



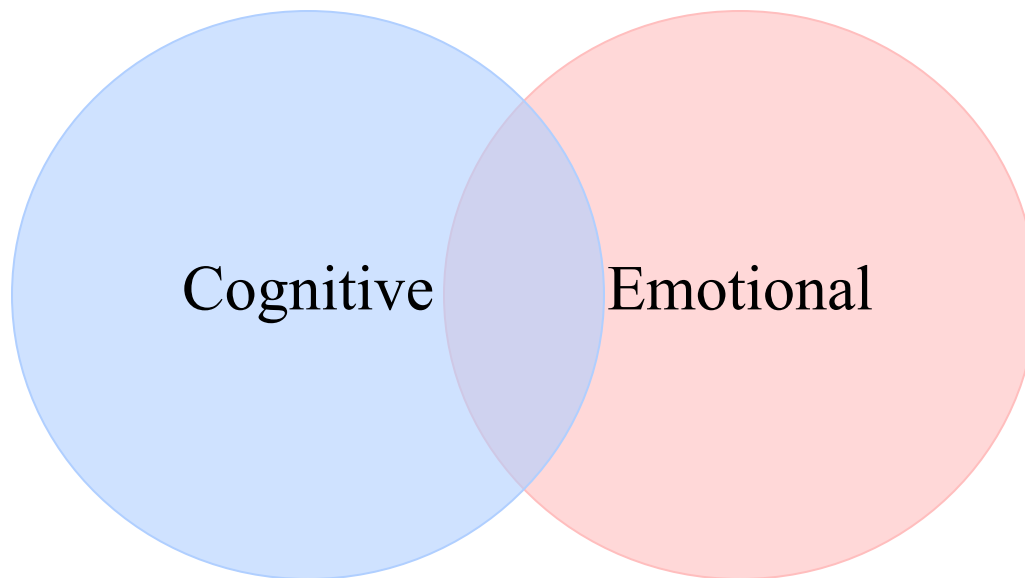
Carnegie Mellon University

# Analytics of Communicative Patterns in Tutoring Dialogues

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# Background



# Background

Cognitive

**Tutor**

No Service 7:22 PM 42%

★ +1 Ms. PV Online

**Tutor:** The powers of 4 are simplified and the remaining factors are kept under the radical.

**Tutor:** Shall we try the same trick on your problem?

**Student:** Sure!

**Tutor:** Our first task would be to write 32 as a power.

**Student:** Ok!

**Tutor:** Any guesses on how we do that?

**Student:** Do we take 16 and 2 because those multiplied is 32?

**Tutor:** Fantastic!

**Tutor:** You identified the 4 power factor immediately.

Type a message Send

**Hint**

**Question**

**Student**

**Hint**

**Question**

**Positive Feedback**

# Background

Emotional



# Background

Tutors commonly used **many instructional strategies** to guide students in dialogue tutoring

Benedict Du Boulay and Rosemary Luckin. 2016. Modelling human teaching tactics and strategies for tutoring systems: 14 Years on. *International Journal of Artificial Intelligence in Education* 26, 1 (2016), 393–404.

# Background

## A strategy of providing negative feedback

**Tutor:** *“Sorry, I saw an error”*

## A strategy of providing hints to students

**Tutor:** *“We should keep in mind that the cost is 51 AUD.”*

# Background

The expression of **some** instructional strategies **might impose negative feelings on students**

Benjamin Brummernhenrich and Regina Jucks. 2013. Managing face threats and instructions in online tutoring. *Journal of Educational Psychology* 105, 2 (2013), 341.

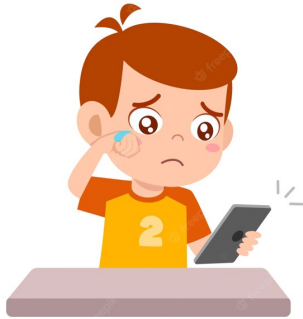
Benjamin Brummernhenrich and Regina Jucks. 2016. “He shouldn’t have put it that way!” How face threats and mitigation strategies affect person perception in online tutoring. *Communication Education* 65, 3 (2016), 290–306.

