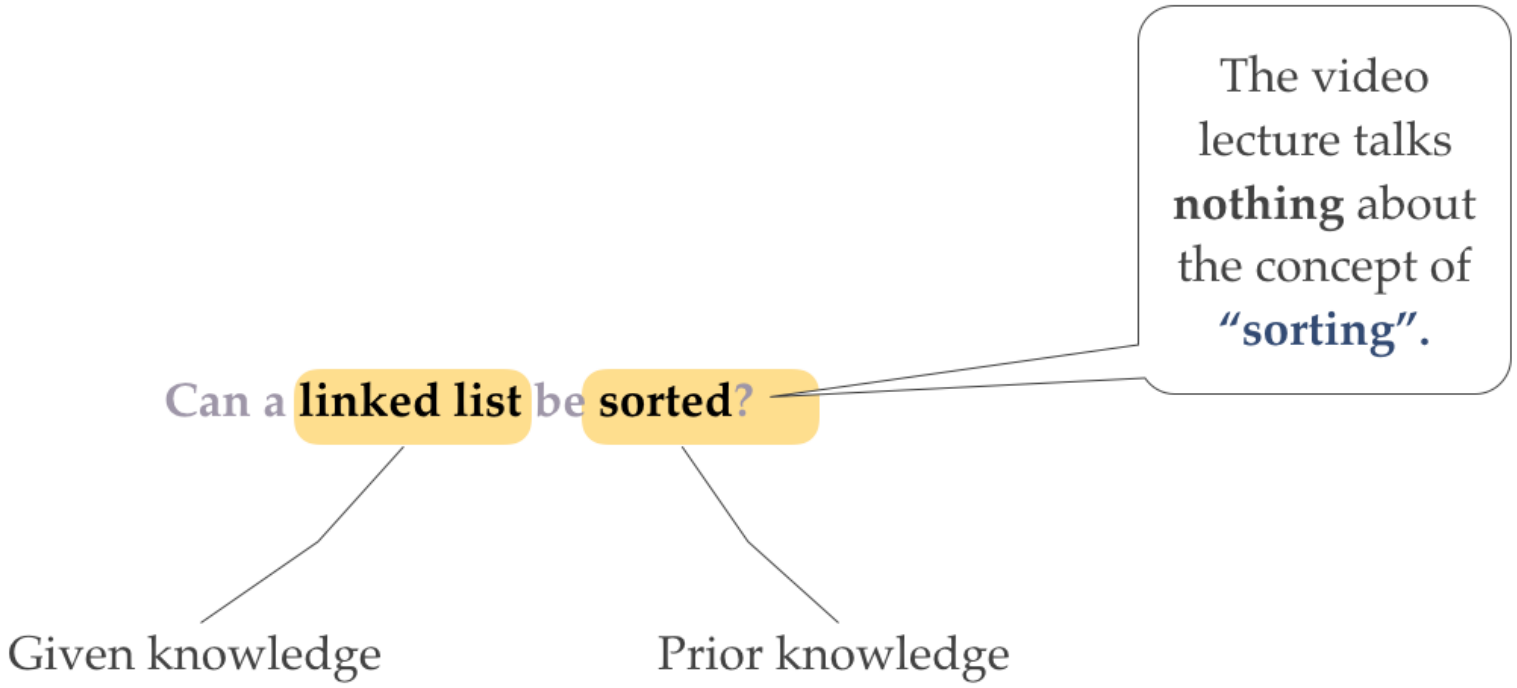
- Explanation Generation (Chang and Linn, 2013)
- Peer discussions (Hoadley and Linn, 2000)
- Concept Maps (Schwendimann, 2016)
- Teacher-designed openers (Zertuche et al., 2012)
- Annotations (Gerard et al. (2016a)
- Student question Posing (King, 1994b)
- etc.

Solution Approach

- ✓ Using Exploratory Question posing (EQP) as a cognitive tool for performing KI processes

Illustrative Example:

After watching a video lecture on linked-list, a student poses following question:



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Illustrative Example:

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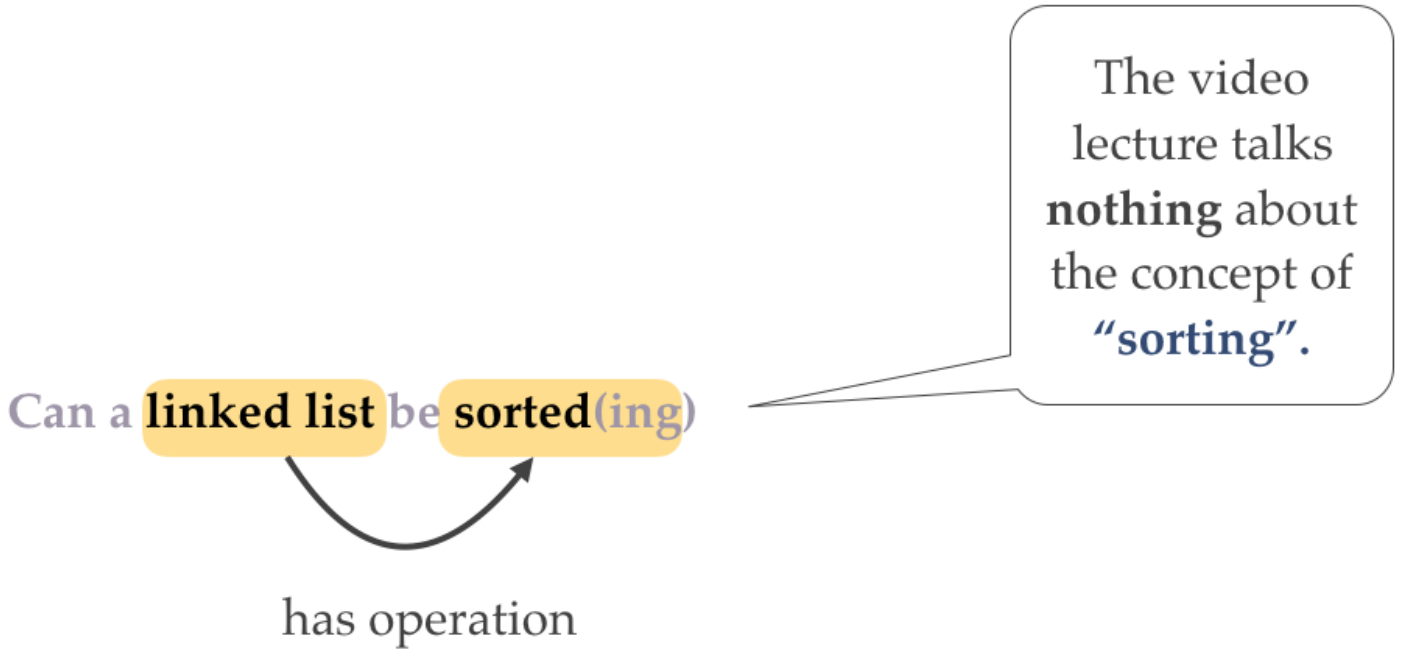


What we see is that questioning has an affordance of knowledge integration.

Solution Approach

- ✓ Using Exploratory Question posing (EQP) as a cognitive tool for performing KI processes
  - ➢ EQP is accompanied with following cognitive processes
    - Eliciting prior knowledge
    - Using the new knowledge
    - Looking into inconsistencies, gaps, conflicts
    - **REPRESENTING each of the above aspects in the form of a question**

Scope of the work

- **Cognitive Processes**
  - We target only first three processes of KI.
    - The 4th one (“sorting out ideas”) is not fully supported.
- **Population**
  - First and Second year engineering undergraduates.
- **Domain**
  - The studies have been administered in the domain of data structures.
    - The artefacts produced are applicable to the data structures and similar* domain.
    - The pedagogy should* be applicable to all domains in general.

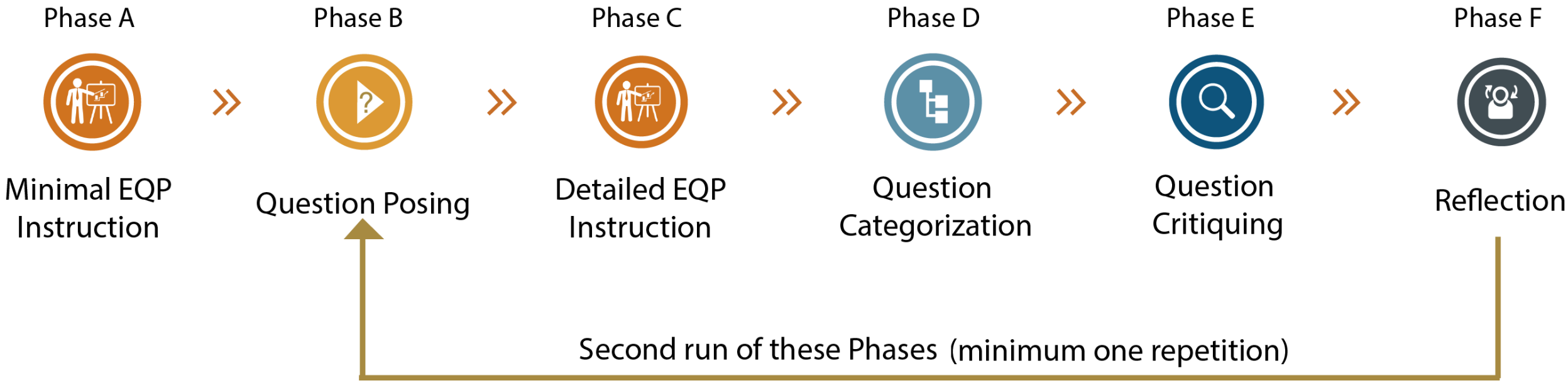
Broad Research Question (RQ)

How to employ exploratory question posing in a Technology Enhanced Learning Environment (TELE) to improve students cognitive processes associated with KI in a data structures course?

Solution (IKnowIT - Pedagogy and Environment)

- **A pedagogy:** Inquiry-based Knowledge Integration Training (IKnowIT) pedagogy
- **A TEL environment:** IKnowIT-environment

Solution (IKnowIT-pedagogy)

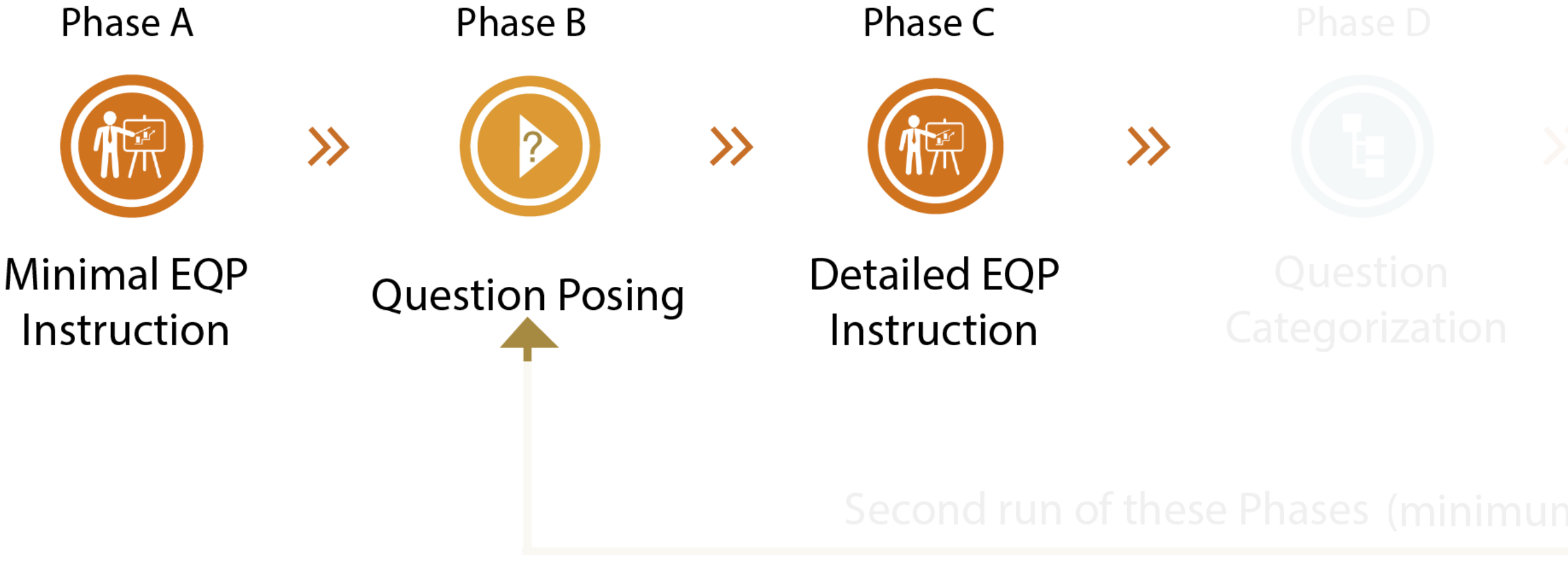


Conceptual design of the
Inquiry-based Knowledge Integration Training (IKnowIT) -pedagogy

Solution (IKnowIT-environment)

<Switch to browser for demo>

Solution (IKnowIT-pedagogy)



Conceptual design of the
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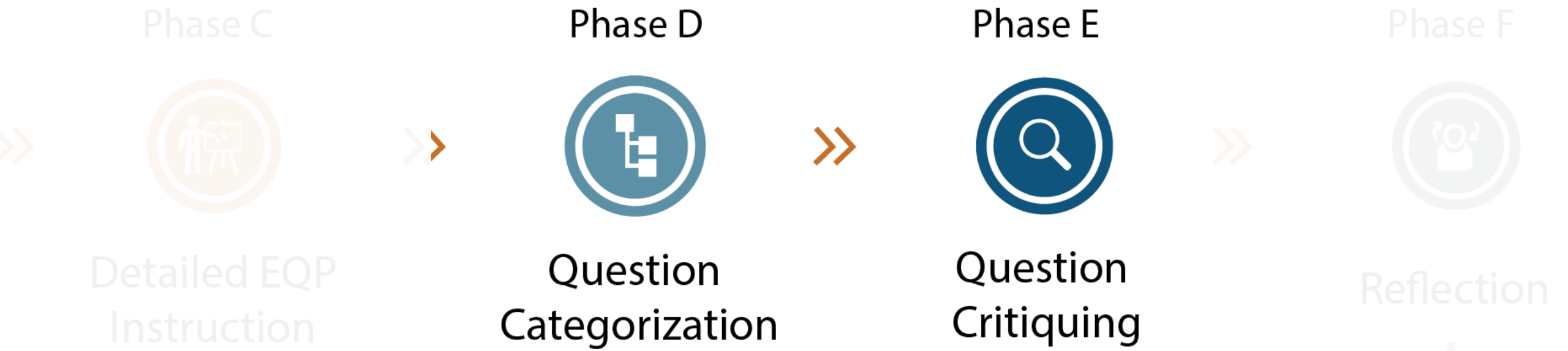
Solution (IKnowIT-pedagogy)



