Computing Education Research: Opportunities in India

Agenda

- Retrospection on Day 1 to Day 4
- Feedback for Day 4
- Introduction to Computing Education Research
- Break
- How to guide PhD/Masters/undergraduate students for research
- Prepare for post lunch individual presentations and share the deck.
- Lunch
- Presentations!

Day 4 Retrospection

1. Design a chatbot that does Socratic questioning for 3 computer science concepts you consider difficult
2. Automate a workflow for one aspect of Software Development Life Cycle (Team: integrate the pipeline)
3. Create an autograder for full stack project submissions of your students
4. Using P5JS, create a visualisation tool for any computer science concept
5. Build a simple software that translates strings from English to any vernacular language you know (Example: Kannada / Telugu / Tamil / Malayalam / Hindi...)

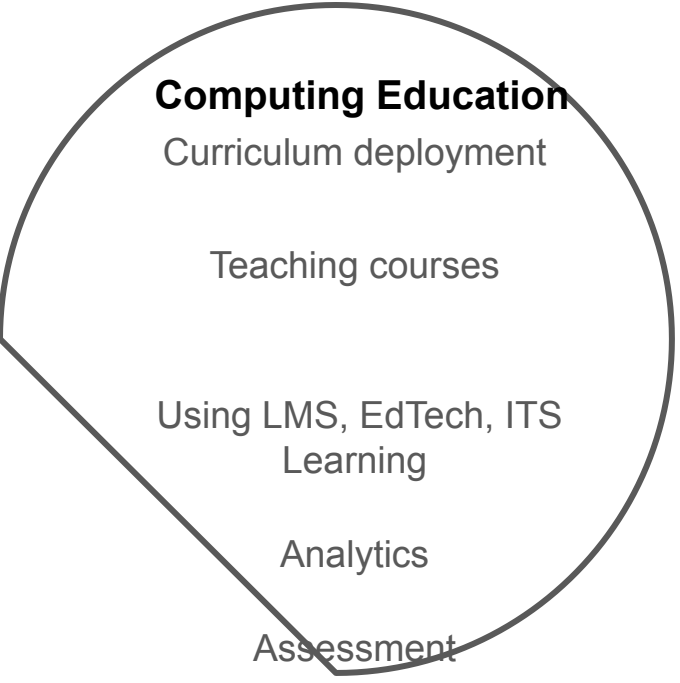
Outline of this talk

- What is computing education research?
- What are levels of education research?
- What are some methods for doing this?
- How to get started?
- What are some opportunities in India?

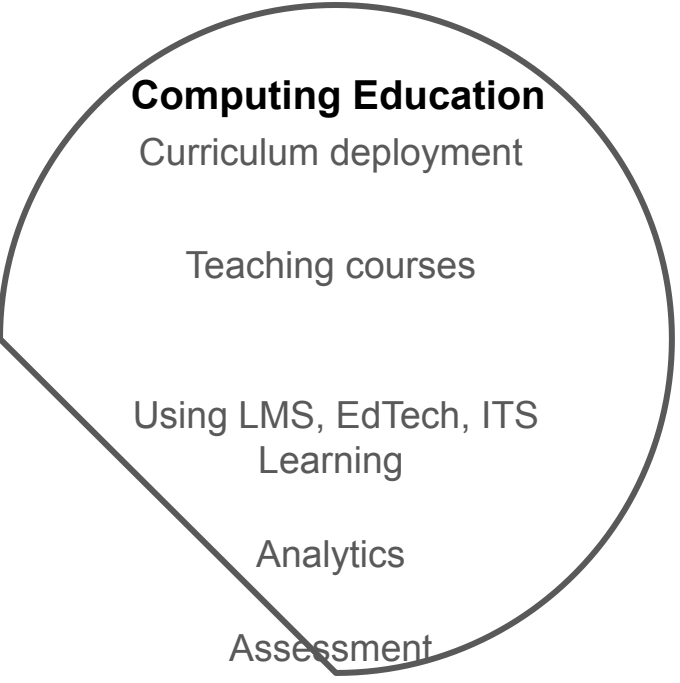
We will answer these through some illustrative examples

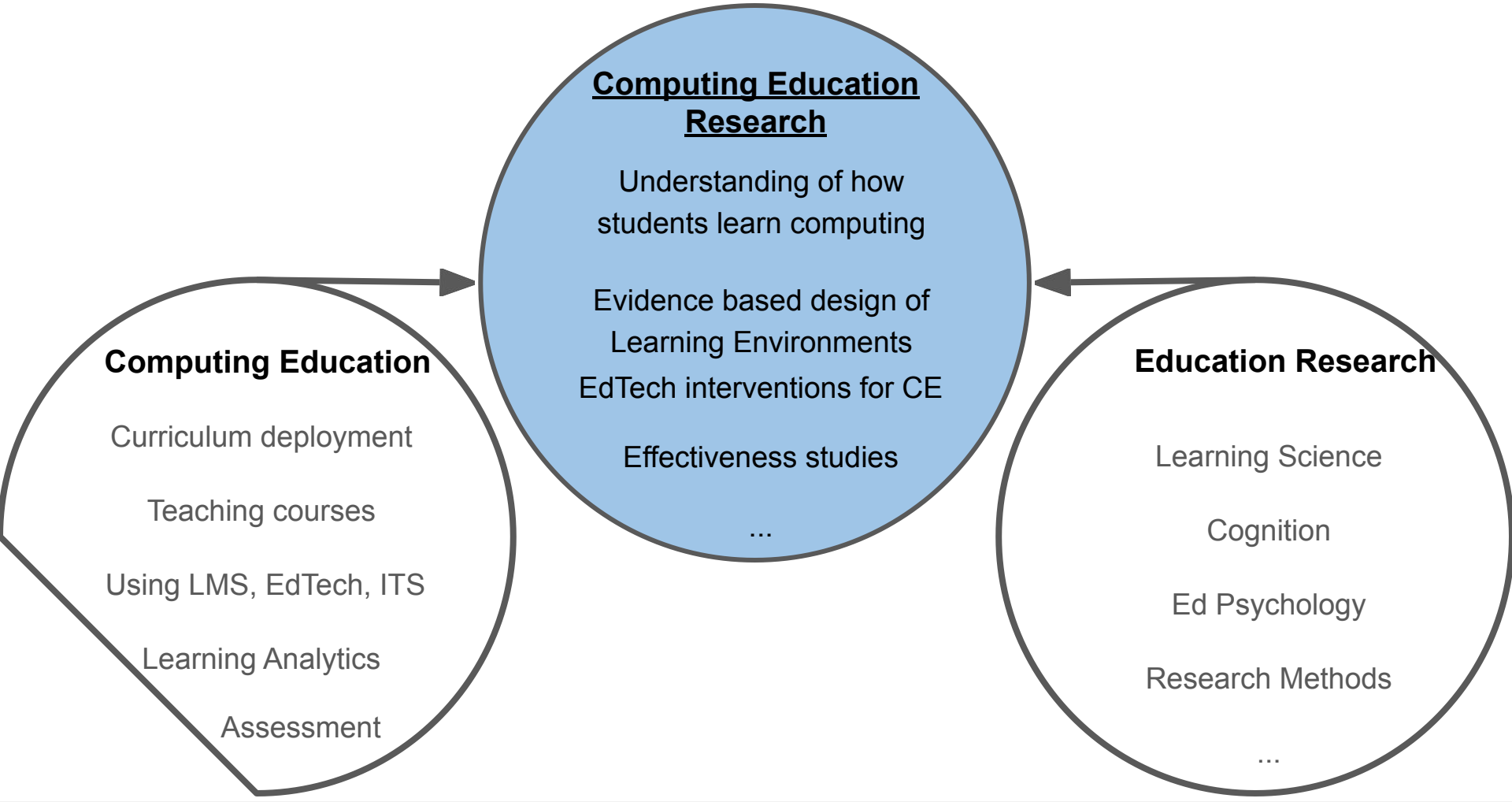
What is Computing Education Research?

