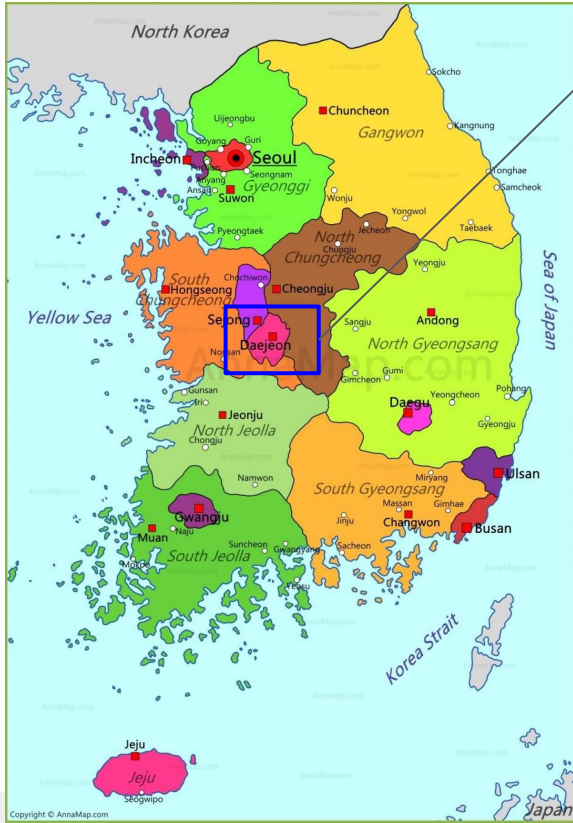


# Data Visualization and Its Application in Online Education

Meng XIA



# Where am I?



Korea Advanced Institute of Science and Technology (KAIST)



KAIST Library

# Where am I?



KAIST Interaction Lab (KIXLAB)



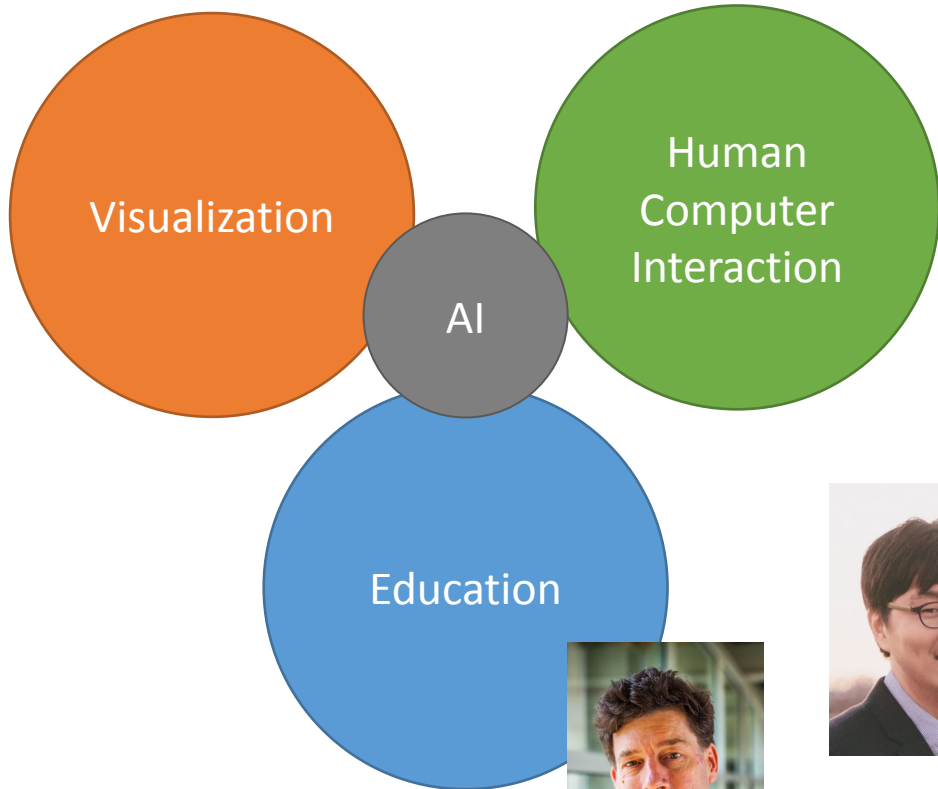
# Work-Life Balance?



# My Research Interest



Prof. Huamin Qu  
(HKUST)



Prof. Xiaojuan Ma  
(HKUST)

