Descriptives

Number of responses
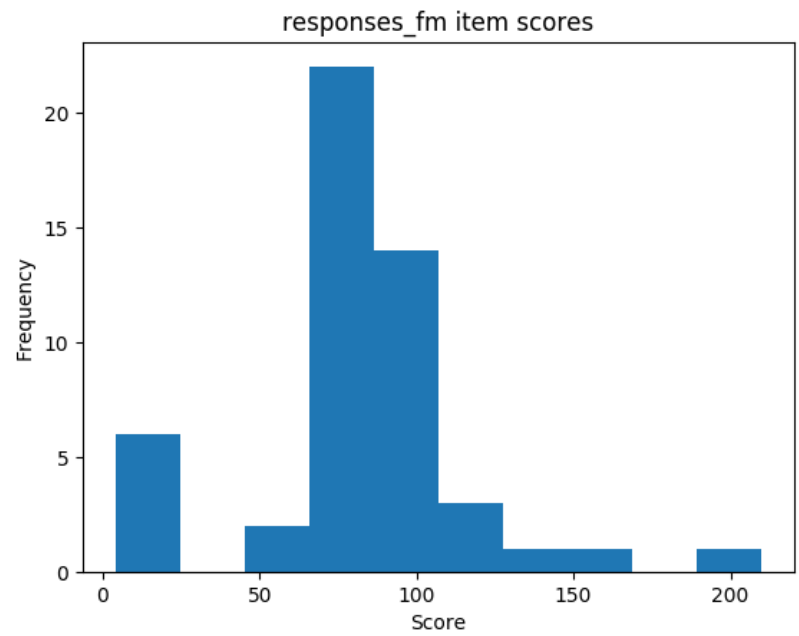
	sample	min	max	mean	variance	skew	kurtosis	normal-t	normal-p	α
abs	12	298	915	408.17	28248.33	2.53	5.26	26.675	0.0000	0.8557
rel	12	6	19	8.87	13.35	2.53	5.26	26.675	0.0000	0.8557
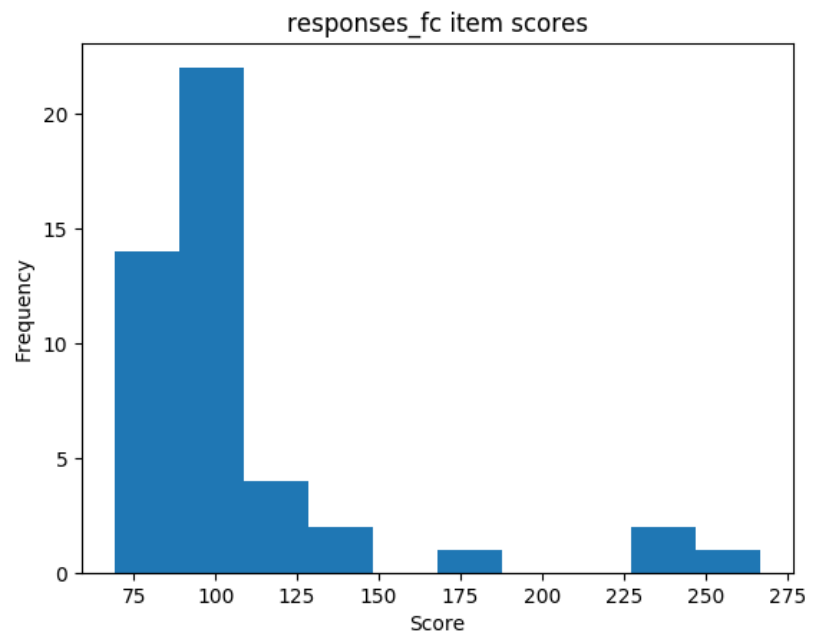
responses_fc item scores

Flashcard conditions

responses_fc person scores
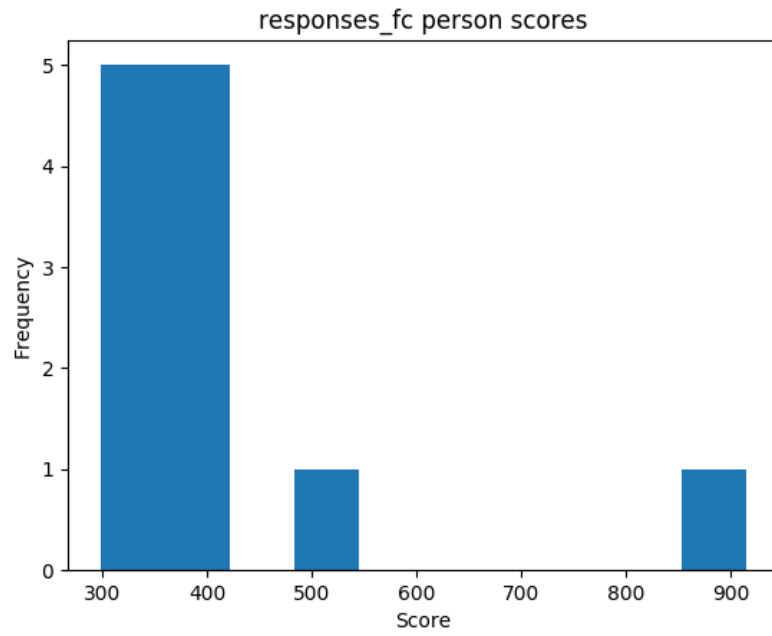
	sample	min	max	mean	variance	skew	kurtosis	normal-t	normal-p	α
abs	11	278	471	374.36	4875.05	0.13	-1.28	1.516	0.4686	0.7098
rel	11	5	9	7.49	1.95	0.13	-1.28	1.516	0.4686	0.7098

responses_fm item scores

Flashmap conditions

responses_fm person scores

3
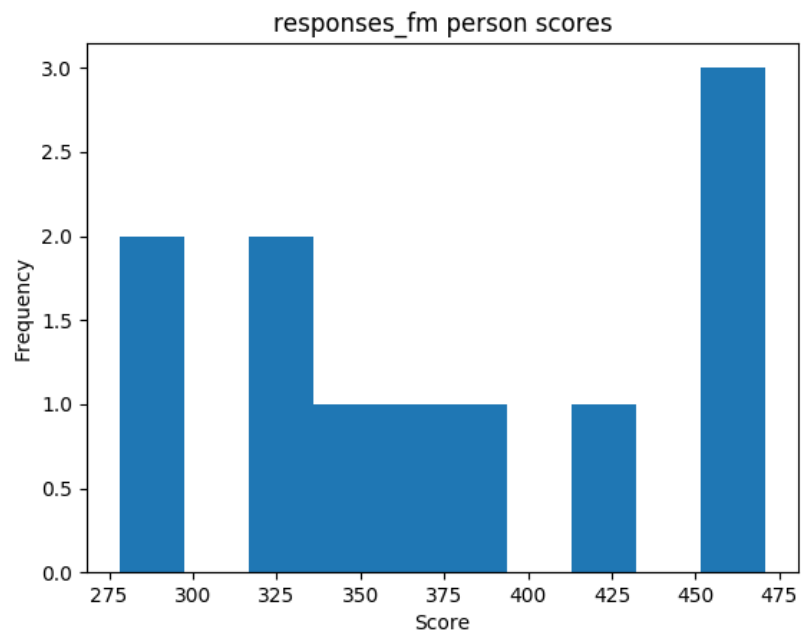
	sample	min	max	mean	variance	skew	kurtosis	normal-t	normal-p	α
abs	23	328	1230	474.74	34192.57	3.12	10.33	41.081	0.0000	0.8731
rel	23	6	24	9.31	13.15	3.12	10.33	41.081	0.0000	0.8731

Combined conditions

4

responses_gen person scores
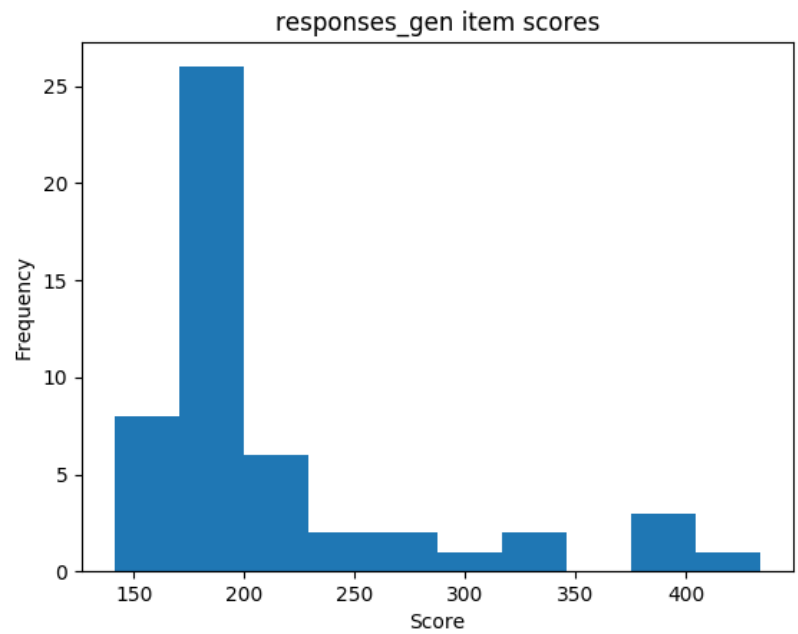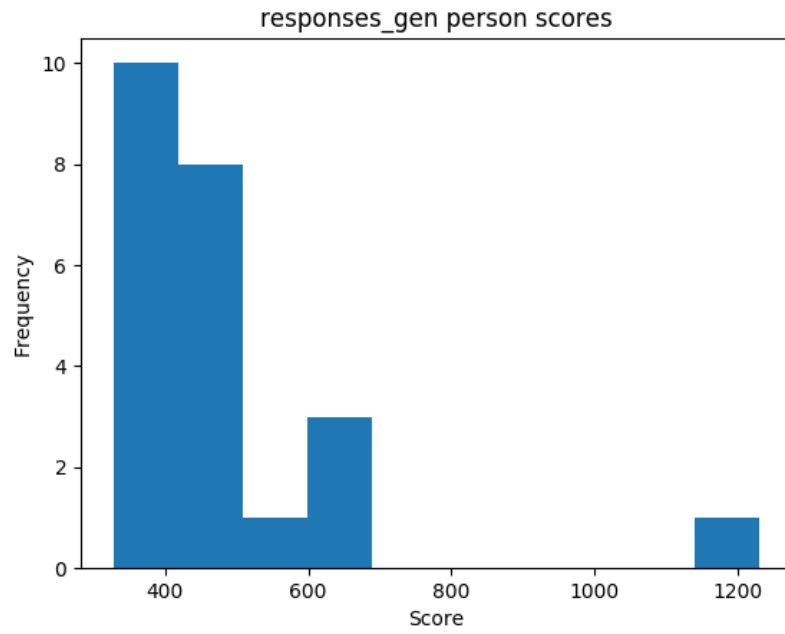
Percentage of responses marked as correct

	sample	min	max	mean	variance	skew	kurtosis	normal-t	normal-p	α
abs	12	35	43	40.42	4.04	-1.15	1.74	8.672	0.0131	0.9106
rel	12	0	0	0.88	0.00	-1.15	1.74	8.672	0.0131	0.9106

score_fc item scores
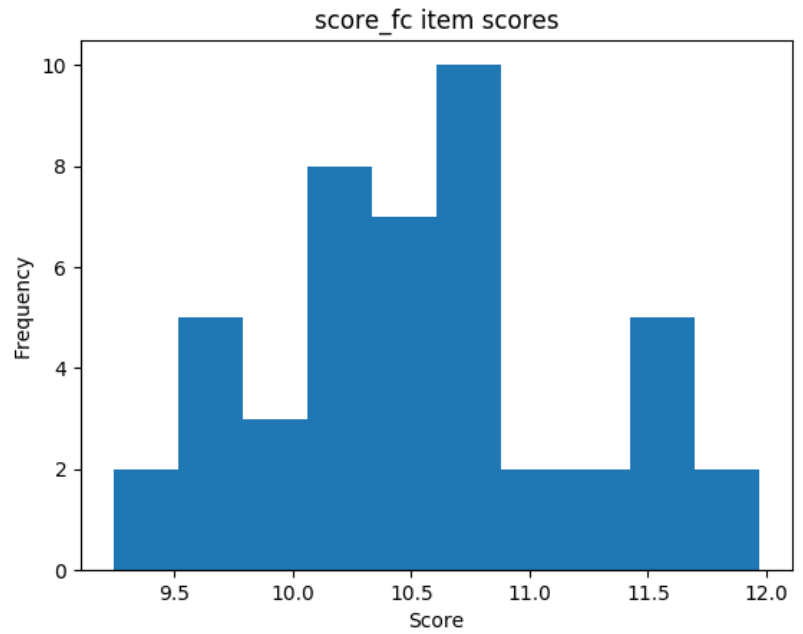
Flashcard conditions

