Appendix I. Training Environment, Hyperparameters, and RTT Settings

Training Environment

All experiments for this work are done on a single NVIDIA A800 GPU on Ubuntu 20.04, python 3.6, torch 1.7, and transformers 4.2.1.

Hyperparameters and RTT Settings

We report the important hyperparameters and datasets of the pre-trained encoder, TNCSE-BERT/RoBERTa(D, UC D), in Table I-1.

TNCSE is divided into two stages of training: the first stage is the pre-training encoder, and the second stage is the training of the dual-tower model, which adds tensor norm constraints. For the first stage, we set the learning rate search space from 1e-5 to 2e-5, and the step size is set to 2.5e-6. The second stage must reduce the learning rate, which is uniformly set to 1e-6.TNCSE-D and TNCSE-UC D are cumulative training, and the learning rate search space and step size are the same as the first stage of TNCSE. The batch size is set to 64, 128, 256, and we do not tune for random seeds, which is uniformly set to 42. We evaluate the performance of the model on the STS-B validation set once every one hundred steps of training, as a checkpoint saved metric.

For the training set, we uniformly employ Wiki1M and unlabelled SICKR. For the selection of RTT languages, four randomly selected languages, en-fr-en, en-ru-en, en-nl-en, and en-zh-en, are used for the first stage of the training of the encoder for TNCSE-BERT/RoBERTa. For the other models in the TNCSE series, we uniformly do not use RTT Data Augmentation.

Appendix II. Impact of Pooling methods

We follow the approach of the SimCSE to take the last hidden state corresponding to the CLS token as the model's output. We further explore the impact of the average pooling of all tokens and pooler output, the experimental results are reported in Table II-1. Average pooling may weaken the features of high-weight outliers. In our approach, the pooler output is only used to assist in optimizing the gradient update of the encoder, which is less rich in semantic distribution information than the last hidden state and results less effectively. CLS pooling aggregates the features of the whole sample and performs best in the STS task.

Pooling Method	CLS	Avg.	Pooler Output
7 STS Avg.	79.58	78.19	69.28

Table II-1: This table reports the impact of pooling methods.

Appendix III. Alignment and Uniformity

Wang and Isola (2020) proposes to use two key metrics, Alignment and Uniformity, to evaluate the representation. Given that a pair of positive samples p_{pos} , l_{align} is defined as the expectation of the second-paradigm of the difference

between the vector representations of this pair of positive samples, defined as Eq. III-1:

$$l_{align} = \mathbf{E}_{(x,x^+ \sim p_{pos})} \| f(x) - f(x^+) \|^2,$$
 (III-1)

where $\|\cdot\|$ denotes the Euclidean paradigm. $l_{uniform}$ is defined as the uniform case of the distribution between sample pair that are mutually soft-negative, defined as Eq. III-2:

$$l_{uniform} = \mathbf{log} \mathbf{E}_{i.i.d} e^{-t \|f(x) - f(y)\|^2}, t > 0, \quad \text{(III-2)} \label{eq:luniform}$$

where $x,y \sim p_{data}$ and t is set to 2. The significance of both of the above in unsupervised comparative learning is that the representations of both mutually positive samples should be close to each other, and the mutually soft-negative samples should be evenly distributed. The smaller both metrics are, the better the model works.

Appendix IV.. Results of MTEB Downstream Experiments

In this section, we report the results of the zero-shot tests of the TNCSE on the MTEB(Muennighoff et al. 2023). For a more comprehensive evaluation, we evaluate the multilingual and cross-lingual STS tasks of TNCSE and baselines on MTEB, reporting STS17 in Table IV-1 and STS22 in Table IV-2, respectively, and the results show that TNCSE is the optimal one. Since we have limited computational resources to evaluate hundreds of other downstream tasks, we randomly select 30 tasks from each of the text classification and retrieval tasks and the nine re-ranking tasks available in the test set to evaluate TNCSE and baselines. The results of these tests are reported in Tables IV-3, IV-4, and IV-5, respectively. The results show that, overall, TNCSE remains the best. All of the above experiments use **Avg** as the primary metric.

References

Muennighoff, N.; Tazi, N.; Magne, L.; and Reimers, N. 2023. MTEB: Massive Text Embedding Benchmark. In Vlachos, A.; and Augenstein, I., eds., *Proceedings of the 17th Conference of the European Chapter of the Association for Computational Linguistics, EACL 2023, Dubrovnik, Croatia, May 2-6, 2023*, 2006–2029. Association for Computational Linguistics.

Wang, T.; and Isola, P. 2020. Understanding Contrastive Representation Learning through Alignment and Uniformity on the Hypersphere. In *Proceedings of the 37th International Conference on Machine Learning, ICML 2020, 13-18 July 2020, Virtual Event*, volume 119 of *Proceedings of Machine Learning Research*, 9929–9939. PMLR.