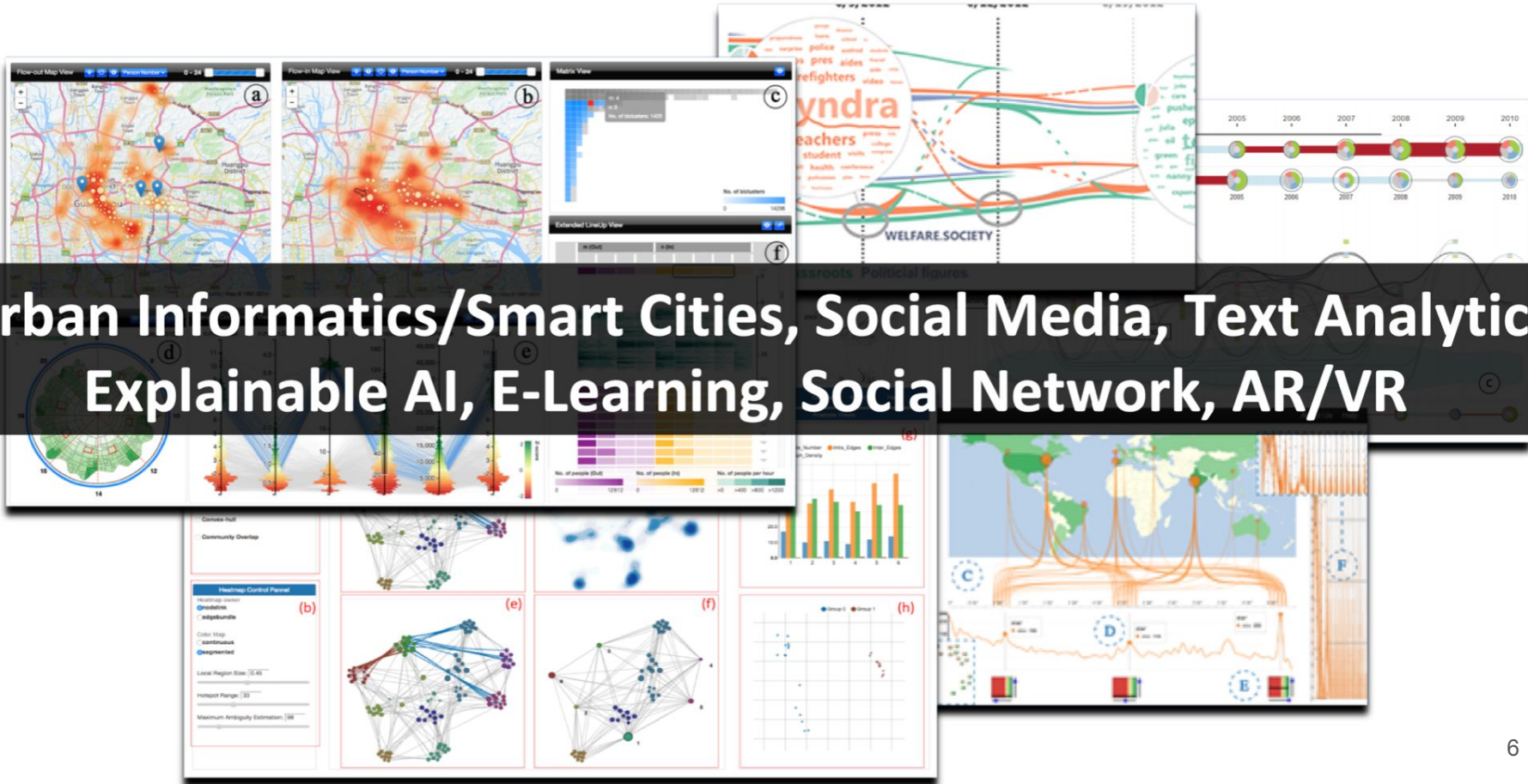


Prof. Juho Kim  
(KAIST)



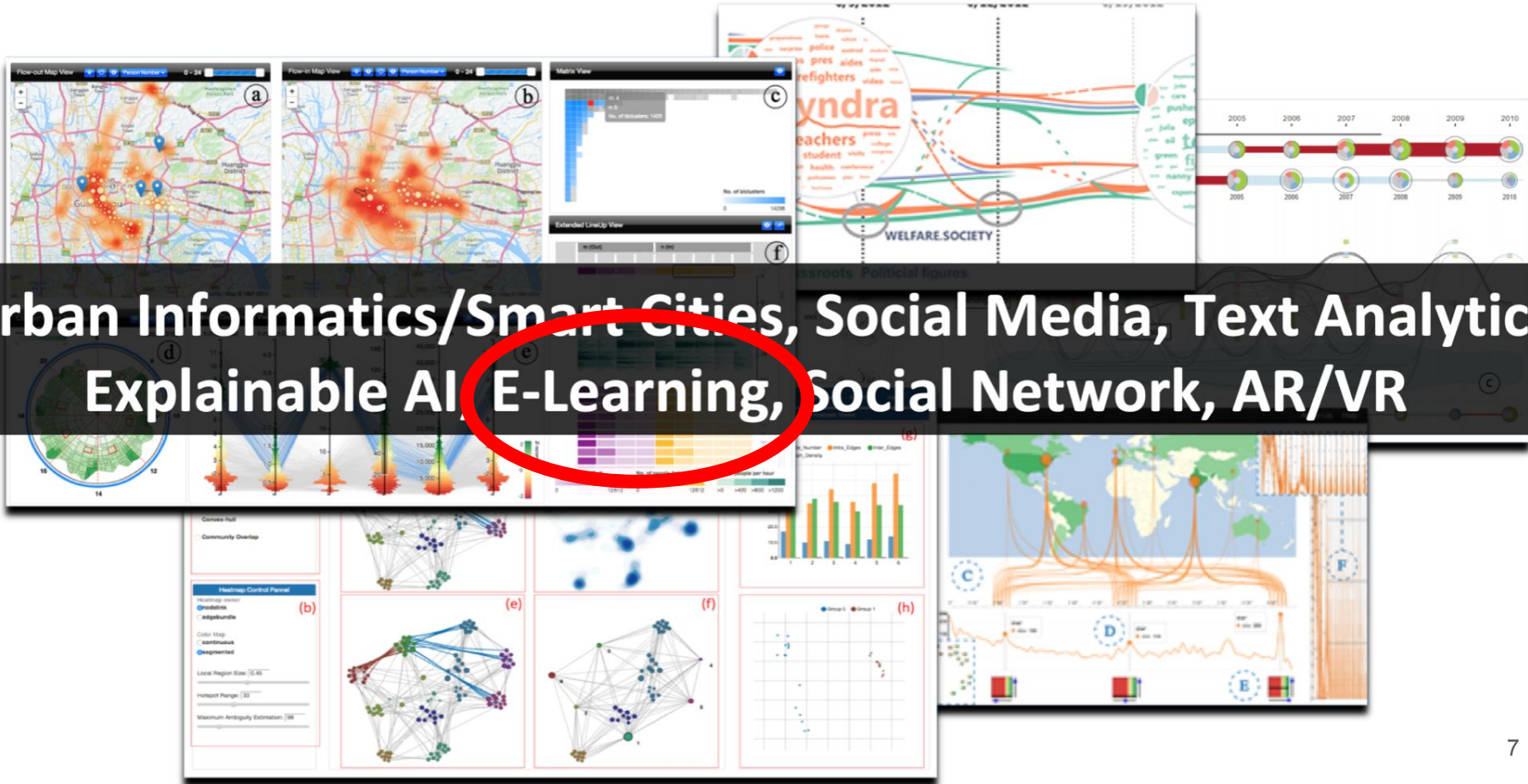
Prof. Vincent Aleven  
(CMU)