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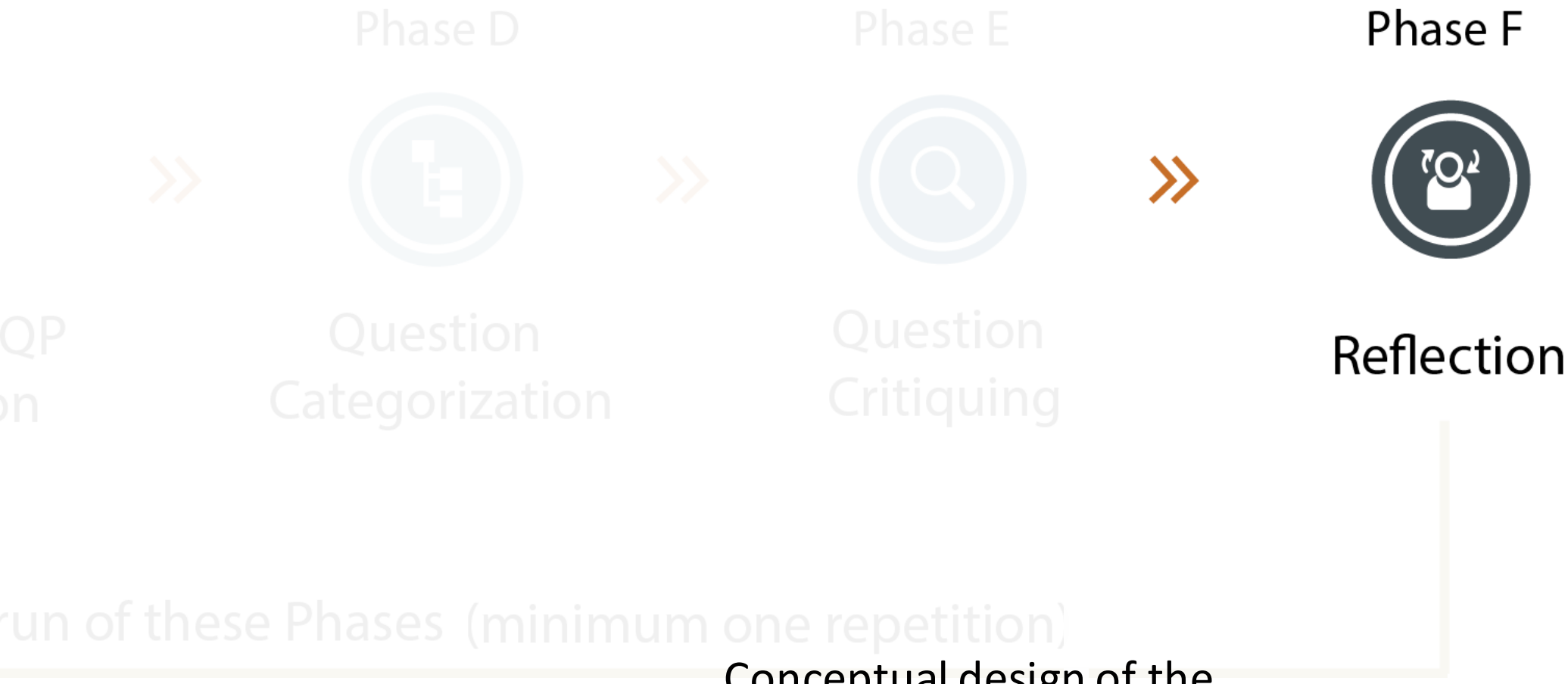

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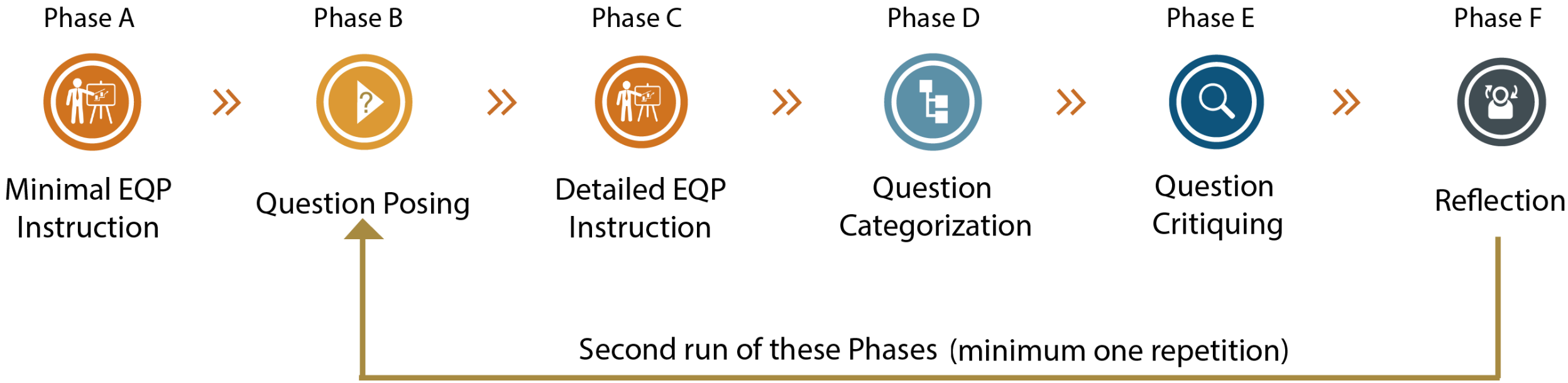


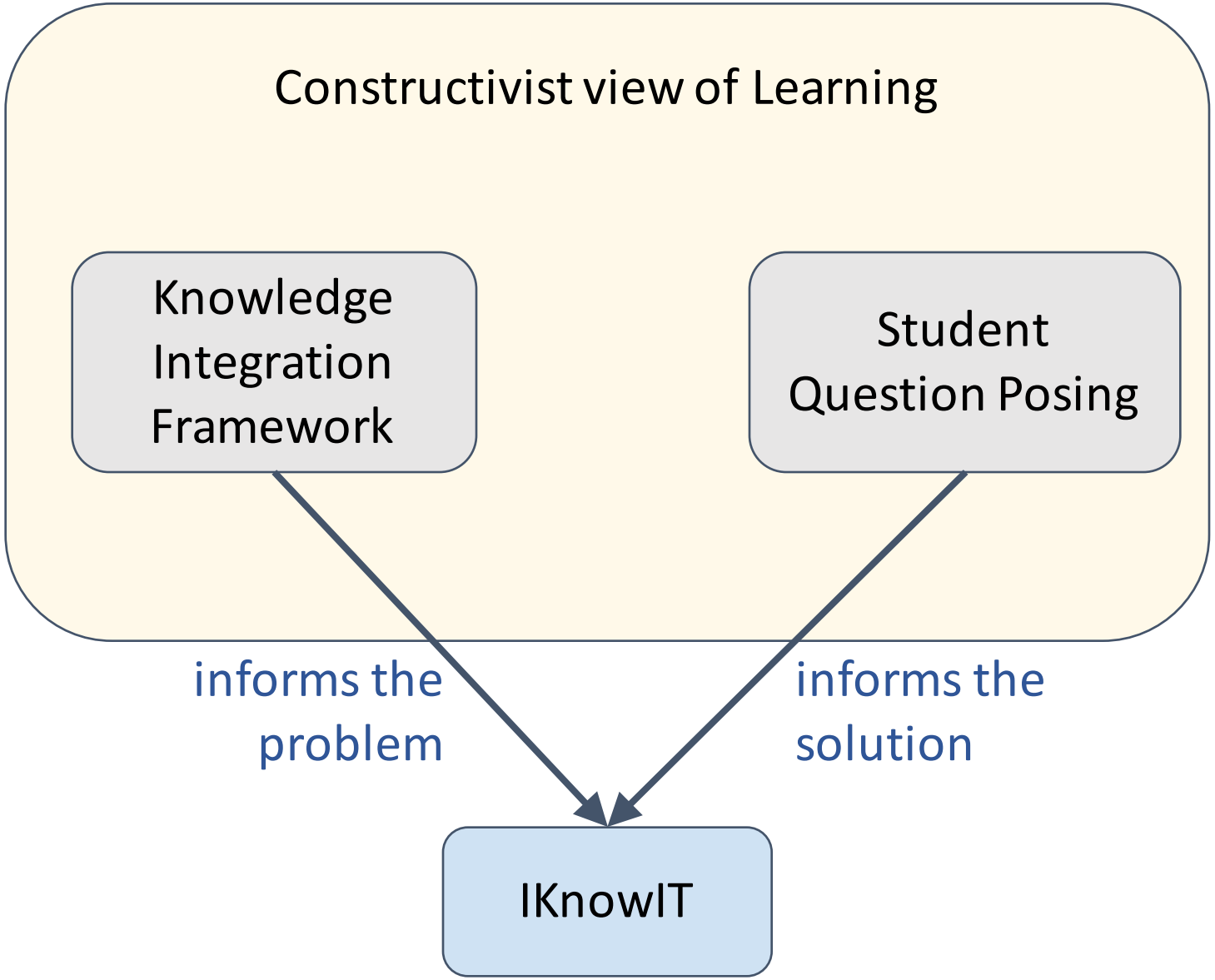
Conceptual design of the
Inquiry-based Knowledge Integration Training (IKnowIT) -pedagogy

A glimpse into the effects of IKnowIT

Students, who completed an IKnowIT session, after watching a new video lecture

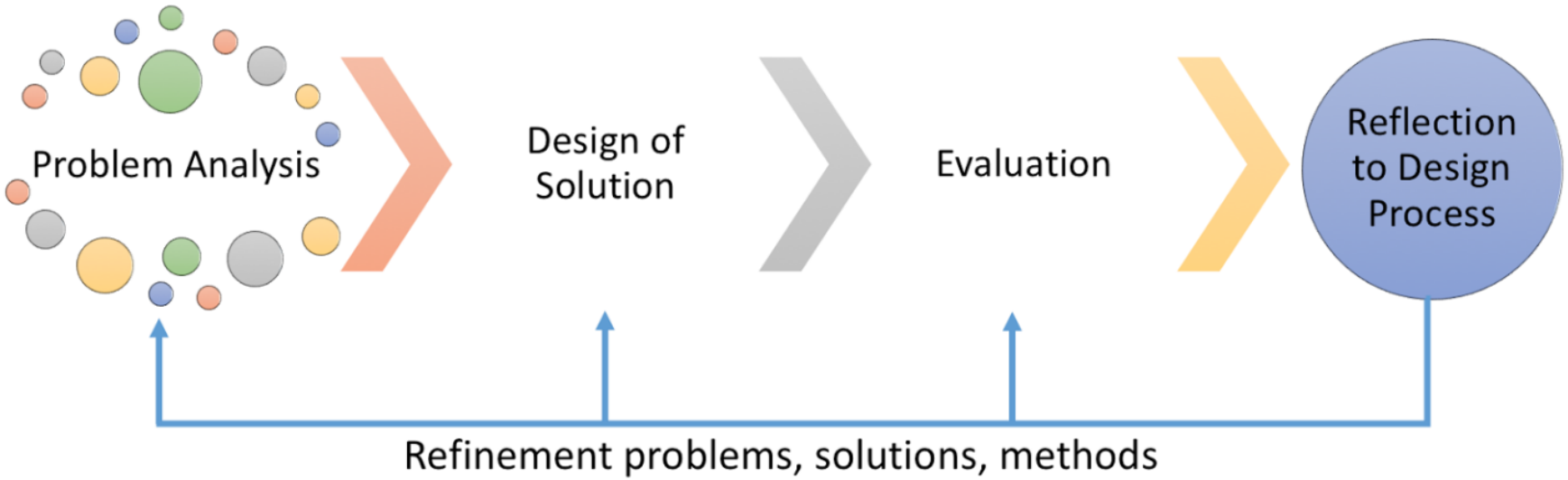
HOWs of this thesis

Theoretical Basis



Research Design

Employed Design-based Research (DBR)

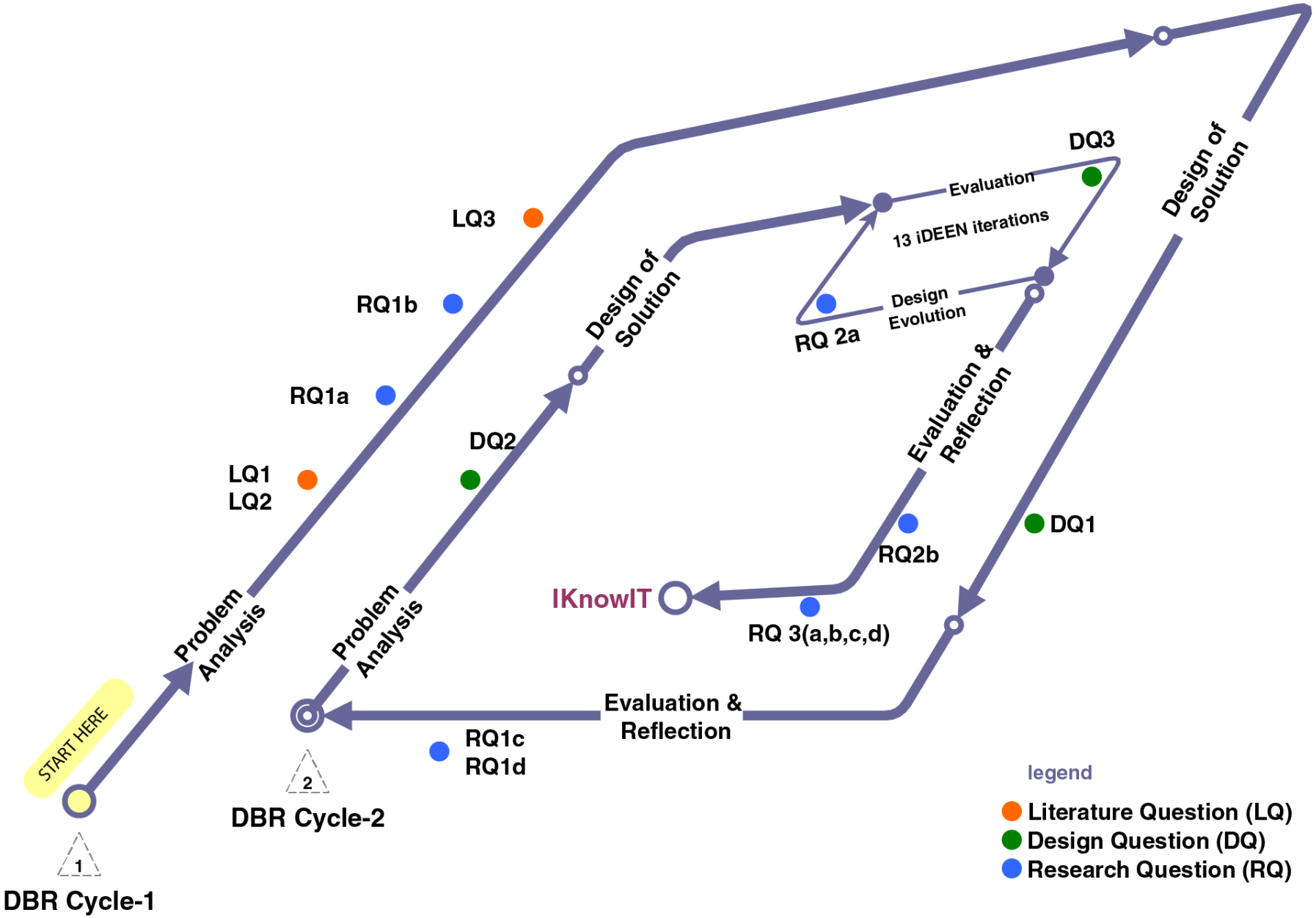


Research Design

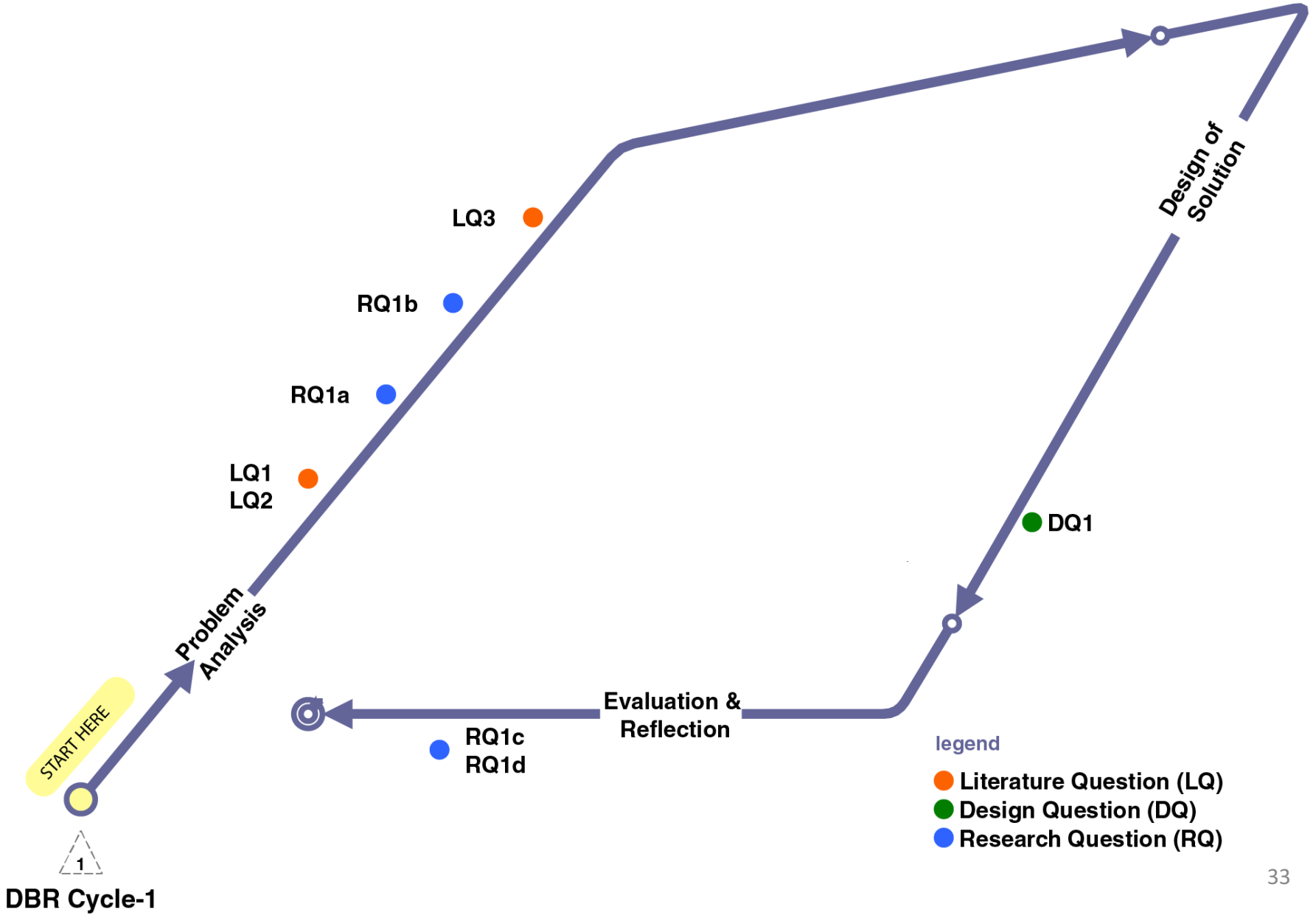
Why Design-based Research (DBR)?