score_fc person scores
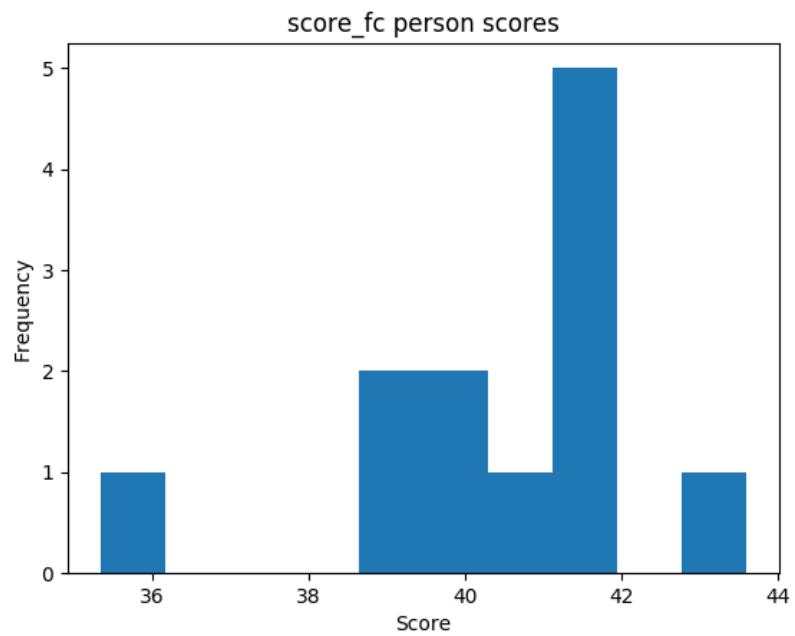
	sample	min	max	mean	variance	skew	kurtosis	normal-t	normal-p	α
abs	11	43	51	47.11	6.19	0.31	-1.17	1.231	0.5404	0.9511
rel	11	0	1	0.92	0.00	0.31	-1.17	1.231	0.5404	0.9511
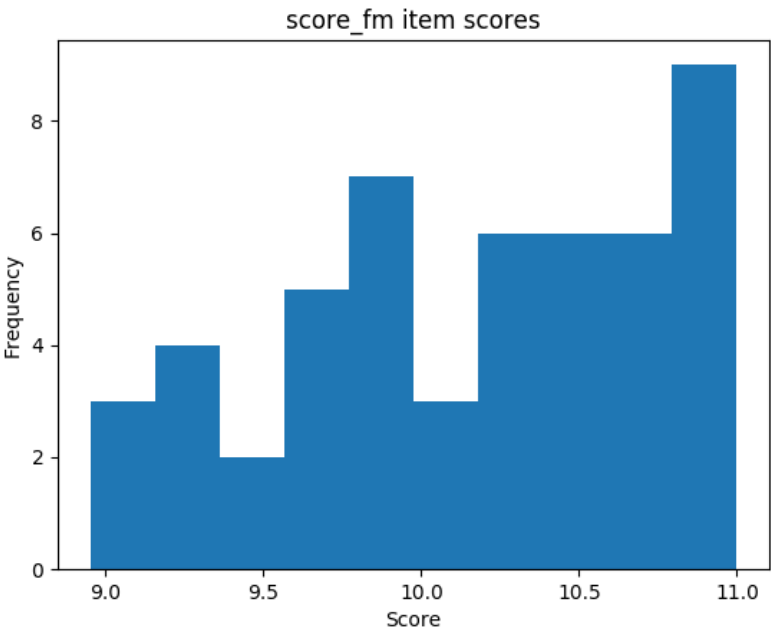
Flashmap conditions

score_fm person scores
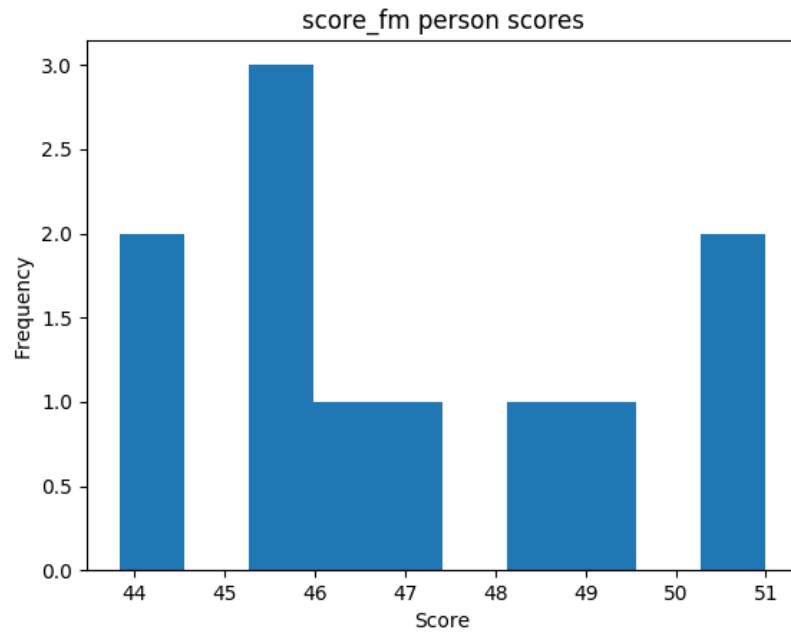
	sample	min	max	mean	variance	skew	kurtosis	normal-t	normal-p	α
abs	23	40	51	45.97	6.47	0.06	0.22	0.711	0.7008	0.9459
rel	23	0	1	0.90	0.00	0.06	0.22	0.711	0.7008	0.9459

score_gen item scores

Combined conditions

score_gen person scores

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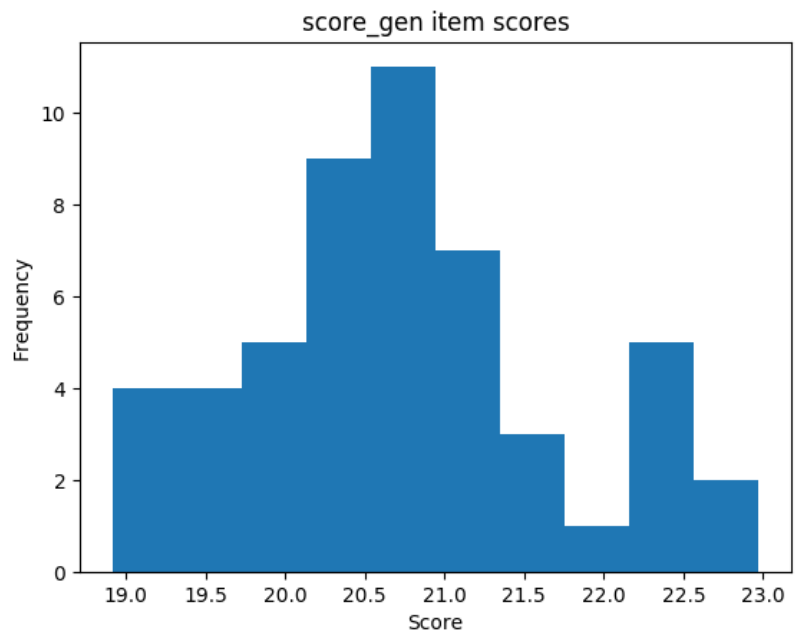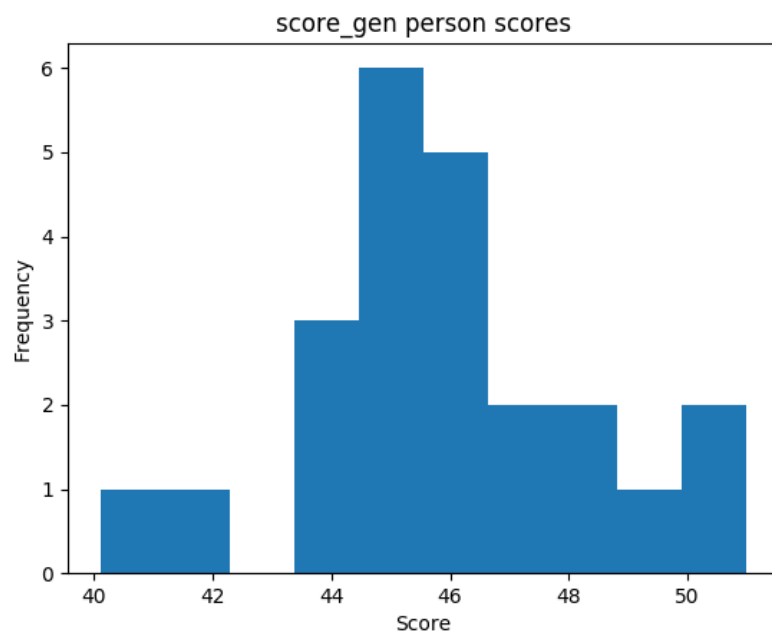
Amount of time spent on the application

	sample	min	max	mean	variance	skew	kurtosis	normal-t	normal-p	α
abs	12	1544	12345	8173.94	10611999.29	-0.77	-0.33	2.156	0.3402	0.8776
rel	12	33	268	177.69	5015.12	-0.77	-0.33	2.156	0.3402	0.8776
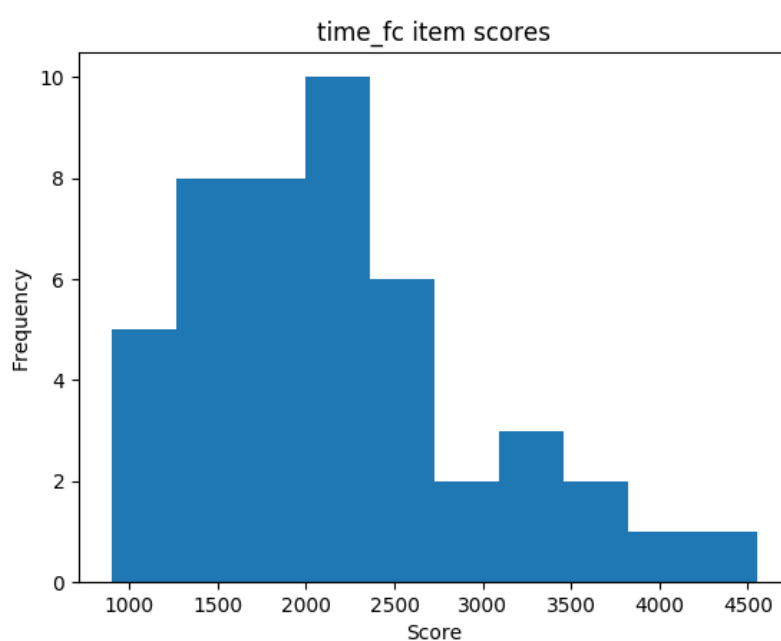
time_fc item scores