# Scenario

A middle school student is working on a math problem

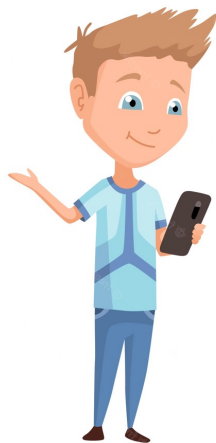






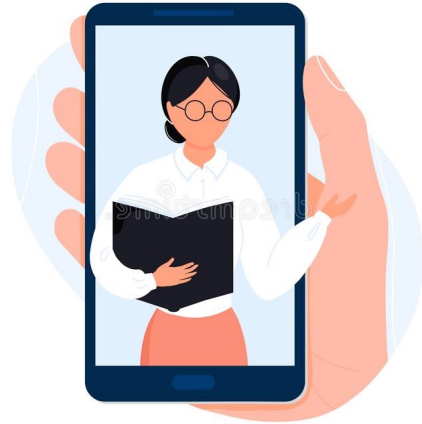
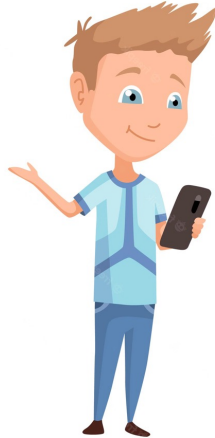
No, you are wrong

Remember, the cost is 51 AUD



Sorry I saw a minor error in here

We should keep in mind that the  
cost is 51 AUD



1. No, you are wrong

2. Remember! the cost is 51 AUD

3. Sorry I saw a minor error in here

4. We should keep in mind that the cost is 51 AUD

**Same meaning but different surface forms**



# Students prefer to work with the polite tutors

Wang, N., Johnson, W. L., Rizzo, P., Shaw, E., & Mayer, R. E. (2005, January). Experimental evaluation of polite interaction tactics for pedagogical agents. In *Proceedings of the 10th international conference on Intelligent user interfaces* (pp. 12-19).

# Tutors' politeness can improve students' performance

Wang, N., Johnson, W. L., Mayer, R. E., Rizzo, P., Shaw, E., & Collins, H. (2008). The politeness effect: Pedagogical agents and learning outcomes. *International journal of human-computer studies*, 66(2), 98-112.

Mikheeva, M., Schneider, S., Beege, M., & Rey, G. D. (2019). Boundary conditions of the politeness effect in online mathematical learning. *Computers in Human Behavior*, 92, 419-427.



Should tutors express politeness **all the time** in the tutoring dialogue?



## Human tutors might spend much time working on polite expressions which can in turn hinder the tutoring process

Brummernhenrich, B., & Jucks, R. (2016). "He shouldn't have put it that way!" How face threats and mitigation strategies affect person perception in online tutoring. *Communication Education*, 65(3), 290-306.

Brummernhenrich, B., & Jucks, R. (2013). Managing face threats and instructions in online tutoring. *Journal of Educational Psychology*, 105(2), 341.

Person, N. K., Kreuz, R. J., Zwaan, R. A., & Graesser, A. C. (1995). Pragmatics and pedagogy: Conversational rules and politeness strategies may inhibit effective tutoring. *Cognition and instruction*, 13(2), 161-188.

# **Students with high prior knowledge often prefer to receive instruction directly expressed**

McLaren, B. M., DeLeeuw, K. E., & Mayer, R. E. (2011). A politeness effect in learning with web-based intelligent tutors. *International Journal of Human-Computer Studies*, 69(1-2), 70-79.