- DBR is meant to come up with an **intervention design**
- DBR is **pragmatic, theory driven**
- **Design** studies are done in **real-world settings**.
- Requires working together with **participants**.
- Initial plan is usually insufficiently detailed
- Research results are connected with the design process and the setting.

The two DBR cycles in this Thesis



DBR Cycle 1


LQ3
RQ1b
RQ1a
LQ1
LQ2
Problem Analysis
START HERE
1
DBR Cycle-1
RQ1c
RQ1d
Evaluation & Reflection
DQ1
Design of Solution
legend
Literature Question (LQ)
Design Question (DQ)
Research Question (RQ)

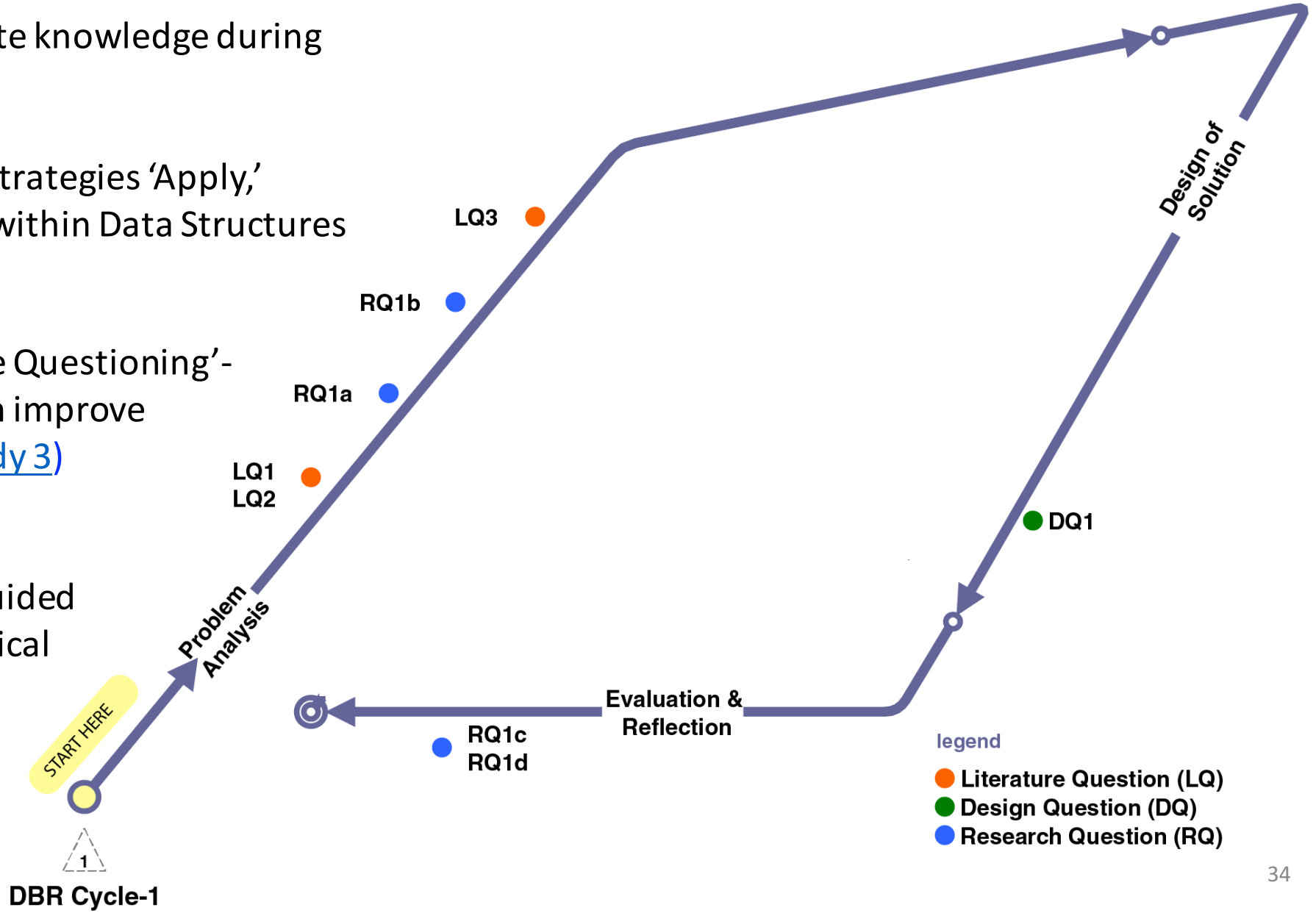
DBR Cycle 1

RQ1a: How do learners integrate knowledge during exploratory QP? (Study 1)

RQ1b: Are the exploratory QP strategies 'Apply,' 'Operate' and 'Associate' valid within Data Structures course? (Study 2)

RQ1c: Can 'Guided Cooperative Questioning'-based pedagogical intervention improve learners' KI performance? (Study 3)

RQ1d: What do the learners perceive about the effects of guided cooperative QP based pedagogical intervention? (Study 4)



DBR Cycle 1

- Objectives
  - Investigate if question posing is applicable for KI
  - Come up with an initial pedagogical design
- Research Activities
  - 4 research studies were conducted (Study1, Study2, Study3, Study4)
  - Inductive qualitative analysis of student-questions provided insight about the student question posing processes.
  - Experimental studies were conducted to get the proof of concept about the applicability of QP for KI.
- Primary Contributions
  - Question posing was empirically found applicable for KI
  - Frequently occurring EQP strategies were identified
  - Initial versions of IKnowIT pedagogy was created (version 1.x)

DBR Cycle 1 - The three EQP Strategies

	Definition	Example
Apply	Where students link the concepts from given knowledge with some goal 'application' or 'structural arrangement' which they already know.	"Can I create social network graph using array?"
Operate	Operate, where the QP involves integrating given knowledge with known goal state (or modifications) and seek operations/procedure to achieve the goal state.	"How can I search a value from the list of values stored as an array?"
Associate	Where concepts from given and prior knowledge are linked to seek insight about the given knowledge or prior knowledge.	"How bad is array than the structures when it comes to using less memory?"

DBR Cycle 1 - Problem Analysis

Return

Studies	Questions (RQs / DQs / LQs)	Method	Findings
--	**LQ1.** What is KI and what does it mean to improve cognitive processes of KI? **LQ2.** What are the viable strategies to improve cognitive processes of KI?	Literature analysis	● Characterization of KI as the three cognitive processes ● Identification of student question posing as a viable strategy.
Study 1	**RQ 1a.** How do students integrate knowledge during exploratory question posing (EQP)?	Inductive thematic analysis on the questions generated by students in question posing sessions	● Multiple patterns of strategies are found by which students integrate new knowledge and prior knowledge pieces.

RQs: Research Questions; DQs: Design Questions; LQs: Literature Questions

DBR Cycle 1 - Problem Analysis contd...

Return

Studies	Questions (RQs / DQs / LQs)	Method	Findings
Study 2	**RQ 1b.** Are the exploratory question posing strategies "Apply", "Operate" and "Associate" valid within data structures course?	Content analysis on the questions generated by students in question posing sessions	● The three broad exploratory questioning strategies are applicable in most (87%) of the exploratory questions that students pose in data structure topics.
--	**LQ3.** Which is the viable QP strategy to start with for designing a QP-based pedagogy for improving cognitive processes of KI?	Literature analysis	● Identification of guided cooperative question posing as a viable QP strategy.

RQs: Research Questions; DQs: Design Questions; LQs: Literature Questions

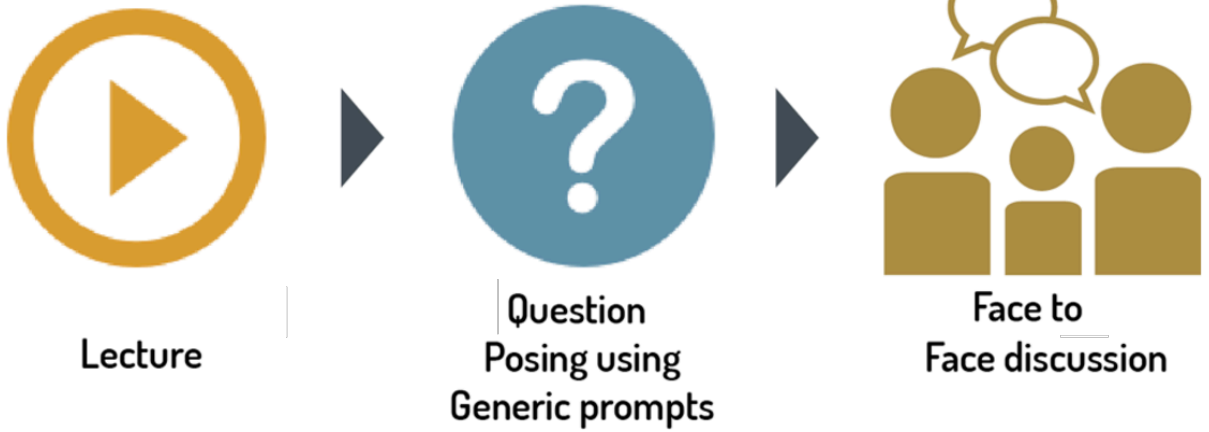
DBR Cycle 1 - Design of Solution

Studies	Questions (RQs / DQs / LQs)	Method	Findings
--	**DQ1.** What should be the adaptation of the design of **guided cooperative questioning** (GCQ) based pedagogy (IKnowIT* version 1) as a semi-online learning intervention?	--	● GCQ was adapted using EQP strategies as domain specific question prompts for semi-online version of IKnowIT.

RQs: Research Questions; DQs: Design Questions; LQs: Literature Questions

DBR Cycle 1 - Design of Solution

Guided Cooperative Questioning (GCQ)



IKnowIT version 1.0

DBR Cycle 1 - Evaluation and Reflection

Return

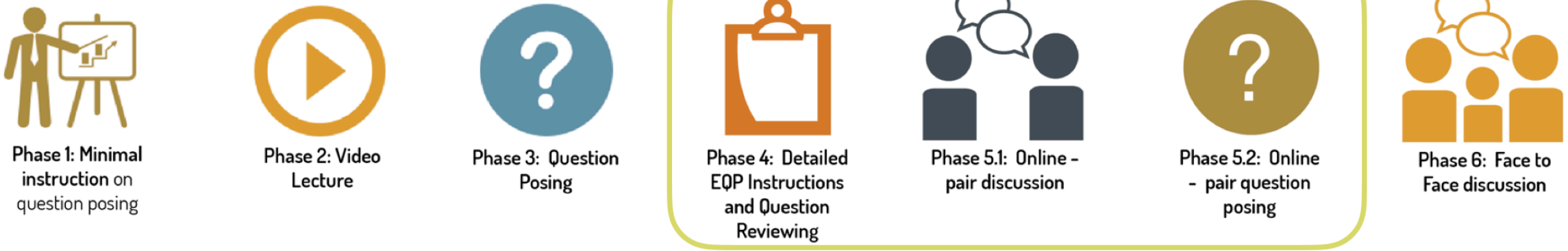
Studies	Questions (RQs / DQs / LQs)	Method	Findings
Study 3	**RQ1c.** Can guided cooperative question posing based pedagogical intervention improve students' knowledge integration performance?	Quantitative analysis of the difference between the experimental and control group performances	● Students who undergo GCQ based exercise perform better KI than the students who do not. (but not statistically significant)
Study 4	**RQ1d.** What do the students perceive about the effects of guided cooperative question posing based pedagogical intervention?	Content analysis of the focused group interviews, survey	● Multiple productive perceptions relating to benefit of GCQ based strategy for knowledge integration are found in the students

RQs: Research Questions; DQs: Design Questions; LQs: Literature Questions; GCQ: Guided Cooperative Questioning

DBR Cycle 1 – Pedagogy version 1.0 and 1.1

IKnowIT version 1.0

IKnowIT version 1.1



DBR Cycle 1 – Pedagogy version 1.1

Phase 1: Minimal instruction on question posing

Phase 2: Video Lecture

Phase 3: Question Posing

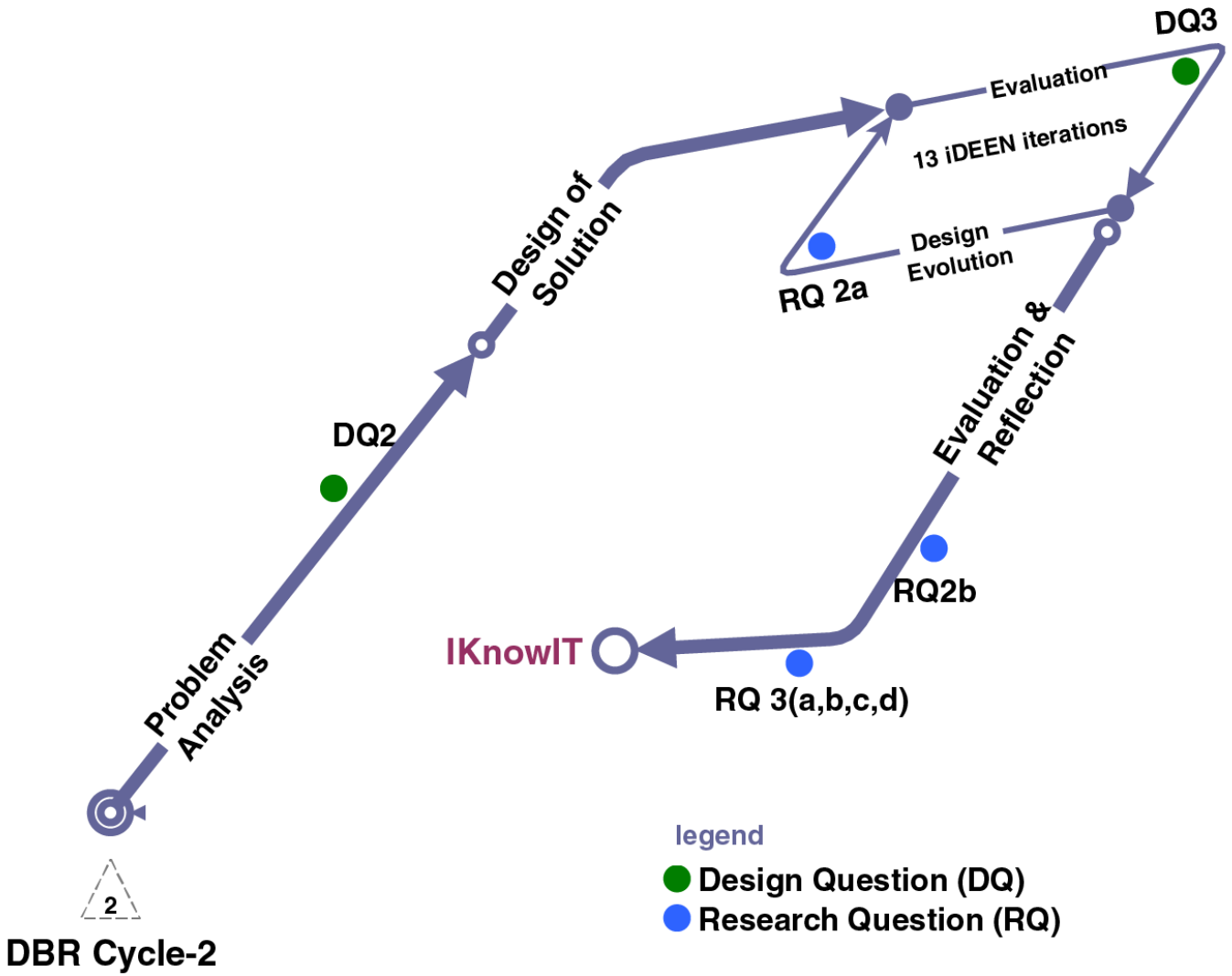
Phase 4: Detailed EQP Instructions and Question Reviewing