Flashcard conditions

time_fc person scores
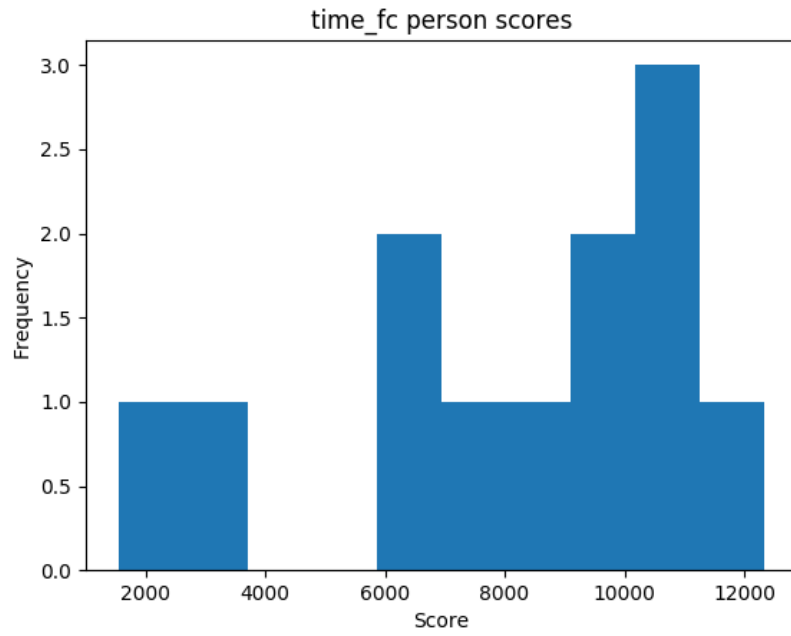
	sample	min	max	mean	variance	skew	kurtosis	normal-t	normal-p	α
abs	11	1707	12233	7221.30	8917086.17	0.05	-0.44	0.092	0.9551	0.8268
rel	11	34	244	144.43	3566.83	0.05	-0.44	0.092	0.9551	0.8268
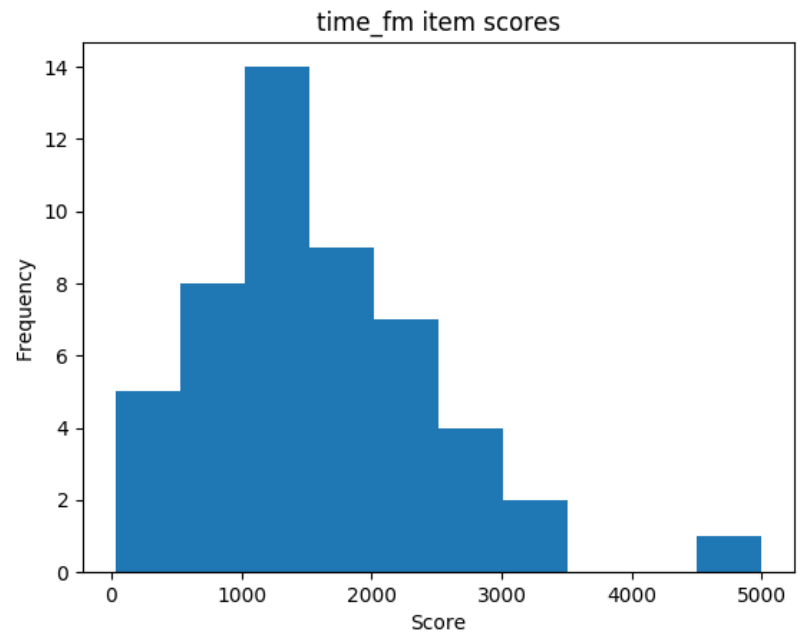
time_fm item scores

Flashmap conditions

time_fm person scores
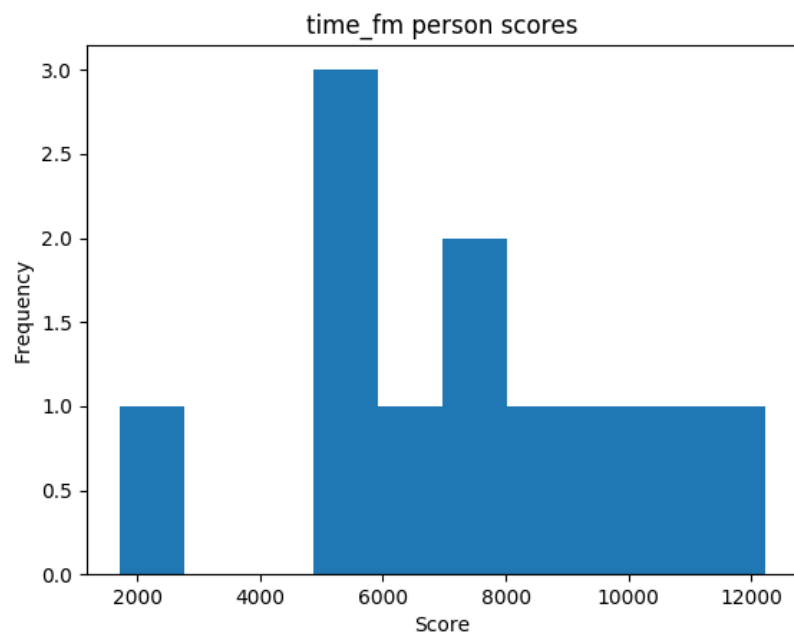
	sample	min	max	mean	variance	skew	kurtosis	normal-t	normal-p	α
abs	23	1426	16484	9283.95	14203173.83	-0.31	-0.29	0.544	0.7617	0.8591
rel	23	27	323	182.04	5460.66	-0.31	-0.29	0.544	0.7617	0.8591

Combined conditions
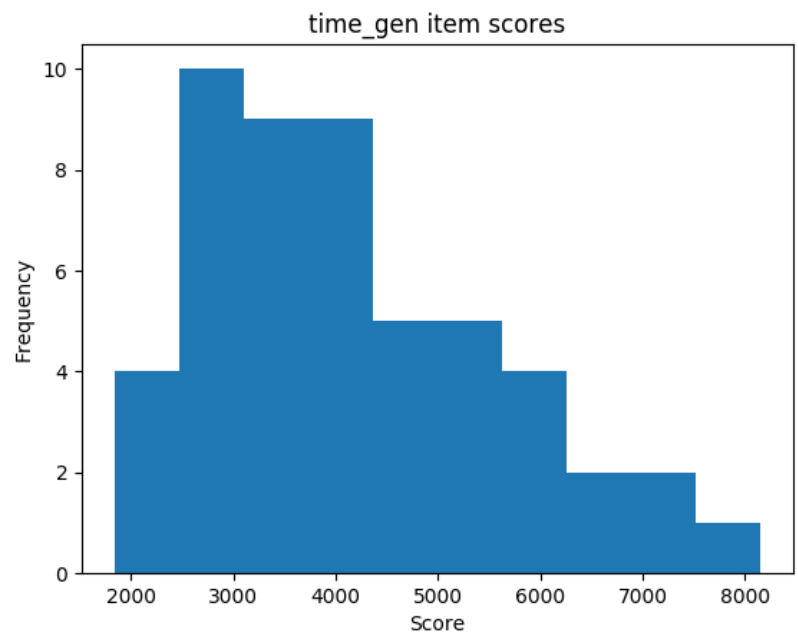
time_gen person scores
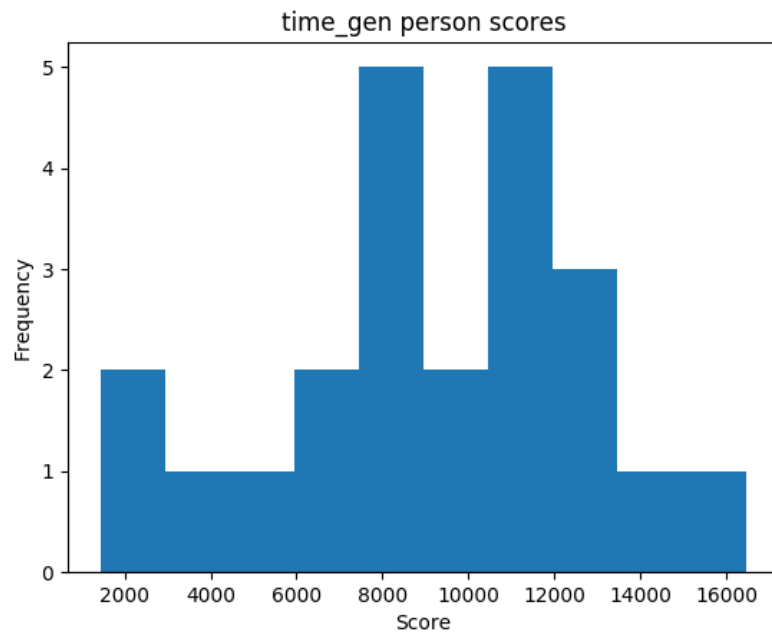
Comparisons

Number of responses

	Mann-Whitney-U k	Mann-Whitney-U p	Welch's t-test k	Welch's t-test p
abs	0.619	0.5426	0.639	0.5324
rel	1.180	0.2513	1.220	0.2420

responses item scores

responses person scores
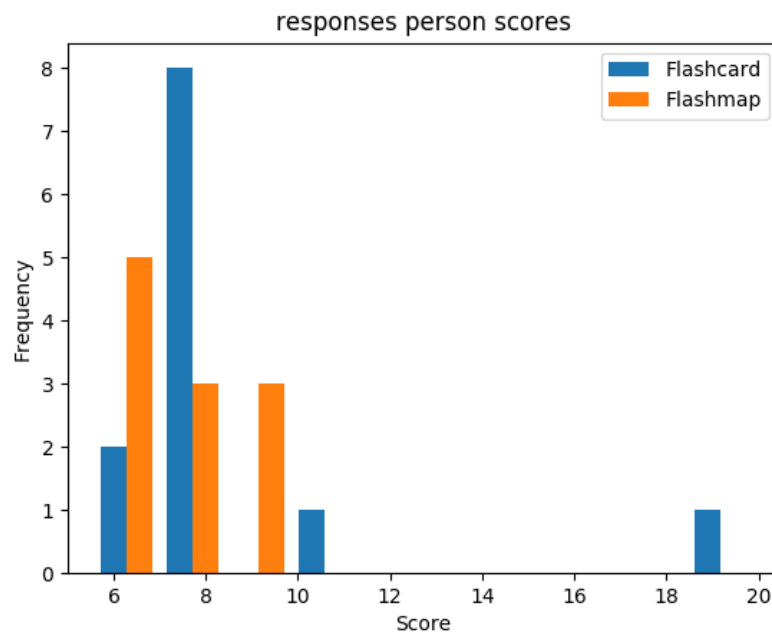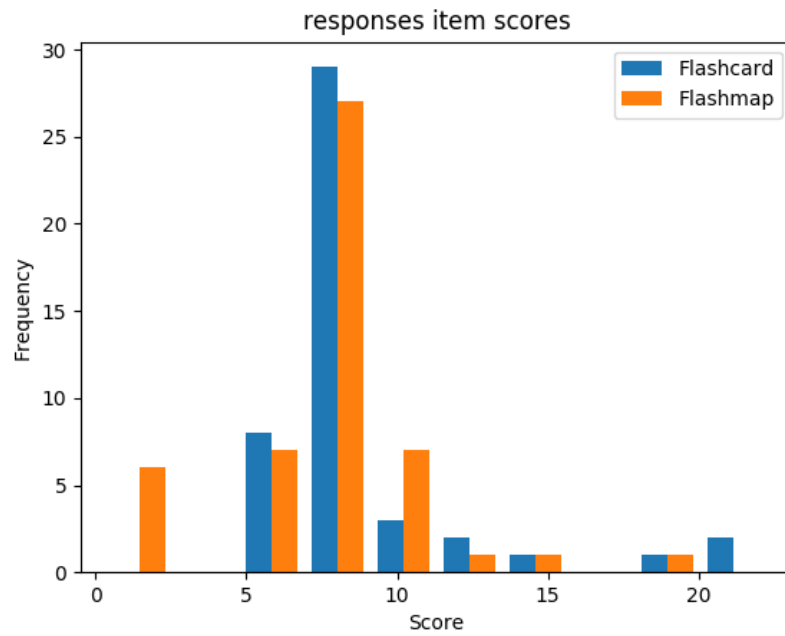
Percentage of responses marked as correct