Computing Education Research

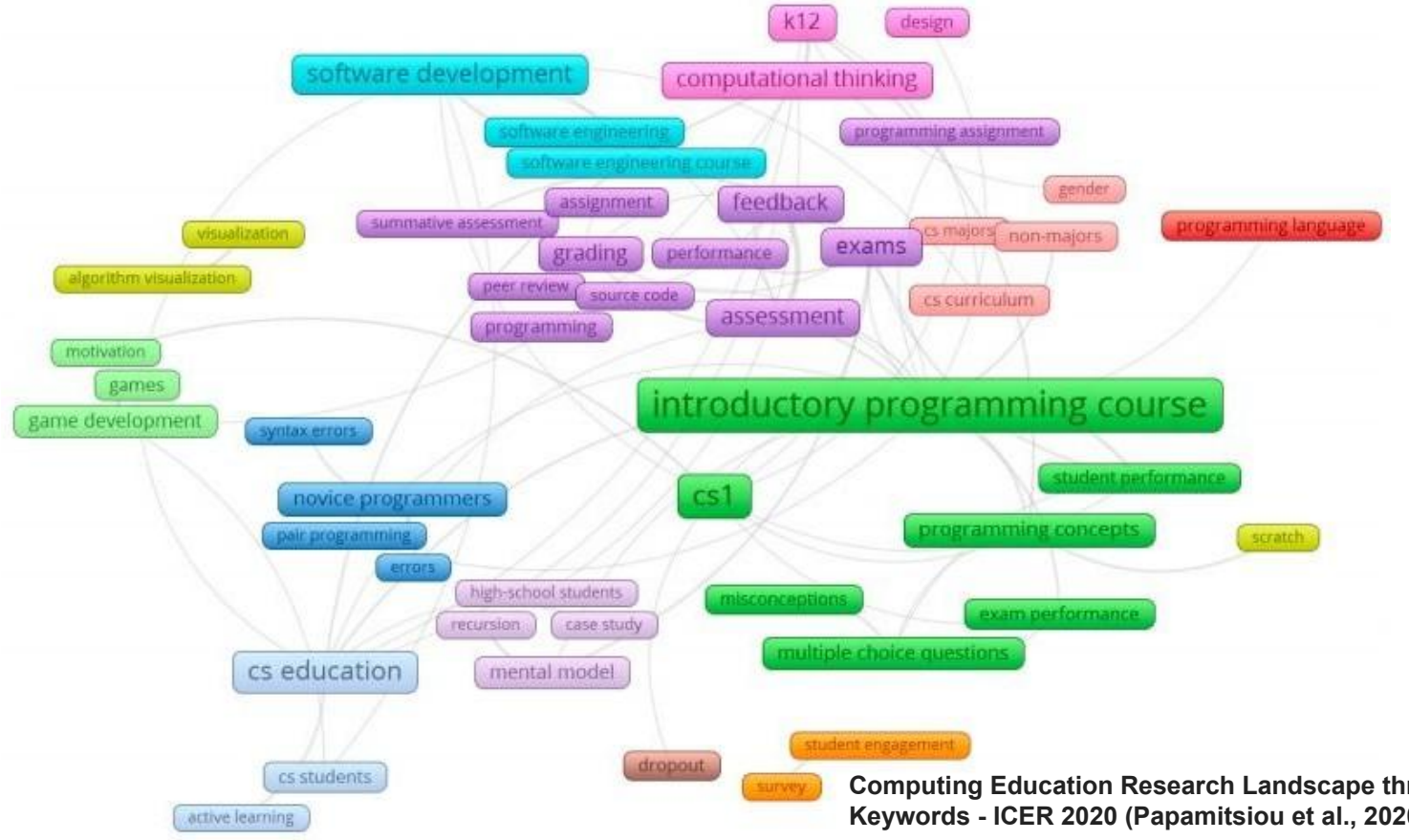


Computing Education Research



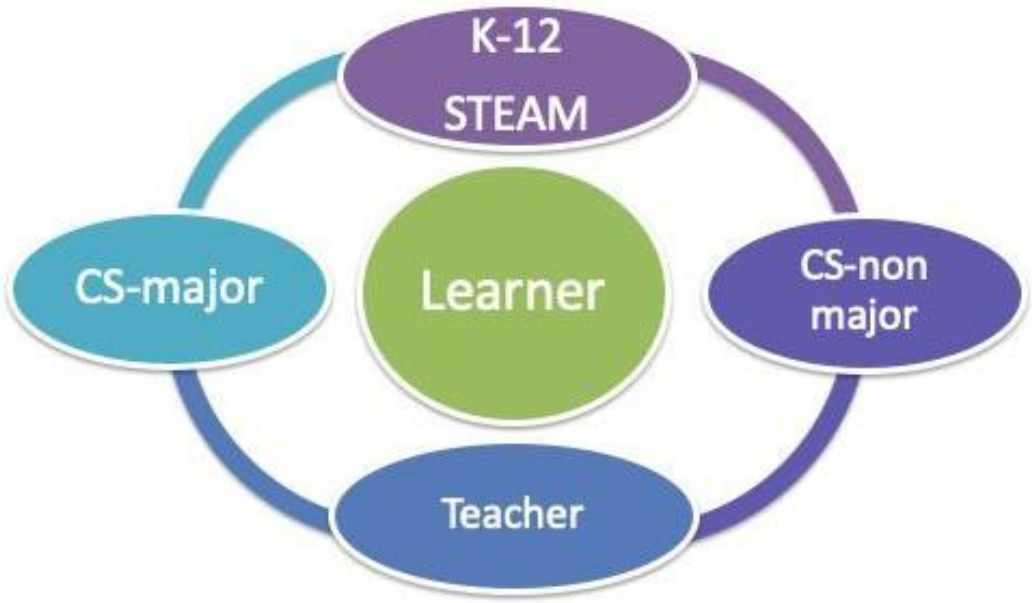

Computing Education Research
Understanding of how students learn computing
Evidence based design of Learning Environments
EdTech interventions for CE
Effectiveness studies
...
Computing Education
Curriculum deployment
Teaching courses
Using LMS, EdTech, ITS
Learning Analytics
Assessment
Education Research
Learning Science
Cognition
Ed Psychology
Research Methods
...