Phase 5.1: Online - pair discussion

Phase 5.2: Online - pair question posing

Phase 6: Face to Face discussion

DBR Cycle 2


DQ3
Evaluation
13 iDEEN iterations
Design of Solution
Design Evolution
RQ 2a
Evaluation & Reflection
DQ2
RQ2b
IKnowIT
RQ 3(a,b,c,d)
Problem Analysis
2
DBR Cycle-2
legend
Design Question (DQ)
Research Question (RQ)

DBR Cycle 2

RQ2a: What are the effects of each of the pedagogical features of IKnowIT-environment on learner's learning process? (Study 5)

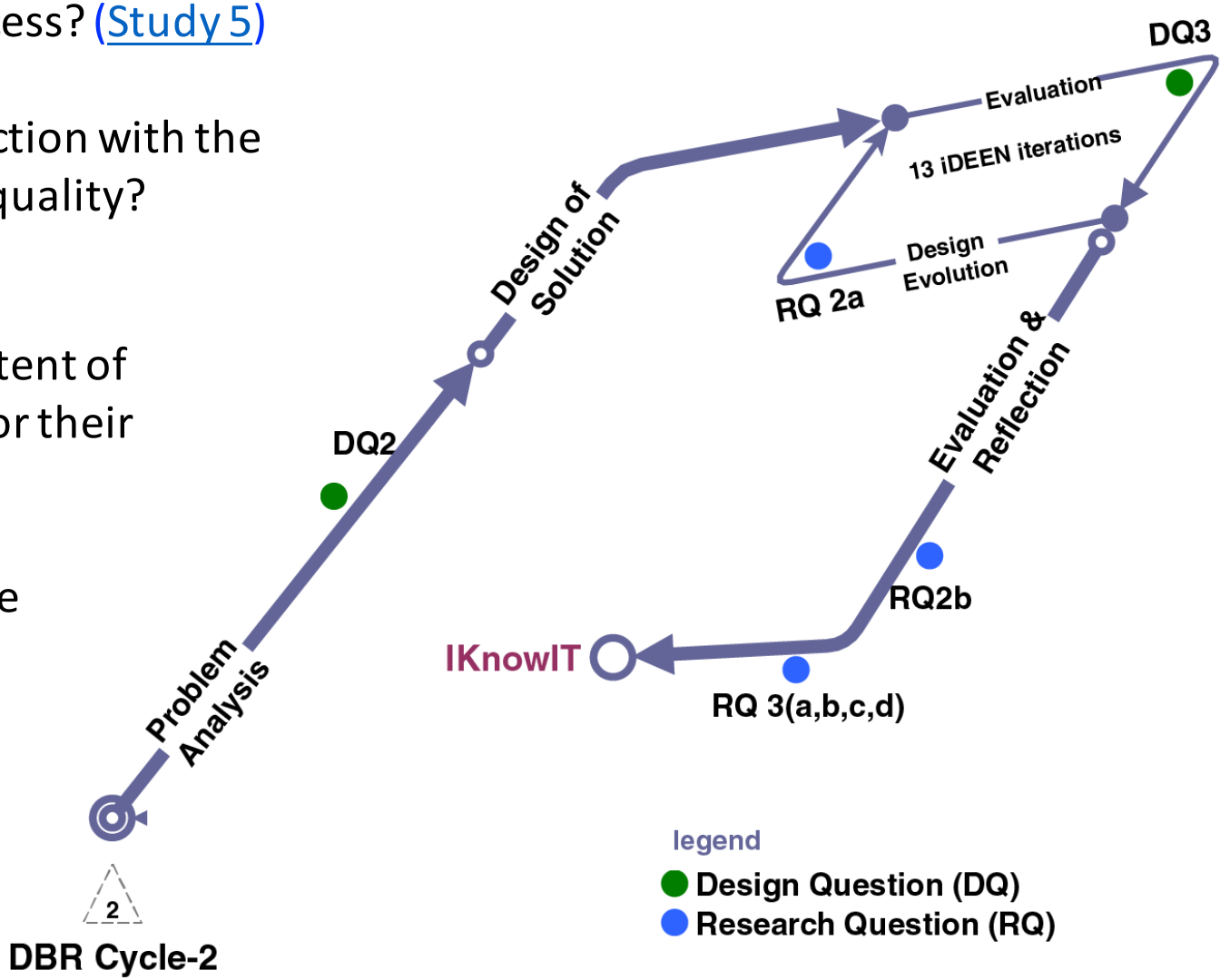
RQ2b: What are the effects of the learners' interaction with the IKnowIT-environment on their improvement of KI quality? (Study 5, Study 6)

RQ3a: What are the learners' perception of the extent of usefulness of each IKnowIT pedagogical features for their learning? (Study 7)

RQ3b: What are the learners' perception about the usefulness of IKnowIT-environment? (Study 7)

RQ3c: What are the learners' perception of the effect of IKnowIT-environment on their KI related abilities? (Study 7)

RQ3d: How usable is the IKnowIT-environment? (Study 7)



DBR Cycle 2

- Objectives
  - Refine and finalize the pedagogical design and come up with a working solution
  - Evaluate the design
  - Extract local learning theories

- Research Activities
  - iDEEN iterations to iteratively evaluate and evolve the pedagogy (Study 5)
  - Triangulation studies to validate effectiveness of the IKnowIT-pedagogy (Study 5, Study 6, Study 7)

- Primary Contributions
  - Final version of IKnowIT pedagogy was created (version 2.6)
  - Local learning theories were extracted
  - Final design was evaluated and found to be effective

DBR Cycle 2 – iDEEN (Iterative Design Evaluation & Evolution) iterations

Pedagogical Design Features	IT1	IT2	IT3	IT4	IT5	IT6	IT7	IT8	IT9	IT10	IT11	IT12	IT13
Participant Count	1	2	2	2	2	2	2	2	2	2	1	2	1
Minimal EQP Instructions – Reading (Post watching Video)	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Minimal EQP Instructions – Reading (Before watching Video)	--	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Video Lecture & QP (Separate)	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Video Lecture & QP (Merged)	--	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Detailed EQP Instructions – Reading (EQP strategies in data structures	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Categorize own questions (Using set of EQP strategies in data structures)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Criticize online-partner's questions (and categories	✓#	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓#	✓#	✓#
Discuss over text chat	--	✓	✓	✗	✗	✓	✗	✓	✗	✗	✗	✗	✗
Strategy classification	--	--	--	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗
Reflection Task – Guided Socratic Reflection (Face to face)	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Reflection Task – Using Reflection Questions (Integrated to the environment)	--	--	--	✓^	✓^	✓^	✓^	✓	✓	✓	✓	✓	✓
Video 2 (as a posttest)	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Video 2 & QP (as a part of pedagogy)	--	--	--	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Categorize & Criticize for Video 2 Questions	--	--	--	--	✓	✓	✓	✓	✓	✓	✓	✓	✓
Reflection Task 2 (Same questions with slight variation the format)	--	--	--	--	--	--	--	--	✓	✓	✓	✓	✓
IKnowIT-pedagogy Version 2.x	v2.0	v2.1	v2.1	v2.2	v2.3	v2.4	v2.3	v2.5	v2.6	v2.6	v2.6	v2.6	v2.6

LEGENDS

***x**: Feature NOT included in an iDEEN iteration*

✓: Feature included in an iDEEN iteration

--: Features NOT conceived till an iDEEN iteration

Green Blocks:
Features retained till the end of the iDEEN study

DBR Cycle 2 – iDEEN iterations

✗ : Feature NOT included in an iDEEN iteration

✓ : Feature included in an iDEEN iteration

-- : Feature NOT conceived till an iDEEN iteration

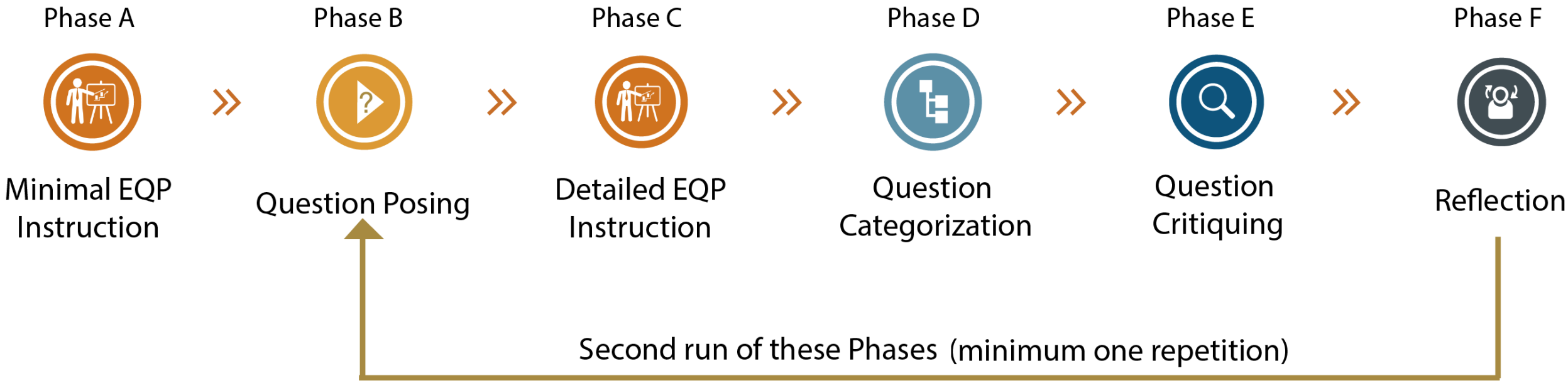
Green Blocks: Feature retained till the end of grounded theory

#: Criticize online partner's question (Canned Partner - Questions were take from previous studies)

*: KI Strategy classification – Visual

^: Google form–based implementation of the Reflection Task

DBR Cycle 2 - Design and Evaluation contd...



IKnowIT version 2.6

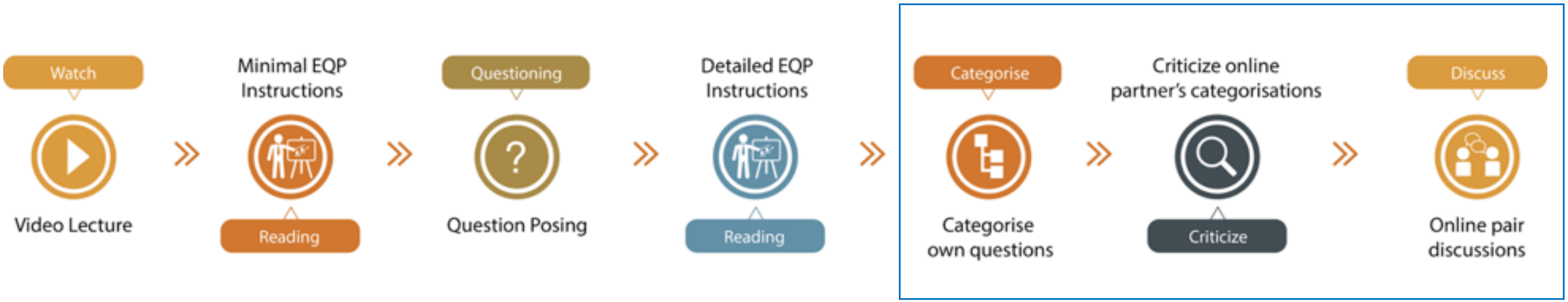
DBR Cycle 2 – Problem Analysis

Studies	Questions (RQs / DQs / LQs)	Method	Findings
--	**DQ2.** What were the design problems in IknowIT version 1, which should be addressed in the next version?	Analysis of findings from DBR 1	● Students do not use questioning prompts - learners need more understanding of the EQP strategies. ● Design should completely cater to the online mode. - Face to face discussion should be converted into online discussion.

RQs: Research Questions; DQs: Design Questions; LQs: Literature Questions

DBR Cycle 2 - Design and Evaluation

DBR Cycle 2 - Design and Evaluation



IKnowIT version 2.0

DBR Cycle 2 - Design and Evaluation

Studies	Questions (RQs / DQs / LQs)	Method	Findings
--	**RQ2.** How can training students on an exploratory question posing - based learning environment (IKnowIT) enable them to perform the cognitive processes associated with KI?	--	--

RQs: Research Questions; DQs: Design Questions; LQs: Literature Questions

DBR Cycle 2 - Design and Evaluation contd...

Return

Studies	Questions (RQs / DQs / LQs)	Method	Findings
Study 5	**DQ3.** What should be the design-features of next version of IKnowIT (version 2.x) to make it capable of fostering in students the cognitive processes of KI?	Iterative Design Evaluation and Evolution Method **(iDEEN)**	● 13 iterations of iDEEN produced 7 sub-versions of IKnowIT version 2.x, until the pedagogical up-gradation requirement ceased.
	RQ2a. What are the effects of each of the pedagogical features of IKnowIT learning environment on students learning process?		● List of mechanisms are found describing how the student's interaction with pedagogical features in IKnowIT that lead to the learning achievements

RQs: Research Questions; DQs: Design Questions; LQs: Literature Questions

DBR Cycle 2 – Evaluation and Reflection

Return

Studies	Questions (RQs / DQs / LQs)	Method	Findings
Study 5	**RQ2b.** What are the effects of the students' interaction with the IKnowIT learning environment on their improvement of knowledge integration quality?	Rubric based analysis of student generated questions (One group pre-post Analysis)	● KI quality of the questions posed by the students after one iteration of the interaction with the environment is significantly more than the KI quality of the questions generated in the very beginning.

RQs: Research Questions; DQs: Design Questions; LQs: Literature Questions

DBR Cycle 2 – Evaluation and Reflection

Return

Studies	Questions (RQs / DQs / LQs)	Method	Findings
Study 6	**RQ2b.** What are the effects of the students' interaction with the IKnowIT learning environment on their improvement of knowledge integration quality?	Quantitative analysis of the difference between the experimental and control group performances using KI rubric. **&** Thematic analysis of instructor's Interview	• Knowledge integration (KI) quality of the responses to the posttest items by the students in the experimental group is more than the students in the control group. (Not statistically significant) • Students attitude changed.

RQs: Research Questions; DQs: Design Questions; LQs: Literature Questions

DBR Cycle 2 – Evaluation and Reflection

Return

Studies	Questions (RQs / DQs / LQs)	Method	Findings
Study 7	**RQ3a.** What are the students' perception about the extent of usefulness of each IKnowIT pedagogical features for their learning?	Frequencies of students' response to the Likert scale questions were obtained.	• Students perceive each of the pedagogical features of IKnowIT highly useful.

RQs: Research Questions; DQs: Design Questions; LQs: Literature Questions

DBR Cycle 2 – Evaluation and Reflection

Return

Studies	Questions (RQs / DQs / LQs)	Method	Findings
Study 7	**RQ3b.** What are the students' perception about the usefulness of IKnowIT learning environment for their **understanding** of (1) the strategies of exploratory question posing; (2) how to use question posing to do better knowledge integration?	Frequencies of students' response to the Likert scale questions were obtained.	• Students perceive the IKnowIT learning environment to be highly useful for their understanding of EQP strategies and how to use question posing to do better knowledge integration.