	Mann-Whitney-U k	Mann-Whitney-U p	Welch's t-test k	Welch's t-test p
abs	-16.597	0.0000	-15.857	0.0000
rel	-16.421	0.0000	-15.689	0.0000

score person scores
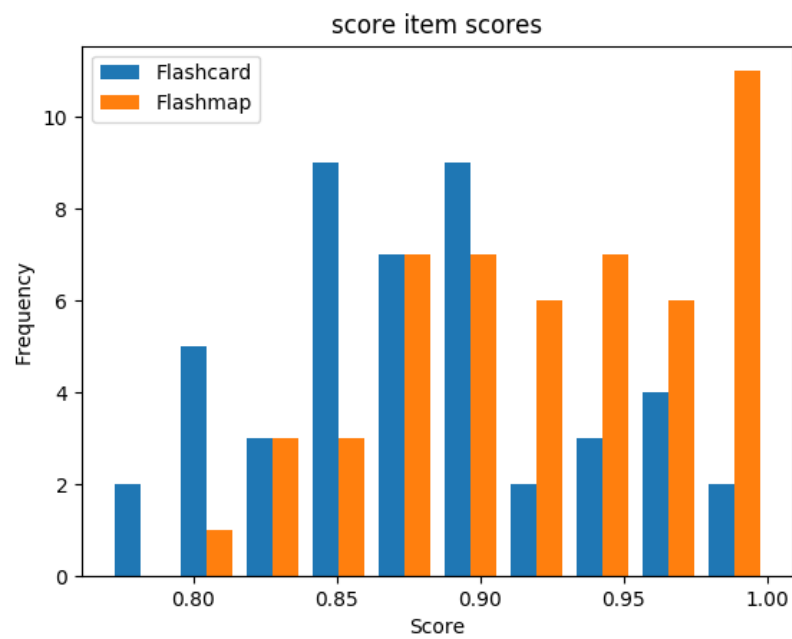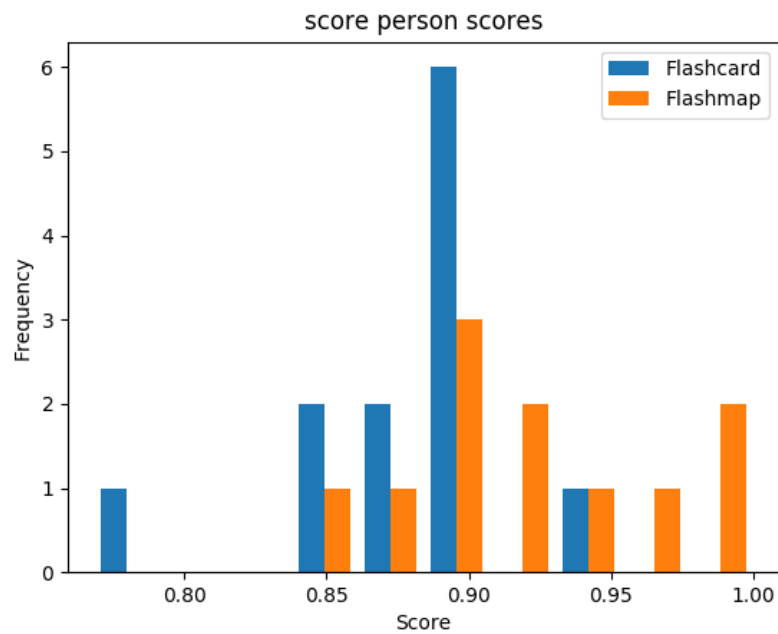
Amount of time spent on the application

	Mann-Whitney-U k	Mann-Whitney-U p	Welch's t-test k	Welch's t-test p
abs	7.924	0.0000	8.292	0.0000
rel	7.954	0.0000	8.324	0.0000

time item scores

time person scores
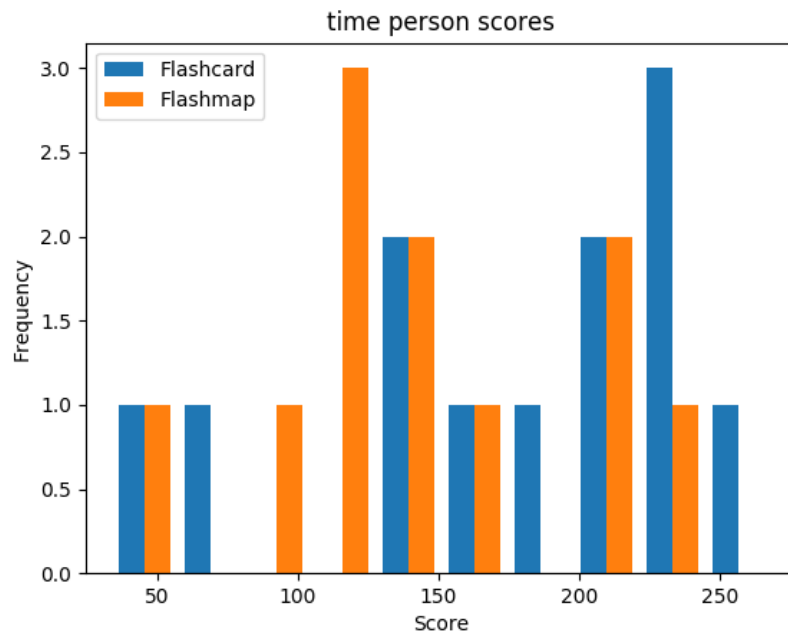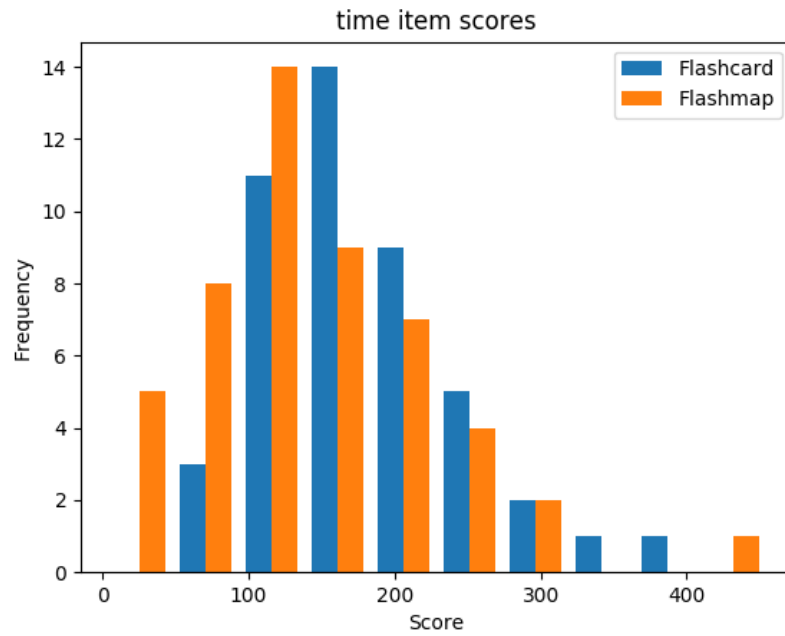
Descriptives

Knowledge questions

	sample	min	max	mean	variance	skew	kurtosis	normal-t	nor
ctt:total	24	0	6	1.29	4.13	1.34	0.40	8.732	
ctt:pretest	12	0	3	0.67	1.15	1.16	-0.19	4.546	
ctt:posttest	12	0	6	1.92	6.63	0.70	-1.29	3.371	
ctt:abs_learn_gain	12	-3	6	1.25	8.39	0.47	-0.84	0.900	
ctt:rel_learn_gain	12	0	0	0.04	0.00	0.43	-0.86	0.810	
irt:total	24	-1	4	-0.03	3.05	1.05	0.04	5.537	
irt:pretest	12	0	0	0.00	0.08	0.62	0.07	2.059	
irt:posttest	12	-2	3	-0.01	2.70	0.61	0.63	3.146	
irt:abs_learn_gain	12	-2	3	-0.01	2.87	0.91	0.61	4.553	
irt:rel_learn_gain	12	0	0	0.02	0.00	0.90	0.59	4.487	
adjusted irt:total	24	-4	3	-0.83	4.14	0.58	-0.36	1.812	
adjusted irt:pretest	12	1	3	2.60	0.17	0.43	0.39	2.010	
adjusted irt:posttest	12	-2	3	-0.07	2.71	0.61	0.63	3.188	
adjusted irt:abs_learn_gain	12	-4	1	-2.67	2.91	1.01	0.64	5.199	
adjusted irt:rel_learn_gain	12	0	0	-0.03	0.00	1.01	0.62	5.132	
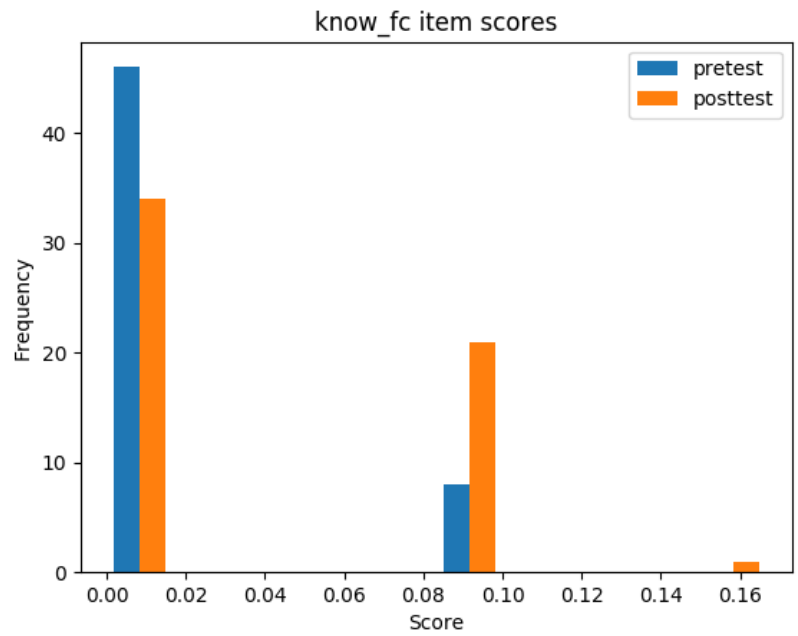
know_fc item scores

Flashcard conditions

know_fc person scores
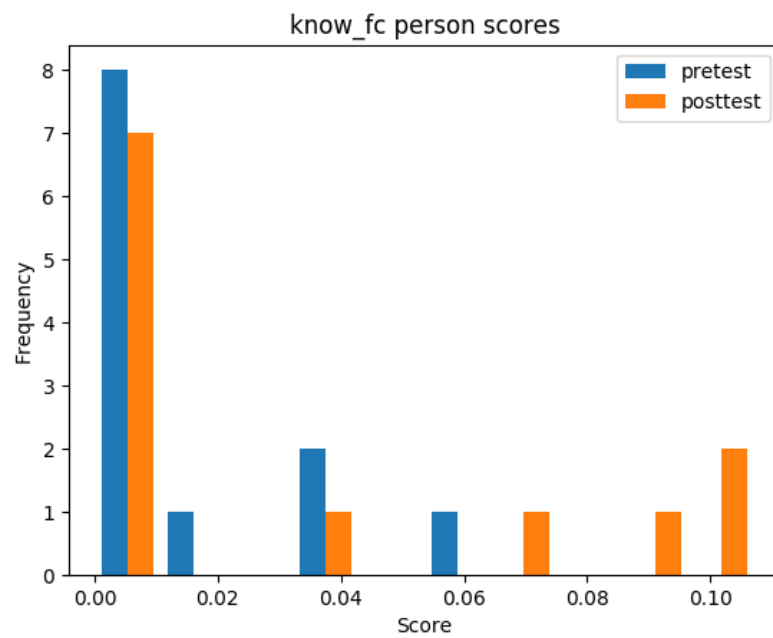
	sample	min	max	mean	variance	skew	kurtosis	normal-t	nor
ctt:total	22	0	7	1.32	4.89	1.48	0.77	10.348	
ctt:pretest	11	0	1	0.18	0.16	1.65	0.72	9.711	
ctt:posttest	11	0	7	2.45	7.27	0.45	-1.31	2.304	
ctt:abs_learn_gain	11	-1	7	2.27	7.42	0.45	-1.14	1.448	
ctt:rel_learn_gain	11	0	0	0.05	0.00	0.44	-1.15	1.490	
irt:total	22	-2	4	-0.03	3.02	0.62	0.46	3.124	
irt:pretest	11	0	0	-0.00	0.00	1.65	0.72	9.711	
irt:posttest	11	-1	1	-0.00	0.76	-0.00	2.50	6.534	
irt:abs_learn_gain	11	-1	1	-0.00	0.76	-0.00	2.50	6.534	
irt:rel_learn_gain	11	0	0	0.02	0.00	0.00	2.50	7.592	
adjusted irt:total	22	-4	3	-0.80	3.94	0.17	0.04	0.556	
adjusted irt:pretest	11	0	0	0.11	0.00	0.00	-3.00	1.057	
adjusted irt:posttest	11	2	4	3.27	0.15	-0.02	2.44	6.403	
adjusted irt:abs_learn_gain	11	2	4	3.17	0.15	-0.02	2.44	6.403	
adjusted irt:rel_learn_gain	11	0	0	0.07	0.00	-0.02	2.44	6.403	