# Applications of Data Visualization



Urban Informatics/Smart Cities, Social Media, Text Analytics  
Explainable AI, E-Learning, Social Network, AR/VR

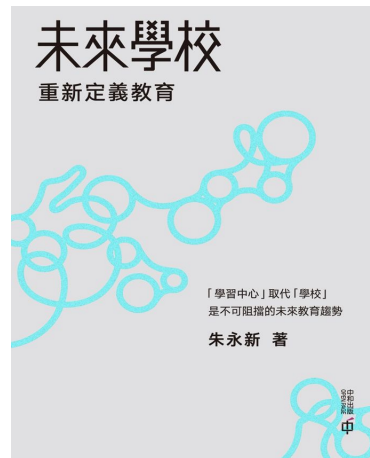
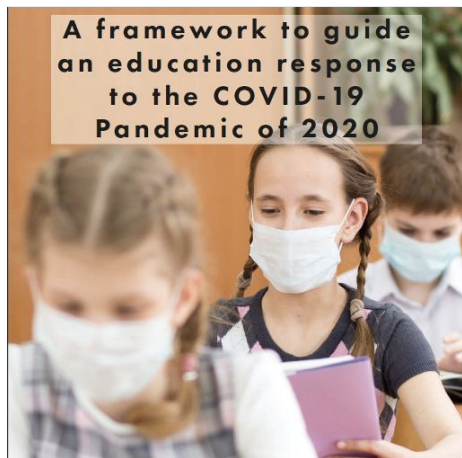
# Applications of Data Visualization





# Online Education is Important

- During Covid, most countries closed the schools and encouraged online learning at home
- It is an irresistible trend that “online learning centre” will replace the “school” in the future



*A Framework to Guide and Education Response to the COVID-19 Pandemic by OECD (Organization for Economic Co-operation and Development), 2020*

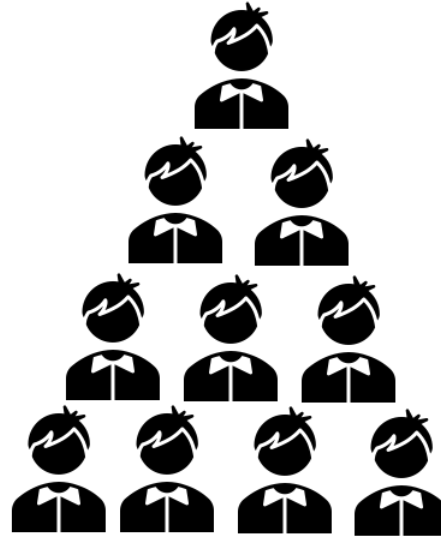


# The Biggest Challenge in Education

- **Imbalance** in the number of educators and students and it's hard for **educators** to give and **students** to get **personalized instructions**.