RQs: Research Questions; DQs: Design Questions; LQs: Literature Questions

DBR Cycle 2 – Evaluation and Reflection

Return

Studies	Questions (RQs / DQs / LQs)	Method	Findings
Study 7	**RQ3c.** What are the students' perception about the effect of IKnowIT learning environment on their **KI related abilities**?	Frequencies of students' response to the Likert scale questions were obtained.	• Students perceive the IKnowIT learning environment to be highly useful for the improvement of all the mentioned abilities.
Study 7	**RQ3d.** How much is the IKnowIT learning environment usable?	System usability score based on SUS* survey	• Learning environment is sufficiently usable. (SUS Score: 73.5)

RQs: Research Questions; DQs: Design Questions; LQs: Literature Questions

* Brooke et al., 1996, Bangor et al., 2009

DBR Cycle 2 – Local Learning Theory

- What is Local Learning Theory?
  - Mechanisms that explain how does the learner's interactions with the pedagogical features of the learning environment lead to the desired learning.
  - These are the "theoretical yields" of an education design research.
  - Often construed as "design principles"

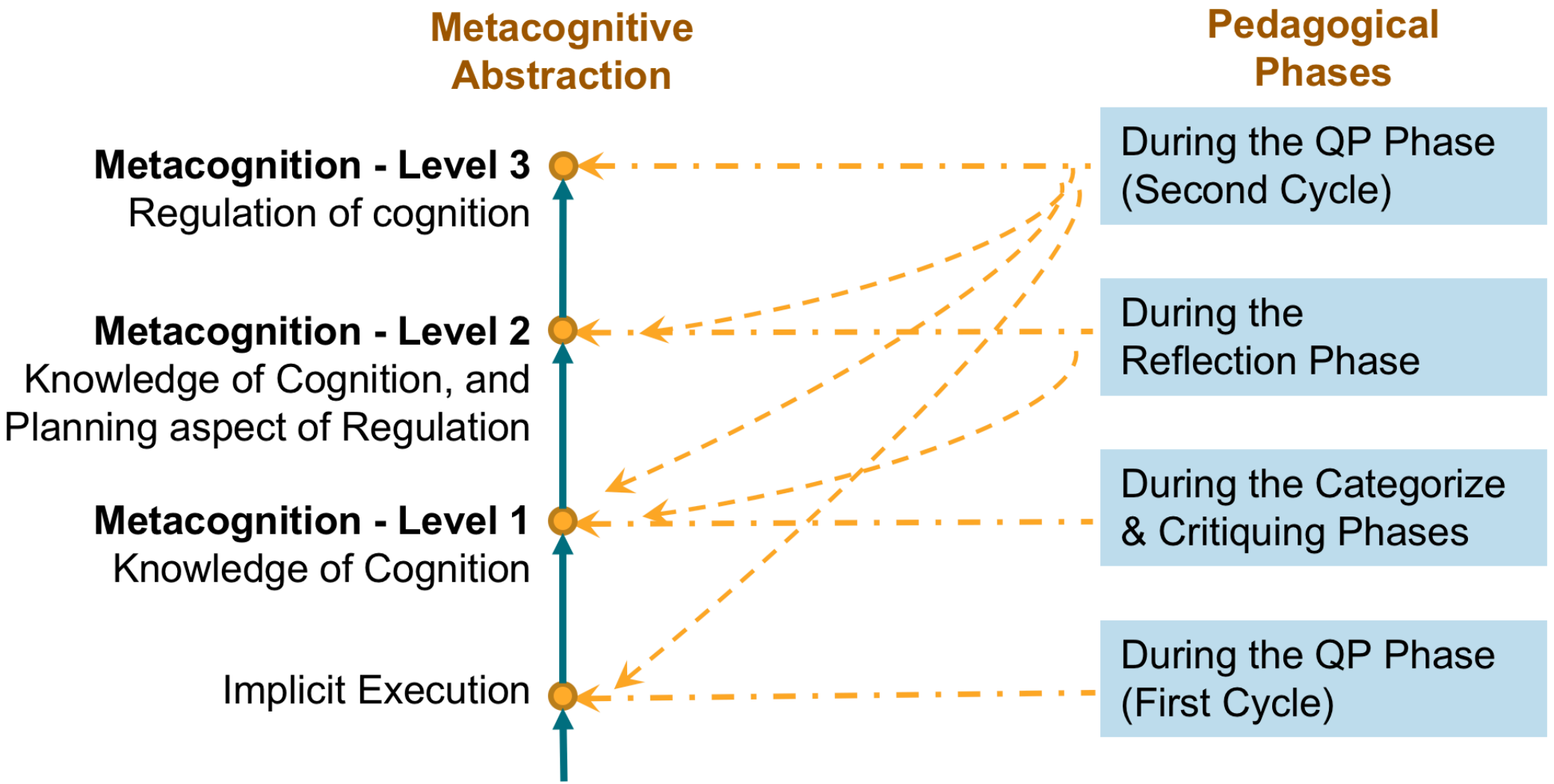
T. Plomp and N. Nieveen. An introduction to educational design research. 2010.

DBR Cycle 2 – Local Learning Theory

- The role of question posing primarily is to set a cognitive requirement of eliciting prior knowledge, focusing on new ideas and identification of gaps and conflict.
- The role of the EQP strategies primarily is to scaffold the execution of these processes.
- These roles are executed at different levels of abstractions at different phases in the IKnowIT pedagogy.

EQP: Exploratory Question Posing

DBR Cycle 2 - Local Learning Theory



DBR Cycle 2 –Local Learning Theory

Local learning theory provide insight into various other learning mechanisms, as follows.

- How and when do the questions arise in learner's mind?
- Effects of learning from the *Minimal EQP Instruction* and being conscious to the goal of the QP task.
- Life Cycles of questions during the IKnowIT Training
- Change in the QP experience in the second run: More intrinsic motivation and authentic questioning
- Factors determining quality and quantity of QP
- Roles of QP in IKnowIT-pedagogy
- Learning of the EQP Strategies
- Anticipated vs. Counter-intuitive vs. Unanticipated Roles of EQP strategies

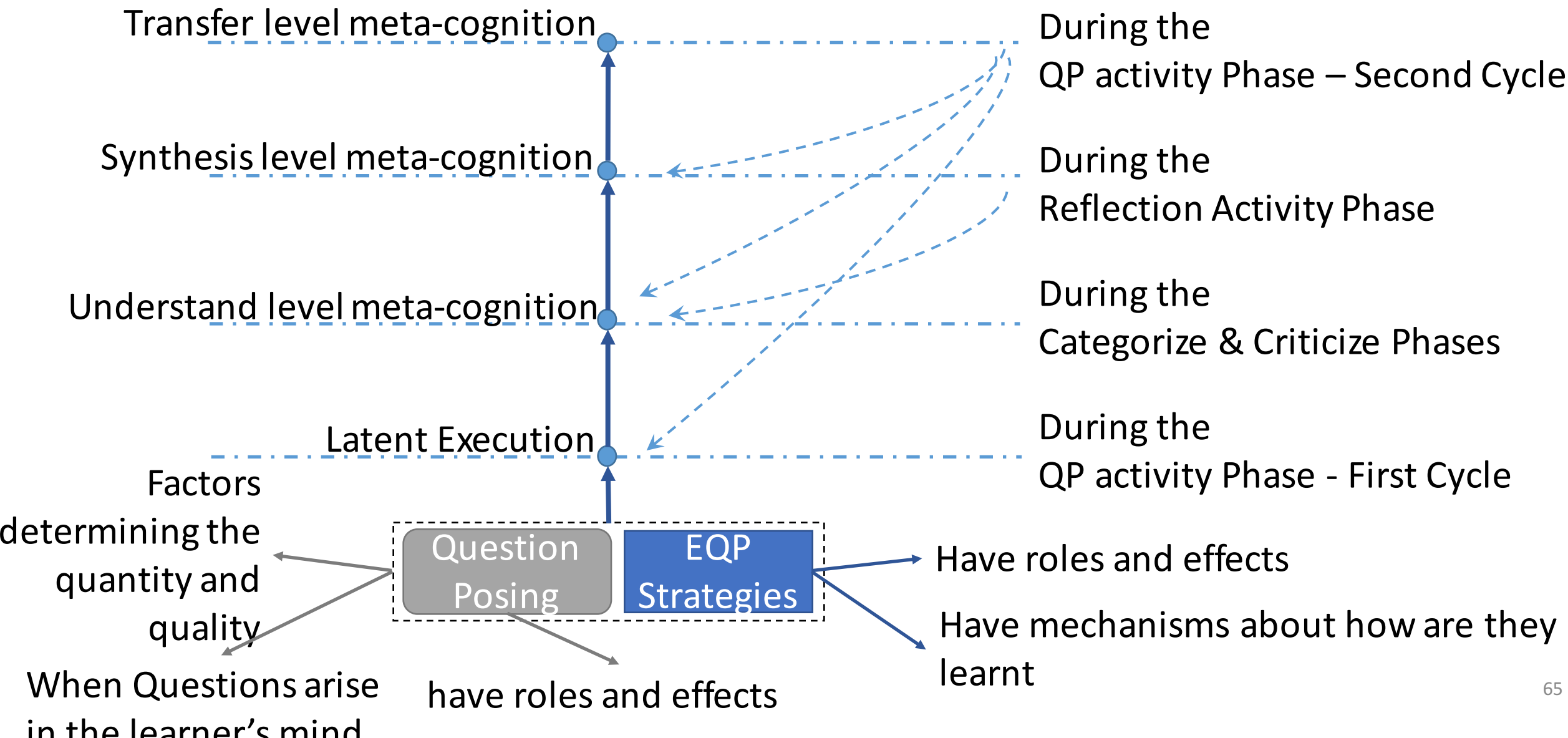
DBR Cycle 2 – Evaluation of final design (Triangulation)

Positive effects of IKnowIT pedagogy have been corroborated by several studies.

- Study 5 has quantitatively shown that KI performance of the learners increases, *as seen through the KI quality of the questions posed by the learners.*

- Study 6 has also shown that KI performance of the learners increases, *as seen through the KI quality of the open responses given by the learners to to KI assessment questions by the learners.*

- Study 7 also corroborates that it's useful for the the objective of fostering cognitive processes of KI. It also establishes that the IKnowIT-environment is fairly usable.


Transfer level meta-cognition
Synthesis level meta-cognition
Understand level meta-cognition
Latent Execution
During the
QP activity Phase – Second Cycle
During the
Reflection Activity Phase
During the
Categorize & Criticize Phases
During the
QP activity Phase - First Cycle
Factors
determining the
quantity and
quality
When Questions arise
in the learner's mind
Question
Posing
EQP
Strategies
have roles and effects
Have roles and effects
Have mechanisms about how are they
learnt

Conclusion

- Two DBR cycles were executed.
- First for getting an initial pedagogical design, second for refining and finalizing the design
- Broad three EQP strategies were identified and used in the IKnowIT learning environment
- IKnowIT pedagogy was evaluated
  – Primarily Qualitatively
  – & Quantitatively
- Following claims and contribution come out of this thesis.

Claims (1/5)

#	Claims	Evidence
1.	Students KI **cognitive processes improves** after they are trained using IKnowIT.	● In the iterative design evaluation and evolution (iDEEN) study in DBR2, it was found that **the learners improves their cognitive processes of knowledge integration by traversing through following levels of progressive abstraction of thinking processes** while interacting with the IKnowIT learning environment. ● Different levels of cognition and metacognition

Claims (2/5)

#	Claims	Evidence
2.	Students **KI quality** improves after they are trained using IKnowIT.	**1. Proof of concept level evidences from DBR1: (Study 3 & 4)** **a.** Students participated in question posing based activities show better knowledge integration performance than other students. **b.** Qualitative results show that students demonstrated indicators of better knowledge integration after participating in question posing based activities. **2. Evidences from DBR2** • Quantitative study shows that the KI quality of the questions posed by the students after one iteration of the interaction with the environment is significantly more than the KI quality of the questions generated in the very beginning. **(Study 5)** • Instructor's interview show shift in students' attitude.

Claims (3/5)

#	Claims	Evidence
3.	The three exploratory question posing (EQP) strategies: **Apply, Operate and Associate** are the most prominent EQP strategies that students employ while generating exploratory questions in data structures domain.	**Study 1 and 2** establishes the prominence of the three categories in data structures. 1. Inductive qualitative analysis of 2 corpus of student generated questions coming from 3 studies has resulted in the identification of EQP strategies using at least one of these three knowledge integration pattern. 2. Analysis of another corpus of 112 student generated questions has shown that 87% of all the the exploratory questions fall under these three categories.

Claims (4/5)

#	Claims	Evidence
4.	Local learning theories about how students pose questions in IKnowIT learning environment are true.	These theories were extracted from the iDEEN methodology based inquiry. **Study 5**
5.	Local learning theories about the role of EQP strategy-based prompts in IKnowIT learning environment are true.	
6.	Local learning theories about how the IKnowIT learning environment improves learner's cognitive processes of KI are true.	

Claims (5/5)

#	Claims	Evidence
7.	**Students perceive** IKnowIT leaning environment to be **useful** for improving cognitive processes related to KI	Survey results from **study 7.**
8.	**Students perceive** IKnowIT pedagogical features to be useful for their learning.	Survey results from **study 7.**
9.	The developed IKnowIT learning environment is **"highly usable"**	SUS Survey results from **study 7**

Contributions (1/3)

➢Research Contribution

a) IKnowIT-pedagogy

- A pedagogy to improve learner's cognitive processes of knowledge integration
  - Consumer: TEL environment developers, Researchers, Teachers

b) EQP Strategies

Exploratory Question Posing Strategies

- Consumers: Students, Teachers, Researchers (All who want to create any question posing based activities in Data Structures)

c) Established the applicability of EQP for KI

- Consumer: Researchers, Practitioners

d) Local Learning Theories (LLTs)

- Theories describing how do the learners improve their KI cognitive processes as a result of their interaction with IKnowIT learning environment
  - Consumer: Researchers, Practitioners

Contributions (2/3)

➢ **Development Contribution**

a) IKnowIT-environment

- A web-based technology enhanced learning environment for improving students cognitive processes of KI.
- Consumer: Students, Teachers

b) iDEEN

Iterative Design Evaluation and Evolution method

- Consumers: Researchers(Who want to develop a technology enhanced learning environments)

Contributions (3/3)

➢ Outreach Contribution

- We trained 785 undergraduate students in Data Structures topics at various stages of this exploratory research.

- Studies included in this thesis (Study 1 through 7) was administered with total 255 out of these 785 learners.

Credits

- All ET Research Scholars
- Rahul Dolui, Ajit Mhatre, Ashwanth Unni
- My friends outside ET RS including Dipti, Govardhan, Sreelakshmi, Neha
- My Professors and Family

Other outputs from this exploratory research

- **SQDL: Student Question Driven Learning**
  A question-posing based instructional strategy for enabling student directed learning.

- **SQDL – Classroom Tool**
  A handheld device-based tool for efficient execution of SQDL.

- **PPE: Problem Posing Exercises**
  Another question-posing based instructional and assessment strategy for CS1 learners.

Publications (Related to thesis)

Journal

- Shitanshu Mishra, Sridhar Iyer. **An Exploration of Problem Posing Based Activities as an Assessment Tool, and as an Instructional Strategy**. Research and Practice in Technology Enhanced Learning (RPTEL), June 2015.

Conferences

- Shitanshu Mishra, Sridhar Iyer. **Exploratory question posing: Towards improving students' knowledge integration performance.** Learning Environments for Deep Learning in Inquiry and Problem-Solving Contexts, the pre-Conference workshop at the 12th International Conference of the Learning Sciences (ICLS), Singapore, June 2016.

- Shitanshu Mishra, Sridhar Iyer. **Question-Posing Strategies used by Students for Exploring Data Structures**. ACM International conference on Innovation and Technology in Computer Science Education (ITiCSE), Vilnius, Lithuania, June 2015.

Publications (Related to thesis)

Conferences contd…

- **Shitanshu Mishra**, Mukulika Maity. **A Software Solution to Conduct Inquiry Based Student Directed Learning.** IEEE International conference on Technology for Education (T4E), Amritapuri, India, December 2014.

- Shitanshu Mishra. **Developing Students' Problem-Posing Skills.** ACM conference on International Computing Education Research, Glassgow, Scottland, August 2014.

- Shitanshu Mishra and Sridhar Iyer. **Problem Posing Exercises (PPE): An Instructional Strategy for Learning of Complex Material in Introductory Programming Courses**. IEEE Conference on Technology for Education (T4E 2013), Kharagpur, India, December 2013.

Publications (Others)

- Michael Hewner, **Shitanshu Mishra**. **When Everyone Knows CS is the Best Major.** Decisions about CS in an Indian context. ACM International Computing Education Research (ICER) Conference, Melbourne, Australia, September 2016.

- Daniela Giordano, Andrew Paul Csizmadia, Simon Marsden, Charles Riedesel, **Shitanshu Mishra**, Lina Vinikienė. **New Horizons in the Assessment of Computer Science at School and Beyond**: Leveraging on the ViVA Platform. Proceedings of the 2015 ITiCSE on Working Group Reports, ACM, 2015.

- Abhinav Anand, **Shitanshu Mishra**, Anurag Deep, Kavya Alse. **Generation of Educational Technology Research Problems using Design Thinking Framework**. IEEE conference on Technology for Education (T4E), Warangal, India, December 2015.

