

Computing Education Research: Opportunities in India



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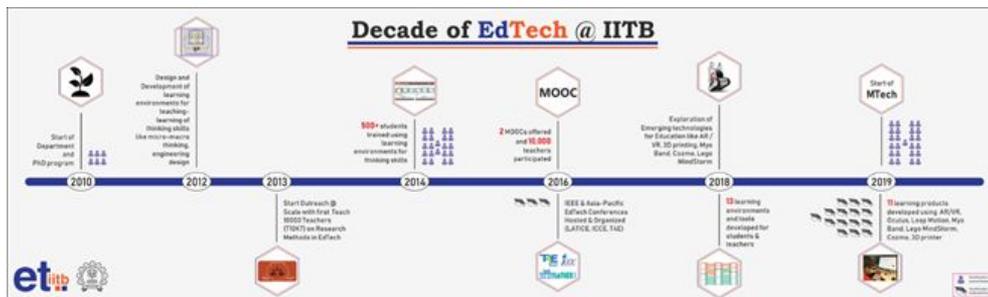


ACM COMPUTE 2020



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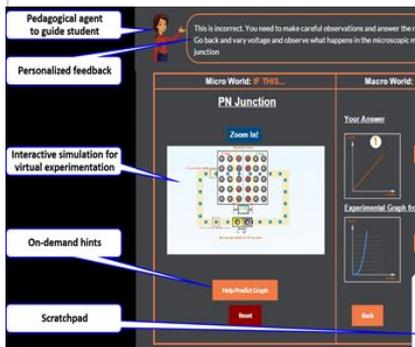
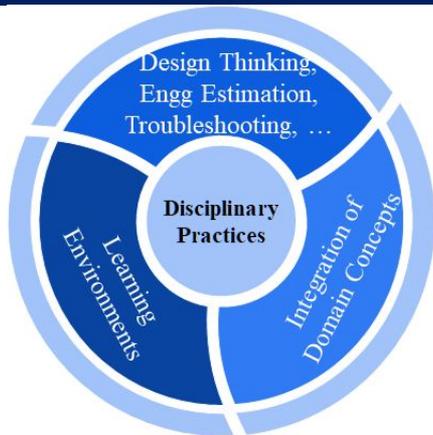
- Interdisciplinary Program, started 2010
 - 5 Core faculty, 15 Associate faculty; Post-docs, research staff
 - PhD - 25 current, 15 alumni
 - MTech - started 2019
-
- Research: TEL environments for students, Models for large scale blended courses
 - Development & Outreach – tools to support teachers & learners, MOOCs
 - Engagement with govt, NGOs & industry: Sponsored projects, Consultancy



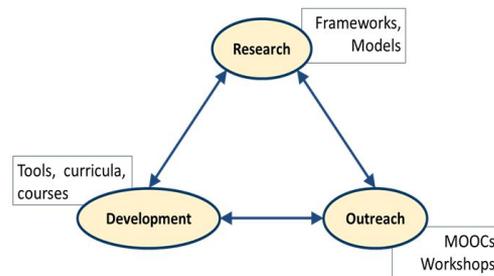
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Research

Technology enhanced learning



Teacher Integration of EdTech



LCM Model

Learner Centric MOOCs

Swayam, EdX, IITBombayX

30+ Blended courses

50000+ teachers

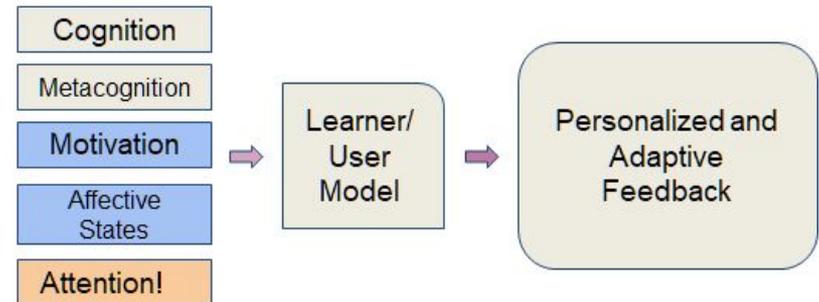
LOBE Framework for evaluation of edtech

Emerge



Wearables, Augmented Reality, Virtual Reality, Makerspaces, Embodied learning, ...

Educational Data Analytics





- 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

Curriculum deployment

Teaching courses

Using LMS, EdTech, ITS

Learning Analytics

Assessment



Computing Education

Curriculum deployment

Teaching courses

Using LMS, EdTech, ITS

Learning Analytics

Assessment

Education Research

Learning Science

Cognition

Ed Psychology

Research Methods

...