Computing Ed-Research Landscape



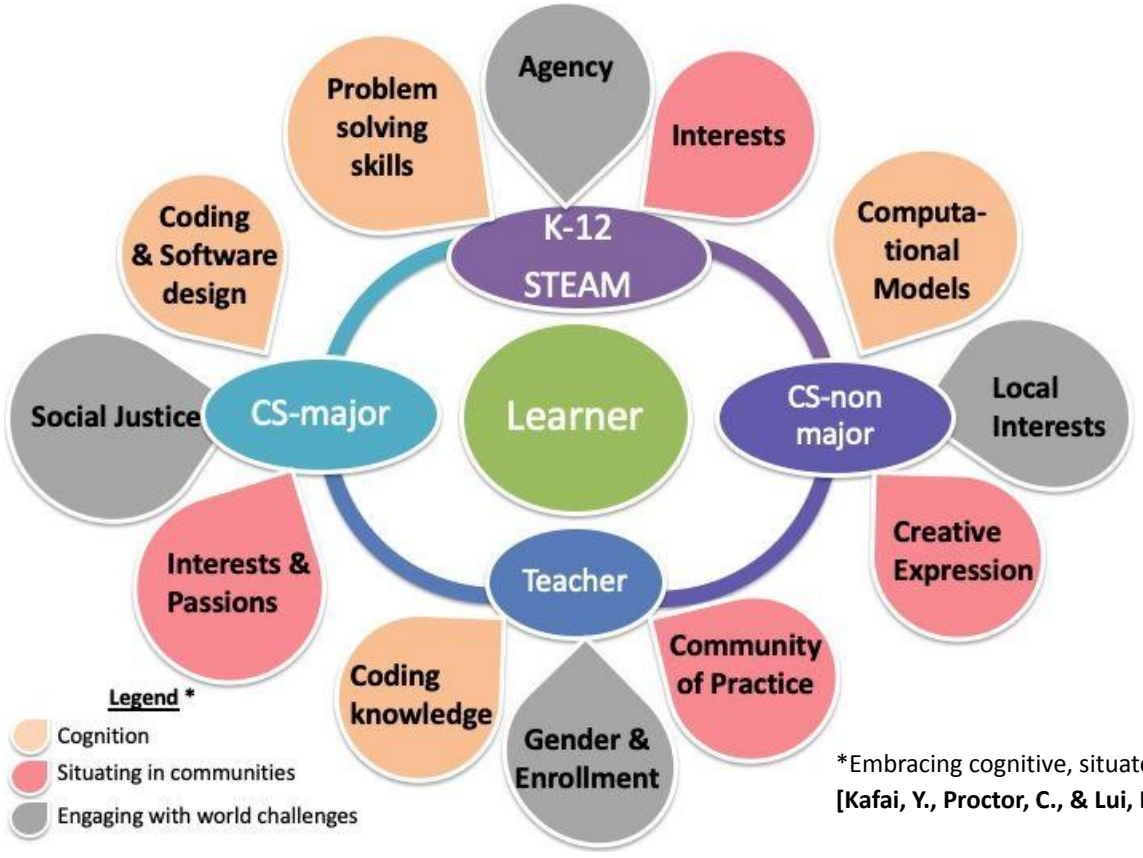
Computing Education Research Landscape through an Analysis of Keywords - ICER 2020 (Papamitsiou et al., 2020)

Another view - Learner Centered CER



- Engage with different learners with multiple perspectives
- Different kinds of learners (ovals)

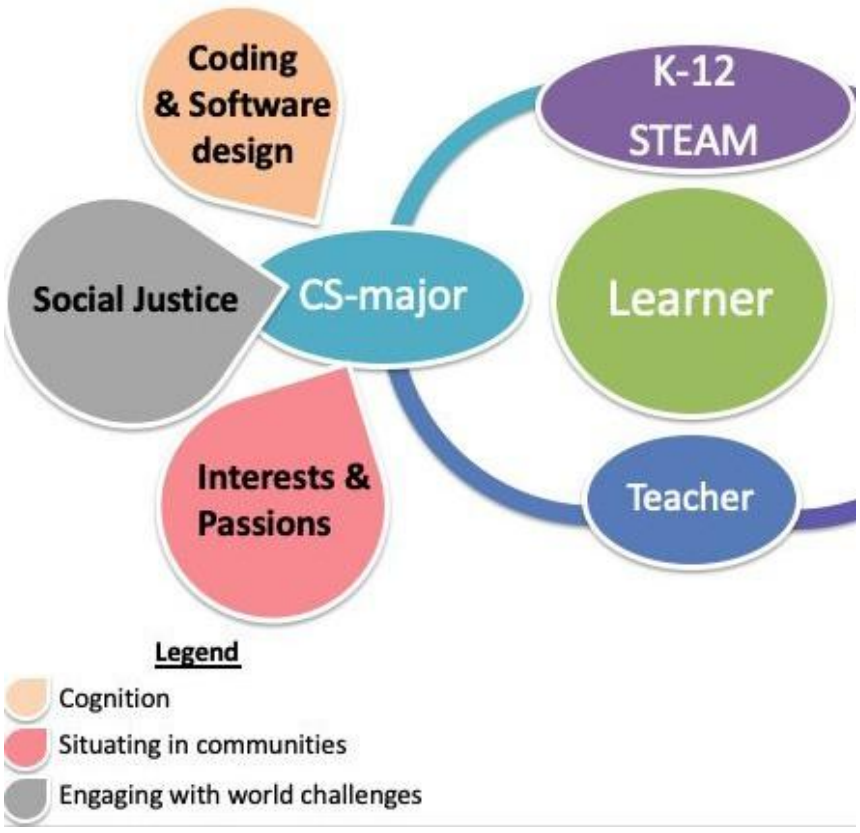
Another view - Learner Centered CER



- Engage with different learners with multiple perspectives
- Different kinds of learners (ovals)
- They have different learning goals (petals are some examples)
- The learning goals are of different nature (colour of petals)
  - Cognitive
  - Situated
  - Critical

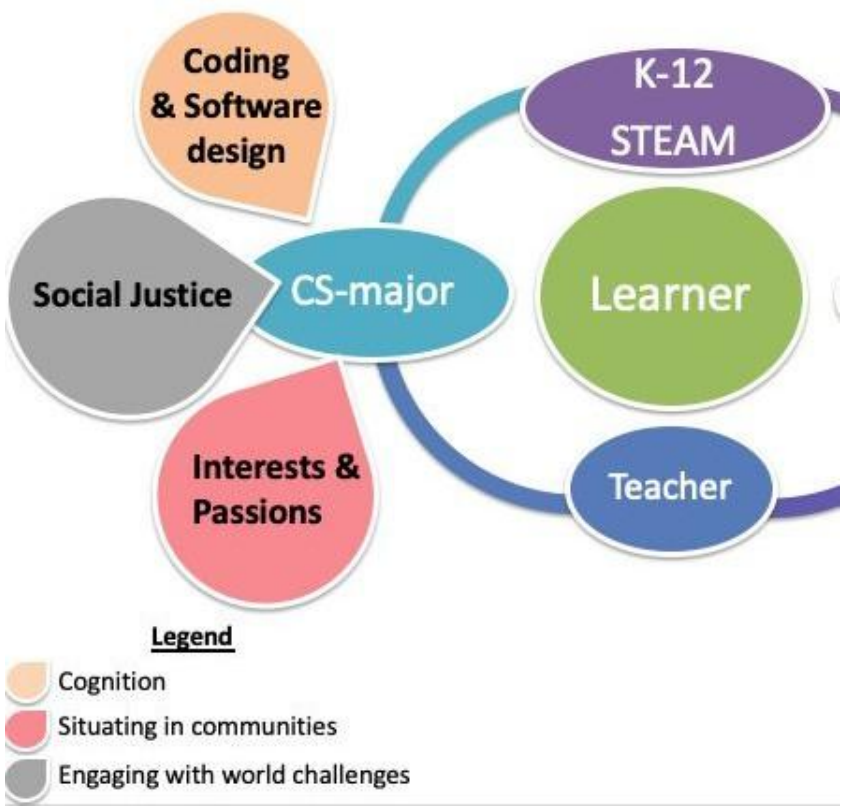
*Embracing cognitive, situated, and critical framings of computational thinking - ICER 2019 **[Kafai, Y., Proctor, C., & Lui, D. 2019]**

Learner Centered CER



- Emphasizing *skill building and competencies* useful in college and future careers
  - Example - coding & software design
- Engaging in *activities of personal interests to join groups* and form communities
  - Example - open source projects, FOSEE
- Engaging in *personally relevant social issues*
  - Example - Ethics in AI