- Deepti Reddy, **Shitanshu Mishra**, Ganesh Ramakrishnan, Sahana Murthy. **Thinking, Pairing, and Sharing to Improve Learning and Engagement in a Data Structures and Algorithms (DSA) Class.** IEE Conference on Teaching and Learning in Computing and Engineering (LaTiCE), Taipei, Taiwan, April 2015.

Publications (Others)

- Rekha Ramesh, **Shitanshu Mishra**, M Sasikumar, Sridhar Iyer. **Semi-Automatic Generation of Metadata for Items in a Question Repository**. IEEE conference on Technology for Education (T4E), Amritapuri, India, December 2014.

- Abhinav, et al. **Designing Engineering Curricula Based on Phenomenographic Results: Relating Theory to Practice**. IEEE conference on Technology for Education (T4E), Amritapuri, Indi, December 2014.

- **Shitanshu Mishra**, Sudish Balan, Sridhar Iyer, Sahana Murthy. **Effect of a 2-week Scratch Intervention in CS1 on Learners with Varying Prior Knowledge**. ACM conference on Innovation Technology in Computer Science Education (ITiCSE), Uppsala, Sweden, June, 2014.

- **Shitanshu Mishra** and Rekha Ramesh. **A Software Solution to Facilitate Moderation, Observation and Analysis in a Focused Group Interview.** IEEE Conference on Technology for Education (T4E 2013), Kharagpur, India, December, 2013.

Thank you for your attention

Your questions and feedback are highly needed

<Link to the rebuttal table>

Study 1 (DBR 1 – Problem Analysis)

- **Research Question**
  - **RQ 1a.** How do students integrate knowledge during exploratory question posing?
- **Sample**
  - 95, second-year CS engineering undergrads (Mumbai University)
- **Design / Implementation**
  - A small 15 minutes lecture followed by a question posing (QP) session.
- **Data Collected**
  - Questions generated by the students in the QP session.
  - Students generated 129 questions.

Study 1 (DBR 1 – Problem Analysis)

- **Data Analysis**
  - Inductive thematic analysis* of the questions generated.
    - **Open Coding:**
      Explored the question data and identified incidents, i.e., units of analysis to code for meanings, feelings, actions, events and so on.
    - **Axial Coding:**
      Incidents obtained in the open coding were reorganized on the basis of connections between the incidents into subcategories and core categories.

* J. Fereday and E. Muir-Cochrane (2006)

Study 1 (DBR 1 – Problem Analysis)

- **Three levels of findings**
  1. Two types of questions: Clarification and Exploratory.
  2. Students use the knowledge pieces from the given new knowledge and/or their prior knowledge to come up with a question.
  3. Exploratory question posing (EQP) strategies.
     1. APPLY
     2. OPERATE
     3. ASSOCIATE

Study 2 (DBR 1 – Problem Analysis)

- **Research Question**
  - **RQ 1b.** Are the exploratory question posing strategies “Apply”, “Operate” and “Associate” valid within data structures course?
- **Sample**
  - 112 questions generated by 45, second-year CS engineering undergrads (DIT University)
- **Design / Implementation**
  - Content analysis on the questions generated by students in question posing sessions
- **Data Collected**
  - Questions generated by the students in the QP session.

Study 2 (DBR 1 – Problem Analysis)

return

- **Findings**
  - The three broad exploratory questioning strategies are applicable in most (87%) of the exploratory questions that students pose in data structure topics.

Study 3 (DBR 1 – Evaluation & Reflection)

- **Research Question**
  - **RQ1c.** Can guided cooperative question posing based pedagogical intervention improve students' knowledge integration performance?
- **Sample**
  - 24 second semester computer science undergraduate engineering students (Mumbai University)
- **Design / Implementation**
  - Two group control study
- **Data Collected**
  - Concept Maps generated by the students in the posttest.

Study 3 (DBR 1 – Evaluation & Reflection)

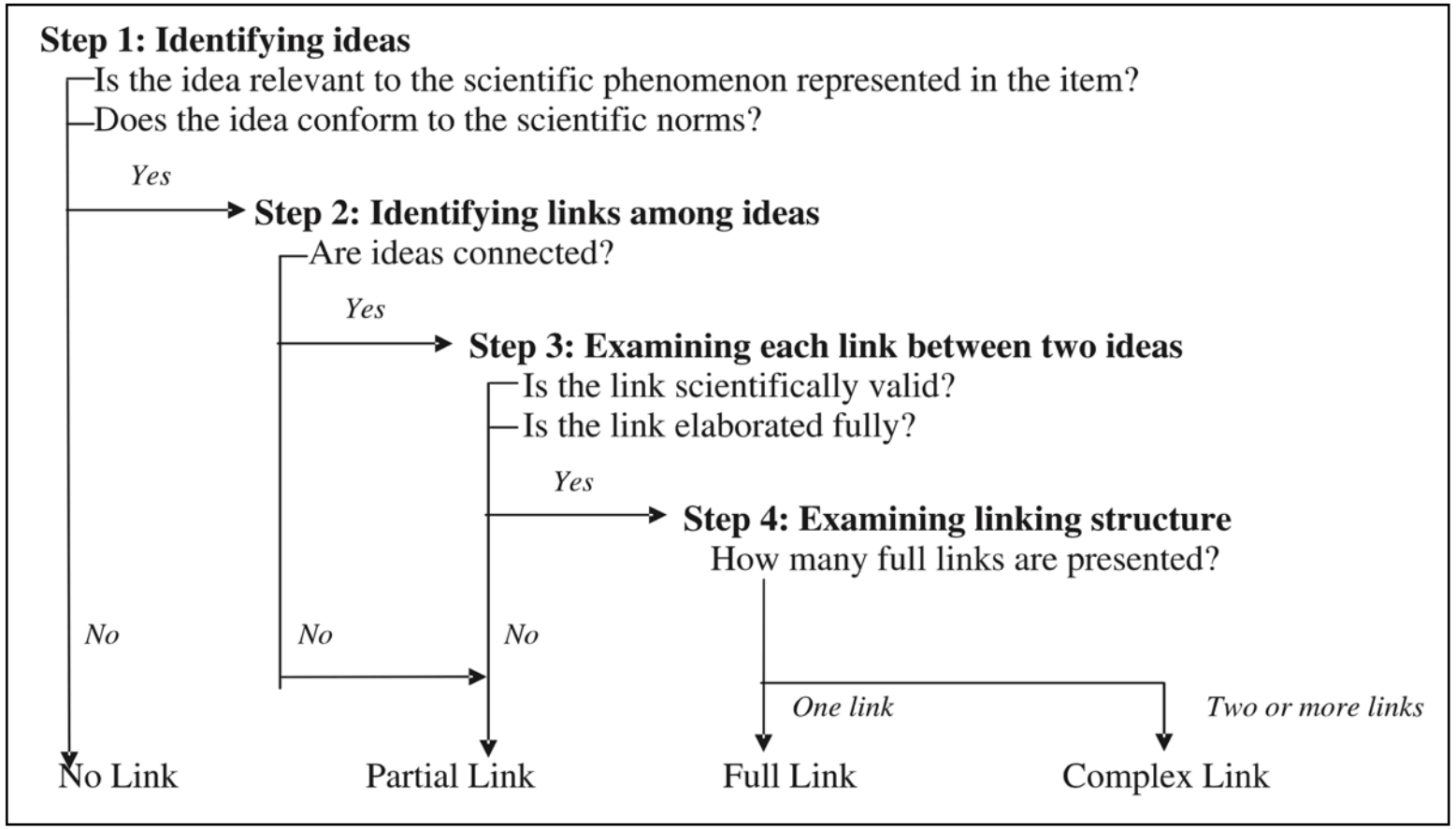
- **Design / Implementation**
  - Two group control study

Study 3 (DBR 1 – Evaluation & Reflection)

- **Data Analysis**
  - Measured KI performances by analyzing concept-maps generated by the students as a posttest.
  - Used standard KI Assessment Rubric by Liu, et al. (2008)

Study 3 (DBR 1 – Evaluation & Reflection)

- **Data Analysis**



No Valid and relevant (to the video lecture) TRIPLETS

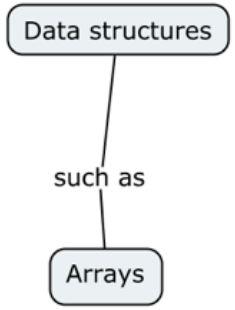
Valid, relevant TRIPLETS

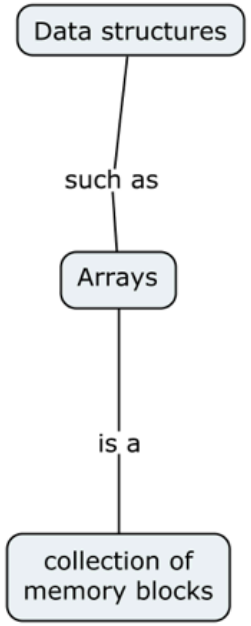
Valid, relevant, 1 step extended TRIPLETS

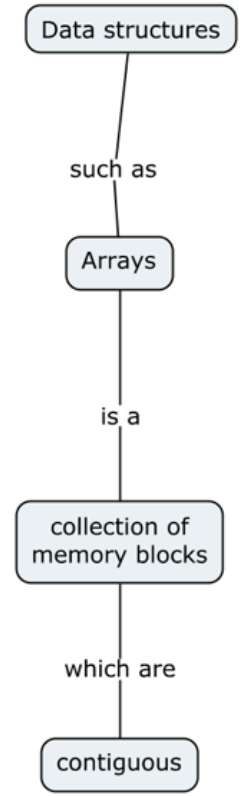
Valid, relevant, more than 1 step extended TRIPLETS

Study 3 (DBR 1 – Evaluation & Reflection)

- **Data Analysis**







1 Triplet

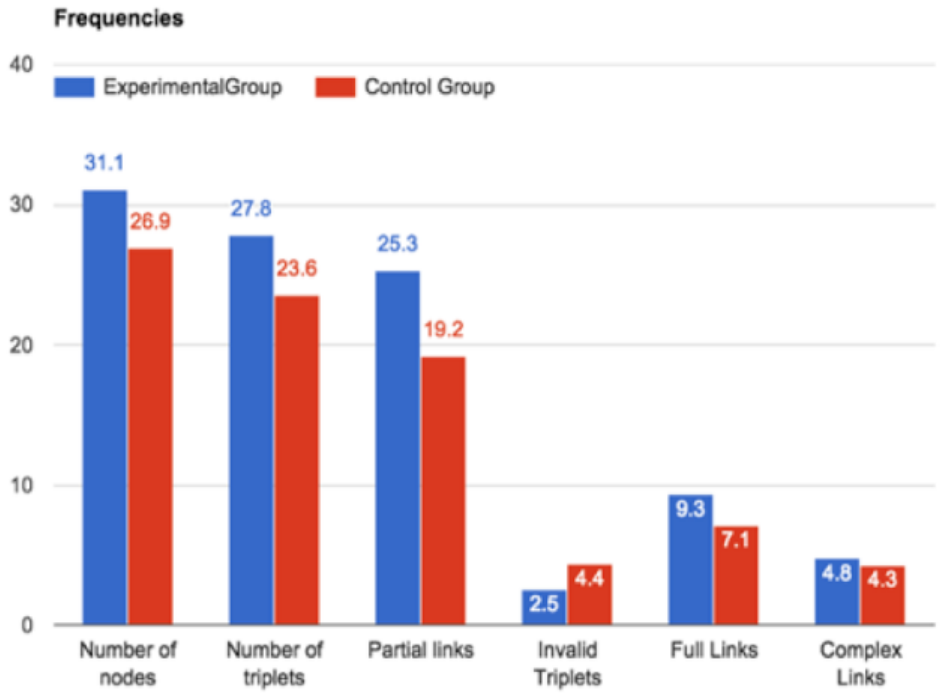
Triplet after 1 step extension

Triplet with more than 1 step extension

Study 3 (DBR 1 – Evaluation & Reflection)

return

- **Findings**



	Nodes	Triplets	Valid triplets	Invalid triplets	Full links	Complex links
Mann-Whitney U	50.50	42.00	40.00	41.50	61.50	72.00
Wilcoxon W	128.50	120.00	118.00	119.50	139.50	150.00
Z	-1.24	-1.74	-1.85	-1.79	-.61	.00
P (2-tailed)	.213	.082	.064	.073	.541	1.000

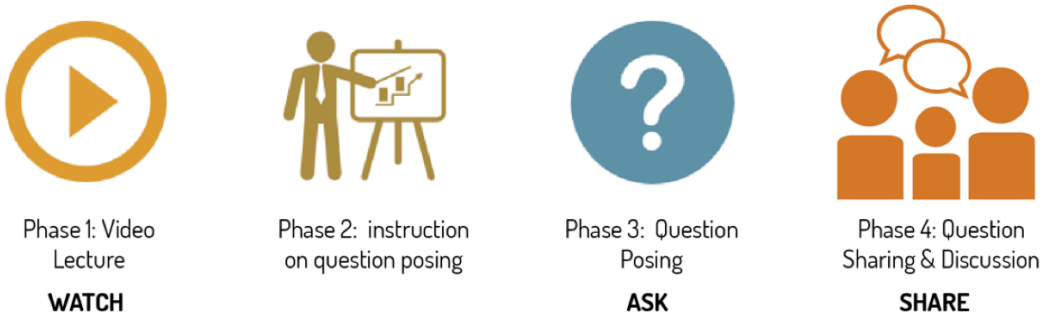
Test Statistics, $N^{experimental} = N^{Control} = 12$

Study 4 (DBR 1 – Evaluation & Reflection)

- **Research Question**
  - **RQ1d.** What do the students perceive about the effects of guided cooperative question posing based pedagogical intervention?
- **Sample**
  - 15, second-year CS engineering undergrads (Mumbai University)
- **Design / Implementation**
  - Two group control study
- **Data Collected**
  - Post intervention group interview and survey

Study 4 (DBR 1 – Evaluation & Reflection)

- **Design / Implementation**



Version 1.0 (Adapted from Guided Cooperative Questioning)

Version 1.1 (Updated from version 1.0)

Study 4 (DBR 1 – Evaluation & Reflection)

- **Findings**

A. Students' perception about question posing after the workshop:

1. Learning "how to question" would help in understanding the concepts better.
2. "I have learnt that **all questions are important** and we should **not restrain ourselves from asking** questions just by thinking it inferior."
3. "We can **think** about a topic in **different ways** and therefore can learn more concepts at the same time."
4. Question posing can bring students out of passive learning.

Study 4 (DBR 1 – Evaluation & Reflection)

- **Findings**

B. Students perceptions of what they learnt from the workshop:

1. "I learnt how to pose different kinds of questions and how to improvise on question posing."
2. Students learnt how to deeply look into any concept.

Study 4 (DBR 1 – Evaluation & Reflection)

- **Findings**

A. Cognitive

1. Quality of questions improved.
2. Learnt - how to question in many ways.
3. Learnt importance of questioning to learning.
4. Improved the thought process - "out of the box" thinking.
5. Learnt to see the topic(s) with different view and deeply.
6. Learnt content as well.

Study 4 (DBR 1 – Evaluation & Reflection)

return

- **Findings**

B. Behavioural

1. Students try to ask many exploratory questions.
2. Included questioning as a part of learning.
3. Improved self learning.
4. Started to question own-self.
5. Students try to debate on merit-demerit, not just “loud voice”.