know_fm item scores

Flashmap conditions

know_fm person scores
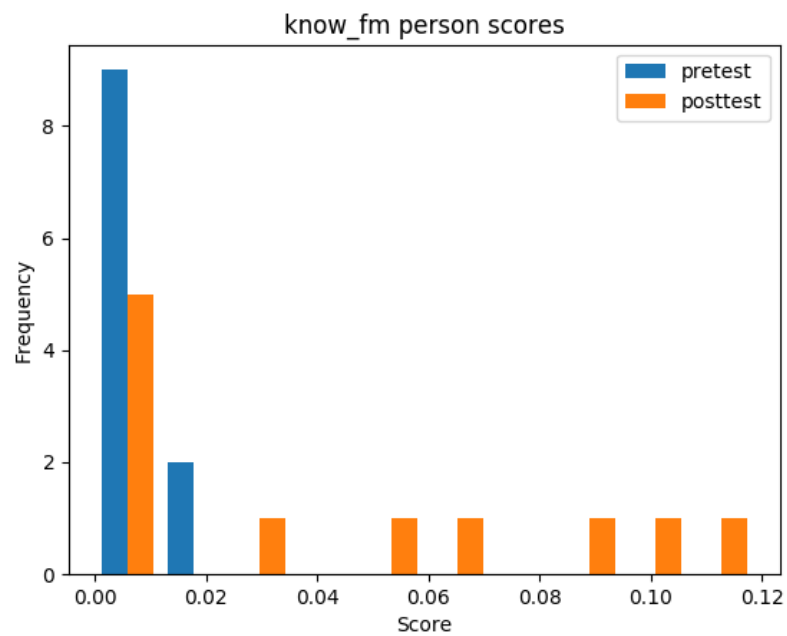
	sample	min	max	mean	variance	skew	kurtosis	normal-t	nor
ctt:total	46	0	7	1.30	4.39	1.42	0.64	14.471	
ctt:pretest	23	0	3	0.43	0.71	1.83	2.28	17.317	
ctt:posttest	23	0	7	2.17	6.70	0.58	-1.30	6.839	
ctt:abs_learn_gain	23	-3	7	1.74	7.84	0.40	-0.93	2.023	
ctt:rel_learn_gain	23	0	0	0.03	0.00	0.39	-0.93	1.977	
irt:total	46	-3	5	-0.10	4.92	0.98	-0.23	7.303	
irt:pretest	23	-2	2	-0.00	1.22	0.97	2.19	9.614	
irt:posttest	23	-3	3	-0.02	3.68	0.87	-0.19	3.757	
irt:abs_learn_gain	23	-4	4	-0.02	5.31	0.42	-0.29	0.967	
irt:rel_learn_gain	23	0	0	0.01	0.00	0.38	-0.27	0.833	
adjusted irt:total	46	-5	3	-1.85	5.68	0.80	-0.29	5.224	
adjusted irt:pretest	23	-2	2	-0.01	1.22	0.98	2.19	9.677	
adjusted irt:posttest	23	-4	3	-0.88	5.74	0.31	-0.53	0.564	
adjusted irt:abs_learn_gain	23	-7	4	-0.88	8.23	-0.21	0.11	0.742	
adjusted irt:rel_learn_gain	23	0	0	0.00	0.00	-0.26	0.19	1.015	

know_gen item scores

General

know_gen person scores
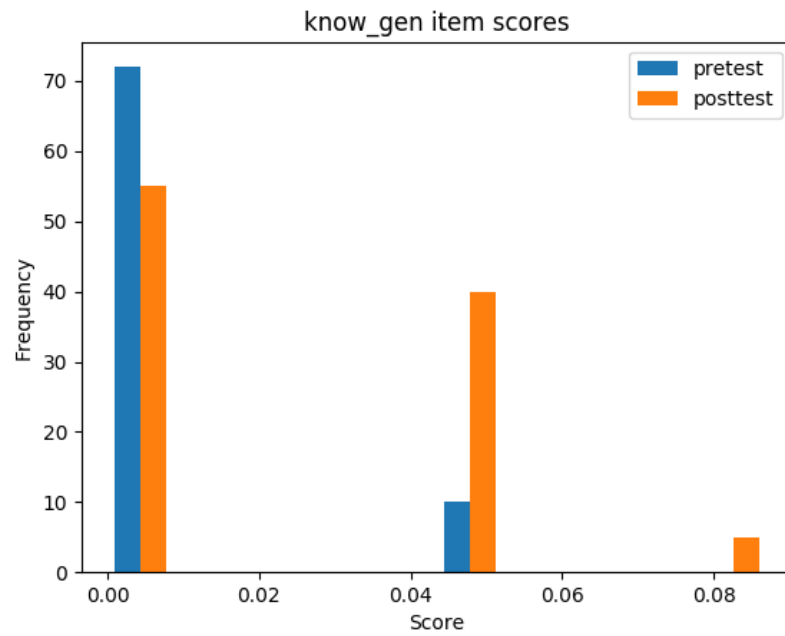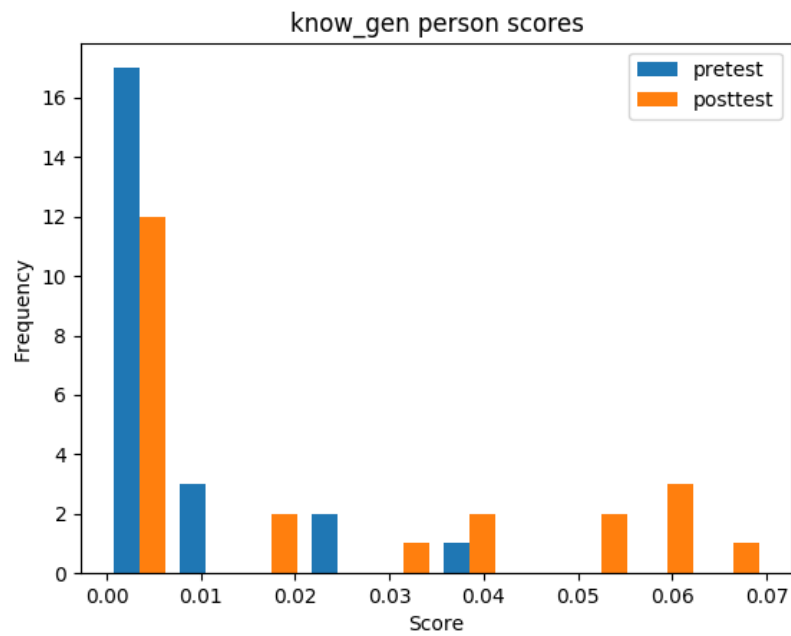
Comprehension questions

	sample	min	max	mean	variance	skew	kurtosis	normal-t	nor
ctt:total	24	0	6	1.33	4.23	1.19	-0.05	6.646	
ctt:pretest	12	0	4	0.33	1.33	3.02	7.09	33.648	
ctt:posttest	12	0	6	2.33	5.33	0.41	-1.25	2.077	
ctt:abs_learn_gain	12	0	6	2.00	5.45	0.72	-0.96	2.091	
ctt:rel_learn_gain	12	0	0	0.07	0.00	0.72	-0.95	2.097	
irt:total	24	-2	4	0.05	4.71	0.80	-0.83	4.030	
irt:pretest	12	-1	4	-0.09	2.62	2.47	5.19	26.077	
irt:posttest	12	-2	2	0.01	3.51	0.00	-1.31	1.869	
irt:abs_learn_gain	12	-3	3	0.10	5.54	-0.07	-1.19	1.211	
irt:rel_learn_gain	12	0	0	0.02	0.00	-0.15	-1.11	0.886	
adjusted irt:total	24	-3	3	-1.15	3.83	0.90	-0.52	4.058	
adjusted irt:pretest	12	0	5	0.42	2.58	2.72	6.04	29.551	
adjusted irt:posttest	12	-3	1	-0.87	3.16	0.03	-1.30	1.835	
adjusted irt:abs_learn_gain	12	-5	2	-1.28	5.01	-0.15	-1.04	0.652	
adjusted irt:rel_learn_gain	12	0	0	-0.01	0.00	-0.29	-0.81	0.411	

comp_fc item scores

Flashcard conditions

comp_fc person scores

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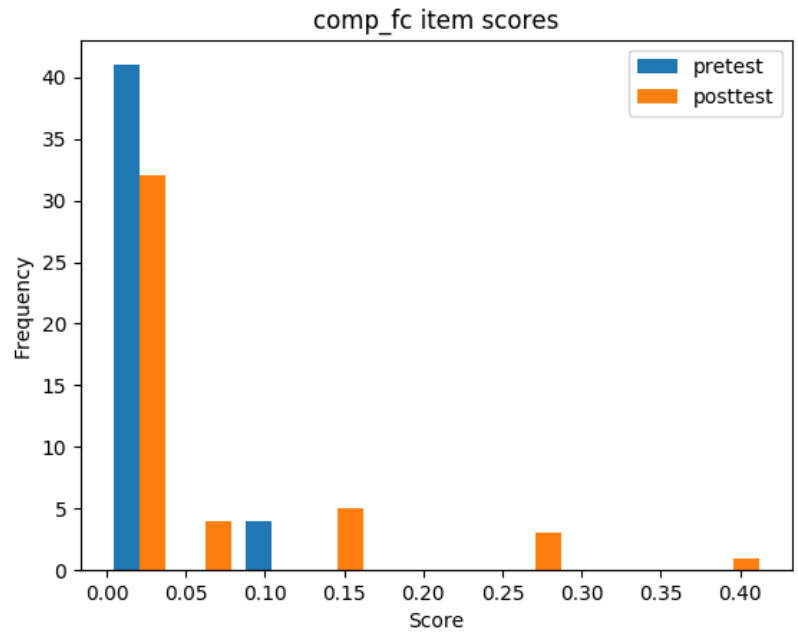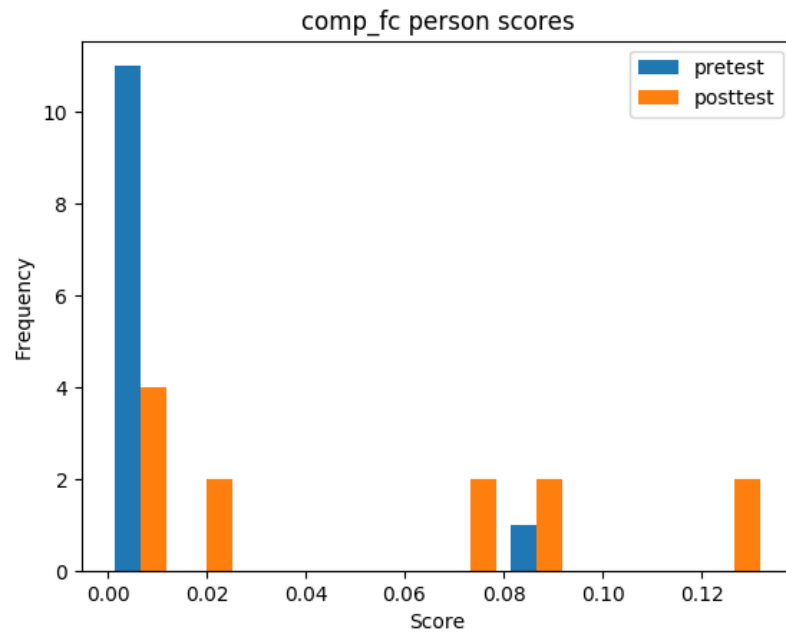
Flashmap conditions

	sample	min	max	mean	variance	skew	kurtosis	normal-t	nor
ctt:total	22	0	8	1.27	3.92	2.06	4.13	22.828	
ctt:pretest	11	0	4	0.82	1.56	1.64	1.82	12.332	
ctt:posttest	11	0	8	1.73	6.22	1.58	1.62	11.397	
ctt:abs_learn_gain	11	-1	4	0.91	2.89	1.04	-0.35	3.526	
ctt:rel_learn_gain	11	0	0	0.04	0.00	1.09	-0.23	3.961	
irt:total	22	-1	3	0.01	2.83	0.65	-1.02	3.743	
irt:pretest	11	-1	3	-0.00	2.98	0.91	-0.34	2.786	
irt:posttest	11	-2	2	0.01	3.41	0.19	-1.62	4.801	
irt:abs_learn_gain	11	-1	2	0.01	1.71	1.00	-0.12	3.564	
irt:rel_learn_gain	11	0	0	0.02	0.00	0.99	-0.11	3.521	
adjusted irt:total	22	-1	3	0.05	2.92	0.66	-1.01	3.727	
adjusted irt:pretest	11	0	4	1.54	2.10	0.93	-0.32	2.893	
adjusted irt:posttest	11	-1	3	0.57	3.81	0.15	-1.64	5.133	
adjusted irt:abs_learn_gain	11	-2	1	-0.97	1.88	1.08	0.01	4.284	
adjusted irt:rel_learn_gain	11	0	0	0.00	0.00	1.08	0.01	4.277	