# Student prior knowledge

# Student prior knowledge



**When should tutors express  
politeness in the tutoring?**



$$1 \div 100 = 0.1$$

## Providing negative feedback



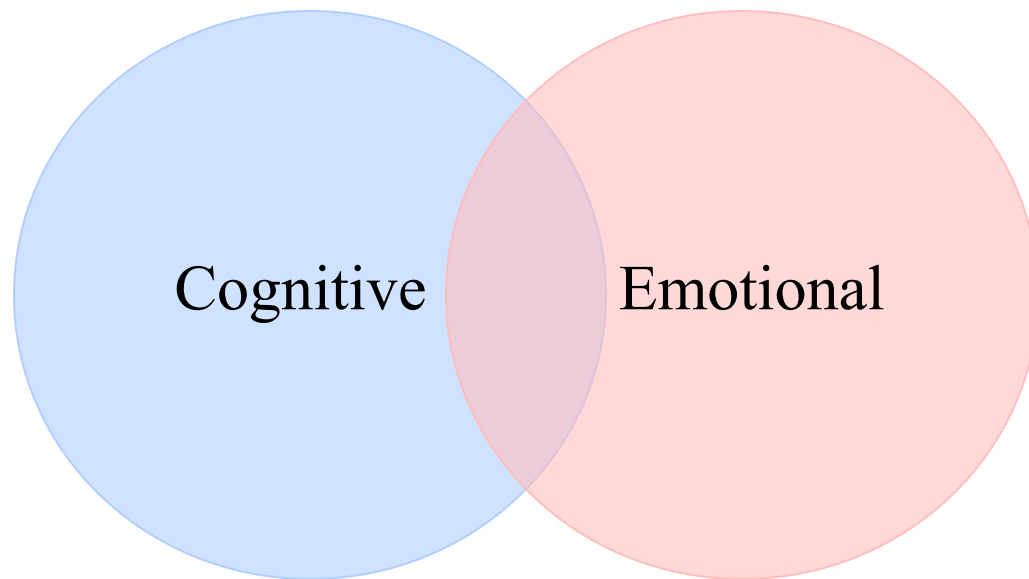
**Tutor A:** *"Sorry, I saw an error"*

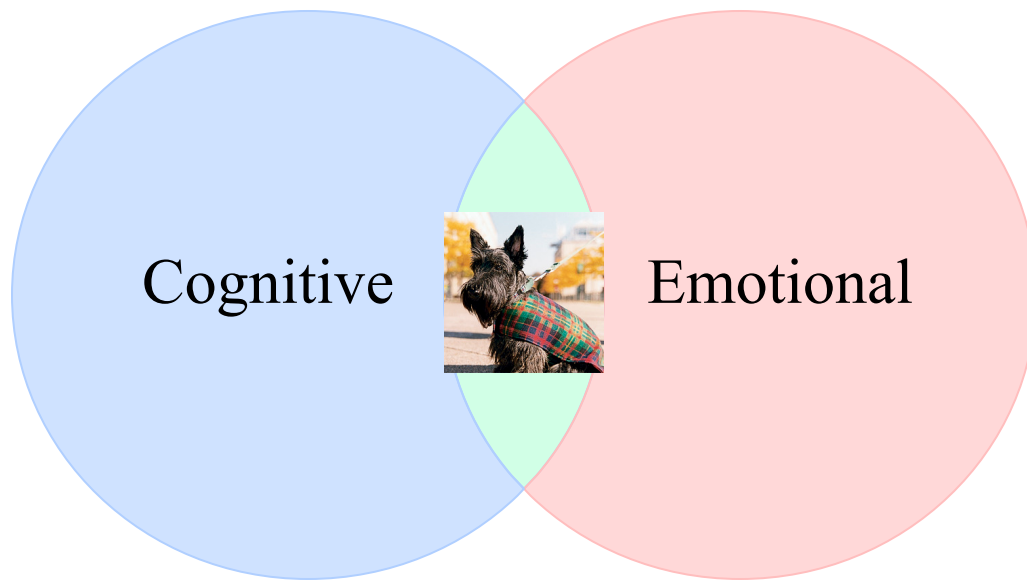


**Tutor B:** *"There is a mistake"*



**Tutor C:** *"No, you are wrong"*







# Data

## Yup Tutoring Dialogue Data (dataset for immediate feedback)

# Total tutorial sessions: 14,562

# Tutors: 116

# Students: 5,165 (K-12 level)

## Student Performance

Gap-clarified (low performance, **ineffective** tutoring session)