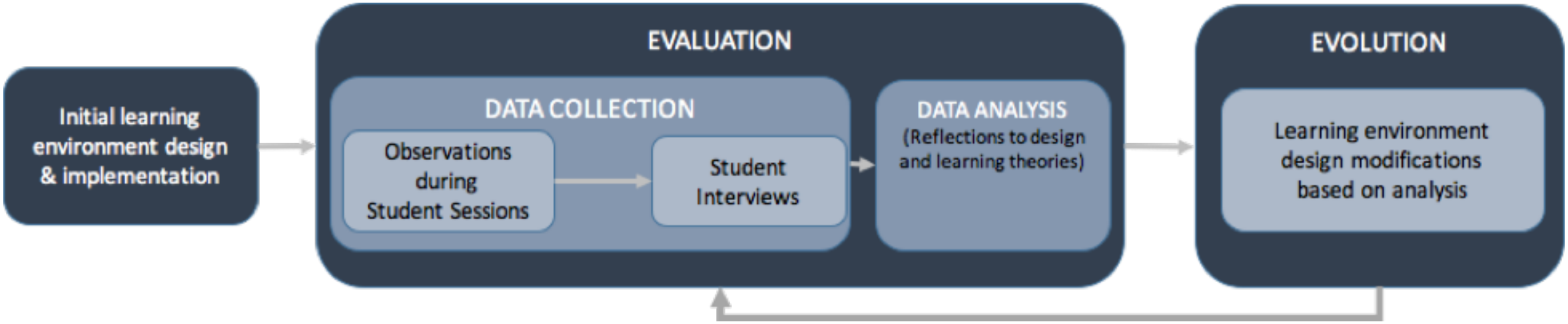
Study 5 (DBR 2 – Design & Evaluation)

- **Research Question**
  - **DQ3.** What should be the design-features of next version of IKnowIT (version 2.x) to make it capable of fostering in students the cognitive processes of KI?
  - **RQ2a.** What are the effects of each of the pedagogical features of IKnowIT learning environment on students learning process?
- **Sample**
  - 23, second-year CS engineering undergrads (Mumbai University)

Study 5 (DBR 2 – Design & Evaluation)

- **Study Method**

  iDEEN - Iterative Design Evaluation and Evolution method



Study 5 (DBR 2 – Design & Evaluation)

iDEEN – Process

1. **Interviews**: 35-60 minutes semi-structured interviews - Non-leading and detailed.
2. **Initial Coding**: Individual segments from interview transcripts are coded
3. **Focused Codes**: Similar segments of different interviews are combined to explain larger segments of the data.
4. Third, the focused codes are abstracted into categories in a tentative theory that is then checked against other parts of the data to test its explanatory power.
5. **Constant comparison:** Tentative theory is tested back against the corpus of transcripts
6. Tentative theory suggests new design principles and questions to interview

References: Hewner, 2013, Corbin & Strauss. 2008, Charmaz, 2006

Study 5 (DBR 2 – Design & Evaluation)

iDEEN – Example of Analysis

S2: …I am from IT background, so my question would be about application… I would be more interested so that I can use it… …different background would lead to different point of view… S1: If prior knowledge is different then conflict would also be accordingly different. If my prior knowledge is shallow then I would perhaps not rely on the new one [knowledge]. If my prior knowledge is deep then I would get conflict more.13:09 I: So do you think that people always associate with prior knowledge?13:12 S1 and S2 : yes sir

- In the initial pass this was coded as *"quality of PK determines quality of questions*".
- In later analysis it was incorporated into a larger focused code of "Role of PK and NK".
- About half way through the process, a second pass was done and codes were reorganized.
- We recognized commonalities between this quote and other QP factors.
- All these ideas became part of the larger "Factors leading to question quality"

Study 5 (DBR 2 – Design & Evaluation)

iDEEN – Cycles

Pedagogical Design Features	IT1	IT2	IT3	IT4	IT5	IT6	IT7	IT8	IT9	IT10	IT11	IT12	IT13
Participant Count	1	2	2	2	2	2	2	2	2	2	1	2	1
Minimal EQP Instructions – Reading (Post watching Video)	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Minimal EQP Instructions – Reading (Before watching Video)	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Video Lecture & QP (Separate)	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Video Lecture & QP (Merged)	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Detailed EQP Instructions – Reading (EQP strategies in data structures	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Categorize own questions (Using set of EQP strategies in data structures)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Criticize online-partner's questions (and categories	✓#	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓#	✓#	✓#
Discuss over text chat	✗	✓	✓	✗	✗	✓	✗	✓	✗	✗	✗	✗	✗
Strategy classification	✗	✗	✗	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗
Reflection Task – Guided Socratic Reflection (Face to face)	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Reflection Task – Using Reflection Questions (Integrated to the environment)	✗	✗	✗	✓^	✓^	✓^	✓^	✓	✓	✓	✓	✓	✓
Video 2 (as a posttest)	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗		
Video 2 & QP (as a part of pedagogy)	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Categorize & Criticize for Video 2 Questions	✗	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓
Reflection Task 2 (Same questions with slight variation the format)	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✓	✓	✓

✗ : Feature NOT included in an iDEEN iteration
✓ : Feature included in an iDEEN iteration
Green Blocks: Feature retained till the end of grounded theory
#: Criticize online partner's question (Canned Partner - Questions were take from previous studies)
*: KI Strategy classification – Visual
^: Reflection Task – Google Form

Study 5 (DBR 2 – Design & Evaluation)

iDEEN – Cycles

Pedagogical Design Features	IT1	IT2	IT3	IT4	IT5	IT6	IT7	IT8	IT9	IT10	IT11	IT12	IT13
Participant Count	1	2	2	2	2	2	2	2	2	2	1	2	1
Minimal EQP Instructions – Reading (Post watching Video)	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Minimal EQP Instructions – Reading (Before watching Video)	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Video Lecture & QP (Separate)	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Video Lecture & QP (Merged)	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Detailed EQP Instructions – Reading													

Study 5 (DBR 2 – Design & Evaluation)

iDEEN – Cycles

Detailed EQP Instructions – Reading (EQP strategies in data structures	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Categorize own questions (Using set of EQP strategies in data structures)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Criticize online-partner's questions (and categories	✓#	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓#	✓#	✓#

Study 5 (DBR 2 – Design & Evaluation)

iDEEN – Cycles

Discuss over text chat	✗	✓	✓	✗	✗	✓	✗	✓	✗	✗	✗	✗	✗
Strategy classification	✗	✗	✗	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗
Reflection Task – Guided Socratic Reflection (Face to face)	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Reflection Task – Using Reflection Questions (Integrated to the environment)	✗	✗	✗	✓ ^	✓ ^	✓ ^	✓ ^	✓	✓	✓	✓	✓	✓

Study 5 (DBR 2 – Design & Evaluation)

iDEEN – Cycles

(integrated to the environment)													
Video 2 (as a posttest)	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗		
Video 2 & QP (as a part of pedagogy)	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Categorize & Criticize for Video 2 Questions	✗	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓
Reflection Task 2 (Same questions with slight variation the format)	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✓	✓	✓

Study 5 (DBR 2 – Design & Evaluation)

iDEEN – Cycles

return

Pedagogical Design Features	IT1	IT2	IT3	IT4	IT5	IT6	IT7	IT8	IT9	IT10	IT11	IT12	IT13
Participant Count	1	2	2	2	2	2	2	2	2	2	1	2	1
Minimal EQP Instructions – Reading (Post watching Video)	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Minimal EQP Instructions – Reading (Before watching Video)	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Video Lecture & QP (Separate)	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Video Lecture & QP (Merged)	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Detailed EQP Instructions – Reading (EQP strategies in data structures	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Categorize own questions (Using set of EQP strategies in data structures)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Criticize online-partner's questions (and categories	✓#	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓#	✓#	✓#
Discuss over text chat	✗	✓	✓	✗	✗	✓	✗	✓	✗	✗	✗	✗	✗
Strategy classification	✗	✗	✗	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗
Reflection Task – Guided Socratic Reflection (Face to face)	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Reflection Task – Using Reflection Questions (Integrated to the environment)	✗	✗	✗	✓^	✓^	✓^	✓^	✓	✓	✓	✓	✓	✓
Video 2 (as a posttest)	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗		
Video 2 & QP (as a part of pedagogy)	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Categorize & Criticize for Video 2 Questions	✗	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓
Reflection Task 2 (Same questions with slight variation the format)	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✓	✓	✓

✗ : Feature NOT included in an iDEEN iteration
✓ : Feature included in an iDEEN iteration
Green Blocks: Feature retained till the end of grounded theory
#: Criticize online partner's question (Canned Partner - Questions were take from previous studies)
*: KI Strategy classification – Visual
^: Reflection Task – Google Form

Study 5 (DBR 2 – Evaluation)

- **Research Question**
  - **RQ2b.** What are the effects of the students' interaction with the IKnowIT learning environment on their improvement of knowledge integration quality?
- **Sample**
  - 23, second-year CS engineering undergrads (Mumbai University)
- **Data Collected**
  - Student generated questions in the two cycles of the IKnowIT pedagogy on two different topics.
- **Data Analysis**
  - Rubric based analysis of student generated questions **(One group pre-post Analysis)**

Study 5 (DBR 2 – Evaluation)

- **Data Analysis**

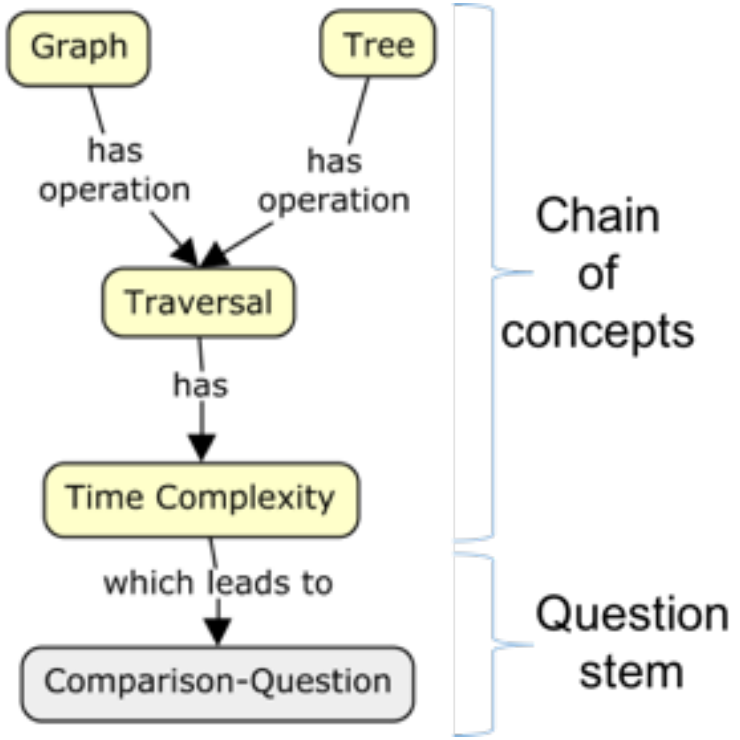
KI scoring rubric for analyzing student responses to explanation items [ref]	**Adapted KI scoring rubric for analyzing students generated questions in data structures**
KI Level 0 - Irrelevant Elicit ideas that are irrelevant to the domain context	**KI Level 0** Elicit ideas that are irrelevant to the data structures context, or Elicit non-normative ideas
KI Level 1- No Links Elicit ideas but make non-normative links between the ideas, or Elicit non-normative ideas	**KI Level 1** Elicit ideas but make non-normative links between the ideas, or Elicit one idea with a valid question stem
KI Level 2 - Partial-Link Elicit normative and relevant ideas but do not fully elaborate the links among them	**KI Level 2** Elicit normative and relevant ideas but do not fully elaborate the links among them along with a question link, or Elicit two relevant ideas and connect them with a question stem
KI Level 3 - Full-Link Elicit two normative and relevant ideas	**KI Level 3** Elicit two relevant and normative ideas

Study 5 (DBR 2 – Evaluation)

- **Data Analysis**
  1. Two analysts analyze each question separately, two identify distinct ideas present in any response.
  2. Analysts then discuss their analysis face to face and come to a common ground (final lists of valid ideas present in the responses).

Study 5 (DBR 2 – Evaluation)

- **Data Analysis**
  - For each question
    - Separate the “chain of concepts” and “question stem”
    - Apply the KI rubric



KI-Tree corresponding to the question, “Which, between graphs and trees has a better time complexity associated with traversal?”

Study 5 (DBR 2 – Evaluation)

return

- **Result**

N	Z	Asymp. Sig. (2-tailed)
18	-2.463*	.014

*Based on negative ranks.

Wilcoxon Signed Rank Test Statistics

For 18 students:

- 80 questions in the initial QP session
- 69 questions in the second QP session

Study 6 (DBR 2 – Evaluation)

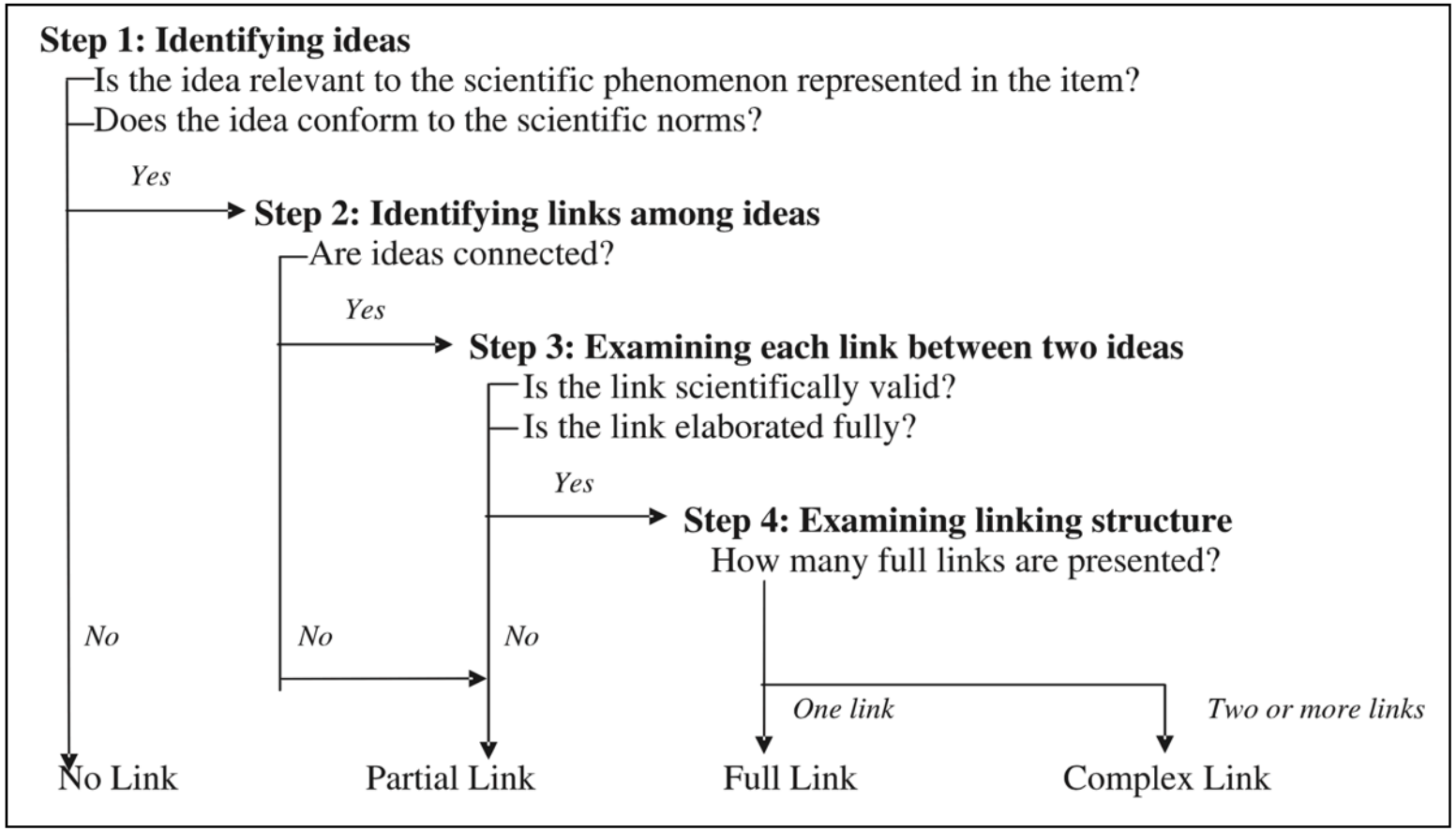
- **Research Question**
  - **RQ2b.** What are the effects of the students' interaction with the IKnowIT learning environment on their improvement of knowledge integration quality?
- **Sample**
  - 31, second-year CS engineering undergrads (Mumbai University)

- **Data Collected**
  1. **Student response to the three posttest questions.**
  2. Instructors' Interview after 20 days of the intervention.

- **Data Analysis**
  - Rubric based analysis of student responses **(two group control study)**

Study 6 (DBR 2 – Evaluation)

- **Data Analysis**



Study 6 (DBR 2 – Evaluation)

- **Data Analysis**
  1. Two analysts analyzed each response separately to identify distinct ideas present in any response.
  2. Analysts then discuss their analysis face to face and come to a common ground (final lists of valid ideas present in the responses).
  3. Since number of ideas in almost all responses exceeded 4 therefore we didn't follow the four levels of KI in the rubric. Instead we used the count of ideas in each response as our measure for the KI performance.