Model	Learning Rate	Batch Size	Datasets
	T	NCSE-BERT	
Encoder I	1.5e-5	64	Wiki1M+Unlabelled en-fr-en RTT
Encoder II	2e-5	64	Wiki1M+Unlabelled en-ru-en RTT
TNCSE-BERT	1e-6	64	Wiki1M+Unlabelled
+D	1e-5	64	Wiki1M+Unlabelled
+UC D	1.5e-5	64	Wiki1M+Unlabelled
	TNO	CSE-RoBERT	Ta .
Encoder I	1.5e-5	64	Wiki1M+Unlabelled en-nl-en RTT
Encoder II	1.25e-5	64	Wiki1M+Unlabelled en-zh-en RTT
TNCSE-RoBERTa	1e-6	64	Wiki1M+Unlabelled
+D	1e-5	256	Wiki1M+Unlabelled
+UC D	1.5e-5	128	Wiki1M+Unlabelled

Table I-1: We report important hyperparameters for model training.

STS17	SimCSE	ESimCSE	DiffCSE	InfoCSE	SNCSE	WhinenedCSE	RankCSE	TNCSE	+D	+UC D
ar-ar	48.98	52.72	51.00	54.99	35.37	47.79	48.79	53.63	53.00	54.63
en-ar	-2.43	4.60	-4.86	0.13	7.66	-4.09	11.73	-1.94	-1.61	0.21
en-de	27.59	32.13	32.68	39.82	11.64	29.20	28.90	37.95	36.12	39.68
en-en	83.90	85.63	86.26	85.05	53.11	85.15	85.88	85.41	85.36	86.38
en-tr	10.58	10.67	-6.25	6.83	4.11	-9.39	15.58	0.58	0.41	4.01
es-en	12.08	20.38	11.90	20.04	12.46	6.78	13.22	20.16	18.96	22.46
es-es	69.49	71.30	71.87	74.94	56.06	73.27	69.64	72.54	71.95	72.39
fr-en	36.18	28.08	26.71	27.47	12.28	26.50	43.60	40.03	39.49	39.29
it-en	20.08	15.72	11.75	12.63	6.92	13.36	23.39	16.73	14.61	18.51
ko-ko	52.62	49.67	52.00	51.06	39.64	51.00	52.58	52.05	50.86	51.96
nl-en	17.40	21.10	14.65	22.50	9.77	16.34	20.20	22.39	20.38	25.52
Avg.	34.22	35.64	31.61	35.95	22.64	30.54	37.59	36.32	35.41	37.73

Table IV-1: The performance of the TNCSE and baseline models on 11 multilingual/cross-language semantic similarity tasks on the STS17 test set.

STS22	SimCSE	ESimCSE	DiffCSE	InfoCSE	SNCSE	WhitenedCSE	RankCSE	TNCSE	+D	+UC D
ar	38.33	32.48	34.94	21.08	33.58	36.08	35.33	31.26	32.88	34.03
de	24.70	28.50	24.47	18.02	2.58	24.99	24.70	28.04	27.75	29.18
de-en	13.13	29.80	33.63	37.03	20.78	30.33	35.51	33.11	31.83	34.89
de-fr	35.92	32.68	38.29	2.44	25.42	31.45	39.27	35.12	39.16	33.72
de-pl	18.82	12.78	11.30	-26.67	7.08	9.58	5.67	28.52	26.64	23.06
en	59.11	60.66	61.15	54.96	54.23	60.16	62.46	63.23	63.79	63.28
es	49.23	52.14	55.03	49.06	39.98	55.16	54.96	58.14	58.14	58.43
es-en	30.44	37.84	36.83	38.53	21.28	34.14	38.50	39.70	37.45	39.57
es-it	31.48	42.50	40.91	44.44	22.54	31.27	42.16	43.34	44.28	44.58
fr	61.55	61.31	60.06	52.95	31.47	52.96	65.35	66.84	66.36	66.51
fr-pl	39.44	50.71	-5.63	16.90	16.90	16.90	39.44	39.44	39.44	39.44
it	54.67	59.89	57.61	52.94	27.64	53.46	60.60	63.98	63.31	62.98
pl	22.79	26.72	23.77	8.23	6.78	23.42	26.09	25.72	25.79	27.13
pl-en	15.44	36.41	30.43	29.48	28.67	22.82	33.62	35.19	30.77	31.79
ru	15.71	17.87	24.03	6.77	14.03	24.59	18.89	20.37	20.09	20.22
tr	28.09	31.56	29.18	24.27	16.92	28.33	28.61	34.01	34.42	32.61
zh	46.42	37.76	48.78	47.06	40.12	40.45	46.38	43.93	41.83	41.65
zh-en	4.82	9.87	13.14	27.61	15.06	11.94	8.60	18.22	17.94	23.58
Avg.	32.78	36.75	34.33	26.48	23.61	32.67	37.01	39.34	38.95	39.26

Table IV-2: The performance of the TNCSE and baseline models on 18 multilingual/cross-language semantic similarity tasks on the STS22 test set.