comp_fm item scores

comp_fm person scores
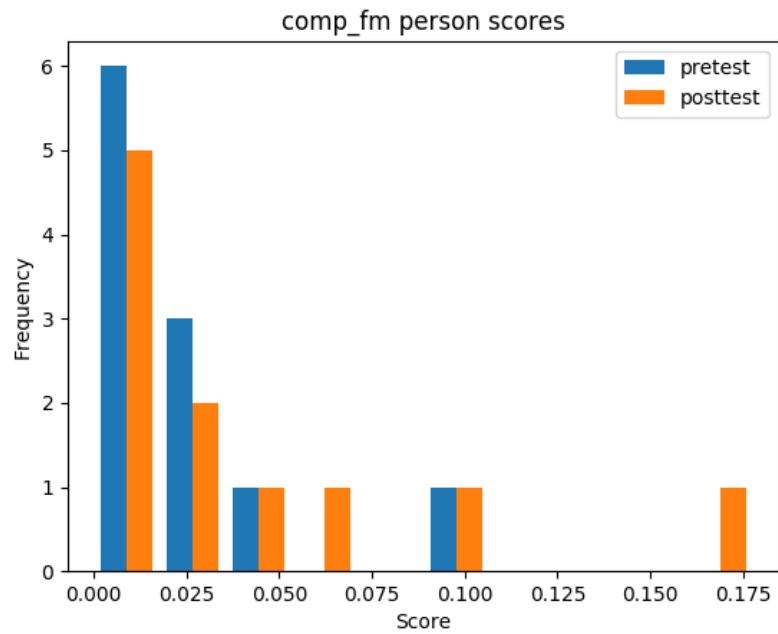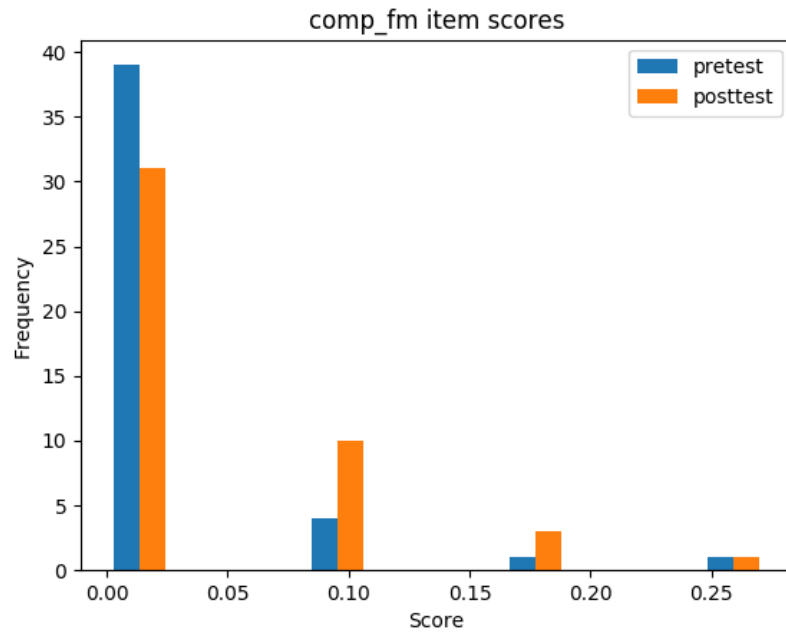
General

	sample	min	max	mean	variance	skew	kurtosis	normal-t	no
ctt:total	46	0	8	1.30	3.99	1.58	1.77	19.890	
ctt:pretest	23	0	4	0.57	1.44	2.19	3.53	23.159	
ctt:posttest	23	0	8	2.04	5.59	0.98	-0.02	4.808	
ctt:abs_learn_gain	23	-1	6	1.48	4.35	0.97	-0.34	4.419	
ctt:rel_learn_gain	23	0	0	0.05	0.00	0.95	-0.42	4.277	
irt:total	46	-1	3	0.00	2.33	0.81	-0.90	8.324	
irt:pretest	23	-1	4	0.01	2.56	1.65	1.53	13.943	
irt:posttest	23	-1	2	0.00	2.04	0.19	-1.52	11.285	
irt:abs_learn_gain	23	-3	3	-0.01	2.86	0.32	-0.85	1.311	
irt:rel_learn_gain	23	0	0	0.02	0.00	0.24	-0.77	0.786	
adjusted irt:total	46	-2	2	-0.62	2.30	0.82	-0.86	8.005	
adjusted irt:pretest	23	-1	4	0.04	2.52	1.66	1.54	13.979	
adjusted irt:posttest	23	-1	2	-0.23	1.97	0.17	-1.56	12.676	
adjusted irt:abs_learn_gain	23	-3	2	-0.26	2.85	0.27	-0.87	1.246	
adjusted irt:rel_learn_gain	23	0	0	0.02	0.00	0.18	-0.76	0.640	

comp_gen item scores

comp_gen person scores
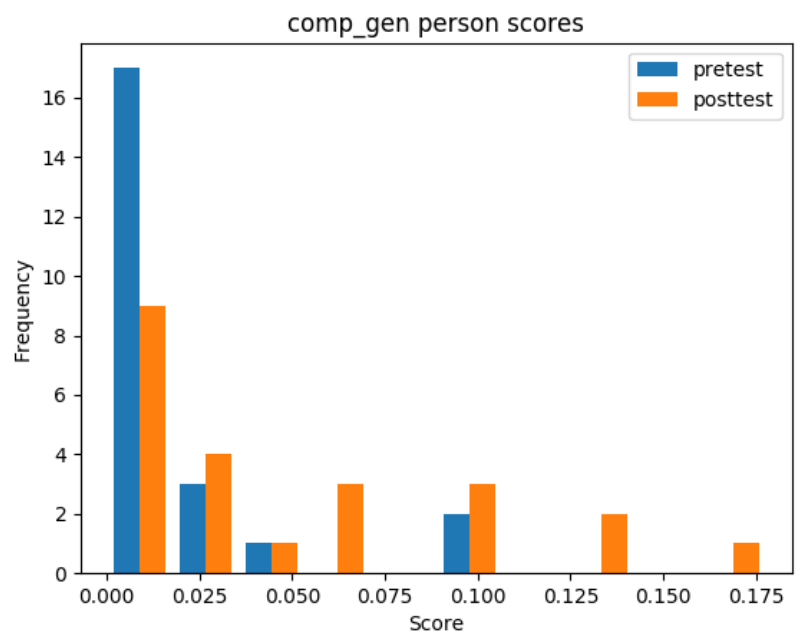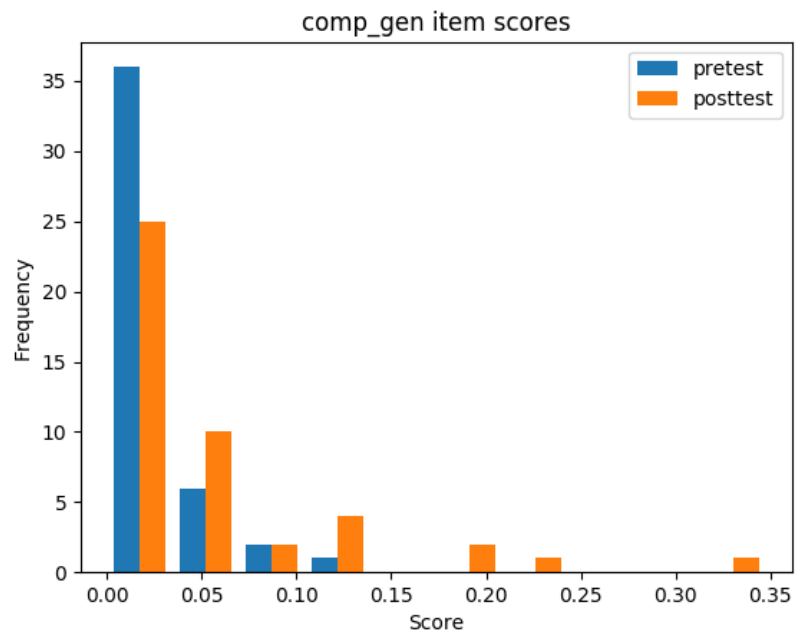
Comparisons

Knowledge questions

Between pre- and posttest

	Mann-Whitney-U k	Mann-Whitney-U p	Welch's t-test k	Welch's t-test p
ctt	-1.552	0.1348	-1.552	0.1418
irt	0.016	0.9872	0.016	0.9873
adjusted irt	5.454	0.0000	5.454	0.0001

Flashcard condition

	Mann-Whitney-U k	Mann-Whitney-U p	Welch's t-test k	Welch's t-test p
ctt	-2.764	0.0120	-2.764	0.0192
irt	-0.000	1.0000	-0.000	1.0000
adjusted irt	-27.206	0.0000	-27.206	0.0000

Flashmap condition

	Mann-Whitney-U k	Mann-Whitney-U p	Welch's t-test k	Welch's t-test p
ctt	-3.065	0.0037	-3.065	0.0049
irt	0.051	0.9597	0.051	0.9598
adjusted irt	1.591	0.1187	1.591	0.1217

Combined

Between conditions

	Mann-Whitney-U k	Mann-Whitney-U p	Welch's t-test k	Welch's t-test p
total	-0.042	0.9664	-0.042	0.966

	Mann-Whitney-U k	Mann-Whitney-U p	Welch's t-test k	Welch's t-test p
pretest	1.407	0.1739	1.456	0.166
posttest	-0.489	0.6297	-0.488	0.630
abs_learn_gain	-0.870	0.3940	-0.873	0.392
rel_learn_gain	-0.747	0.4635	-0.751	0.461

ctt

	Mann-Whitney-U k	Mann-Whitney-U p	Welch's t-test k	Welch's t-test p
total	-0.001	0.9989	-0.001	0.998
pretest	0.000	1.0000	0.000	1.000
posttest	-0.014	0.9889	-0.014	0.988
abs_learn_gain	-0.014	0.9892	-0.014	0.988
rel_learn_gain	0.072	0.9436	0.074	0.942

irt

	Mann-Whitney-U k	Mann-Whitney-U p	Welch's t-test k	Welch's t-test p
total	-0.050	0.9602	-0.050	0.960
pretest	20.261	0.0000	21.204	0.000
posttest	-6.549	0.0000	-6.821	0.000
abs_learn_gain	-11.067	0.0000	-11.531	0.000
rel_learn_gain	-10.401	0.0000	-10.845	0.000

know_gain item scores

adjusted irt

know_gain person scores
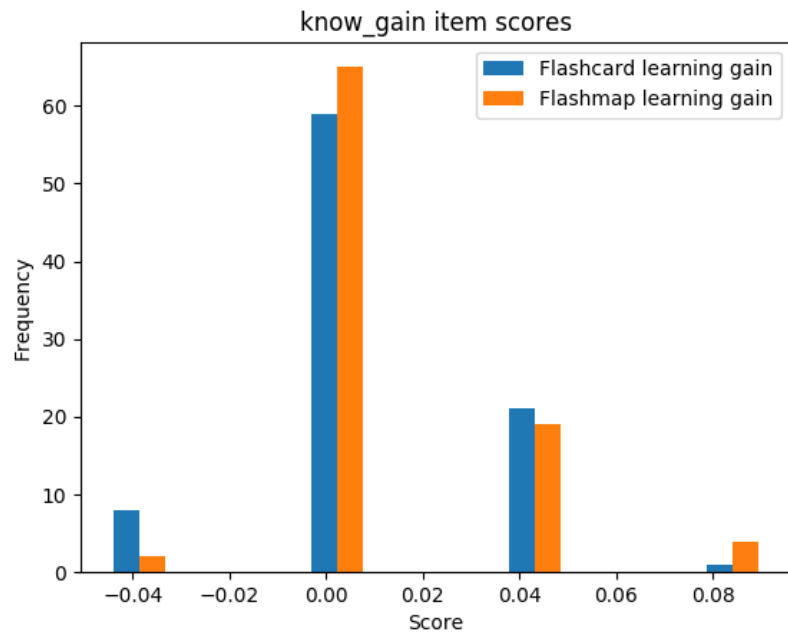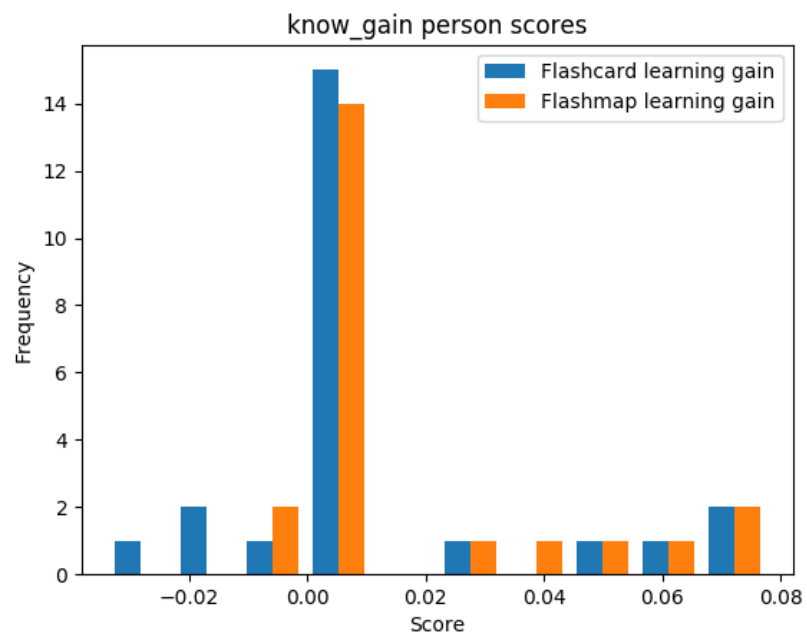
Comprehension questions