Study 6 (DBR 2 – Evaluation)

- **Data Analysis – Example**

Student Response

For any Navigation System Directed Graphs should be used because the roads have a direction(some of them must be one-way). For any Navigation System Weight Graphs should be used because the roads have different lengths. Travelling time is considered so the length of the roads is an important factor.

List of ideas identified

- *Roads have direction*
- *Roads can be one-way*
- *Roads have different length*
- *Length are similar to weights*
- *Length determines travelling time*

Study 6 (DBR 2 – Evaluation)

- **Findings**

	U	Z	p (2-tailed)
Question 1	49	2.367	0.0178
Question 2	94.5	0.409	0.682
Question 3	75.5	1.23	0.219

1. **The first question** was about explaining why a data structure DS is suitable for an application.
2. **The second question** was about identifying (and justifying) an application for a given DS.
3. **The third question** was about identifying an application from the given list (and justifying) for a given DS identifying an application for a given DS.

Study 6 (DBR 2 – Evaluation)

Analysis of the instructor's interview

- Thematic analysis of the instructor's interview.

Example excerpt:

Teacher *: "…So they have been started being attentive now.*
Interviewer*: That because of you or because of the session [workshop]?*
Teacher*: Look, I knew people who'll ask question, right! So what I do is even I used to divert the questions to them.*
Interviewer *: This you used to do before?*
Teacher*: No, I didn't do this before, previously there did not use to be these many questions. To keep that engagement…*
Interviewer*: So you are saying that the students who ask questions, those were not attentive before?*
Teacher*: Yes, they were not attentive…."*

Study 6 (DBR 2 – Evaluation)

return

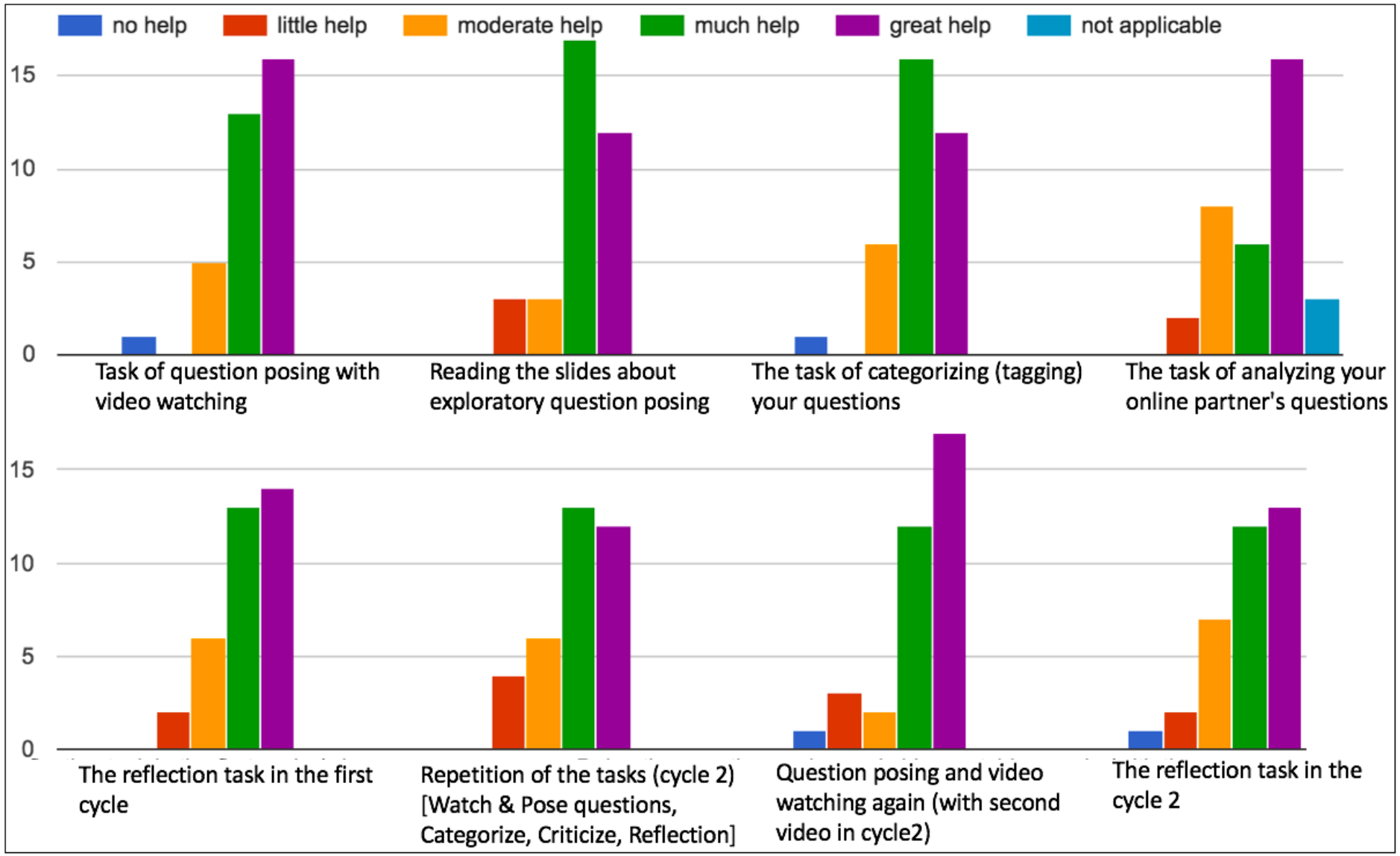
Analysis of the instructor's interview

- Following themes emerged at the end of the thematic analysis.

1. Number of student questions increased
2. Students started exploring concepts more
3. Students started exploring concepts more - using QP
4. On-task behavior increased
5. Classroom attention improved
6. Students experimenting on their own increased

Study 7 (DBR 2 – Evaluation)

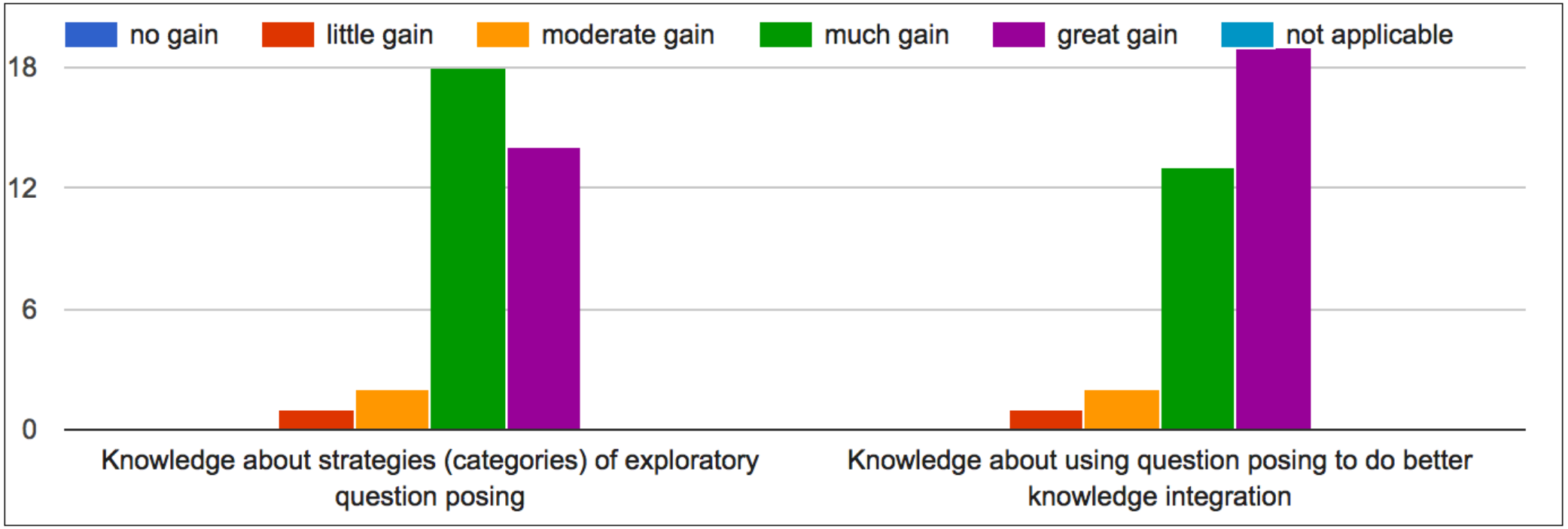
[return]



Study 7 (DBR 2 – Evaluation)

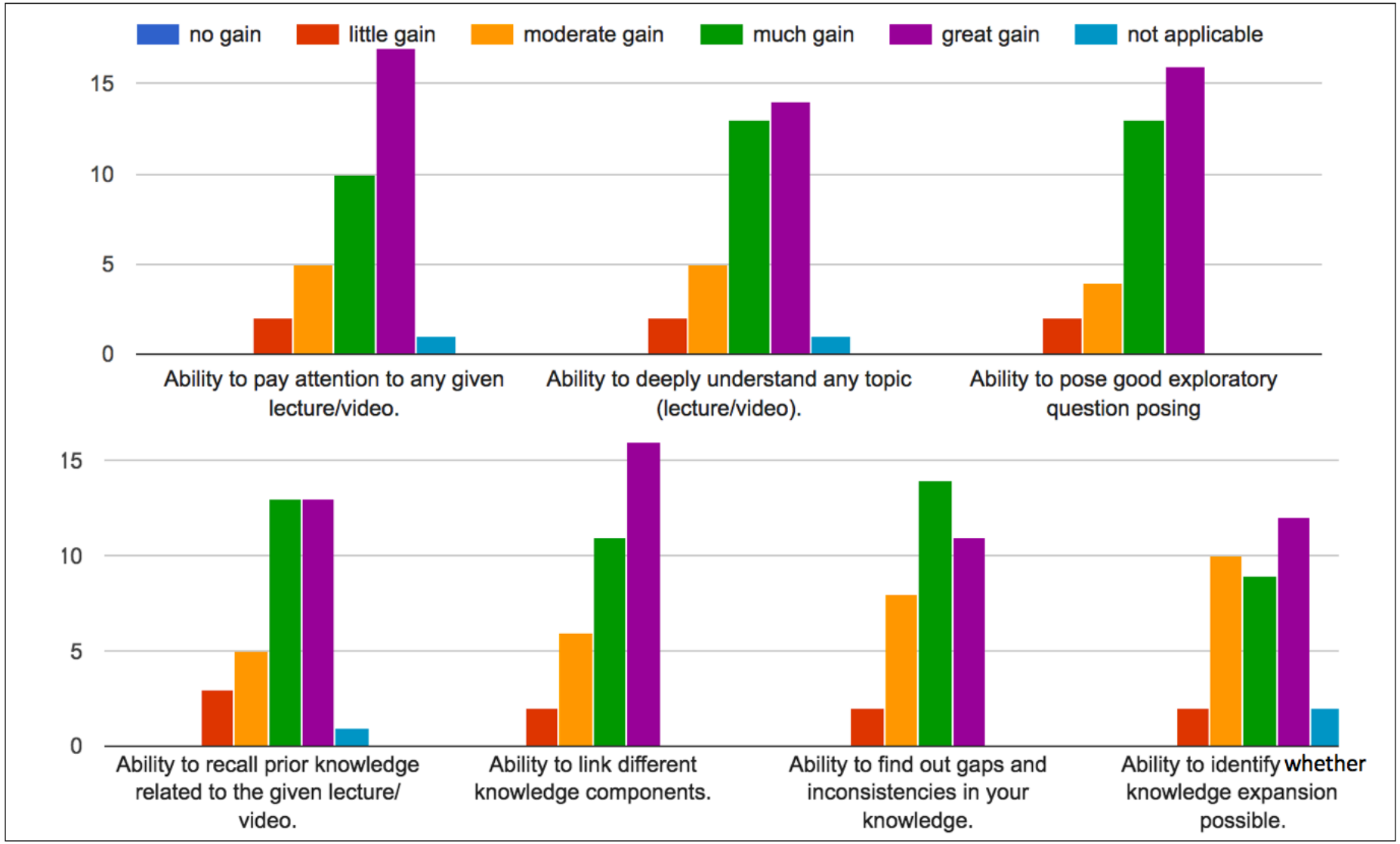
[return]

- **Research Question**
  - What are the **usefulness** and usability of IKnowIT learning environment as perceived by the students?



Study 7 (DBR 2 – Evaluation)

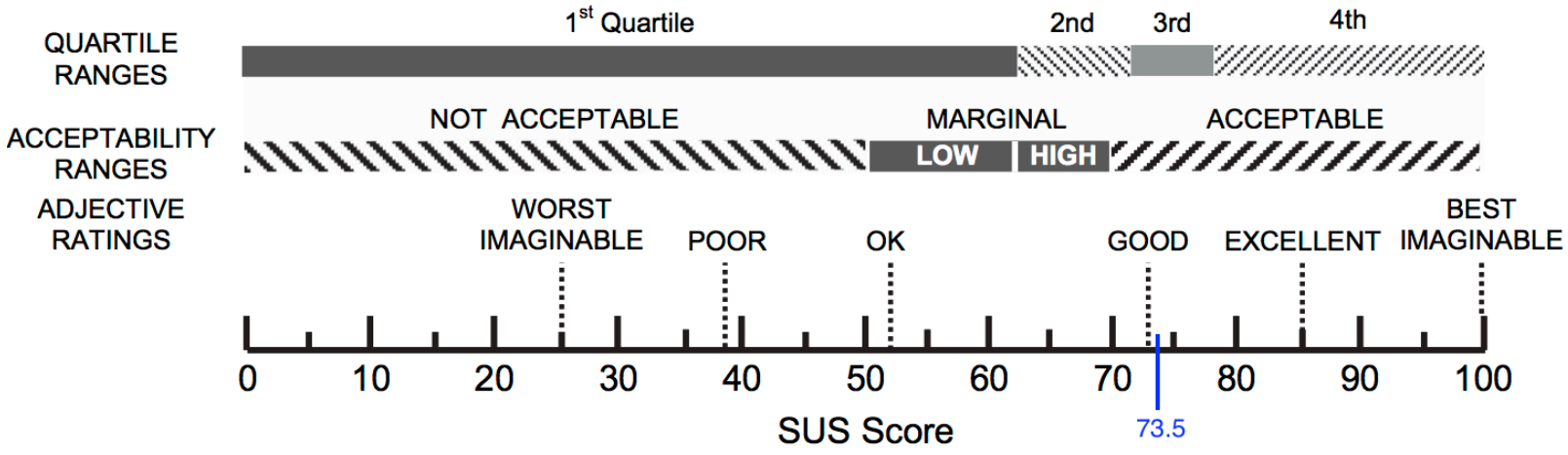
[return]



Study 7 (DBR 2 – Evaluation)

[return]

- **Research Question**
  - What are the usefulness and **usability** of IKnowIT learning environment as perceived by the students?



Local Learning Theory

Effect of EQP Strategies

- Helped in eliciting prior knowledge.
- Improving the focus on the new knowledge.

Local Learning Theory

Anticipated/ Counter intuitive Roles of EQP Strategies

- EQP Strategies are not template to ask questions, but they help in reflecting back on the quality of their questions.
- In the ‘categorize’ and ‘criticize’, questions make the KI thinking processes accessible and the EQP strategies make the KI thinking processes visible.

Local Learning Theory

How do the learners learn the question posing strategies?

- During “minimal EQP instruction” - gets primer.
- During "detailed EQP instruction” - gets detail understanding.
- During "Categorize phase” - gets analyze level learning.
- During “Criticize phase” - gets evaluate level learning.

Local Learning Theory

Factors determining the quantity and quality of questions

- Learner’s level of prior knowledge
  (1) Low, (2) High, (3) None
- Quality of new knowledge (video lecture)
  (1) Length of the video,
  (2) "Very easy" video
  (3) "Too good" video
  (4) Highly Difficult

Local Learning Theory

When Questions arise in student's mind in IKnowIT

- Role of conscious – QP generation
- Role of Focus

DBR Cycle 2 – Evaluation and Reflection

Studies	Questions (RQs / DQs / LQs)	Method	Findings
Study 5	**RQ2b.** What are the effects of the students' interaction with the IKnowIT learning environment on their improvement of knowledge integration	Rubric based analysis of student generated questions (One group pre-post Analysis)	● Knowledge integration (KI) quality of the questions posed by the students after one iteration of the interaction with the environment is significantly more than the KI quality of the questions generated in the very beginning.
		Quantitative analysis of the difference between the experimental and control group	● Knowledge integration (KI) quality of the responses to the posttest items by the students in the experimental group is

RQs: Research Questions; DQs: Design Questions; LQs: Literature Questions