Paulgarian/Classification 2443 73.87 76.09 78.17 65.88 75.59 75.61 75.95 77.22 70.00 78.11 20.13 20.13 20.13 20.15 2	Tasks	SimCSE I	SimCSE ESimCSE DiffCSE	DiffCSE	InfoCSE	InfoCSE SNCSE V	WhinenedCSE RankCSE TNCSE	E RankCSE	TNCSE	4D	+OCD
29.29 30.44 31.92 32.58 34.51 31.54 31.54 31.54 30.00 29.56 20.32 20.28 20.91 20.92 20.11 21.21 20.71 21.03 21.07 71.15 68.70 85.23 76.14 70.45 81.82 77.34 89.12 90.00 94.17 70.45 81.82 77.34 89.13 94.17 70.45 88.80 89.29 90.00 94.17 84.38 75.00 40.06 70.60 40.06 70.60 40.06 70.60 70.73 70.40 86.29 73.53 86.29 73.53 86.29 73.53 86.29 73.53 80.88 77.94 80.88 77.94 80.88 77.94 80.88 77.94 80.88 77.94 80.88 77.94 80.88 77.94 80.88 77.94 80.88 77.94 80.88 77.94 80.88 77.94 80.88 77.94 80.88 77.94 80.88 77.94 80.88 77.94 </th <th>Banking77Classification</th> <th>74.43</th> <th>73.87</th> <th>76.09</th> <th>78.17</th> <th>65.88</th> <th>75.59</th> <th>75.69</th> <th>76.10</th> <th>75.98</th> <th>77.22</th>	Banking77Classification	74.43	73.87	76.09	78.17	65.88	75.59	75.69	76.10	75.98	77.22
20.32 20.28 20.91 20.92 20.11 21.21 20.71 21.03 21.07 71.15 68.10 85.23 76.14 70.45 81.82 72.73 70.45 68.18 94.17 84.38 75.00 69.71 67.19 71.15 66.11 69.95 68.99 94.17 84.38 75.00 75.00 40.60 76.56 71.88 79.49 78.90 77.94 83.82 77.94 85.29 73.53 82.35 80.88 77.94 80.88 77.94 83.82 77.94 85.29 75.00 76.00 74.67 74.67 74.97 74.33 74.43 74.43 74.43 74.43 74.33 74.33 74.33 74.43	BulgarianStoreReviewSentimentClassfication	29.29	30.44	31.92	32.58	34.51	31.54	31.54	30.00	29.56	30.22
78.41 75.00 85.23 76.14 70.45 81.82 72.73 70.45 68.18 71.15 63.70 69.71 67.79 71.15 67.07 66.11 69.95 68.99 94.17 88.64 91.36 91.84 89.51 86.02 90.78 89.42 90.00 78.13 84.38 75.00 64.06 76.00 74.07 77.94 80.83 77.94	CSFDCZMovieReviewSentimentClassification	20.32	20.28	20.91	20.92	20.11	21.21	20.71	21.03	21.07	21.30
71.15 63.70 69.71 67.79 71.15 67.07 66.11 69.95 68.99 94.17 88.64 91.36 91.84 89.51 86.02 90.78 89.42 90.00 94.17 88.43 75.00 64.06 76.56 71.88 79.69 78.13 77.94 83.82 77.94 85.29 74.07 74.04 74.03 74.34 38.21 38.40 88.34 38.40 88.74 38.40 87.00	CUADAffiliateLicenseLicensorLegalBenchClassification	78.41	75.00	85.23	76.14	70.45	81.82	72.73	70.45	68.18	72.73
94.17 88.64 91.36 91.84 89.51 86.02 90.78 89.42 90.00 78.13 84.38 75.00 75.00 64.06 76.56 71.88 79.69 78.13 77.94 83.82 77.94 85.29 75.30 76.00 74.67 74.67 74.93 74.34 86.88 77.44 74.47 74.47 74.44 74.74 74.74 74.74 74.74 74.74 77.78 74.07 77.78 74.07 77.74 77.79 74.74 77.22 77.91 88.33 84.00 87.04 87.24 77.01 77.01 77.01 77.01 77.01 77.01 77.01 77.01 77.01 </th <th>CUADChangeOfControlLegalBenchClassification</th> <th>71.15</th> <th>63.70</th> <th>69.71</th> <th>67.79</th> <th>71.15</th> <th>67.07</th> <th>66.11</th> <th>69.95</th> <th>68.99</th> <th>68.03</th>	CUADChangeOfControlLegalBenchClassification	71.15	63.70	69.71	67.79	71.15	67.07	66.11	69.95	68.99	68.03
78.13 84.38 75.00 75.00 64.06 76.56 71.88 79.69 78.13 77.94 83.82 77.94 85.29 73.53 82.35 80.88 77.94 80.88 74.00 73.67 74.33 74.67 76.00 74.67 74.33 74.33 74.00 73.67 74.33 74.67 76.00 60.00	CUADInsuranceLegalBenchClassification	94.17	88.64	91.36	91.84	89.51	86.02	90.78	89.42	90.00	92.62
77.94 83.82 77.94 85.29 73.53 82.35 80.88 77.94 80.88 74.00 73.67 74.33 74.67 76.00 74.67 74.67 74.33 74.33 74.00 73.67 74.33 74.67 76.00 60.00 61.00 60.07 61.67 88.33 59.67 63.00 62.00 61.33 16.35 15.26 15.80 15.53 23.16 16.35 14.71 17.44 17.44 38.21 36.67 37.98 39.41 40.14 38.68 38.74 38.01 37.45 48.56 49.02 47.28 50.62 50.07 47.82 48.94 48.94 77.78 74.07 72.22 57.41 70.69 72.41 72.22 78.74 70.69 72.41 72.22 79.20 84.00 84.00 70.75 77.10 68.65 71.48 64.99 68.85 71.53 79.20 80.66 57.52 <th>CUADMostFavoredNationLegalBenchClassification</th> <th>78.13</th> <th>84.38</th> <th>75.00</th> <th>75.00</th> <th>64.06</th> <th>76.56</th> <th>71.88</th> <th>69.62</th> <th>78.13</th> <th>76.56</th>	CUADMostFavoredNationLegalBenchClassification	78.13	84.38	75.00	75.00	64.06	76.56	71.88	69.62	78.13	76.56