Learner Centered CER



Examples from India

- Troubleshooting, Software design and evaluation, KI

  https://iitbcomputingedresearch.wordpress.com/research/

- Tinkering

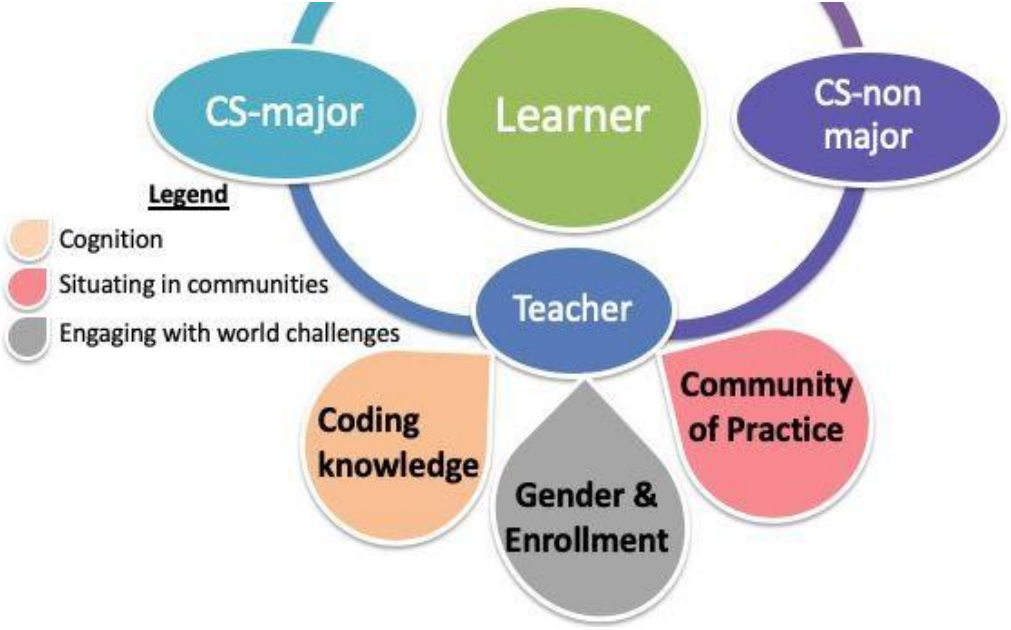
  Raina, A., Murthy, S., & Iyer, S. (2019, December). Designing TinkMate: A Seamless Tinkering Companion for Engineering Design Kits. In *2019 IEEE Tenth International Conference on Technology for Education (T4E)* (pp. 9-14). IEEE.

- Bilingual computing learners & CS enrollment

  Pal, Y. (2016). A Framework for Scaffolding to Teach Programming to Vernacular Medium Learners. *Diss. INDIAN INSTITUTE OF TECHNOLOGY BOMBAY.*

  Hewner, M., & Mishra, S. (2016, August). When Everyone Knows CS is the Best Major: Decisions about CS in an Indian context. In *Proceedings of the 2016 ACM Conference on International Computing Education Research* (pp. 3-11).

Learner Centered CER



Emphasizing *skill building and competencies* useful in future careers

- Example - coding concepts & practices

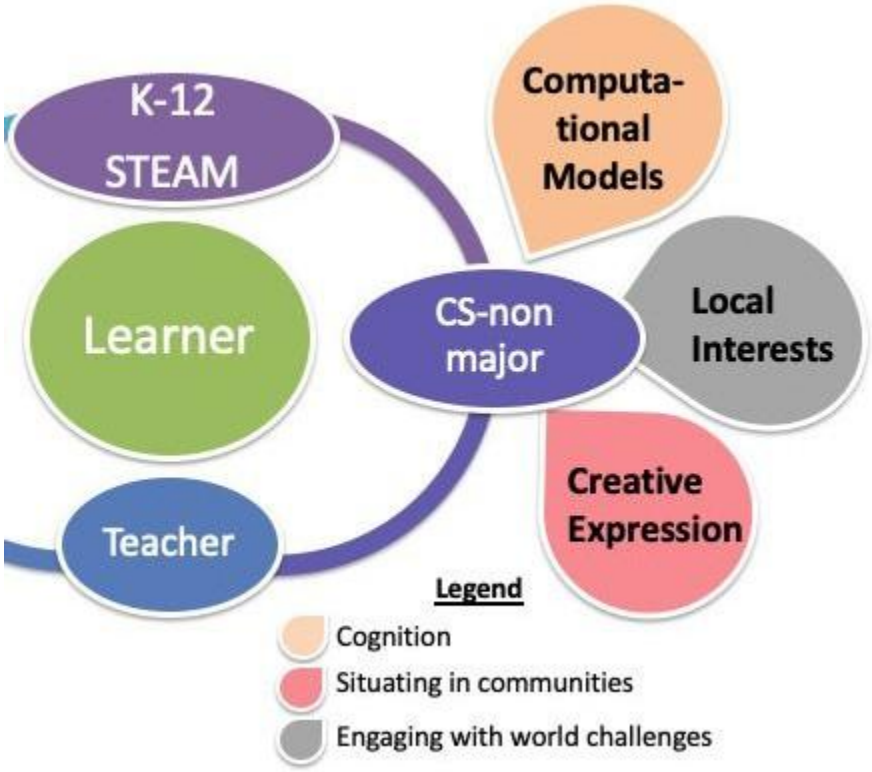
Engaging in *activities of personal interests to join groups* and form communities

- Example - MOOCs and online courses

Engaging in *personally relevant social issues*

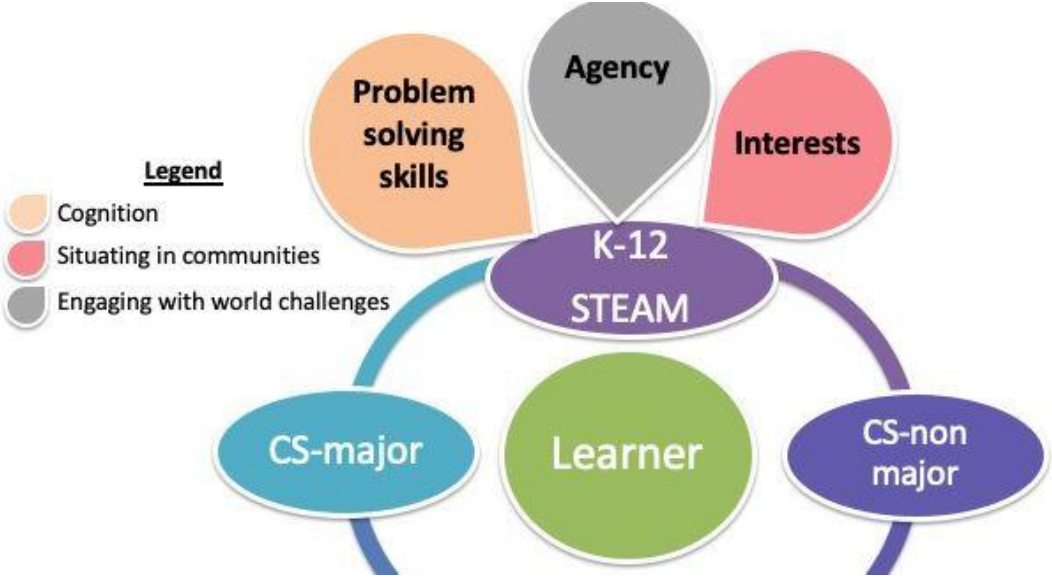
- Example - Understanding the issue of CS enrollment and gender in the teaching profession

Learner Centered CER



- Emphasizing *skill building and competencies* useful in future careers
  - Example - Demystifying networking: teaching non-majors computer networking
- Engaging in *activities of personal interests to join groups* and form communities
  - Example - creative opportunities, enjoyment (arduino clubs, maker-spaces)
- Engaging in *personally relevant social issues*
  - Example - Solving problems of local interest using computation

Learner Centered CER



- Emphasizing *skill building and competencies* useful in college and future careers
  - Example - problem solving skills, Computer Masti, Bebras India (ACM CSPathshala)
- Engaging in *activities of personal interests to join groups* and form communities
  - Example - coding clubs, tinkering labs
- Engaging in *personally relevant social issues*
  - Example - Agency in choosing computers as majors

What are levels of inquiry in Education?