Between pre- and posttest

	Mann-Whitney-U k	Mann-Whitney-U p	Welch's t-test k	Welch's t-test p
ctt	-2.683	0.0136	-2.683	0.0162
irt	-0.146	0.8852	-0.146	0.8852
adjusted irt	1.856	0.0768	1.856	0.0770

Flashcard condition

	Mann-Whitney-U k	Mann-Whitney-U p	Welch's t-test k	Welch's t-test p
ctt	-1.081	0.2926	-1.081	0.2971
irt	-0.018	0.9854	-0.018	0.9854
adjusted irt	1.318	0.2024	1.318	0.2036

Flashmap condition

	Mann-Whitney-U k	Mann-Whitney-U p	Welch's t-test k	Welch's t-test p
ctt	-2.674	0.0105	-2.674	0.0116
irt	0.023	0.9818	0.023	0.9818
adjusted irt	0.595	0.5549	0.595	0.5549

Combined

Between conditions

	Mann-Whitney-U k	Mann-Whitney-U p	Welch's t-test k	Welch's t-test p
total	0.102	0.9195	0.102	0.919
pretest	-0.967	0.3446	-0.963	0.346

	Mann-Whitney-U k	Mann-Whitney-U p	Welch's t-test k	Welch's t-test
posttest	0.605	0.5515	0.603	0.553
abs_learn_gain	1.270	0.2179	1.288	0.212
rel_learn_gain	1.197	0.2448	1.211	0.239

ctt

	Mann-Whitney-U k	Mann-Whitney-U p	Welch's t-test k	Welch's t-test
total	0.071	0.9436	0.072	0.943
pretest	-0.132	0.8961	-0.132	0.896
posttest	-0.002	0.9982	-0.002	0.998
abs_learn_gain	0.112	0.9116	0.115	0.909
rel_learn_gain	0.064	0.9496	0.066	0.948

irt

	Mann-Whitney-U k	Mann-Whitney-U p	Welch's t-test k	Welch's t-test
total	-2.188	0.0340	-2.202	0.033
pretest	-1.748	0.0950	-1.756	0.093
posttest	-1.849	0.0785	-1.842	0.080
abs_learn_gain	-0.407	0.6882	-0.415	0.682
rel_learn_gain	-0.455	0.6537	-0.465	0.647

comp_gain item scores

adjusted irt

comp_gain person scores
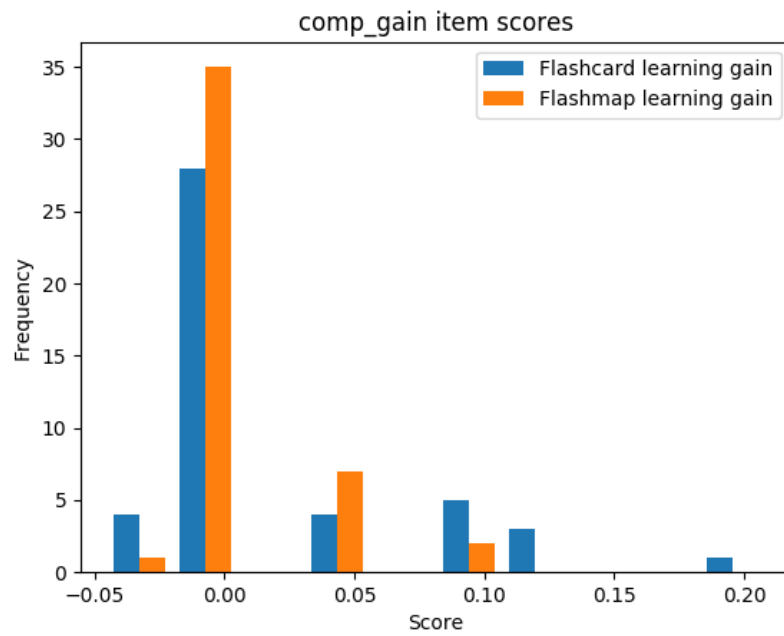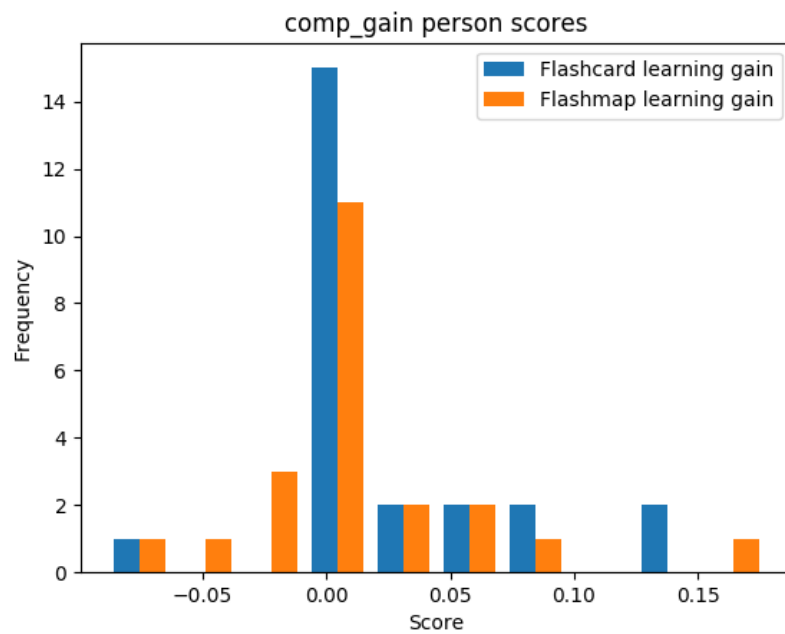
Descriptives

Usefulness

	sample	min	max	mean	variance	skew	kurtosis	normal-t	normal-p	α
ctt	12	-4	14	6.50	27.36	-0.57	-0.52	1.144	0.5643	0.6432
irt	12	-5	1	-0.16	4.40	-1.89	3.15	17.284	0.0002	0.6263
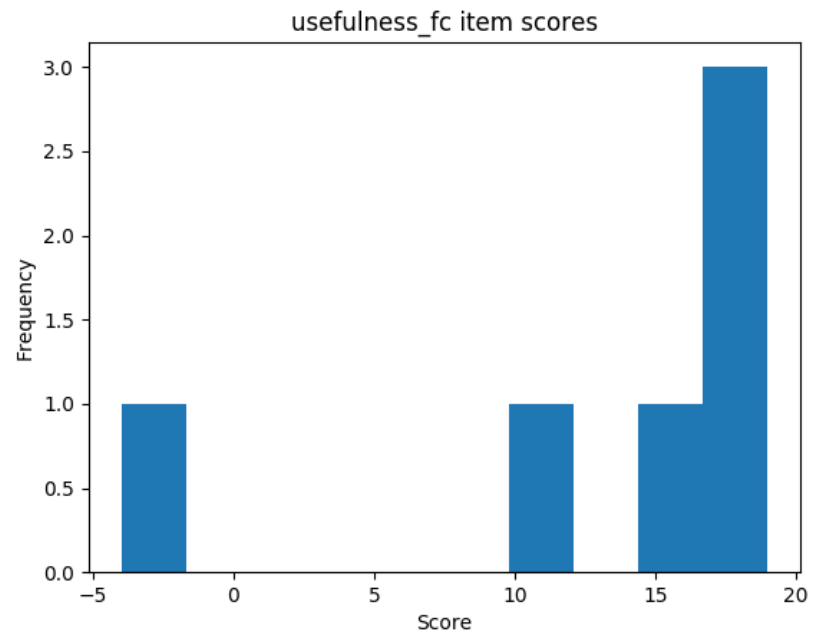
usefulness_fc item scores

Flashcard conditions

usefulness_fc person scores
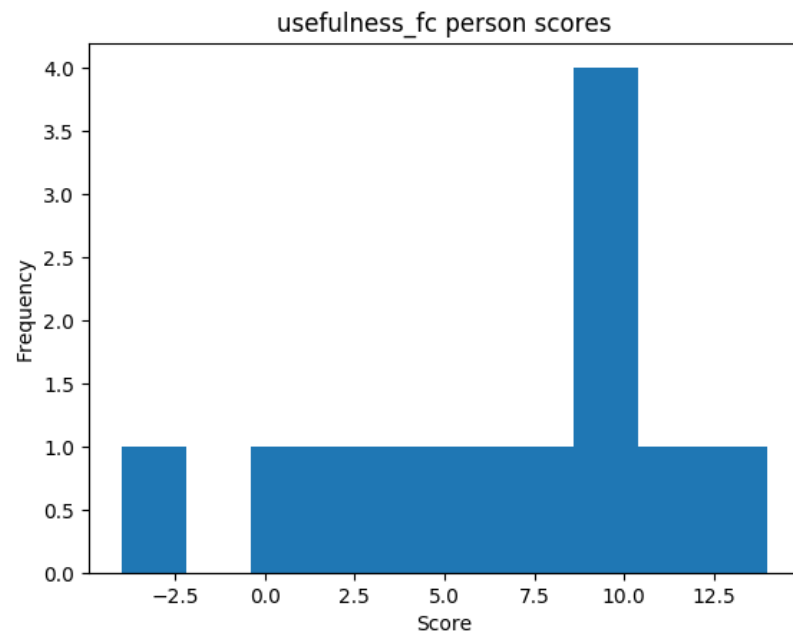
	sample	min	max	mean	variance	skew	kurtosis	normal-t	normal-p	α
ctt	11	0	13	8.82	15.16	-1.05	0.32	4.698	0.0955	0.6777
irt	11	-3	1	-0.15	1.89	-1.41	1.44	9.670	0.0079	0.5298
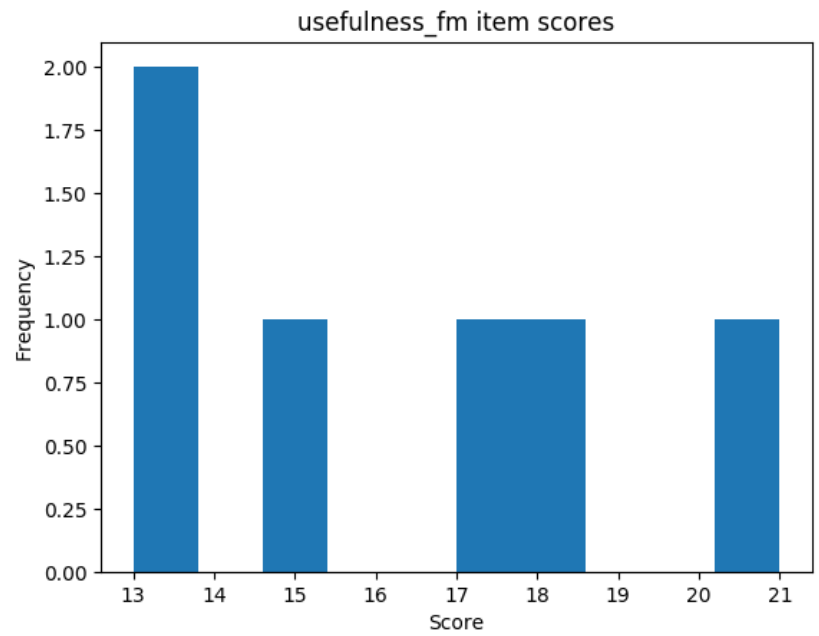
usefulness_fm item scores