74,00 73,67 74,33 74,67 76,00 74,67 74,67 74,33 74,33 60,00 61,00 60,67 61,67 88.33 59,67 63.00 62.00 61.33 16,35 15.26 15.80 15.53 23.16 16.35 14.71 17.44 17.44 38,21 36,67 37.98 39.41 40.14 38.68 38.74 38.01 37.45 54.26 53.89 54.09 54.56 57.57 54.15 53.44 54.68 55.02 48.56 49.02 47.28 50.62 50.07 47.82 48.13 48.81 48.94 77.78 74.07 72.22 57.41 87.04 72.22 75.93 66.67 77.02 76.00 73.3 74.5 80.67 88.33 84.00 84.00 80.66 77.01 77.79 77.50 77.20 72.23 72.23 72.23 72.23 72.10 72.23 72.10	CUADThirdPartyBeneficiaryLegalBenchClassification	77.94	83.82	77.94	85.29	73.53	82.35	80.88	77.94	80.88	79.41
60.00 61.00 60.67 61.67 88.33 59.67 63.00 62.00 61.34 16.35 15.26 15.80 15.53 23.16 16.35 14.71 17.44 17.44 38.21 36.67 37.98 39.41 40.14 38.68 38.74 38.01 37.45 54.26 53.89 54.09 54.56 57.57 54.15 53.44 54.68 55.02 48.56 49.02 47.28 50.62 50.07 47.82 48.13 48.87 48.94 77.78 74.07 72.22 57.41 87.04 72.22 75.93 66.67 72.22 76.00 79.33 78.33 64.67 80.67 83.33 84.00 84.00 77.79 77.10 68.65 71.48 64.99 68.85 71.53 79.20 80.66 57.52 66.81 60.18 72.41 77.86 72.41 75.20 77.10 65.45 66.81	Diversity2LegalBenchClassification	74.00	73.67	74.33	74.67	76.00	74.67	74.67	74.33	74.33	74.67
16.35 15.26 15.80 15.53 23.16 16.35 14.71 17.44 17.53 17.53 17.53 17.53 <th< th=""><th>Diversity5LegalBenchClassification</th><th>00.09</th><th>61.00</th><th>29.09</th><th>61.67</th><th>88.33</th><th>29.62</th><th>63.00</th><th>62.00</th><th>61.33</th><th>61.00</th></th<>	Diversity5LegalBenchClassification	00.09	61.00	29.09	61.67	88.33	29.62	63.00	62.00	61.33	61.00
38.21 36.67 37.98 39.41 40.14 38.68 38.74 38.01 37.45 54.26 53.89 54.09 54.56 57.57 54.15 53.44 54.68 55.02 48.56 49.02 47.28 50.62 50.07 47.82 48.13 48.87 48.94 77.78 74.07 72.22 57.41 87.04 72.22 75.93 66.67 72.22 76.00 79.33 75.33 69.33 64.67 80.67 83.33 84.00 84.00 78.16 77.59 78.74 70.69 72.41 75.86 75.29 78.16 77.01 70.75 77.10 68.65 71.48 64.99 68.85 71.53 79.20 80.66 57.52 66.81 60.18 62.83 59.29 62.83 66.81 67.17 79.20 80.66 57.52 66.81 60.18 74.55 62.83 62.84 67.23 78.16 67.17 <th>Function Of Decision Section Legal Bench Classification</th> <th>16.35</th> <th>15.26</th> <th>15.80</th> <th>15.53</th> <th>23.16</th> <th>16.35</th> <th>14.71</th> <th>17.44</th> <th>17.44</th> <th>14.44</th>	Function Of Decision Section Legal Bench Classification	16.35	15.26	15.80	15.53	23.16	16.35	14.71	17.44	17.44	14.44
54.26 53.89 54.09 54.56 57.57 54.15 53.44 54.68 55.02 48.56 49.02 47.28 50.62 50.07 47.82 48.13 48.87 48.94 77.78 74.07 72.22 57.41 87.04 72.22 75.93 66.67 72.22 76.00 79.33 75.33 69.33 64.67 80.67 83.33 84.00 84.00 76.00 79.33 75.33 69.33 64.67 80.67 75.29 78.16 72.22 70.75 77.10 68.65 71.48 64.99 68.85 71.53 79.20 80.66 57.52 66.81 60.18 62.83 59.29 62.83 66.81 64.16 67.70 57.52 66.81 60.18 62.83 59.29 62.83 66.81 64.16 67.73 57.52 61.82 77.44 37.94 37.16 67.53 67.53 67.53 67.53 <th>GermanPoliticiansTwitterSentimentClassification</th> <th>38.21</th> <th>36.67</th> <th>37.98</th> <th>39.41</th> <th>40.14</th> <th>38.68</th> <th>38.74</th> <th>38.01</th> <th>37.45</th> <th>37.65</th>	GermanPoliticiansTwitterSentimentClassification	38.21	36.67	37.98	39.41	40.14	38.68	38.74	38.01	37.45	37.65
48.56 49.02 47.28 50.62 50.07 47.82 48.13 48.87 48.99 77.78 74.07 72.22 57.41 87.04 72.22 75.93 66.67 72.22 76.00 79.33 75.33 69.33 64.67 80.67 83.33 84.00 84.00 78.16 77.59 78.74 70.69 72.41 75.86 75.29 78.16 77.01 70.75 77.10 68.65 71.48 64.99 68.85 71.53 79.20 80.66 57.52 66.81 60.18 62.83 59.29 62.83 66.81 64.16 77.01 65.45 61.82 71.48 64.99 68.85 71.53 79.20 80.66 57.52 66.81 60.18 62.83 59.29 62.83 66.81 64.16 67.77 67.94 67.27 65.44 69.09 35.75 56.74 37.94 37.94 37.16 67.53 64.72 <th>IndonesianIdClickbaitClassification</th> <th>54.26</th> <th>53.89</th> <th>54.09</th> <th>54.56</th> <th>57.57</th> <th>54.15</th> <th>53.44</th> <th>54.68</th> <th>55.02</th> <th>55.36</th>	IndonesianIdClickbaitClassification	54.26	53.89	54.09	54.56	57.57	54.15	53.44	54.68	55.02	55.36
