NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

# Automatically Linking Digital Signal Processing Assessment Questions to Key Engineering Learning Outcomes

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# Objective

- Knowledge **(K)**
- Application **(A)**
- Transfer **(T)**

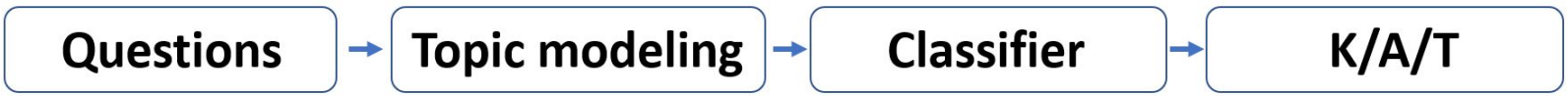
**Constructive alignment** [1]

| Assessment Questions | Label |
|---|---|
| Question 1 | K/A/T? |
| Question 2 | K/A/T? |
| Question 3 | K/A/T? |

**Automatic question classifier**

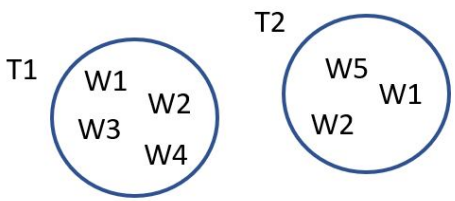
[1] D. Boud and N. Falchikov, "Aligning assessment with longterm learning," Assess. Eval. High. Edu., vol. 31, pp. 399-413, 2006.

# Paradigm for question classification

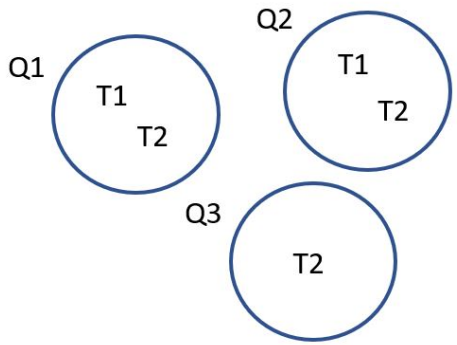



- Topic modeling
  - Latent Dirichlet allocation (LDA)
  - Word network topic model (WNTM)

**Topic: mixture of words (vocabulary)**




**Question: mixture of topics**




**Proportions of topics: label (K/A/T)**

| Topic 1 | Topic 2 | Label |
|---|---|---|
| 0.6 | 0.4 | K |
| 0.8 | 0.2 | A |
| 0.01 | 0.99 | T |

- Classifier - Extreme Learning Machine (ELM)