Gap-explained (medium performance, **less effective** tutoring session)

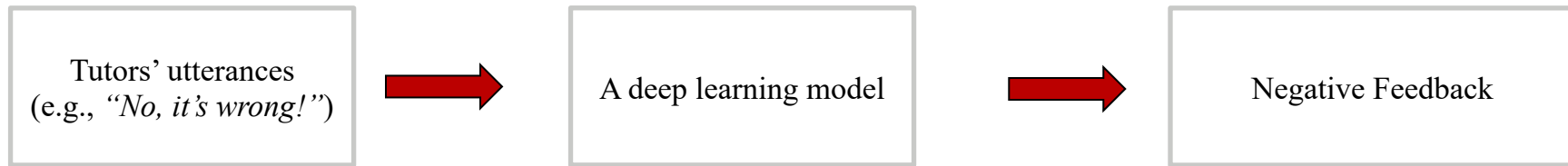
Gap-bridged (high performance, **effective** tutoring session)

# Dialogue Act Classifier

Input

Model

Output



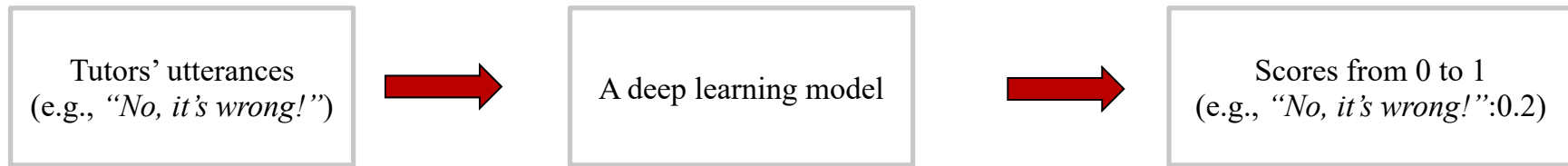
Lin, J., Singh, S., Sha, L., Tan, W., Lang, D., Gašević, D., & Chen, G. (2022). Is it a good move? Mining effective tutoring strategies from human-human tutorial dialogues. *Future Generation Computer Systems*, 127, 194-207