Educators



Students

# Common E-learning Platforms

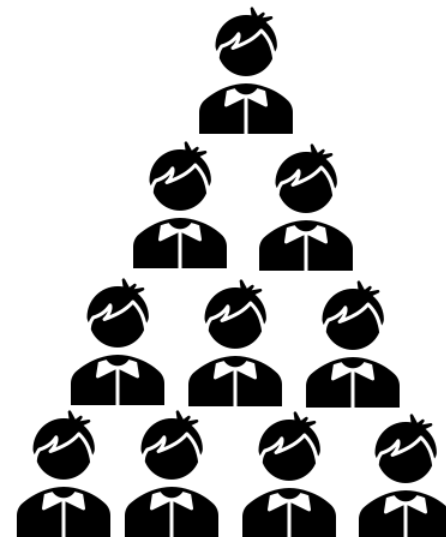
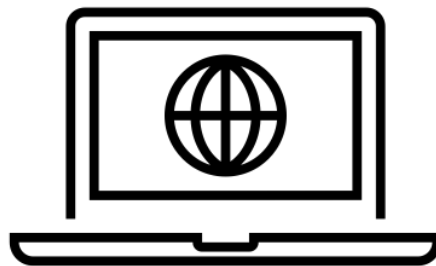
Online learning platforms	Function	Examples
Learning management system	a software application for administration, documentation, tracking, reporting, and delivery of educational courses.	Canvas, Moodle, Coursera, EdX, Udacity
Intelligent tutoring system	computer system that aims to provide immediate and customized instruction or feedback to learners.	Algebra Tutor, SmartTutor
Test and quiz systems	evaluate and practice students' level of knowledge by providing a series of questions.	Uva, LeetCode
Learning objects repositories, wikis, forums, educational games, Q/A systems	sometimes used independently or together with other learning platforms.	StackOverflow

*(Cristobal Romero & Sebastian Ventura, 2010)*



Educators

Personalized?



Students

# Powered by Data

<b>Meta Data</b>	Profile information	Learners' profile (demographic, student knowledge)
	Learning materials	Course-like learning materials, non-course-like learning materials
<b>Behavior Data</b>	Personal behavior	Facial expressions, gaze data, audio utterances, etc.
	Interactive behavior	Click-stream, problem solving sequence, submission stream, typing stream
	Communicative activity	Forum discussion, chatting room, Blog
<b>Personal status</b>	Mental/physical status	Heart rate, EEG data, etc.
<b>Performance &amp; others</b>	Students' performance	Assignments, quizzes, and exams
	Others	Family factors, etc.

*A Survey on Visual Analytics of Online Learning Data, Meng XIA, 2018*



# Different Stakeholders and Needs

<b>Learner</b>	Obtaining personalized recommendations	<b>Educator</b>	Understanding motivation
	Getting adaptive feedback		Behavior modeling
	Achieving self-regulation		Predicting learners performance
<b>Instructor</b>	Understanding the learning material utilization		Social network analysis
	Identifying learning behavior patterns	<b>Administrator</b>	Retaining learners or avoiding dropout
	Monitoring learning progress, engagement, collaboration		Anomaly detection and volume control

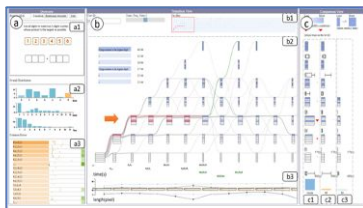
*A Survey on Visual Analytics of Online Learning Data, Meng XIA, 2018*

# Our Works

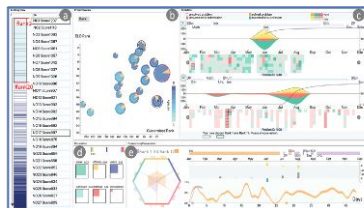


Empower  
educators

**Qlens**: multi-step question analysis. VIS 2020



**SeqDynamics**: cognitive and non-cognitive traits. Euro VIS, 2020



Mobile MOOC guideline:  
CHI 2022

Distributed tutorship:  
LAK 2022

Authoring tool for  
intelligent tutor  
(ongoing)

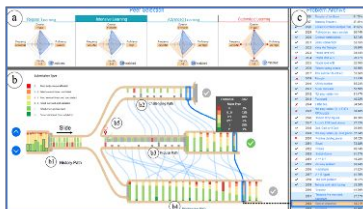
Problem-solving Data

Text Data & Others

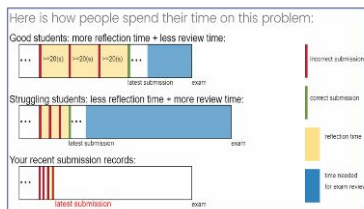


Empower  
students

**Peerlens**: learning path planning. CHI, 2019



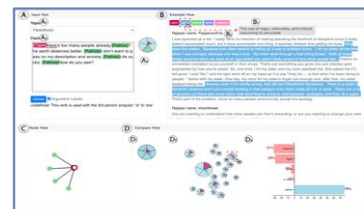
**“Game the system”**: learning behavior regulation. L@S, 2020



AlgoSolve: CHI 2022

English speaking  
reflection: KSC 2021

**\*\*\***: persuasives strategies  
CSCW 2022 (major revision)

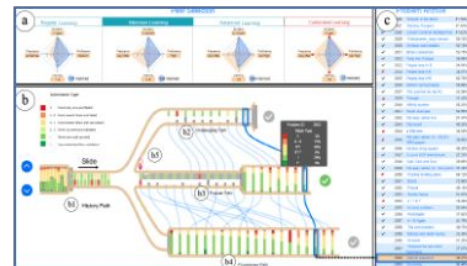


## Learners: Obtaining personalized recommendations

Pro. ID	
1000	A + B Problem
1001	Sum Problem
1002	A + B Problem II
1003	Max Sum
1004	Let the Balloon Rise
1005	Number Sequence
1006	Tick and Tick
1007	Quoit Design
1008	Elevator
1009	FatMouse' Trade
1010	Tempter of the Bone
1011	Starship Troopers