77.78 74.07 72.22 57.41 87.04 72.22 75.93 66.67 72.22 76.00 79.33 75.33 69.33 64.67 80.67 83.33 84.00 84.00 78.16 77.59 78.74 70.69 72.41 75.86 75.29 78.16 77.01 70.75 77.10 68.65 71.48 64.99 68.85 71.53 79.20 80.66 57.52 66.81 60.18 62.83 59.29 62.83 66.81 64.16 77.01 65.45 61.82 71.48 64.99 68.85 71.53 79.20 80.66 65.45 66.81 60.18 62.83 59.29 62.83 66.81 64.16 67.71 65.45 61.82 71.44 36.74 37.94 37.16 67.27 65.44 69.09 35.76 66.81 66.81 66.81 64.72 67.24 57.04 57.04 57.04 57.04 57.04 <th>Itacola</th> <th>48.56</th> <th>49.02</th> <th>47.28</th> <th>50.62</th> <th>50.07</th> <th>47.82</th> <th>48.13</th> <th>48.87</th> <th>48.94</th> <th>49.64</th>	Itacola	48.56	49.02	47.28	50.62	50.07	47.82	48.13	48.87	48.94	49.64
76.00 79.33 75.33 69.33 64.67 80.67 83.33 84.00 84.00 78.16 77.59 78.74 70.69 72.41 75.86 75.29 78.16 77.01 70.75 77.10 68.65 71.48 64.99 68.85 71.53 79.20 80.66 57.52 66.81 60.18 62.83 59.29 62.83 66.81 64.16 77.01 65.45 61.82 58.18 60.00 74.55 63.64 67.27 66.81 64.16 63.72 65.09 35.72 36.09 37.44 36.74 37.94 37.16 67.27 65.46 69.09 35.72 36.09 37.44 36.71 60.61 67.53 67.27 63.64 69.09 22.44 15.71 21.47 19.87 24.04 23.08 51.79 25.64 25.04 50.59 51.39 50.29 50.73 53.03 51.88 50.10 52.04 <th>JCrewBlockerLegalBenchClassification</th> <th>77.78</th> <th>74.07</th> <th>72.22</th> <th>57.41</th> <th>87.04</th> <th>72.22</th> <th>75.93</th> <th>29.99</th> <th>72.22</th> <th>68.52</th>	JCrewBlockerLegalBenchClassification	77.78	74.07	72.22	57.41	87.04	72.22	75.93	29.99	72.22	68.52
78.16 77.59 78.74 70.69 72.41 75.86 75.29 78.16 77.01 70.75 77.10 68.65 71.48 64.99 68.85 71.53 79.20 80.66 57.52 66.81 60.18 62.83 59.29 62.83 66.81 64.16 63.72 65.45 61.82 58.18 60.00 74.55 63.64 67.27 66.81 64.16 63.72 35.72 36.09 37.44 36.74 37.94 37.16 66.81 64.16 63.72 22.44 15.71 21.47 19.87 24.04 23.08 21.79 25.64 25.00 22.44 15.71 21.47 19.87 24.04 23.08 21.79 25.64 25.00 55.98 55.76 56.77 58.01 53.55 57.43 55.95 57.18 57.04 57.04 57.04 57.04 57.04 57.04 57.04 57.04 57.04 57.04 57.0	LearnedHandsDivorceLegalBenchClassification	76.00	79.33	75.33	69.33	64.67	29.08	83.33	84.00	84.00	83.33
70.75 77.10 68.65 71.48 64.99 68.85 71.53 79.20 80.66 57.52 66.81 60.18 62.83 59.29 62.83 66.81 64.16 63.72 65.45 61.82 58.18 60.00 74.55 63.64 67.27 66.91 63.72 35.72 36.09 37.44 36.74 37.94 37.16 66.23 36.89 36.72 22.44 15.71 21.47 19.87 24.04 23.08 21.79 25.64 25.00 55.98 55.76 56.77 58.01 53.55 57.25 57.18 50.59 51.39 50.29 57.43 55.95 57.25 57.18 50.59 51.39 50.29 57.43 55.95 57.24 57.04 50.59 51.39 50.25 57.43 57.94 58.04 64.20 60.44 70.63 59.26 73.81 66.14 57.94 58.05 53.03	LearnedHandsDomesticViolenceLegalBenchClassification	78.16	77.59	78.74	69.07	72.41	75.86	75.29	78.16	77.01	76.44
57.52 66.81 60.1862.8359.2962.8366.8164.1663.7265.4561.8258.1860.00 74.55 63.6467.2766.9669.0935.7236.0937.4436.7437.9437.1636.5036.8936.721 62.9964.7266.2372.5160.6167.5367.5364.7264.7222.4415.7121.4719.8724.0423.0821.79 25.6425.00 55.9855.7656.7758.0153.5557.2557.1850.5951.3950.2950.7253.0351.8850.10 52.04 51.6067.4670.6359.26 73.81 66.1448.2860.4252.0451.6069.4768.5066.3171.0169.7864.6068.2171.3268.5756.4827.2028.5328.3029.3728.5954.5154.5354.5958.1558.2657.4458.1556.5354.3054.59	LearnedHandsFamilyLegalBenchClassification	70.75	77.10	68.65	71.48	64.99	68.85	71.53	79.20	80.66	78.52
65.4561.8258.1860.0074.5563.6467.2763.6469.0935.7236.0937.4436.7437.9437.1636.5036.8936.721 62.9964.7266.2372.5160.6167.5367.5364.7264.7222.4415.7121.4719.8724.0423.0821.7925.6425.0055.9855.7656.7758.0153.5557.4355.9557.2557.1850.5951.3950.2950.7253.0351.8850.1052.0451.6067.4670.6359.2673.8166.1457.9458.2063.4964.2969.4768.5066.3171.0169.7864.6068.2171.3268.5726.4827.2028.5328.3029.3728.5956.5354.5157.1027.1254.2758.2657.4458.1556.5354.5458.5954.5358.59	LearnedHandsHealthLegalBenchClassification	57.52	66.81	60.18	62.83	59.29	62.83	66.81	64.16	63.72	65.04
35.72 36.09 37.44 36.74 37.94 37.16 36.50 36.80 36.72 36.89 36.72 1 62.99 64.72 66.23 72.51 60.61 67.53 67.53 64.72 64.72 22.44 15.71 21.47 19.87 24.04 23.08 21.79 25.64 25.00 55.98 55.76 56.77 58.01 53.55 57.43 55.95 57.25 57.18 50.59 51.39 50.29 50.29 53.03 51.88 50.10 52.04 51.60 67.46 70.63 59.26 73.81 66.14 57.94 58.20 63.49 64.29 58.31 59.10 50.66 63.32 46.44 48.28 60.42 53.03 53.56 69.47 68.50 66.31 71.01 69.78 64.60 68.21 71.32 68.57 54.48 57.54 58.53 53.53 54.53 54.53 58.53 <th>LegalReasoningCausalityLegalBenchClassification</th> <th>65.45</th> <th>61.82</th> <th>58.18</th> <th>00.09</th> <th>74.55</th> <th>63.64</th> <th>67.27</th> <th>63.64</th> <th>60.69</th> <th>60.69</th>	LegalReasoningCausalityLegalBenchClassification	65.45	61.82	58.18	00.09	74.55	63.64	67.27	63.64	60.69	60.69