# Existing method - LDA [2]

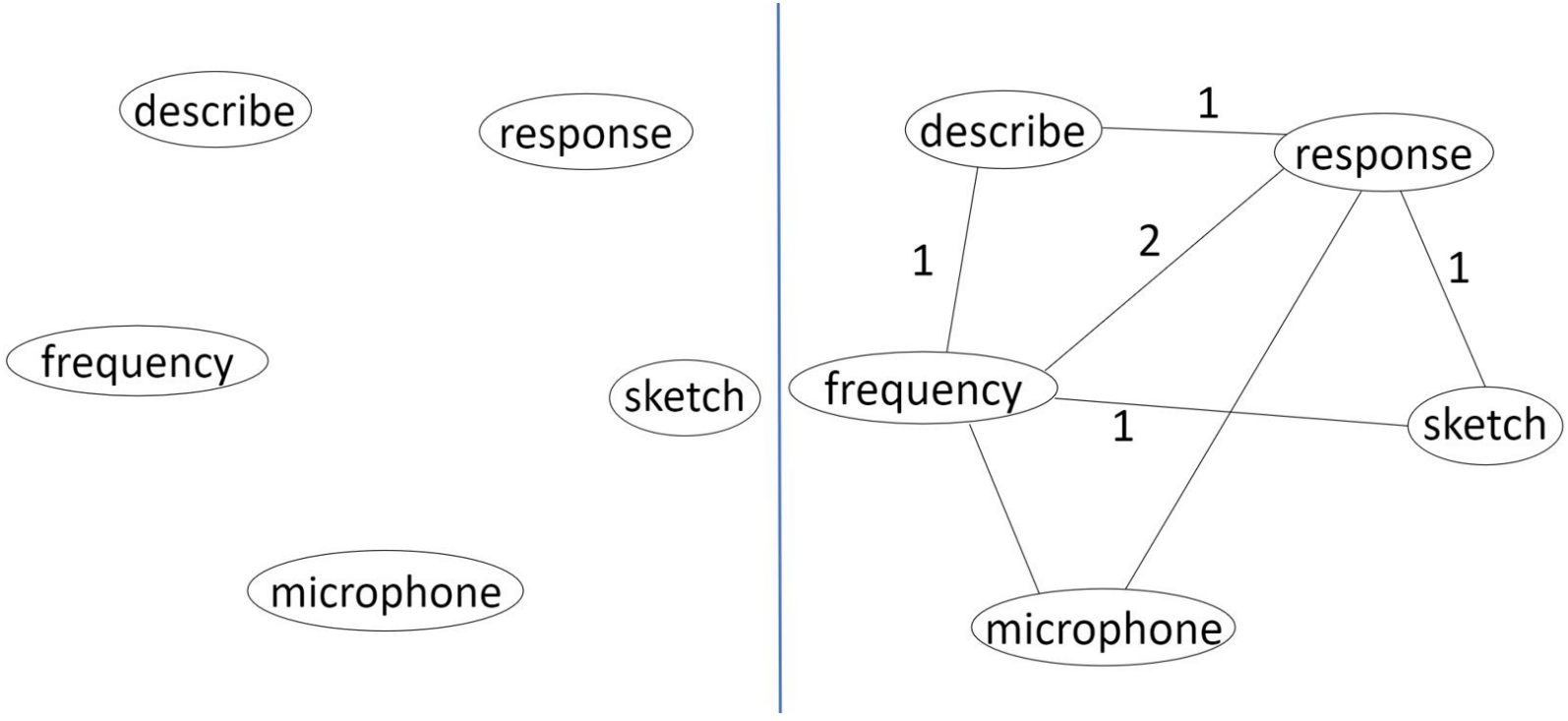
| Question | Ground truth | Predicted label |
|---|---|---|
| Question 1: Describe (T2) frequency (T1) response (T1). | K | T |
| Question 2: Sketch (T2) the frequency (T1) response (T1). | A | A |
| Question 3: Describe (T2) the frequency (T1) response (T1) of a microphone (T2). | T | K |

- Too few words in short texts to determine relationships between co-occurrences of words across questions
- Incorrect grouping of words and topics to determine labels

[2] D. M. Blei, A. Y. Ng, and M. I. Jordan, "Latent Dirichlet allocation," J. Mach. Learn. Res., vol. 3, pp. 993-1022, 2003.

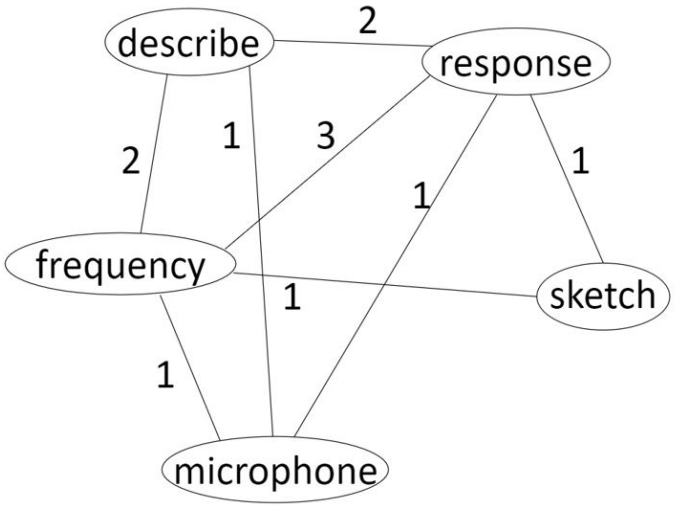
# Existing method - WNTM [3]

- Word level co-occurrences
- Distribution over topics in dense word-word space




[3] Y. Zuo, J. Zhao, and K. Xu, "Word network topic model: A simple but general solution for short and imbalanced texts," Knowledge, Inform. Syst., vol. 48, pp. 379-398, 2016.