- A lengthy list indexed by their problem IDs
- No pre-determined syllabus
- Hidden learning concepts

Peerlens: learning path planning. CHI, 2019



# Learners: Obtaining personalized recommendations

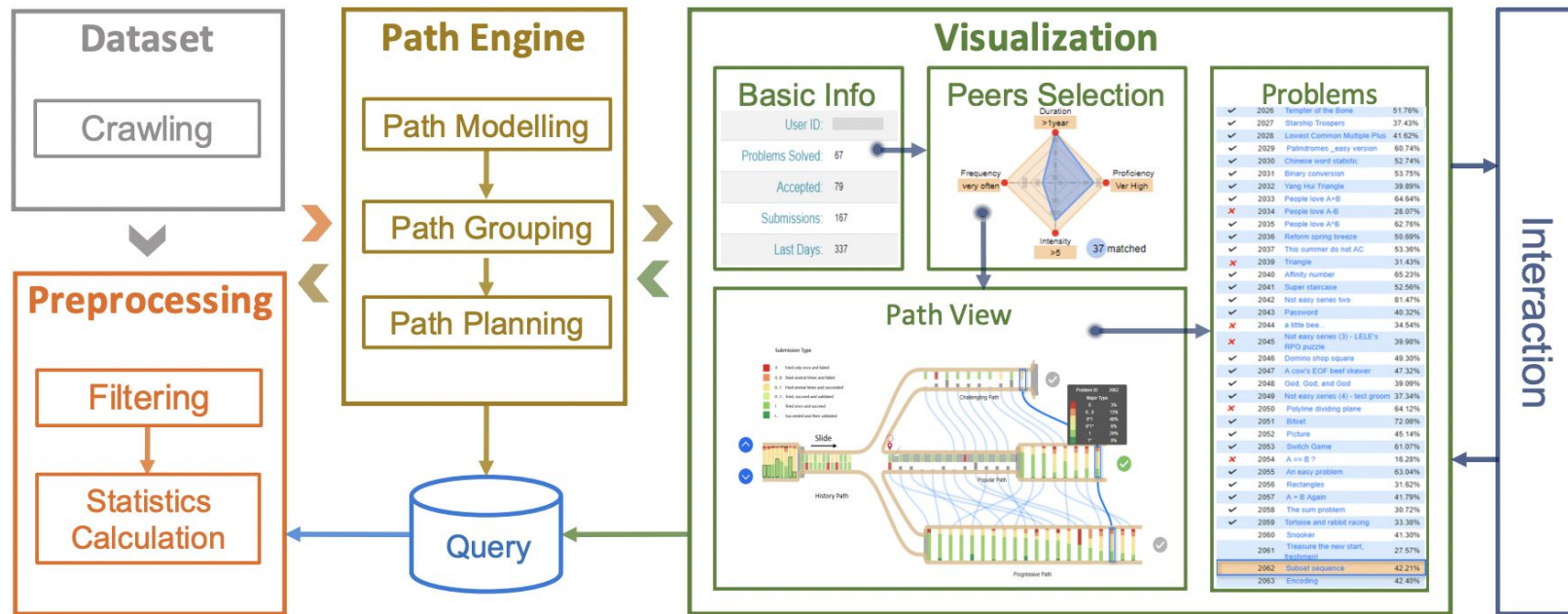
## A user-centered design process

- Semi-structure interviews:
  - Online questions pool designers (E1, E2)
  - Online question pool users (S1, S2)
- Design requirements:
  - R1: Find peers for a specific learning scenario
  - R2: Compare with peers' performance
  - R3: Offer flexible learning path suggestions with reasoning
  - R4: Provide convenient interaction and intuitive visual designs for learning path planning