62.99 64.72 66.23 72.51 60.61 67.53 67.53 64.72 64.72 22.44 15.71 21.47 19.87 24.04 23.08 21.79 25.64 25.00 55.98 55.76 56.77 58.01 53.55 57.43 55.95 57.25 57.18 50.59 51.39 50.29 50.72 53.03 51.88 50.10 52.04 51.60 67.46 70.63 59.26 73.81 66.14 57.94 58.20 63.49 64.29 58.31 59.10 50.66 63.32 46.44 48.28 60.42 53.03 53.56 69.47 68.50 66.31 71.01 69.78 64.60 68.21 71.32 68.57 26.48 27.20 28.53 28.33 53.25 54.30 54.55 54.27 52.36 53.25 53.91 56.53 54.30 54.95 58.15 58.26 57.44	MacedonianTweetSentimentClassification	35.72	36.09	37.44	36.74	37.94	37.16	36.50	36.89	36.72	37.38
22.4415.7121.4719.8724.0423.0821.79 25.6425.00 55.9855.7656.7758.0153.5557.4355.9557.2557.1850.5951.3950.2950.7253.0351.8850.10 52.04 51.6067.4670.6359.26 73.81 66.1457.9458.2063.4964.2958.3159.1050.66 63.32 46.4448.2860.4253.0353.5669.4768.5066.3171.0169.7864.6068.2171.3268.5726.4827.2028.5328.3029.3728.5926.0727.1027.1254.2752.3654.5454.2353.2553.91 56.53 54.3054.9558.1558.2657.4458.1558.0557.6058.15 58.3858.39	OPP115UserAccessEditAndDeletionLegalBenchClassification	65.99	64.72	66.23	72.51	60.61	67.53	67.53	64.72	64.72	26.79
55.98 55.76 56.77 58.01 53.55 57.43 55.95 57.25 57.18 50.59 51.39 50.29 50.72 53.03 51.88 50.10 52.04 51.60 67.46 70.63 59.26 73.81 66.14 57.94 58.20 63.49 51.60 58.31 59.10 50.66 63.32 46.44 48.28 60.42 53.03 53.56 69.47 68.50 66.31 71.01 69.78 64.60 68.21 71.32 68.57 26.48 27.20 28.53 28.30 29.37 28.59 26.07 27.10 27.12 54.27 52.36 54.54 54.23 53.25 53.91 56.53 54.30 54.95 58.15 58.15 58.36 58.36 58.38 58.39	Oral Argument Question Purpose Legal Bench Classification	22.44	15.71	21.47	19.87	24.04	23.08	21.79	25.64	25.00	25.00
50.59 51.39 50.29 50.72 53.03 51.88 50.10 52.04 51.60 67.46 70.63 59.26 73.81 66.14 57.94 58.20 63.49 51.60 58.31 59.10 50.66 63.32 46.44 48.28 60.42 53.03 53.56 69.47 68.50 66.31 71.01 69.78 64.60 68.21 71.32 68.57 26.48 27.20 28.53 28.30 29.37 28.59 26.07 27.10 27.12 54.27 52.36 54.54 54.23 53.25 53.91 56.53 54.30 54.95 58.15 58.26 57.44 58.15 58.38 58.38 58.39	PersianFoodSentimentClassification	55.98	55.76	26.77	58.01	53.55	57.43	55.95	57.25	57.18	57.60
67.46 70.63 59.26 73.81 66.14 57.94 58.20 63.49 64.29 64.29 58.31 59.10 50.66 63.32 46.44 48.28 60.42 53.03 53.55 69.47 68.50 66.31 71.01 69.78 64.60 68.21 71.32 68.57 26.48 27.20 28.53 28.30 29.37 28.59 26.07 27.10 27.12 54.27 52.36 54.54 54.23 53.25 53.91 56.53 54.30 54.95 58.15 58.26 57.44 58.15 58.05 57.60 58.15 58.38 58.39	RestaurantReviewSentimentClassification	50.59	51.39	50.29	50.72	53.03	51.88	50.10	52.04	51.60	51.77
58.31 59.10 50.66 63.32 46.44 48.28 60.42 53.03 53.56 69.47 68.50 66.31 71.01 69.78 64.60 68.21 71.32 68.57 26.48 27.20 28.53 28.30 29.37 28.59 26.07 27.10 27.12 54.27 52.36 54.54 54.23 53.25 53.91 56.53 54.30 54.95 58.15 58.26 57.60 58.15 58.38 58.38 58.59	SCDDCertificationLegalBenchClassification	67.46	70.63	59.26	73.81	66.14	57.94	58.20	63.49	64.29	65.34
69.47 68.50 66.31 71.01 69.78 64.60 68.21 71.32 68.57 26.48 27.20 28.53 28.30 29.37 28.59 26.07 27.10 27.12 54.27 52.36 54.54 54.23 53.25 53.91 56.53 54.30 54.95 58.15 58.26 57.44 58.15 58.05 57.60 58.15 58.38 58.59	SCDDTrainingLegalBenchClassification	58.31	59.10	99.09	63.32	46.44	48.28	60.42	53.03	53.56	54.09
tEmotionClassification 26.48 27.20 28.53 28.30 29.37 28.59 26.07 27.10 27.12 27.12 28.50 29.37 28.59 26.07 27.10 27.12 24.50 25.21 24.51 27.12 27.12 27.13 28.51 28.52 27.13	ToxicChatClassification	69.47	68.50	66.31	71.01	82.69	64.60	68.21	71.32	68.57	71.41
tSentimentExtractionClassification 54.27 52.36 54.54 54.23 53.25 53.91 56.53 54.30 54.95 58.05 57.64 58.15 58.05 57.60 58.15 58.38 58.39	TweetEmotionClassification	26.48	27.20	28.53	28.30	29.37	28.59	26.07	27.10	27.12	27.54
58.15 58.26 57.44 58.15 58.05 57.60 58.15 58.38 58.59	TweetSentimentExtractionClassification	54.27	52.36	54.54	54.23	53.25	53.91	56.53	54.30	54.95	55.31
	Avg.	58.15	58.26	57.44	58.15	58.05	27.60	58.15	58.38	58.59	58.84