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

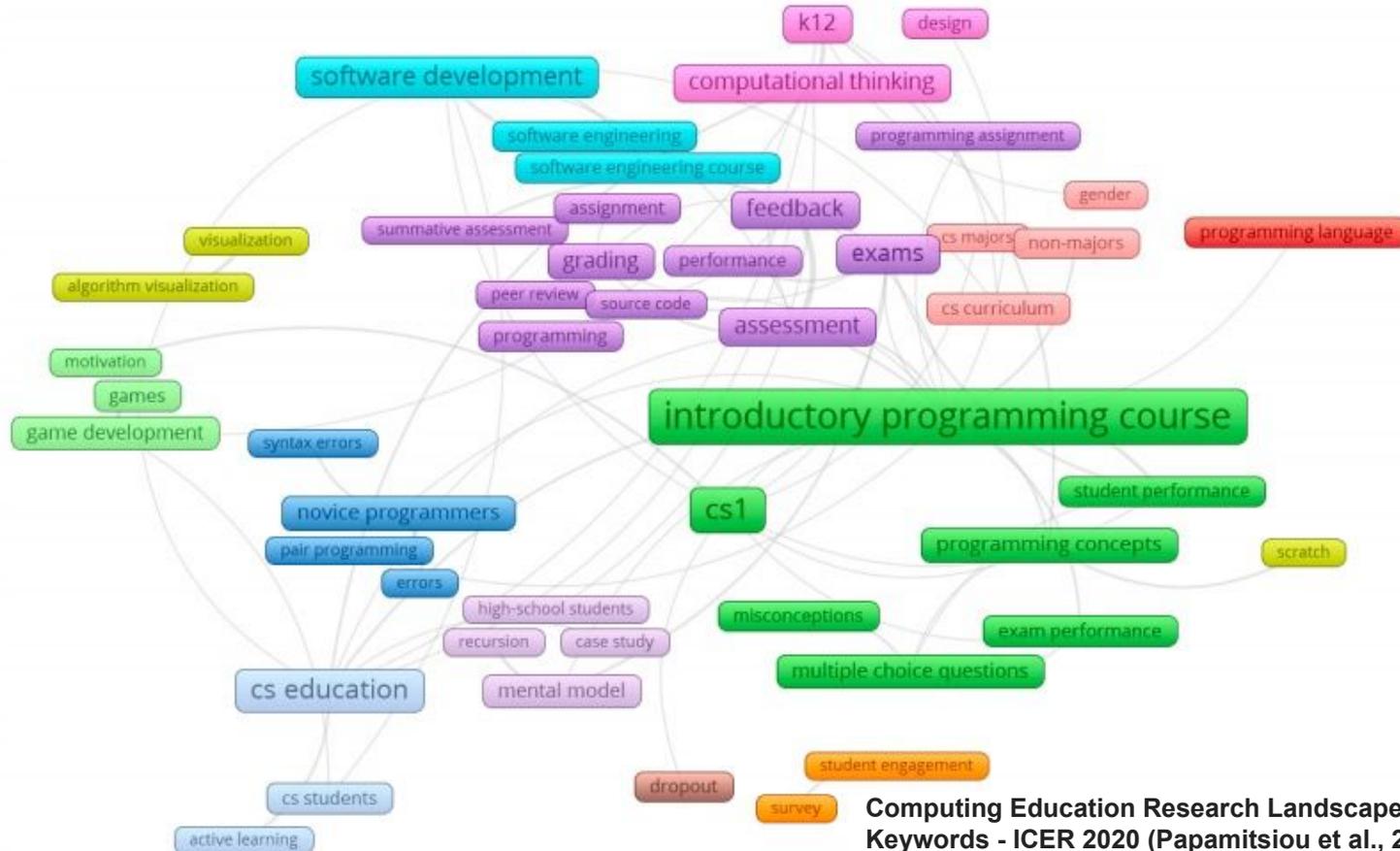
Cognition

Ed Psychology

Research Methods

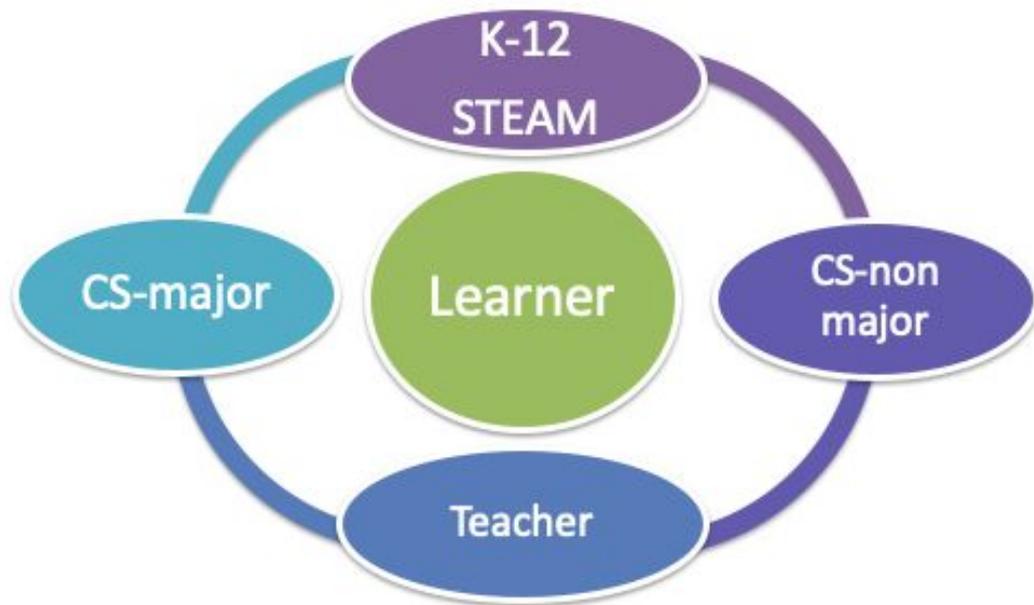
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Computing Ed-Research Landscape