# Existing method - WNTM



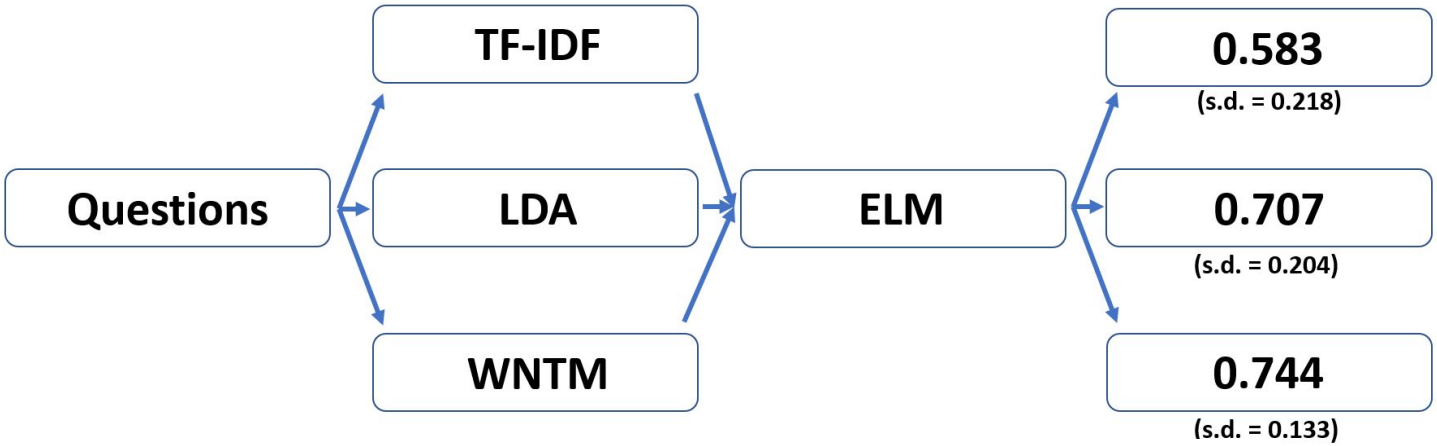

| Word | Pseudo-question |
|---|---|
| describe | frequency response<br>frequency response<br>microphone |
| response | describe frequency sketch<br>frequency describe<br>frequency microphone |
| sketch | frequency response |
| microphone | describe frequency response |
| frequency | describe response sketch<br>response describe<br>response microphone |

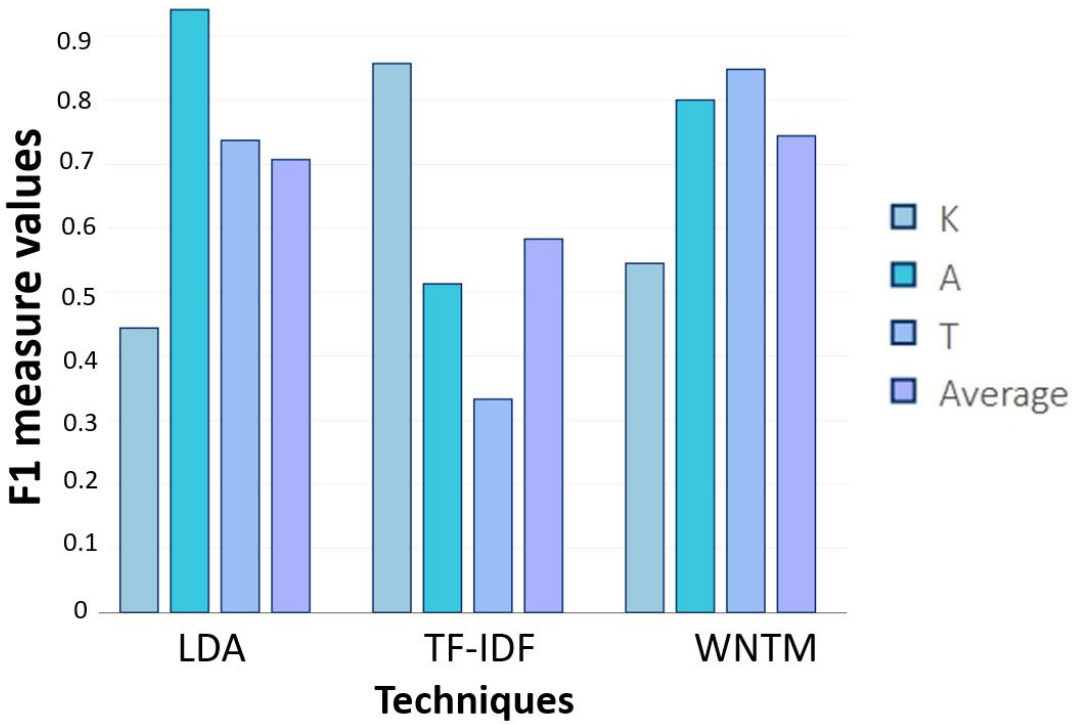
| Question | Ground truth | Predicted label |
|---|---|---|
| Question 1: Describe frequency response. | K | A |
| Question 2: Sketch the frequency response. | A | A |
| Question 3: Describe the frequency response of a microphone. | T | T |