Levels of inquiry in Engineering Education

- **Level 0** Teacher
  - Teach as taught
- **Level 1** Effective teacher
  - Teach using accepted teaching theories and practices
- **Level 2** Scholarly teacher
  - Assesses performance and makes improvements
- **Level 3** Scholarship of Teaching and Learning (SoTL)
  - Engages in educational experimentation, shares results
- **Level 4** Engineering Education Researcher
  - Conducts educational research, publishes archival papers, deals with “why” or “how” of learning

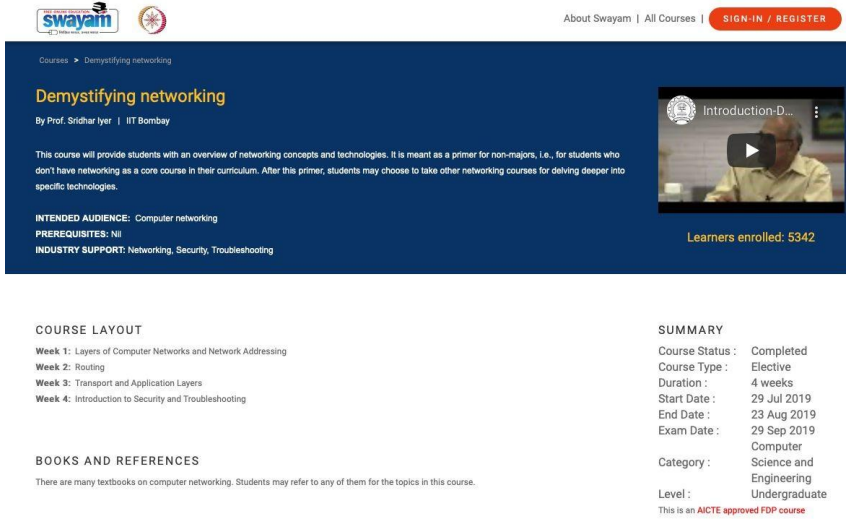
Source: Streveler, R., Borrego, M. and Smith, K.A. 2007. Moving from the “Scholarship of Teaching and Learning” to“Educational Research:” An Example from Engineering. To Improve the Academy, Vol. 25, 139-149.

Level 1 - Effective teacher

- Uses accepted teaching theories and practices
- Uses active learning strategies
- Uses relevant type of content (text, images, video etc)
  - Ex: Using algorithm visualizations in classroom
- No evaluation of those strategies; At most a course-evaluation form

Example:

Demystifying Networking - Swayam NPTEL



Course website: https://onlinecourses.nptel.ac.in/noc19_cs75/preview

Level 1 - Effective teacher

TPS in large CS 101 class:-

Face-to-face course (Lectures + Labs), 14 weeks, 450 non - CS majors

Predict the output

```
int main() { int A[4], *p;

for (int i = 0; i < 4; i++) A[i] = i;

p = &A[0]; cout << *p << " " << *(p +=2) << *(p+1)+ *(p-1) << endl; }
```

- **Think** (2 mins): Individually, students drew the memory arrangement and wrote down their prediction of the output.
- **Pair** (2 mins): Examine neighbor's solution. Discuss and agree upon one solution
- **Share** (3-5 mins): Instructor elicits responses, runs code to show output. Students to propose modification that would lead to other outputs. Instructor modifies and shows output.

Level 2 - Scholarly teacher

Assesses performance and makes improvements

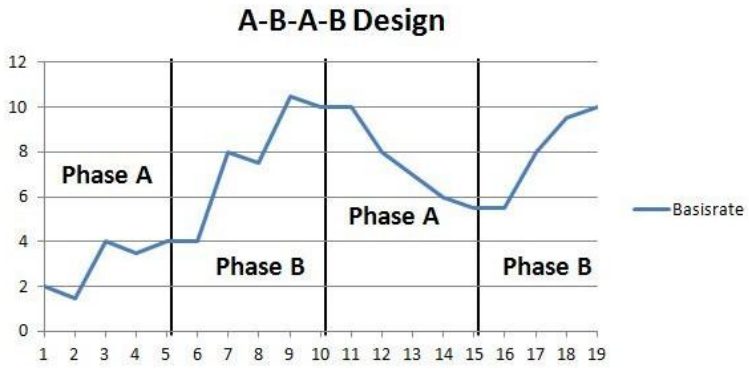
Evaluates performance of students

- Course: Data structure & algorithm
  - 42 students of 2nd year bachelors, majors from various engineering disciplines
- ABAB study design
- Evaluation:
  - Pre-post assessment
  - Observation using a protocol
  - Student perception questionnaire
  - Instructor's interview

Reddy, Patil Deepti, et al. "Thinking, Pairing, and Sharing to Improve Learning and Engagement in a Data Structures and Algorithms (DSA) Class." *2015 International Conference on Learning and Teaching in Computing and Engineering*. IEEE, 2015.

Level 2 - Scholarly teacher

Assesses performance and makes improvements
Evaluates performance of students
Focus is on how the method worked for that teacher;
Generalizabilty is not a goal



- Course: Data structure & algorithm
  - 42 students of 2nd year bachelors, majors from various engineering disciplines
- Evaluation:
  - Pre-post assessment
  - Observation using a protocol
  - Student perception questionnaire
  - Instructor's interview
- Results:
  - relative gain is higher for topics taught using TPS than topics without TPS

Reddy, Patil Deepti, et al. "Thinking, Pairing, and Sharing to Improve Learning and Engagement in a Data Structures and Algorithms (DSA) Class." *2015 International Conference on Learning and Teaching in Computing and Engineering*. IEEE, 2015.

Level 3 - Scholarship of Teaching and Learning (SoTL)

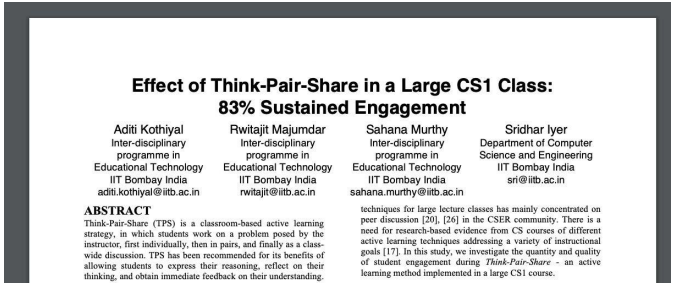
Engages in educational experimentation, shares results, can give recommendations

Some generalizability exists

- Research Methods
  - Controlled study
- Data Collection
- Multiple sources of data: Survey, Muddy points, in-class observation, focus group interview

Example: -

- TPS in large CS 101 class
  - Face-to-face course (Lectures + Labs), 14 weeks, 450 non - CS majors
- Metrics considered: Engagement + learning



Effect of Think-Pair-Share in a Large CS1 Class: 83% Sustained Engagement

Aditi Kothiyal, Inter-disciplinary programme in Educational Technology, IIT Bombay India, aditi.kothiyal@iitb.ac.in
Rwitajit Majumdar, Inter-disciplinary programme in Educational Technology, IIT Bombay India, rwitajit@iitb.ac.in
Sahana Murthy, Inter-disciplinary programme in Educational Technology, IIT Bombay India, sahana.murthy@iitb.ac.in
Sridhar Iyer, Department of Computer Science and Engineering, IIT Bombay India, sri@iitb.ac.in

ABSTRACT

Think-Pair-Share (TPS) is a classroom-based active learning strategy, in which students work on a problem posed by the instructor, first individually, then in pairs, and finally as a class-wide discussion. TPS has been recommended for its benefits of allowing students to express their reasoning, reflect on their thinking, and obtain immediate feedback on their understanding.

techniques for large lecture classes has mainly concentrated on peer discussion [20], [26] in the CSER community. There is a need for research-based evidence from CS courses of different active learning techniques addressing a variety of instructional goals [17]. In this study, we investigate the quantity and quality of student engagement during *Think-Pair-Share* – an active learning method implemented in a large CS1 course.