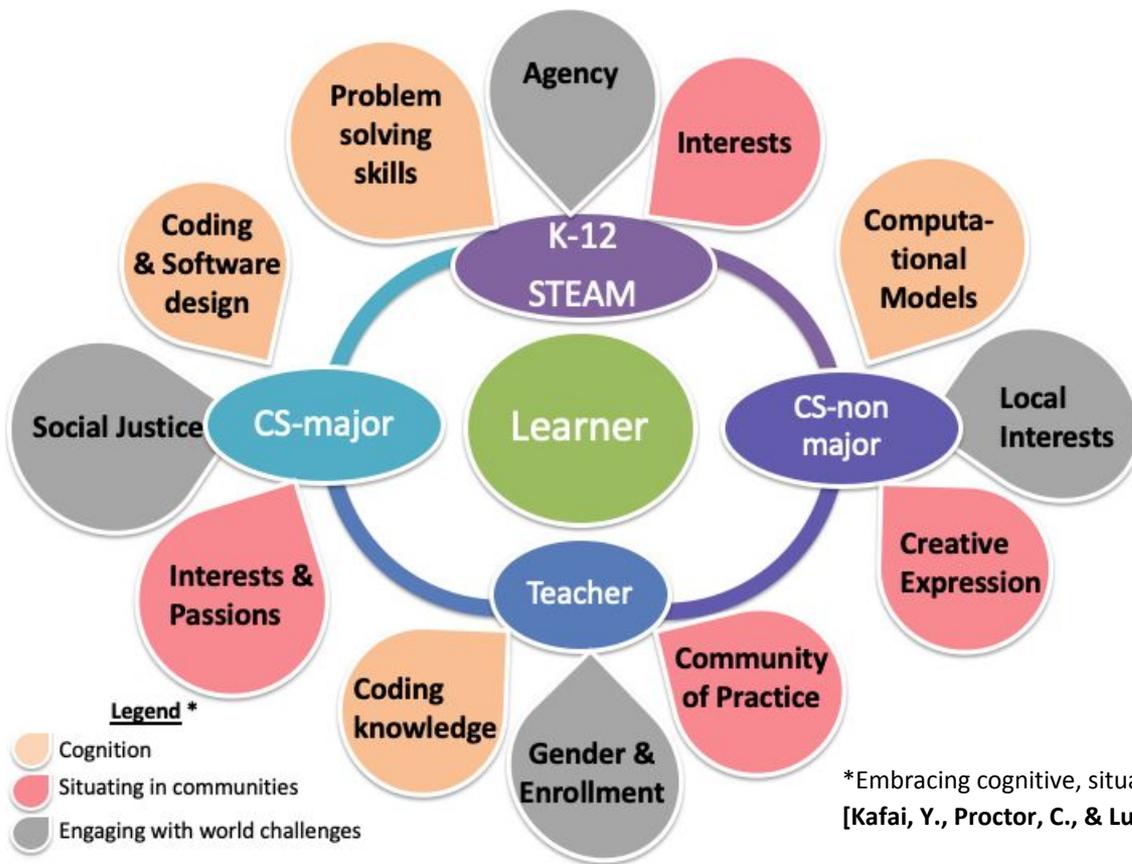
Computing Education Research Landscape through an Analysis of Keywords - ICER 2020 (Papamitsiou et al., 2020)