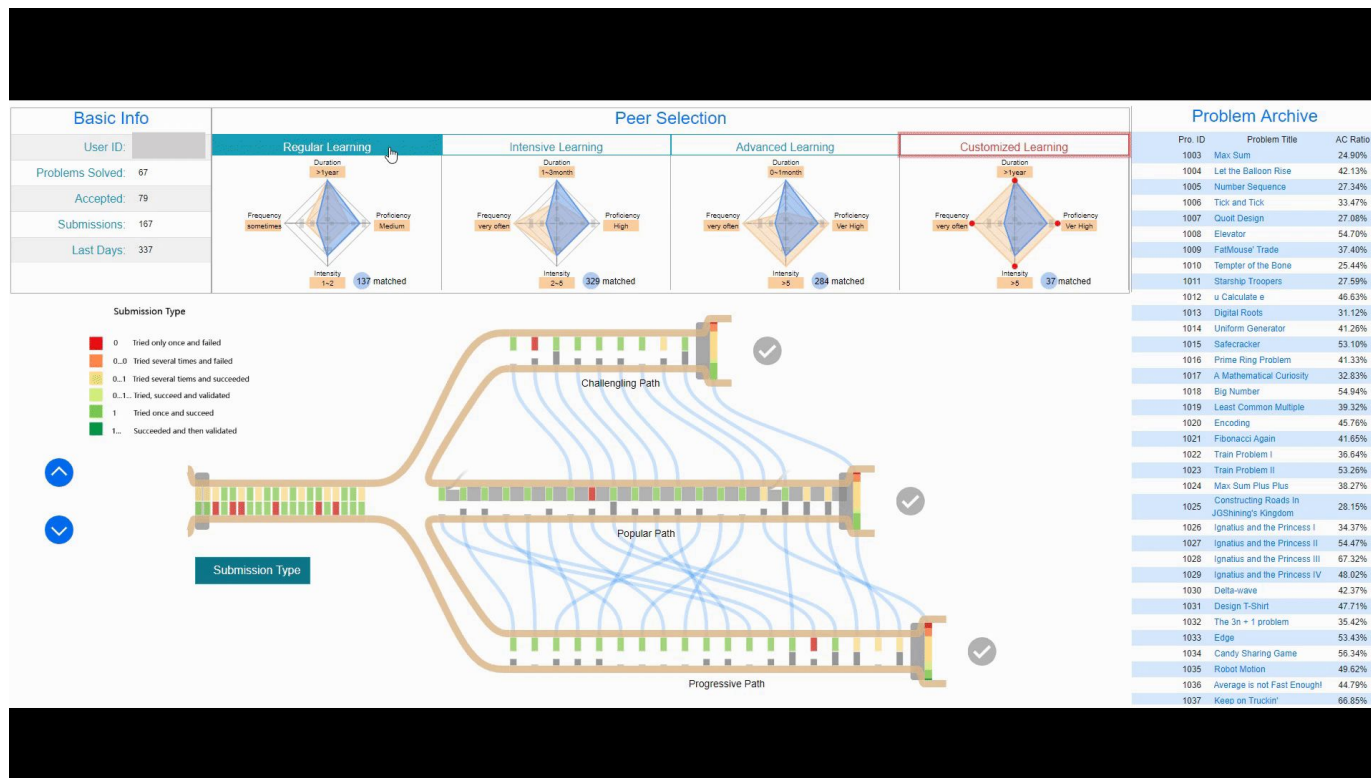


# Learners: Obtaining personalized recommendations



The system architecture of PeerLens.

# Learners: Obtaining personalized recommendations



# Educators: Identifying learning behavior patterns


**Qlens:** multi-step question analysis. VIS 2020

Five people stand in a line.

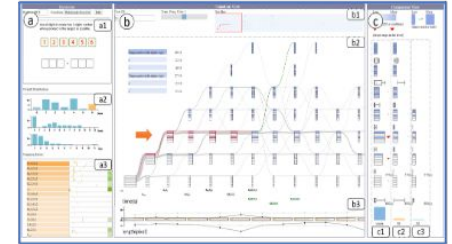
Mark stands ahead of Paul.  
Helen stands ahead of Jane.  
Paul stands behind Helen but ahead of Luke.  
No boy is next to another boy in the line.

👉 Move each person to their place in the line.

Mark Helen Paul Luke Jane



Back Front



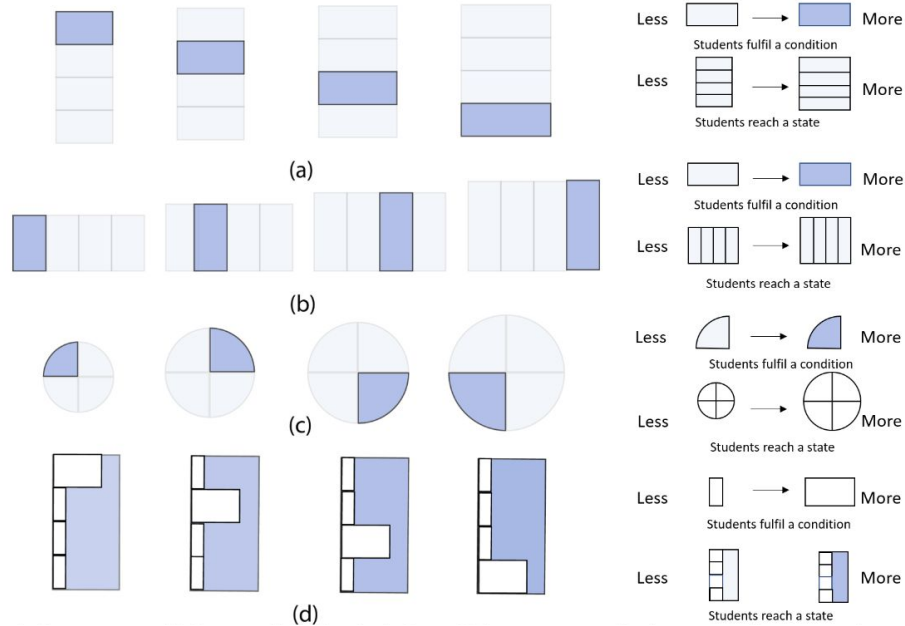
# Educators: Identifying learning behavior patterns

## A user-centered design process

- Four domain experts
  - Question designers (E1, E2)
  - System developer (E3)
  - Project manager (E4)
- Requirements gathering iteratively  $\geq$  one year
  - R1: Show students' overall problem-solving performance.
  - R2: Summarize and present the multi-step problem-solving behaviors.
  - R3: Enable the comparison of students from different groups.
  - R4: Evaluate the feasibility of providing feedback based on existing data.