# Politeness Level Identifier (PLI)

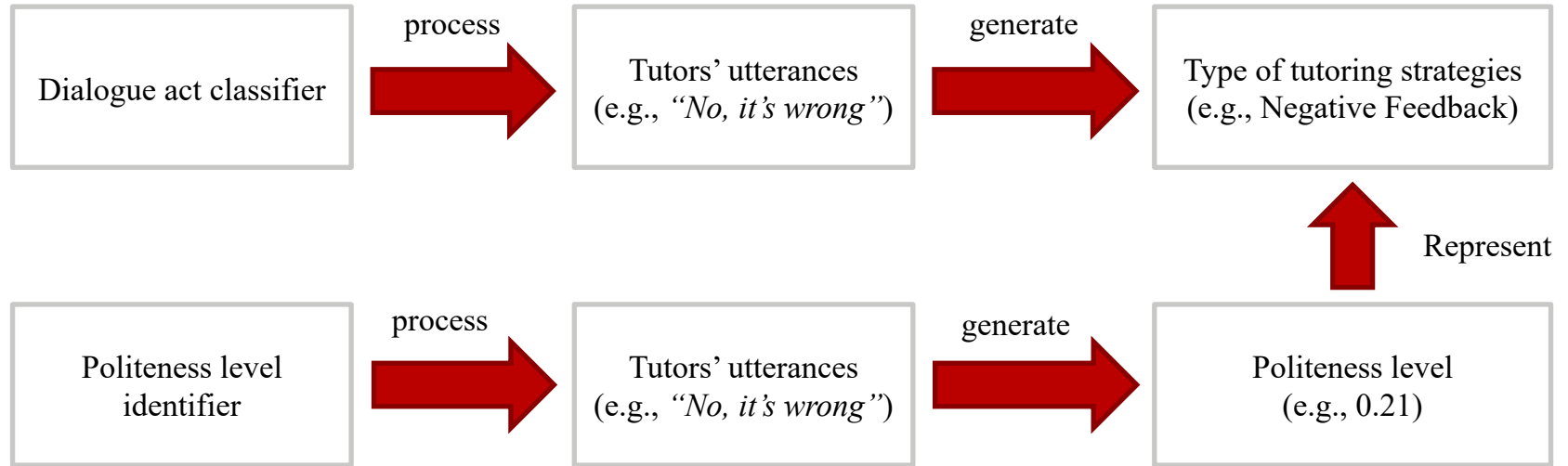
Input

Model

Output



# Method



Lin, J., Rakovic, M., Lang, D., Gasevic, D., & Chen, G. (2022, March). Exploring the Politeness of Instructional Strategies from Human-Human Online Tutoring Dialogues. In *LAK22: 12th International Learning Analytics and Knowledge Conference* (pp. 282-293).

# Findings

## Politeness levels for each instructional strategies in different categories

**WP:** With prior progress **WoP:** Without prior progress

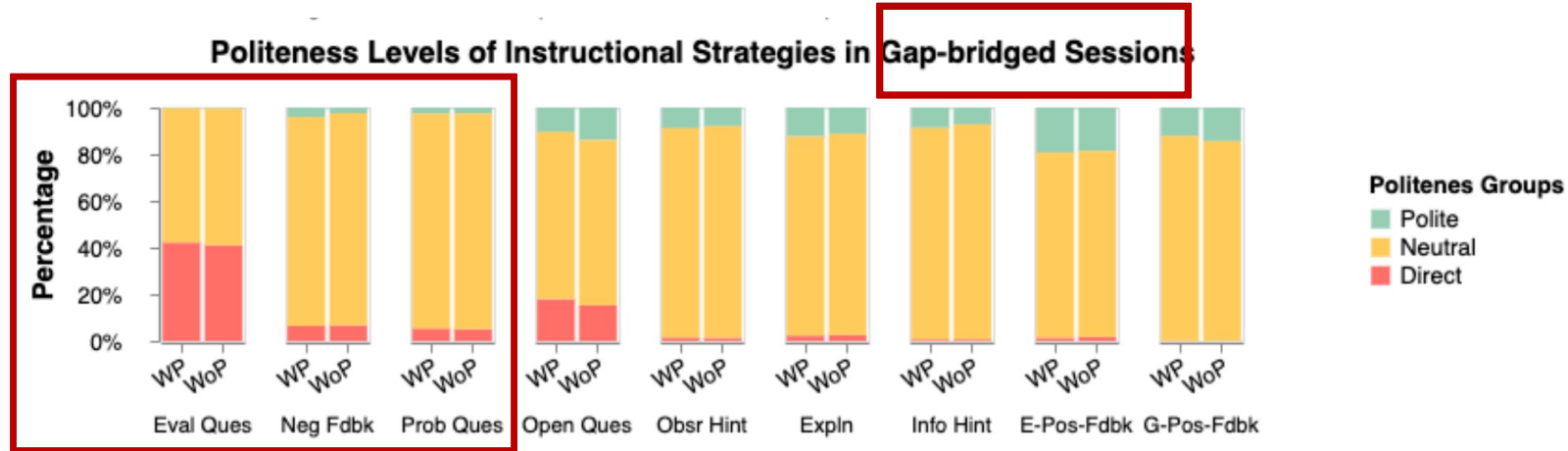
Strategy	All	Gap-clarified		Gap-explained		Gap-bridged	
		WP	WoP	WP	WoP	WP	WoP
1. Evaluation Question	0.22	0.24	0.22	0.22	0.22	0.22	0.22
2. Negative Feedback	0.39	0.43	◇ 0.42	<b>0.40</b>	◇ <b>0.37</b>	<b>0.40</b>	<b>0.38</b>
3. Probing Question	0.44	♣ 0.46	♣ 0.48	† 0.45	† 0.46	† ♣ 0.43	† ♣ 0.44
4. Open Question	0.49	<b>0.52</b>	◇ ♣ <b>0.63</b>	0.48	◇ 0.52	<b>0.47</b>	♣ <b>0.49</b>
5. Observation Hint	0.56	♣ 0.60	◇ ♣ 0.61	† 0.58	◇ † 0.58	† ♣ 0.56	† ♣ 0.56
6. Explanation	0.57	♣ 0.61	0.60	0.58	0.57	♣ 0.57	0.57
7. Information Hint	0.62	◇ ♣ 0.65	◇ ♣ 0.65	◇ 0.62	◇ † 0.63	♣ 0.62	† ♣ 0.62
8. Elaborated Positive Feedback	0.63	0.64	0.65	0.65	† 0.65	<b>0.63</b>	† <b>0.62</b>
9. General Positive Feedback	0.72	♣ 0.74	◇ ♣ 0.75	† 0.73	◇ † 0.74	† ♣ 0.72	† ♣ 0.72