Another view - Learner Centered CER



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

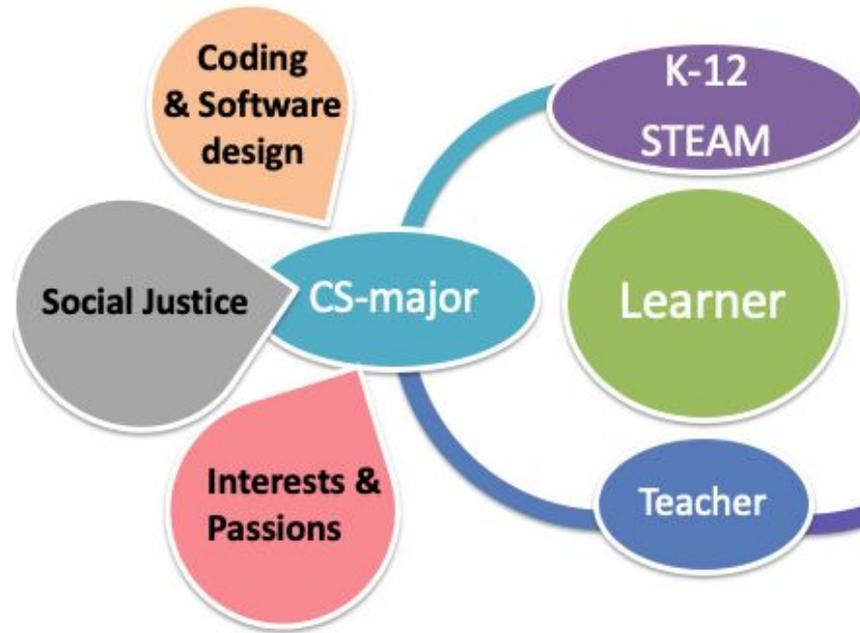
Another view - Learner Centered CER



- 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

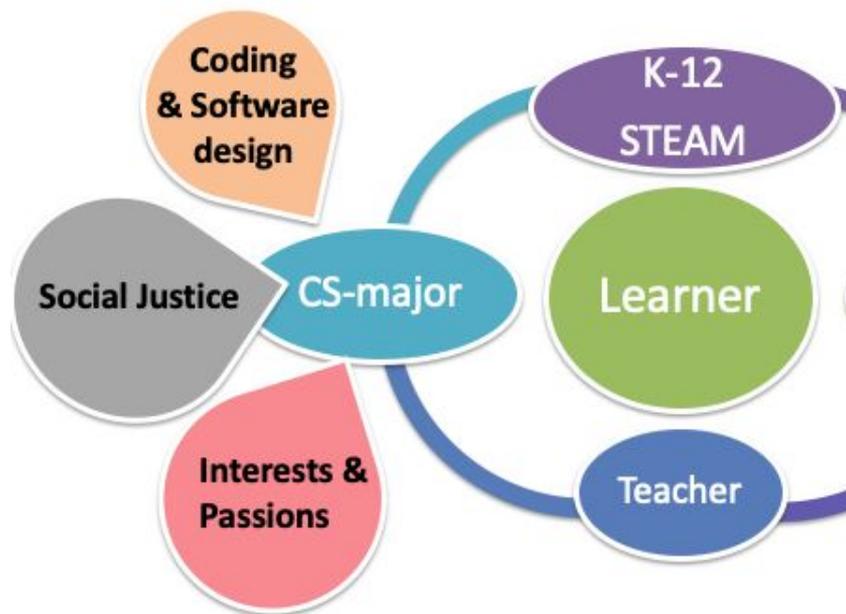


Legend

-  Cognition
-  Situating in communities
-  Engaging with world challenges

-  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



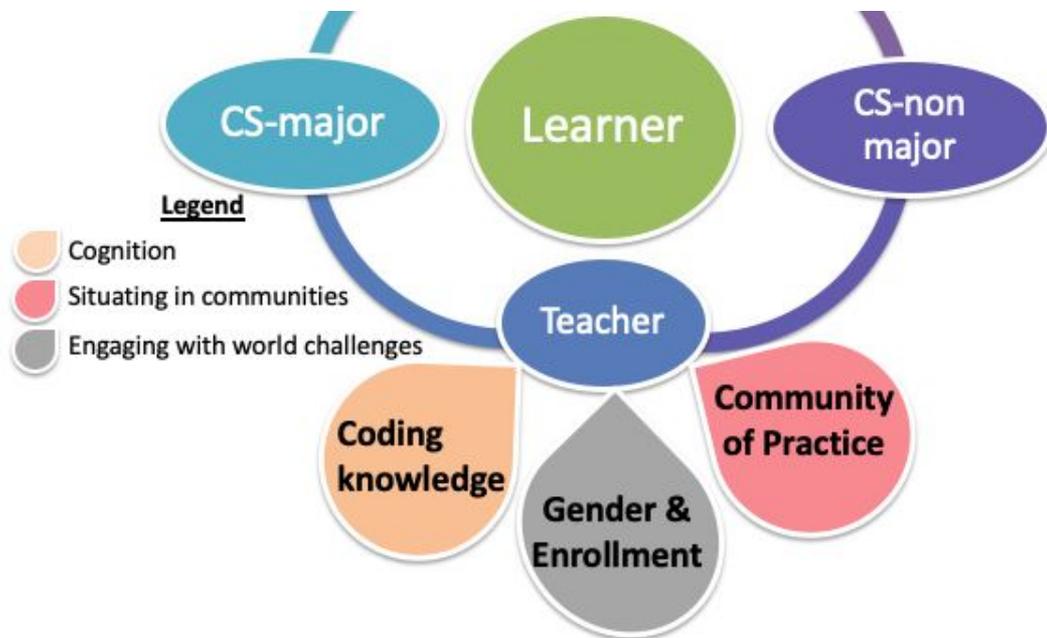
Legend

- Cognition
- Situating in communities
- Engaging with world challenges

Examples from EdTech @ IIT B

- 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

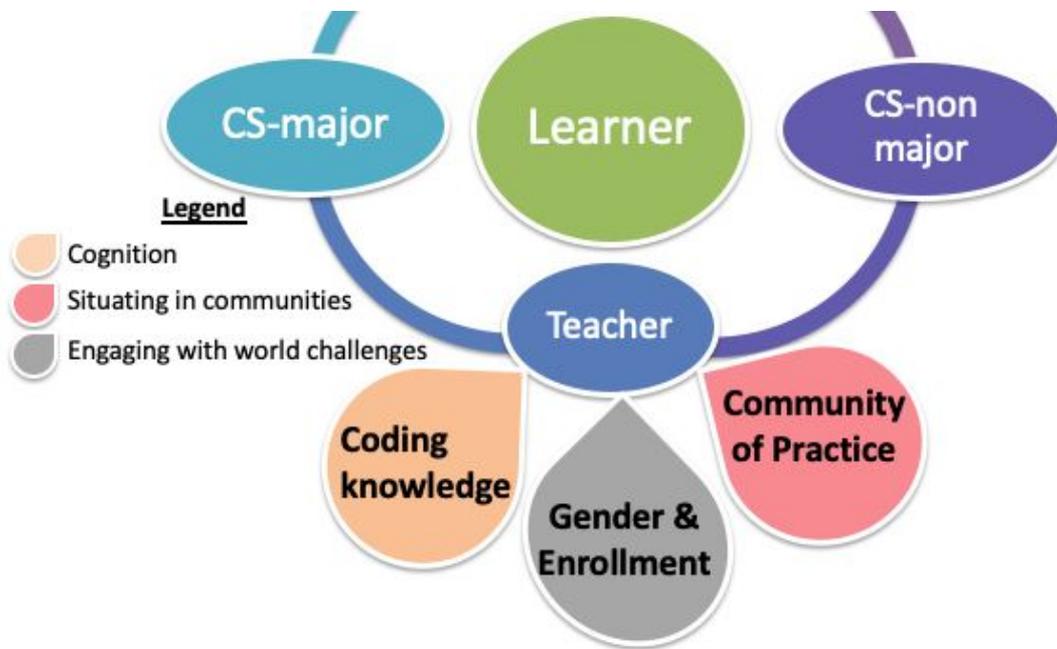
Engaging in *activities of personal interests* to join groups and form communities