Table IV-3: We report TNCSE and baselines performance on 30 classification tasks.

Tasks	SimCSE	ESimCSE	DiffCSE	InfoCSE	SNCSE V	VhitenedCSE	RankCSE	TNCSE	Q +	+UC D
AILAStatutes	8.17	9.78	7.03	8.83	7.43	6.25	6.58	9:36	8.84	8.55
AlloprofRetrieval	3.68	6.27	2.71	2.74	2.67	1.56	3.57	6.13	6.46	5.26
ArguAna-PL	5.47	6.65	92.9	8.05	6.58	6.25	4.76	7.39	7.30	8.15
CQADupstackEnglishRetrieval	16.78	16.16	16.61	22.06	13.27	16.68	15.49	15.25	16.31	19.64
CQADupstackGamingRetrieval	23.83	23.51	25.41	31.13	20.73	25.18	22.34	24.92	25.25	29.20
CQADupstackMathematicaRetrieval	4.39	5.33	5.26	68.9	4.41	4.88	5.14	80.9	5.98	7.72
CQADupstackTexRetrieval	4.42	6.40	6.21	8.44	5.77	6.38	5.48	6.57	6.72	8.55
CQADupstackWebmastersRetrieval	13.32	13.41	14.16	16.00	13.49	14.89	12.20	14.31	15.11	17.33
EstQA	21.14	31.41	25.73	28.58	17.63	22.02	19.55	31.17	32.43	31.70
FQuADRetrieval	27.77	25.71	24.55	31.10	19.41	17.30	28.04	27.91	28.58	30.05
GeorgianFAQRetrieval	2.88	2.59	3.45	2.85	3.03	3.16	2.35	3.08	3.40	3.66
GerDaLIRSmall	1.65	1.93	1.60	1.72	1.60	1.38	1.32	1.94	1.95	2.12
GermanGovServiceRetrieval	19.73	28.04	19.45	36.45	12.49	15.37	18.23	28.50	27.15	29.20
GermanQuAD-Retrieval	26.60	37.19	22.51	22.42	24.00	11.63	29.97	38.45	38.21	36.68
JaQuADRetrieval	3.00	3.16	2.72	4.01	3.21	3.27	3.89	4.99	4.53	4.40
LegalBenchCorporateLobbying	77.23	78.34	77.50	78.02	74.84	74.41	69.61	77.18	77.10	78.18
LegalSummarization	45.57	45.80	44.45	46.20	43.43	43.29	44.25	48.62	48.30	20.96
LEMBNarrativeQARetrieval	8.63	8.96	8.36	8.98	7.29	8.20	9.93	11.90	11.13	11.35
LEMBQMSumRetrieval	9.64	11.54	10.10	10.82	9.47	60.6	10.84	12.82	12.47	13.12
LEMBSummScreenFDRetrieval	39.88	45.34	41.75	38.93	28.58	41.46	40.40	52.69	51.54	52.36
LEMBWikimQARetrieval	27.48	26.72	25.67	31.47	27.86	25.77	25.63	29.38	28.50	31.61
MedicalQARetrieval	20.25	18.06	17.35	27.73	17.66	22.09	19.20	21.47	21.81	21.30
NFCorpus	3.66	3.55	3.43	4.4 4	2.51	3.81	2.10	3.97	3.70	3.67
ON	9.79	8.53	9.50	15.84	9.04	9.41	8.51	8.92	10.58	10.93
QuoraRetrieval	75.58	74.23	75.66	77.57	20.06	74.54	76.41	77.08	76.76	78.21
SCIDOCS	4.22	4.26	4.45	2.06	3.97	4.17	3.01	4.37	4.55	4.68
SciFact	32.07	34.37	33.05	34.83	27.34	32.22	23.13	30.65	29.47	33.51
SlovakSumRetrieval	5.51	24.52	10.18	8.71	7.00	5.68	12.13	29.96	30.40	27.86
SyntecRetrieval	26.56	31.72	26.42	25.72	21.15	18.91	25.49	27.52	29.19	34.37
TRECCOVID	0.64	0.56	0.65	0.63	0.56	0.61	0.48	0.53	0.51	0.54
Avg.	18.98	21.13	19.09	21.54	16.88	17.66	18.33	22.10	22.14	23.16