Lin, J., Rakovic, M., Lang, D., Gasevic, D., & Chen, G. (2022, March). Exploring the Politeness of Instructional Strategies from Human-Human Online Tutoring Dialogues. In *LAK22: 12th International Learning Analytics and Knowledge Conference* (pp. 282-293).

# Findings

## Politeness levels for each instructional strategies as tutoring progressed



The abbreviations include **Eval-Ques** (Evaluation Question), **Neg-Fdbk** (Negative Feedback), **Prob Ques** (Probing Question), **Open Ques** (Open Question), **Obsr Hint** (Observation Hint), **Expln** (Explanation), **Info Hint** (Information Hint), **E-Pos-Fdbk** (Elaborated Positive Feedback), and **G-Pos-Fdbk** (General Positive Feedback).



**Lin, J.**, Rakovic, M., Lang, D., Gasevic, D., & Chen, G. (2022, March). Exploring the Politeness of Instructional Strategies from Human-Human Online Tutoring Dialogues. In *LAK22: 12th International Learning Analytics and Knowledge Conference* (pp. 282-293).

# Findings

Strategy	Politeness Groups	Examples
1. Evaluation Question	Direct	<i>Do you understand what I mean?</i>
	Neutral	<i>Would that make sense?</i>
	Polite	<i>I hope this make sense?</i>
2. Negative Feedback	Direct	<i>Not exactly!</i>
	Neutral	<i>You made one slight mistake.</i>
	Polite	<i>Sorry, I saw the wrong numbers.</i>
3. Probing Question	Direct	<i>1g SiO<sub>2</sub> = ??</i>
	Neutral	<i>If <math>x=85</math>, what will be <math>x - 20 = ?</math></i>
	Polite	<i>How can we simplify square root 27?</i>
4. Open Question	Direct	<i>What is the next step?</i>
	Neutral	<i>What do you think is the next step?</i>
	Polite	<i>What do you think we could try first?</i>
5. Observation (Hint)	Direct	<i>You'll not get exact answer</i>
	Neutral	<i>There are 4 25's in 100.</i>
	Polite	<i>We have <math>(x, y) = D(1, 2)</math></i>
6. Explanation	Direct	<i>That's why it is negative</i>
	Neutral	<i>So the units are equivalent</i>
	Polite	<i>That's the value we want to put in</i>
7. Information (Hint)	Direct	<i>Remember the service charges is 0.51 per therm!</i>
	Neutral	<i>It is <math>P= \text{Force/Area}</math></i>
	Polite	<i>We need to try all the possible rational roots.</i>
8. Elaborated Positive Feedback	Direct	<i>Right, that's exactly what you should get.</i>
	Neutral	<i>That's the correct first step</i>
	Polite	<i>Awesome! We just need to find 1/3 of 60!</i>
9. General Positive Feedback	Direct	<i>Exactly as what I got</i>
	Neutral	<i>You are right</i>
	Polite	<i>Great job!</i>

# Findings

## Track the use of politeness in instructional strategies

Tutors can use **Non-polite** expression for some strategies (e.g., negative feedback) as long as the instruction meets the students' needs of solving problems



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# Findings

## Predictive power of instructional strategies politeness

The politeness levels of instructional strategies can **improve the model performance of predicting student problem-solving performance** compared to the prediction results in RQ2.