- 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



 ACM CSPathshala

[CSPathshala teacher training](#)

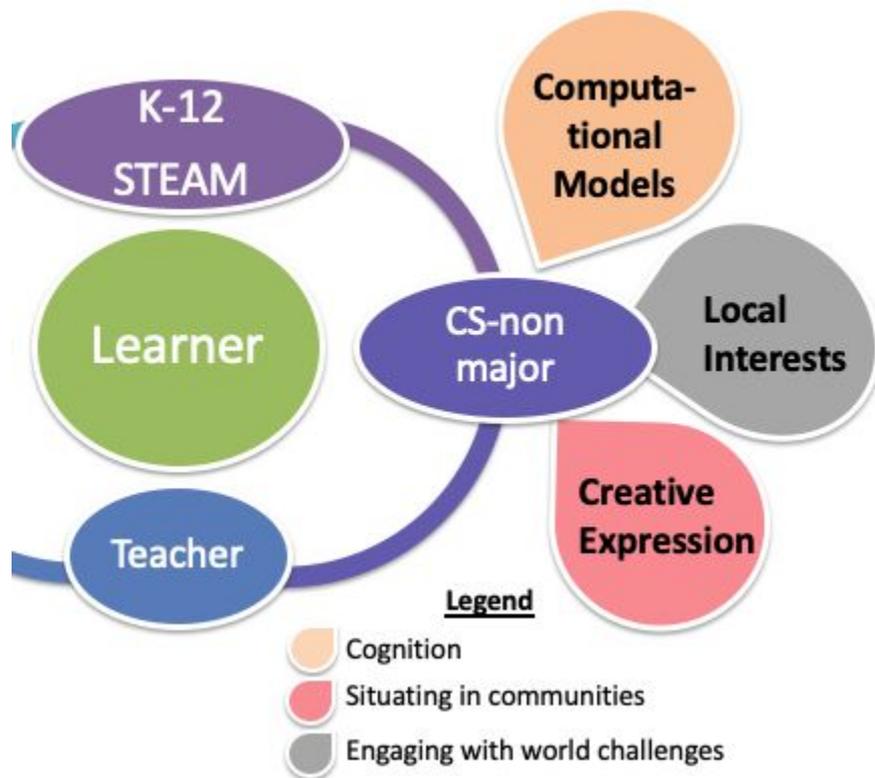
 Online- courses for teaching-learning of networking

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

TPACK - (Pedagogy) Online & F2F on Effective teaching-learning

<http://www.et.iitb.ac.in/Workshops.html>

Learner Centered CER



Emphasizing *skill building and competencies* useful in future careers

- Example - [Demystifying networking: teaching non-majors computer networking](#)

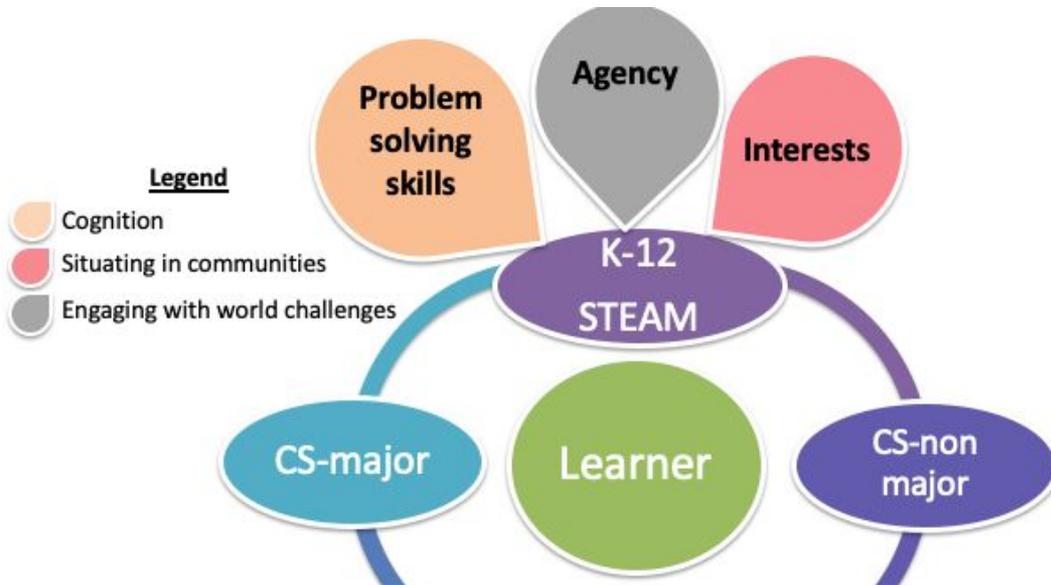
Engaging in *activities of personal interests* to join groups and form communities

- 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: Strevler, 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 (TPS)
- 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

The screenshot shows the Swayam NPTEL course page for 'Demystifying networking'. The page includes the Swayam logo, a navigation bar with 'About Swayam | All Courses | SIGN-IN / REGISTER', and a video player for 'Introduction-D...'. Below the video, the course details are listed: 'By Prof. Sridhar Iyer | IIT Bombay', a description of the course as a primer for non-majors, and 'INTENDED AUDIENCE: Computer networking', 'PREREQUISITES: Nil', and 'INDUSTRY SUPPORT: Networking, Security, Troubleshooting'. The 'COURSE LAYOUT' section lists four weeks: 'Week 1: Layers of Computer Networks and Network Addressing', 'Week 2: Routing', 'Week 3: Transport and Application Layers', and 'Week 4: Introduction to Security and Troubleshooting'. The 'BOOKS AND REFERENCES' section states: 'There are many textbooks on computer networking. Students may refer to any of them for the topics in this course.' The 'SUMMARY' section provides course status (Completed), course type (Elective), duration (4 weeks), start date (29 Jul 2019), end date (23 Aug 2019), exam date (29 Sep 2019), category (Science and Engineering Undergraduate), and level (Undergraduate). It also notes that this is an AICTE approved FDP course.