# Dataset

- 150 digital signal processing questions
  - Textbooks, online sources, undergraduate course
- Manual labeling
  - According to “K”, “A”, “T”
  - Independent of content
- Machine learning algorithm
  - 70% questions randomly chosen for training
  - Remaining 30% for testing model

# Comparison of techniques



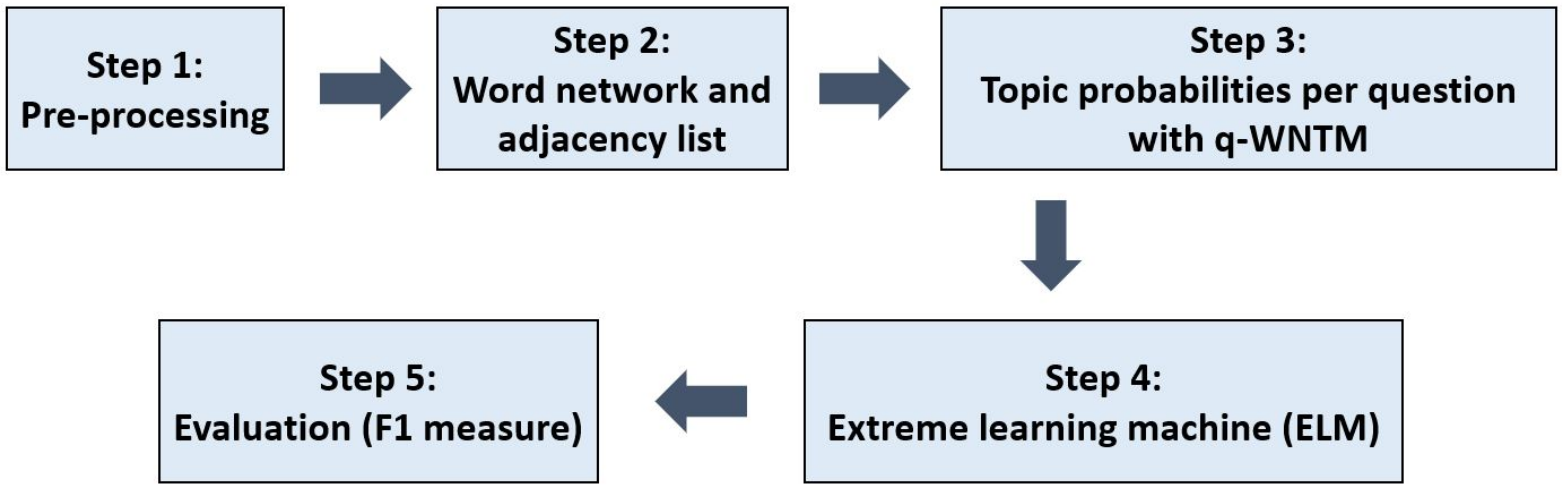



# Customising WNTM

- Stopword selection: Removal of words that cause topics to be overlapped (e.g. articles)
- Redundancy of word combinations which do not contribute to question type
  - Content-agnostic words: "how", "why", "describe"
  - Technical words: "response", "frequency"