Lin, J., Rakovic, M., Lang, D., Gasevic, D., & Chen, G. (2022, March). Exploring the Politeness of Instructional Strategies from Human-Human Online Tutoring Dialogues. In *LAK22: 12th International Learning Analytics and Knowledge Conference* (pp. 282-293).



Any research about **ChatGPT, GPT-4** related to dialogue analysis?

The content in this section has been deliberately omitted because it is currently undergoing review for an academic publication

# Summary

1. Cognitive components (Educational Dialogue Acts) of tutoring dialogues
2. Emotional components (Politeness) of tutoring dialogues
3. Interplay between cognitive and emotional components of tutoring dialogues
4. Enhance the tutor training and tutoring practice by LLMs

# Recommended Readings

- Lin, J.,\*** Singh, S., Sha, L., Tan, W., Lang, D., Gašević, D., & Chen, G. (2022). Is it a good move? Mining effective tutoring strategies from human–human tutorial dialogues. *Future Generation Computer Systems*, 127, 194-207.
- Lin, J.,\*** Tan, W., Nguyen, N. D., Lang, D., Du, L., Buntine, W., ... & Gašević, D. (2023, June). Robust Educational Dialogue Act Classifiers with Low-Resource and Imbalanced Datasets. In *International Conference on Artificial Intelligence in Education* (pp. 114-125). Cham: Springer Nature Switzerland.
- Tan, W., **Lin, J.,\*** Lang, D., Chen, G., Gašević, D., Du, L., & Buntine, W. (2023, June). Does informativeness matter? Active learning for educational dialogue act classification. In *International Conference on Artificial Intelligence in Education* (pp. 176-188). Cham: Springer Nature Switzerland.
- Lin, J.,\*** Tan, W., Du, L., Buntine, W., Lang, D., Gašević, D., & Chen, G. (2023). Enhancing educational dialogue act classification with discourse context and sample informativeness. *IEEE Transactions on Learning Technologies*.
- Lin, J.,\*** Lang, D., Xie, H., Gašević, D., & Chen, G. (2020). Investigating the role of politeness in human-human online tutoring. In *Artificial Intelligence in Education: 21st International Conference, AIED 2020, Ifrane, Morocco, July 6–10, 2020, Proceedings, Part II 21* (pp. 174-179). Springer International Publishing.
- Lin, J.,\*** Raković, M., Li, Y., Xie, H., Lang, D., Gašević, D., & Chen, G. (2023). On the role of politeness in online human–human tutoring. *British Journal of Educational Technology*.
- Lin, J.,\*** Rakovic, M., Lang, D., Gasevic, D., & Chen, G. (2022, March). Exploring the politeness of instructional strategies from human-human online tutoring dialogues. In *LAK22: 12th International Learning Analytics and Knowledge Conference* (pp. 282-293).
- Lin, J.,\*** Thomas, D. R., Han, F., Gupta, S., Tan, W., Nguyen, N. D., & Koedinger, K. R. (2023). Using large language models to provide explanatory feedback to human tutors. *arXiv preprint arXiv:2306.15498*.
- Lin, J.,\*** Thomas, D. R., Han, Z., Tan, W., Nguyen, N. D., Gupta, S., ... & Koedinger, K. R. (2023). Personalized Learning Squared (PLUS): Doubling Math Learning through AI-assisted Tutoring.
- Hirunyasiri, D., Thomas, D. R., **Lin, J.,\*** Koedinger, K. R., & Aleven, V. (2023). Comparative analysis of gpt-4 and human graders in evaluating praise given to students in synthetic dialogues. *arXiv preprint arXiv:2307.02018*.

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