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

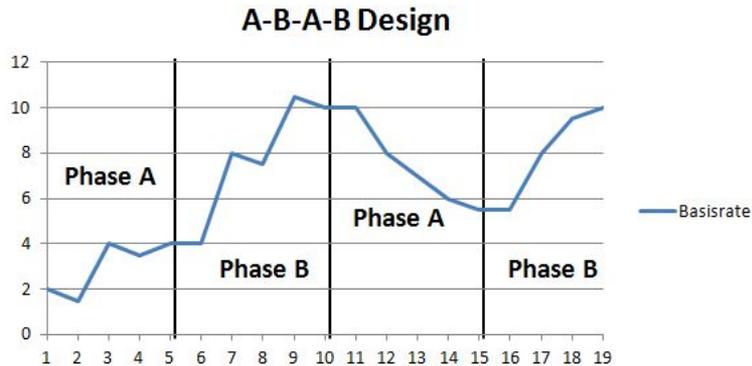
- Course: Data structure & algorithm
 - 42 students of 2nd year bachelors, majors from various engineering disciplines
- ABAB study design
- Evaluation:
 - Pre-post assessment
 - Observation using a protocol
 - Student perception questionnaire
 - Instructor's interview

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;
Generalizability is not a goal



- 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
- 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.



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	Rwitaajit Majumdar Inter-disciplinary programme in Educational Technology IIT Bombay India rwitaajit@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
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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:

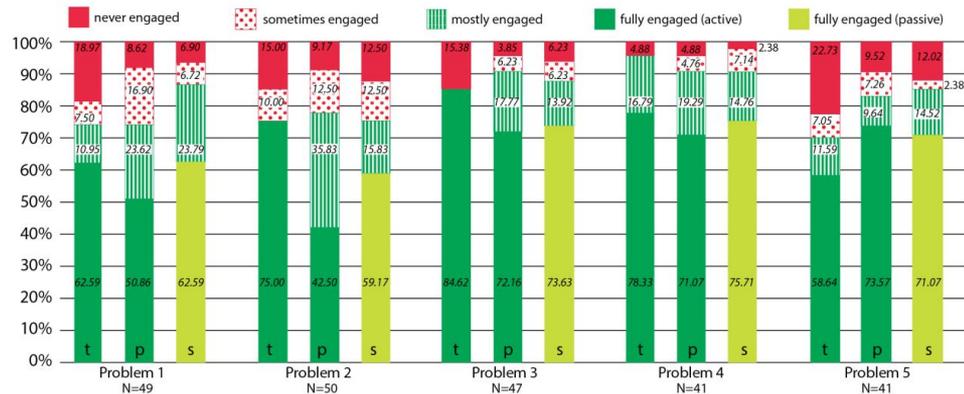
- How much student engagement occurs during the Think-Pair-Share activity?
- How does the amount of engagement change as activity progresses?

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



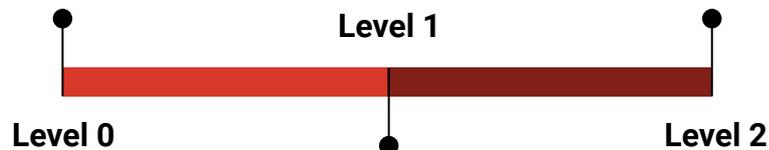
- Evaluate the pedagogies & practices wrt one's class
- Make appropriate changes
- Share experience reports