Kothiyal, Aditi, et al. "Effect of think-pair-share in a large CS1 class: 83% sustained engagement." *Proceedings of the ninth annual international ACM conference on International computing education research*. 2013.

Level 3 - Scholarship of Teaching and Learning (SoTL)

Example - RQs:

- How much student engagement occurs during the Think-Pair-Share activity?
- How does the amount of engagement change as activity progresses?

Data Analysis

- Observation data at 3 levels: behaviour, class & student
- Triangulation of data from various sources
- Considering validity threats, reliability

Results (Engagement)

- Think: 70%
- Pair: 95% depending on problem
- Share: 75% to 90%

Kothiyal, Aditi, et al. "Effect of think-pair-share in a large CS1 class: 83% sustained engagement." *Proceedings of the ninth annual international ACM conference on International computing education research*. 2013.

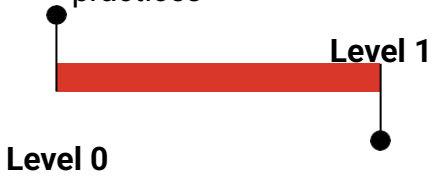
Level 4 Computing Education Researcher

Conducts educational research, publishes archival papers, deals with “why” or “how” of learning

- **Play examples video - https://youtu.be/naVcx07dEos**
- Examples
  - How do novices approach software conceptual design?
  - What difficulties do novices face while solving a network troubleshooting problem?
  - What effects does the VeriSIM have on students’ design diagram evaluation skills?
  - How effective is Fathom for novices in doing and learning of Expand-Reduce skills?
  - What are the effects of the learners’ interaction with the IKnowIT-environment on their improvement of Knowledge Integration quality?
  - How effective is TIMeR for improving students’ mental rotation skill?
  - How to incorporate tinkering for nurturing computational thinking?
  - How to teach programming for local language learners?
  - How to automatically generate fair assessment from a question repository?
- More information about these examples - https://www.cse.iitb.ac.in/~sri/students/

Moving across the levels

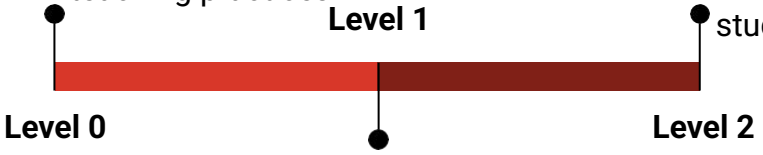
- Identify the need and usefulness of various pedagogies and teaching practices



- Evaluate the pedagogies & practices wrt one's class
- Make appropriate changes
- Share experience reports

Output	Domain knowledge	+ Useful practices, strategies and course materials in a context

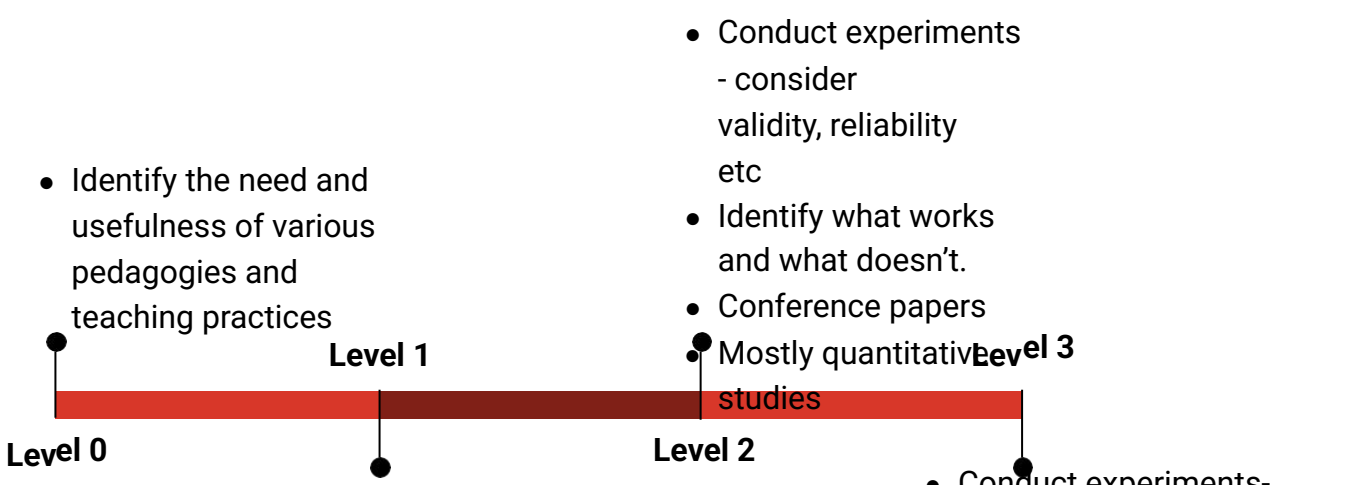
- Identify the need and usefulness of various pedagogies and teaching practices



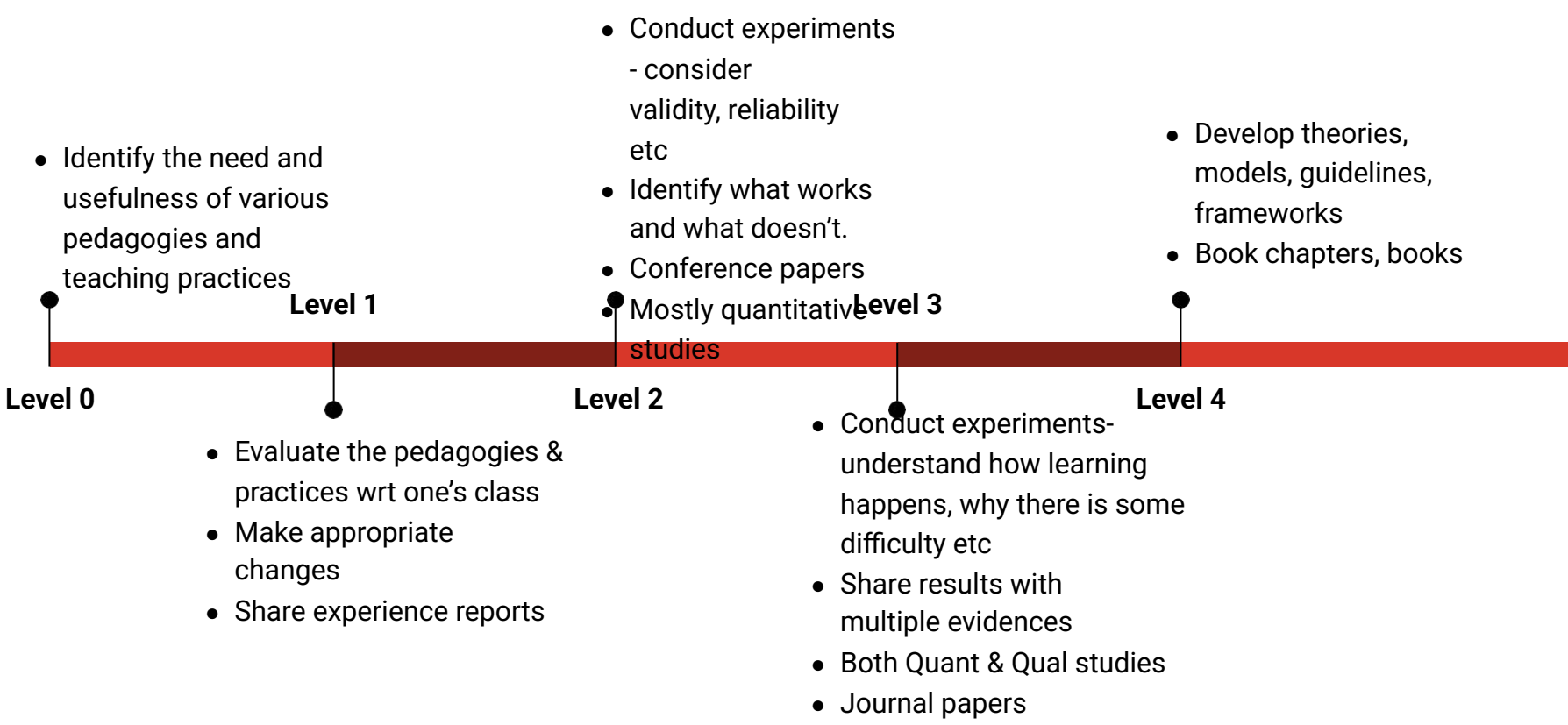
- Conduct experiments - consider validity, reliability etc
- Identify what works and what doesn't.
- Conference papers
- Mostly quantitative studies