Table IV-4: We report TNCSE and baselines performance on 30 retrieval tasks.

Model	SimCSE	SimCSE ESimCSE	DiffCSE	InfoCSE	SNCSE	WhitenedCSE	RankCSE	INCSE	TNCSE D	TNCSE UCD
AlloprofReranking	30.46	32.74	28.33	27.97	25.31	27.34	29.25	33.63	31.76	33.94
AskUbuntuDupQuestions	51.88	52.28	52.08	52.83	45.53	51.60	53.76	52.44	53.65	52.56
CMedQAv1	13.07	13.63	14.05	17.23	11.01	14.61	14.04	14.42	15.61	14.25
CMedQAv2-reranking	13.97	14.78	15.26	17.21	11.69	15.06	14.47	14.42	16.01	14.68
MMarcoReranking	2.48	3.77	3.64	4.96	2.70	4.02	3.34	3.54	4.32	3.51
SciDocsRR	67.87	70.48	70.37	71.29	58.90	67.63	68.69	69.87	71.47	69.74
StackOverflowDupQuestions	39.57	40.64	42.77	44.21	31.06	42.64	41.18	42.05	43.25	41.94
SyntecReranking	56.53	58.92	51.37	52.87	49.25	53.98	52.43	56.55	57.93	57.40
T2Reranking	55.20	55.87	56.27	56.71	52.10	56.16	55.59	56.44	56.41	56.61
Avg.	36.78	38.12	37.13	38.36	31.95	37.01	37.11	38.15	38.93	38.29

Table IV-5: We report TNCSE and baselines performance on nine reranking tasks.