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



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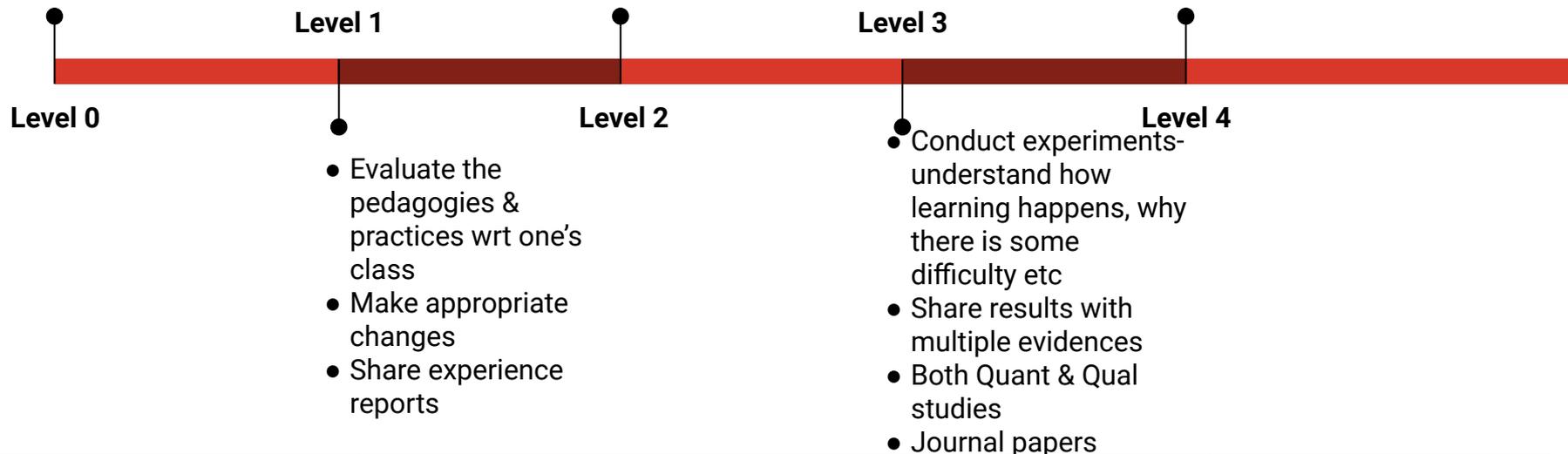
Output	Domain knowledge	+ Useful practices, strategies and course materials in a context	+ Evaluation metric, experimental variables in the context,	+ Recommendations for similar contexts, rich descriptions of contexts
Dec 9, 2020			ACM Compute 2020	



- 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

- Develop theories, models, guidelines, frameworks
- Book chapters, books



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
Dec 9, 2020			ACM Compute 2020		

Journey across the levels for a college teacher



Level 0-1

**Teacher (1999-2004)
Effective teacher
(2004-2013)**

I started teaching in engineering college with no prior formal training in teaching-learning.

With experience I was able to identify effective teaching methods useful for teaching specific type of content.

For example, for teaching abstract concepts, real life examples were useful.

Level 2

**Scholarly teacher
(2013- 2014)**

After attending QIP on “Effective Teaching-Learning Strategies”, started exploring student-centric teaching methods.

For example, attempted TPS, PI, Flipped classroom techniques.

Level 3

**Scholarship of TL
(2014-2016)**

Started PhD in ET, IITb.

Learned how to read and interpret education research articles.

Completed courses on Educational research methods cognitive science, learning theories, etc.,

Conducted preliminary research studies to evaluate teaching methods

Used various data collection methods and analysis techniques and published research articles.

Level 4

**Engineering Education
Researcher (2016-2020)**

Design and development of technological solutions for one of my teaching-learning problem.

Base the solution on existing theoretical framework

Formulate research questions to investigate on how and why aspects of students learning.

Conducted rigorous studies till significant findings yielded that are useful for other researchers, educationists, or instructional designers.

<https://youtu.be/i1pTu2HDWZs>



What are some methods for CER?



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.