- Evaluate the pedagogies & practices wrt one's class
- Make appropriate changes
- Share experience reports

Output	Domain knowledge	+ Useful practices, strategies and course materials in a context	+ Evaluation metric, experimental variables in the context,



Output	Domain knowledge	+ Useful practices, strategies and course materials in a context	+ Evaluation metric, experimental variables in the context,	+ Recommendations for similar contexts, rich descriptions of contexts



Output	Domain knowledge	+ Useful practices, strategies and course materials in a context	+ Evaluation metric, experimental variables in the context,	+ Recommendations for similar contexts, rich descriptions of contexts	+ Model of learning in a context, guidelines for teaching

What are some methods for CER?

Theory & Methods: Need to borrow from outside the discipline

1. Making claims about effective teaching and learning in computing requires different methods than making claims about computing itself

2. Borrow theory and methods from psychology, cognition, education, statistics ...
   - Theories about learning, motivation, cognitive development, disciplinary ways of thinking, social interaction, assessment
   - Methods of investigation including how to collect and analyze data, how to choose participants, how to establish validity & reliability

3. Theory and method are tightly coupled
4. Context plays a key role - conditional generalizations rather than universal.

Entry Points for Computing Education Research, J. Tenenberg & R. McCartney. ACM ToCE, 2011, *1* https://doi.org/10.1145/1921607.1921608

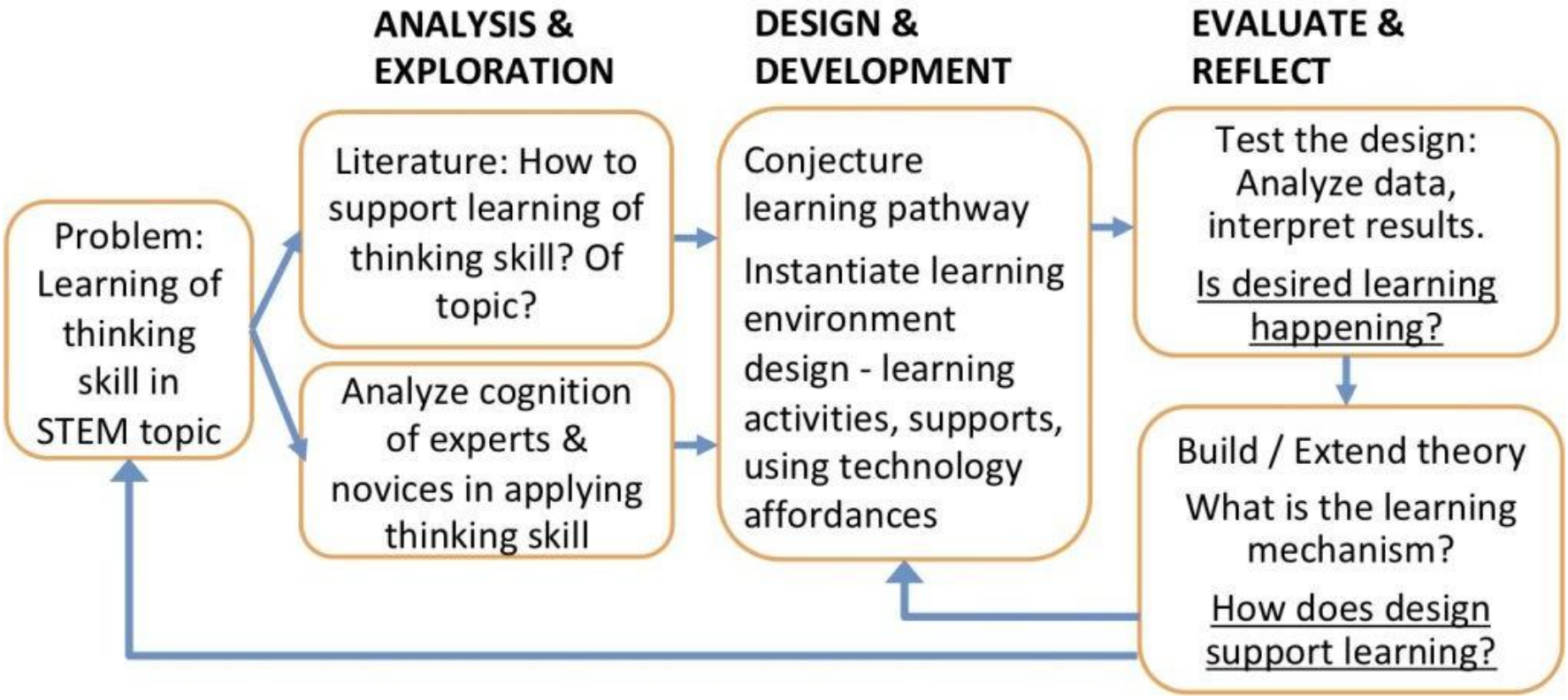
Research Methods in CER

Methods	Research goals	Data collection	Data analysis
Interpretivist (qualitative)	Rich in-depth understanding of a phenomenon. Answers 'how' &'why' questions	Fieldwork, interviews, focus groups	Grounded theory, Interaction analysis
Interpretivist / scientific boundary	Understand categories, trends	Questionnaires (eg likert scale surveys)	Statistical descriptive analysis, distributions, correlations Content analysis
Scientific (quantitative)	Develop and test models, hypotheses	Quasi- experimental designs, pre-post tests	Inferential statistics, comparison of groups

Note: Often multiple or mixed methods are used

Takeaway: Choose a method appropriate for your research goal

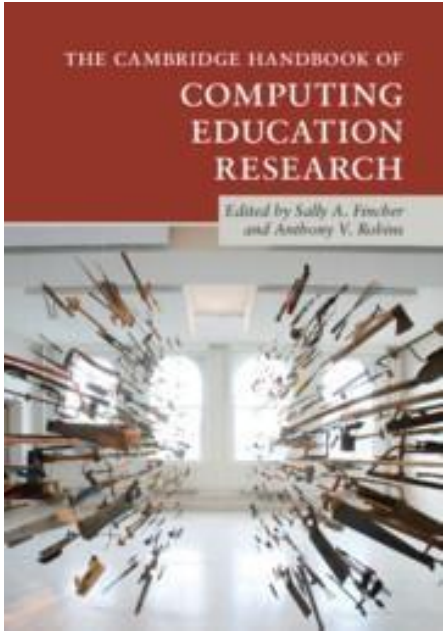
Design Based Research Method

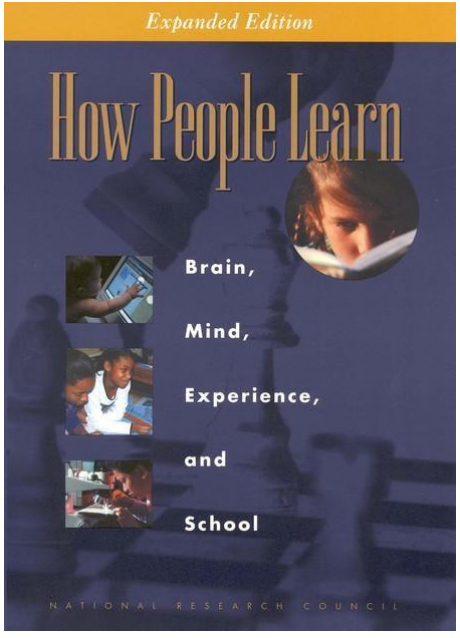


I’m interested! How do I start doing Computing Education Research?