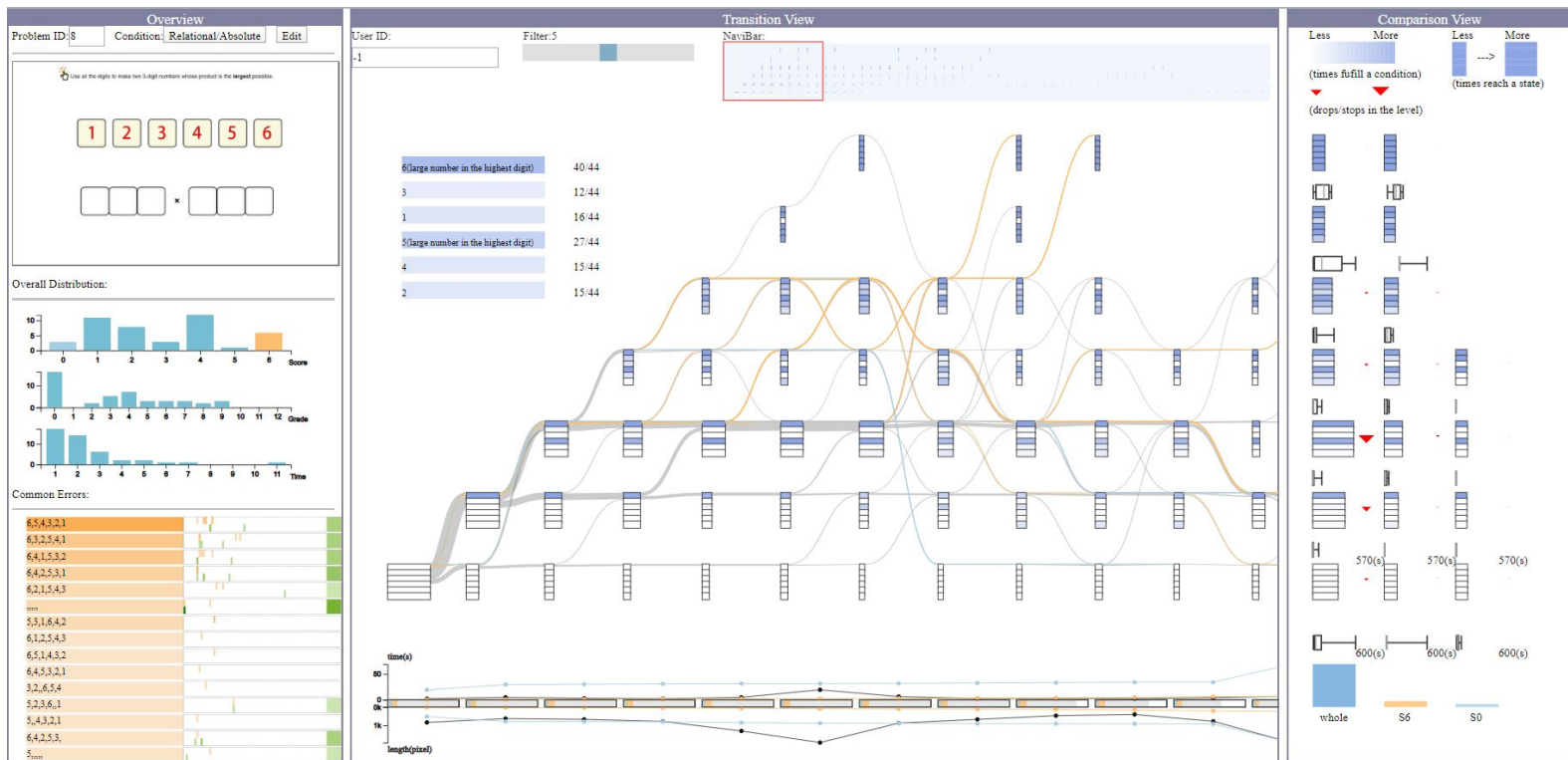


# Iterative Design Process



Alternative designs during the ideation and development process

# Educators: Identifying learning behavior patterns



*QLens: Visual Analytics of Multi-step Problem-solving Behaviors for Improving Question Design (Xia et al., TVCG 2021)*

# Future Work

1. Authoring tools of intelligent tutoring systems for educators
2. Intelligent Dashboards for students
  - a. personalized and actionable (Data mining and AI)
  - b. explainable (VIS)
  - c. interactive (HCI)
  - d. integrated (Design)
3. Evaluation: more testings with real-world deployment
4. Design pattern summarization: tasks and optimized visualizations
5. Ethical issues: deidentification the data

Technology won't replace teachers ...

but teachers who use technology will probably replace teachers who do not.

*What's your imagination of future education?*

# PhD

## Some Tips for PhD Life





# 1. Don't Miss Deadline

## Reasons:

1. Benefits for all sides (you, your supervisor, collaborators, company if there is)
2. A good rest after the paper submission
3. Feedback from the reviewers ...