Research Methods in CER

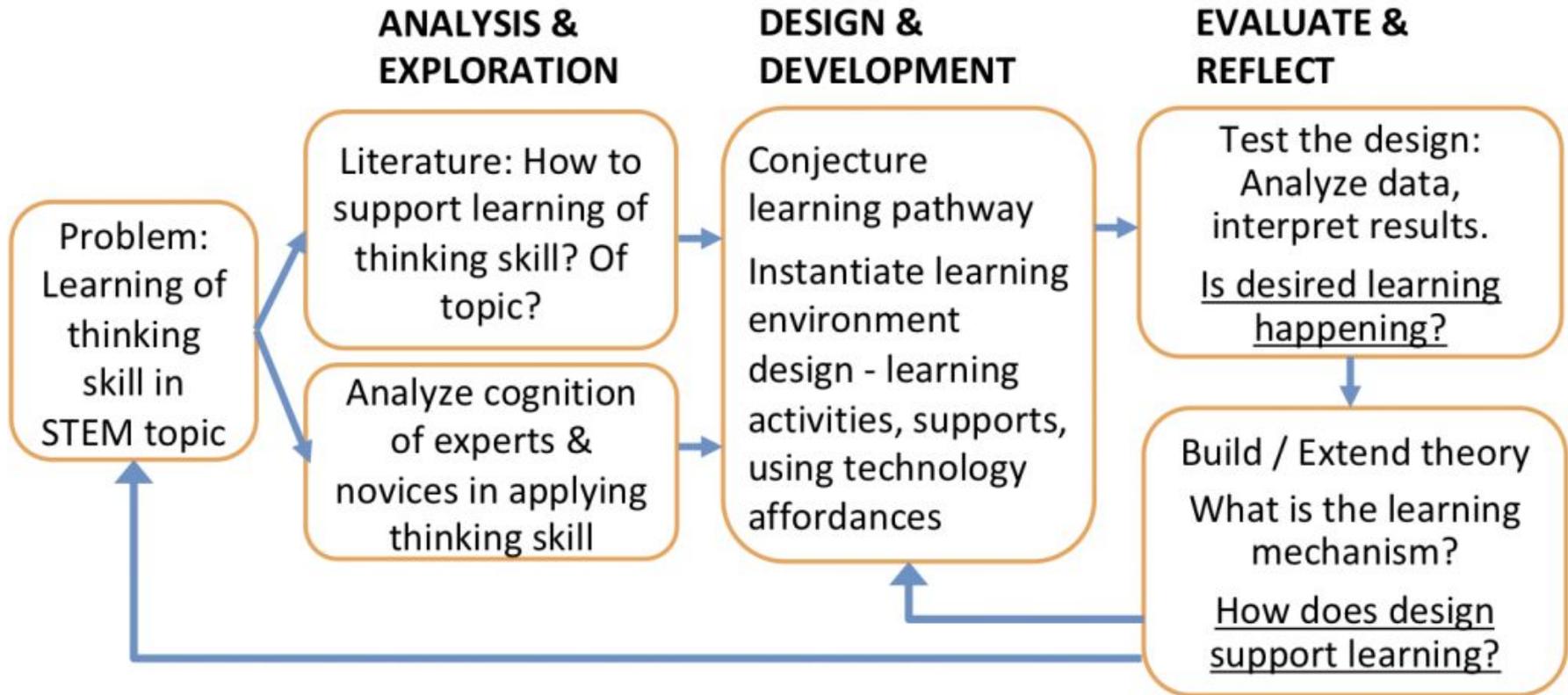


Methods	Research goals	Data collection	Data analysis
Interpretivist (qualitative)	Rich in-depth understanding of a phenomenon. Answers 'how' & 'why' questions	Fieldwork, interviews, focus groups	Grounded theory, Interaction analysis
Interpretivist / scientific boundary	Understand categories, trends	Questionnaires (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?



IIT B Computing Education Research



Settings

Tools

About 29,900,000 results (0.80 seconds)

iitbcomputingedresearch.wordpress.com ▾

Computing Education Research at EdTech, IIT Bombay – The ...

The **Computing Education Research** group is a part of the Interdisciplinary Programme in Educational Technology. We work towards the need for systematic ...

<https://iitbcomputingedresearch.wordpress.com>



Computing Education Research at EdTech, IIT Bombay

The EdTech lab's research and outreach efforts in computing education research

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Welcome



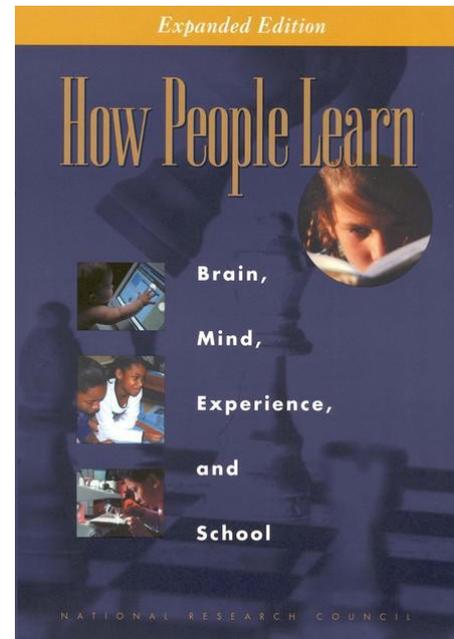
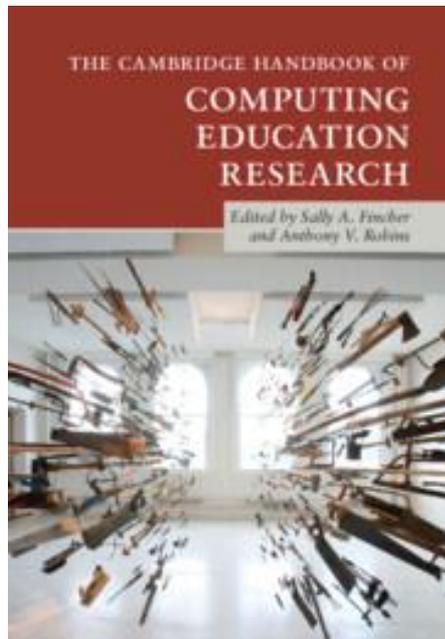
The Computing Education Research group is a part of the **Interdisciplinary Programme in Educational Technology**. We work towards the need for systematic research and dissemination of evidence-based teaching-learning practices across various computing subjects.

We have designed interactive learning environments for various concepts and skills such as knowledge integration, software design skills and troubleshooting. These learning environments are grounded in computing courses such as data structures, software design and computer networks. We have also implemented several active learning strategies like Think-Pair-Share in programming and data structure classrooms. Results of the effectiveness of these learning environments and classroom strategies have been published in computing education conferences like ITiCSE, SIGCSE and ICER.

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

ITiCSE - Innovation and Technology in Computer Science Education

ICER - International Computing Education Research Workshop

COMPUTE, T4E

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

Read journals:

ACM Transactions in Computing Education (TOCE)

Computer Science Education Journal (CSE)

Journal of Learning Analytics (JLA)

How do I start doing computing education research?



Attend seminars, conferences and sessions

Attend the next session! - Workshop on Designing & Conducting Research Studies.

Due to the pandemic, almost all computing ed conferences have moved online. Reduced registration rates. Opportunities to learn and network. All these conferences are online

- [SIGCSE](#) - to be held in March 2021
- [ITICSE](#) - to be held in June 2021
- [ICER](#) - to be held in August 2021
- CompEd will be held in India in 2022

Follow researchers on Twitter

Many researchers maintain an active presence in 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?



www.et.iitb.ac.in/ResearchResources.html

Home Research Academics Admissions People Resources Sponsored Labs Professional Services

Research Resources

Teaching Online
E-books
Handbooks
Research Resources
Teaching Resources

Templates for Research Planning and Paper Writing in Educational Technology

1. Read More  
2. ET Research Guidelines 
3. T4E2013 Tutorial Slides 
4. Idea Proposal Template  
5. Study Planning Template  
6. Paper Planning Template  
7. Paper Writing Template  
8. Literature Review Template 

www.et.iitb.ac.in



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



- 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>)

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