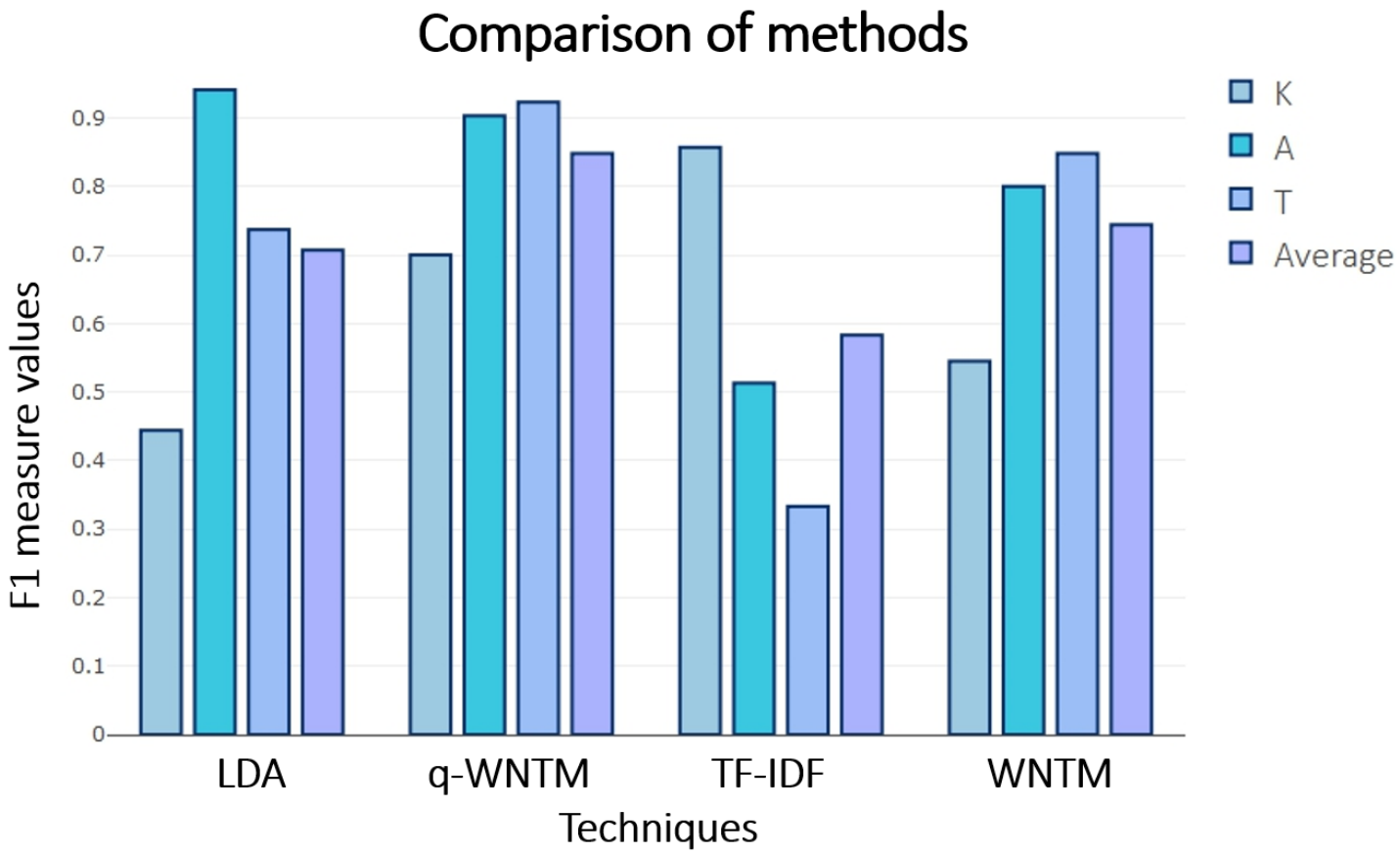
| Word | Pseudo-question |
|---|---|
| describe | frequency response frequency response microphone |
| response | describe ~~frequency~~ sketch ~~frequency~~ describe ~~frequency~~ ~~microphone~~ |
| sketch | frequency response |
| microphone | describe ~~frequency~~ ~~response~~ |
| frequency | describe ~~response~~ sketch ~~response~~ describe ~~response~~ ~~microphone~~ |