How do I start doing computing education research?

Read Books:





How do I start doing computing education research?

Read blogs:

Mark Guzdial - https://computinged.wordpress.com/ - Regular updates about current topics in computing education research

Amy Ko - https://faculty.washington.edu/ajko/cer - An FAQ about computing education research, what does it entail, what are important research questions, list of computing education researchers etc.

How do I start doing computing education research?

Read conference papers:

SIGCSE- Special Interest Group in Computer Science Education (Core A)

ICER - International Computing Education Research (Core A)

ITiCSE - Innovation and Technology in Computer Science Education (Core B)

CompED - ACM Global Computing Education Conference (Alternate years)

SIGCSE Virtual - ACM Virtual Global Computing Education Conference (Alternate years)

COMPUTE – ACM Compute by iSIGCSE

T4E – International Conference on Technology 4 Education by EdTech Society

Others:

AIED, LAK, EDM - Focusses on AI, Data mining and analytics in education

How do I start doing computing education research?

Read journals:

ACM Transactions in Computing Education (TOCE)

Computer Science Education Journal (CSE)

Journal of Learning Analytics (JLA)

IEEE Transactions on Education

Education and Information Technologies

How do I start doing computing education research?

Attend seminars, conferences and sessions! Join iSIGCSE, EdTech Society for a nominal fee.

Or join the CS Ed Researchers, Karnataka Wing for free.

- SIGCSE- March 2026
- ICER – August 2025
- ITiCSE – July 2025
- CompED – Oct 2025
- SIGCSE Virtual – Dec 2026
- COMPUTE – Dec 2025, IIT-Ropar
- T4E – Dec 2025, IIT Madras

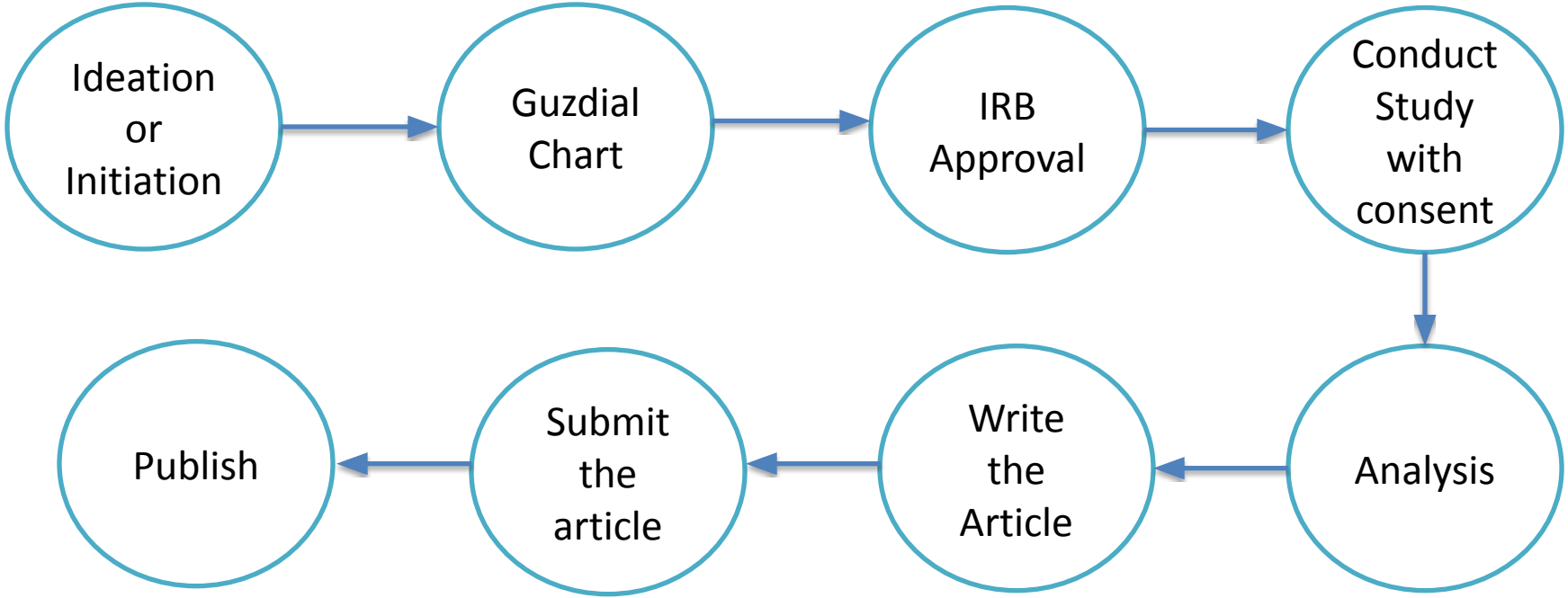
Follow researchers on X (Twitter)

Many researchers maintain an active presence in X (Twitter), and update about published work, seminars, conferences etc

How do I collaborate for computing education research?

- Start with topics, questions which you really care about, feel strongly for, or you see as an opportunity to do research in
- Collaborate with like-minded colleagues and plan a research study
- Start study groups in your department, or even across institutes!
  - Groups can run much like a reading group, with a schedule of topics, meeting once/twice a month online and having discussion forums
- Participate in the “Multi-Institutional” Study

How do I plan my study?



Why do we need CER in India?

How accepted is computing education research as an area?

- ACM recognizes it - Transactions on Computing Education; ICER, SIGCSE, ITiCSE, ...
- There are several researchers around the world doing research in computing education. This page gives a fairly comprehensive listing - https://faculty.washington.edu/ajko/cer
- Many CS departments around the world include computing education research as a research area. Example: Uppsala University, Glasgow University, Brown University, University of Illinois Urbana-Champaign, University of California San Diego, University of Toronto, Aalto University
- Opportunity to be a part of an emerging and relevant area of research in **India!**

Opportunities for CSEd Research specific to India

- So far, we saw examples of research goals that are of interest to researchers in CER community worldwide, for example:
  - How does Think, Pair, Share helps improving students' engagement in a large CS1 classroom?
  - How do novices approach software conceptual design?
  - What difficulties do novices face while solving a network troubleshooting problem?
  - ...
- These are of course also relevant to India

In addition

Leverage the diversity in India

- India is different + India is diverse
- Therefore different education innovations exclusive for Indian context is needed

Some factors that contribute to these differences include:

- Cultural diversity
- Economical diversity
- Different states have different CS curriculum at the school level
- Internet penetration
- Perceived higher job opportunities in the IT sector
- ...

Some research questions from the diversity perspective

- How do language and gender affect computing learning, teaching, and curricula?
  - Example: How students from vernacular language respond to CS contents in English vs. CS contents with a mix of English and vernacular language [Pal, PhD Thesis, 2016]
- How does diversity of identities interact with people's learning of computing?
- What are the factors that influence students' choice of computing as an undergraduate major?
- Example: perception that computing is the most lucrative job providing domain makes students choose CS as their major at the undergraduate level [Hewner and Mishra 2016]
- How do these factors influence choice of subject matter and curriculum?

More India-specific open-ended research questions

- How can access to computing education be improved in India?
- How can computing education be delivered equitably to all in India?
- How does computing education affect people's lives in India?
- What are the societal costs of computing illiteracy India?
- ...

* Research questions adapted from several sources such as Hewner & Mishra, 2016, Amy Ko's FAQ (https://faculty.washington.edu/ajko/cer)