## Actions:

1. Set milestones and stick to them
2. Ask other people (collaborators, labmates) to monitor/encourage you

## 2. Set goals as improving atomic research skills instead of paper acceptance

Reasons:

1. Paper acceptance has uncontrollable factors (e.g., reviewer)
2. Improvement on basic skills is necessary for good work

Actions:

- Coding: 7 -> 8
- Writing: 4 -> 5
- Idea:
- Research question framing
- Interpersonal/communication skills:
- Critical thinking:
- Project management
- Stress/Emotion Management
- Time Management
- Video making skills
- Interview conduction skills
- Qualitative data analysis skills
- Statistics analysis skills
- Latex skills
- Git skills
- Knowledge of HCI/VIS/...

### 3. Focus on cultivating research habits

#### Reasons:

1. Ph.D. is a long-term work, and research is a life-long thing
2. Good habits can guarantee the success

#### Actions:

1. attend every group meeting (80% success is just showing up)
2. reading notes (e.g., read the papers regularly and deeply with summarization, critical thinking, creative thinking, what have been learned)
3. how to have efficient meetings (e.g., recall, discussion agenda, to-dos, and minuting minutes)
4. record/log all the progress of the project and regular progress report and
5. reflection on each project/submission
6. communication with other labmates

# Others

For example:

1. What if I have too much peer pressure?
  - ⇒ Compare with others but not change your direction
  - ⇒ Know yourself is the thing you need to think about all the time
2. What if I think my supervisor gives me limited feedback?
  - ⇒ A Ph.D. is supposed to develop independent thinking skills
  - ⇒ The supervisor is **not** the person who helps you make the decision but who guides you to explore or explore together with you

# Tips for Project Management

1. Always be grateful that you have someone to help you, that you have team members.
2. Set reasonable expectations. Learn about the students and share your thoughts, not limited to the research side to build trust and have a more smooth collaboration. For example, what's a purpose to the student join this project, what does he/she want, how motivated. This information can help you decide how much expectation you can have for this student and how much you/this project can provide for this student.
3. Assign suitable tasks. Try to figure out the strength of the student in terms of the project -> coding? Front-end? Backend? Communication? Writing? -> assign the tasks that fit the student's strengths. Or if the student has strong motivation to learn something new even if no previous experience.
4. Help the students to set their own goals and let them know they are working for themselves.
5. Set the milestones, break down the tasks, set the responsible students and deadline for each task. Iteratively.
6. Must have regular meetings (e.g., weekly meetings) to avoid loose progress and communication. For example, recall what has been done and not finished since the last meeting, discussion agenda, to-dos, and keep minuting minutes)
7. Must give feedback every time when the student updates something.

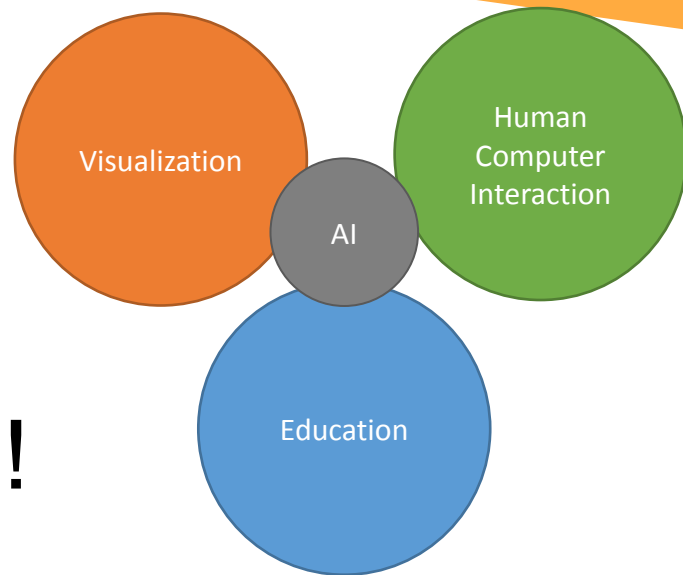
# Tips for Project Management

8. Encourage the student every time they do something you feel is correct/good and give the reasons why it is good.
9. Cultivate the culture of collaboration, that treating the team as a union, that everyone works for the same goal. For example,
  1. repeat the purpose of the project again and again
  2. make the tasks both independent and dependent. Independent: that the students can do by themselves; dependent: that one output should be used for another student and they should encourage each other. If the task is too independent, the student might feel what he/she does will not be that helpful for the whole team, while if there is some dependency, they know at least their work is important for other team members.
  3. ask other team members to give feedback
10. Keep every team member on the same page. Assign the task and tell the reason why we need to do this.
11. Assign the hardest tasks that you can do to yourself or make sure you have the ability or be prepared to deal with the hardest part.
12. You should know that you are the person who needs to make decisions and is responsible for the decisions.
13. Don't count on students to make decisions for you but definitely involve them in every discussion and take their opinions if you can; don't be proud, everyone has their wisdom that you can learn from.
14. Adapt to students (e.g., the meeting time, working time, etc) instead of treating all students/every project the same.



*What's your imagination of  
future education?*

Thank you!



Free feel to contact me if you are interested or  
have any further question!

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