# Proposed q-WNTM




- Specific stopwords: *"the"*, *"and"*, *"a"*, *"an"*
- Removed technical-technical word combinations
- Topic representation of technical words closely linked to surrounding agnostic words

# Results (1)




- Mean F1 measure of q-WNTM 0.848, about 10% increase compared to WNTM
- q-WNTM has lowest standard deviation of 0.101

# Results (2)

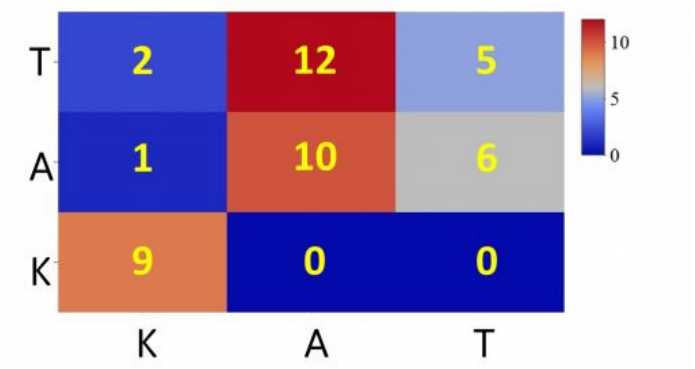



Figure 1: TF-IDF

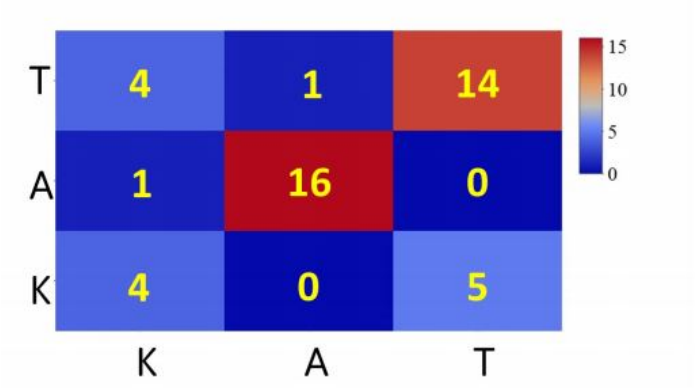



Figure 2: LDA

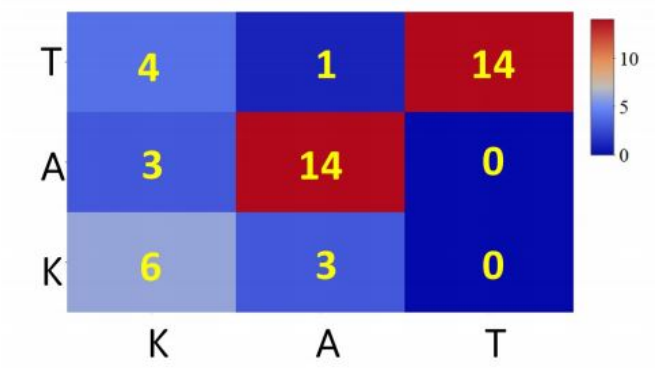



Figure 3: WNTM

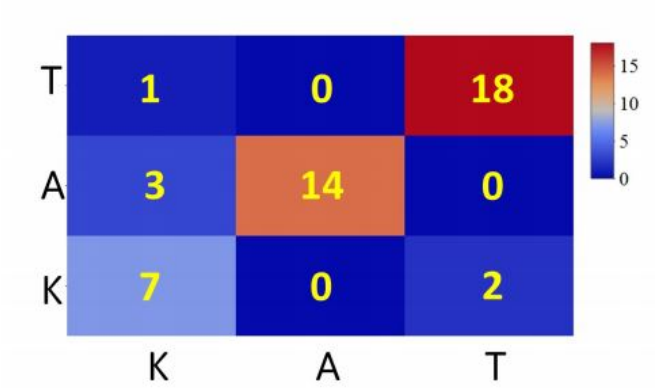



Figure 4: q-WNTM

- q-WNTM minimizes misclassifications

# Conclusions

- Proposed q-WNTM addressed:
  - Appropriate stopword selection for questions
  - Word co-occurrence redundancy which increases co-occurrences amongst agnostic words and reduces relationships with technical words
- Enables more accurate classification of assessment questions in line with intended learning outcomes

# THANK YOU!

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