Flashmap conditions

usefulness_fm person scores
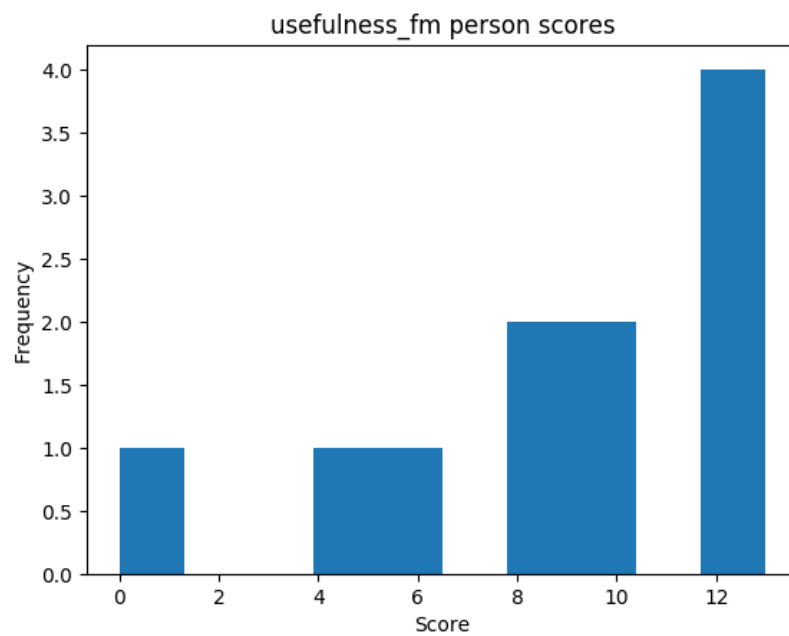
	sample	min	max	mean	variance	skew	kurtosis	normal-t	normal-p	α
ctt	23	-4	14	7.61	21.98	-0.86	-0.02	3.864	0.1448	0.6509
irt	23	-3	2	0.49	1.82	-0.73	0.55	4.058	0.1315	0.4619

usefulness_gen item scores

Combined conditions
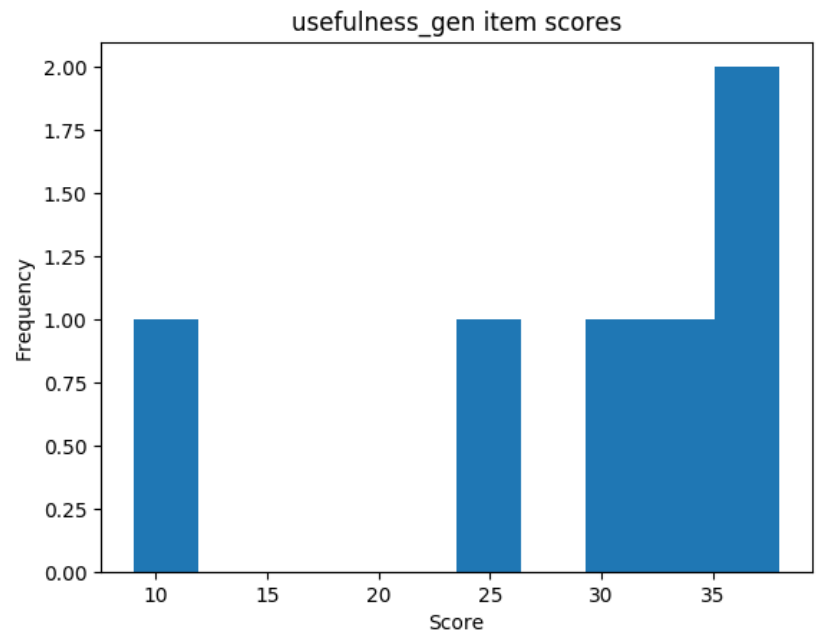
usefulness_gen person scores
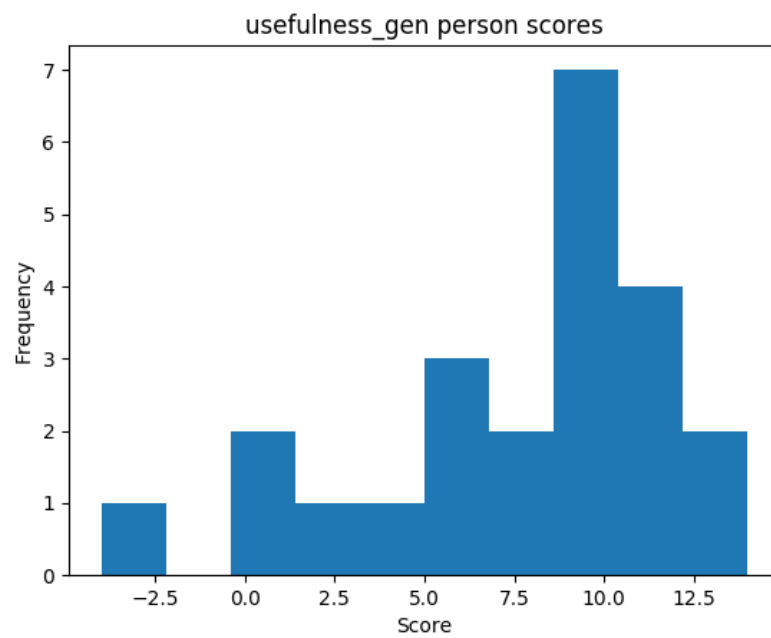
Ease of use

	sample	min	max	mean	variance	skew	kurtosis	normal-t	normal-p	α
ctt	12	-4	17	6.58	38.08	-0.26	-0.62	0.232	0.8904	0.8794
irt	12	0	4	0.91	1.87	1.08	0.52	5.358	0.0686	0.2295
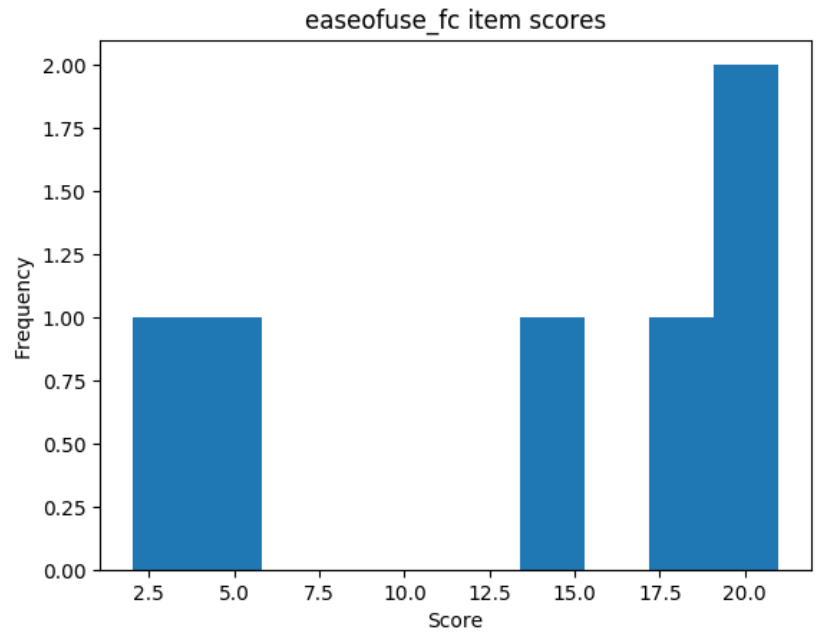
easeofuse_fc item scores

Flashcard conditions

easeofuse_fc person scores

44
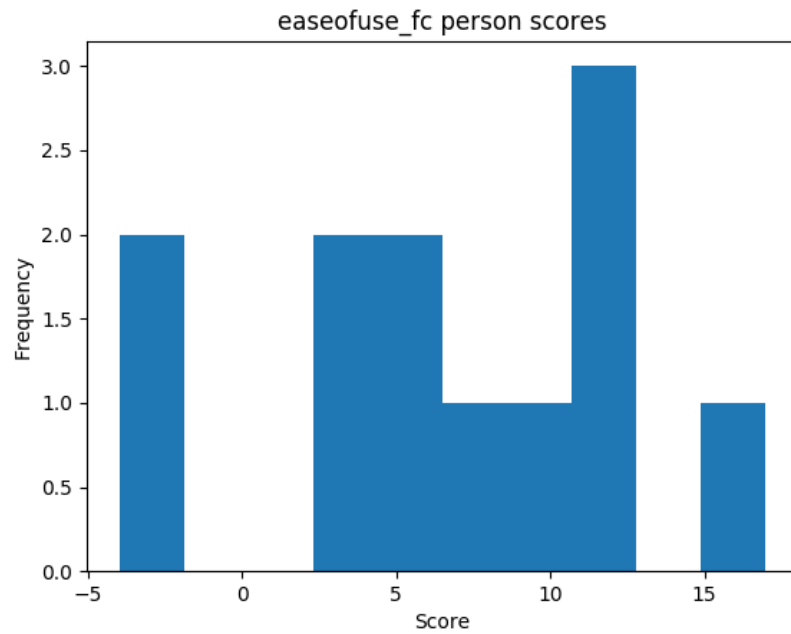
	sample	min	max	mean	variance	skew	kurtosis	normal-t	normal-p	α
ctt	11	0	19	8.27	26.22	0.50	0.12	1.725	0.4220	0.7689
irt	11	-2	2	0.22	1.87	-0.20	1.01	3.041	0.2186	0.2538
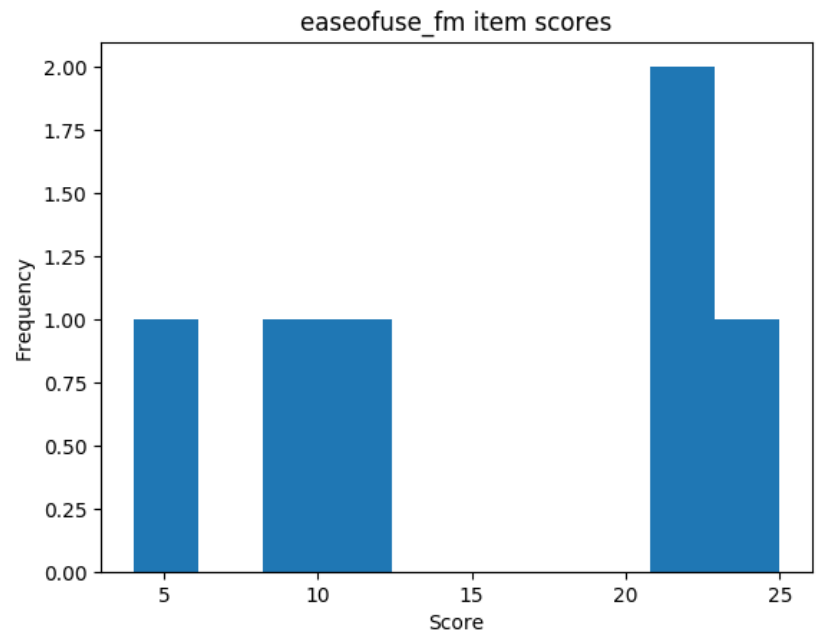
easeofuse_fm item scores

Flashmap conditions

easeofuse_fm person scores
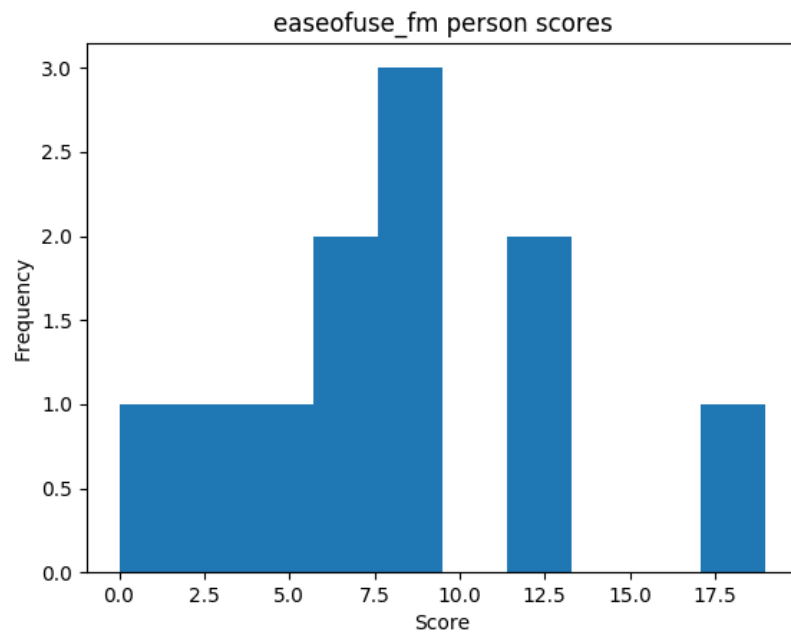
	sample	min	max	mean	variance	skew	kurtosis	normal-t	normal-p	α
ctt	23	-4	19	7.39	31.70	-0.08	-0.10	0.239	0.8876	0.8285

easeofuse_gen item scores

Combined conditions

easeofuse_gen person scores

48
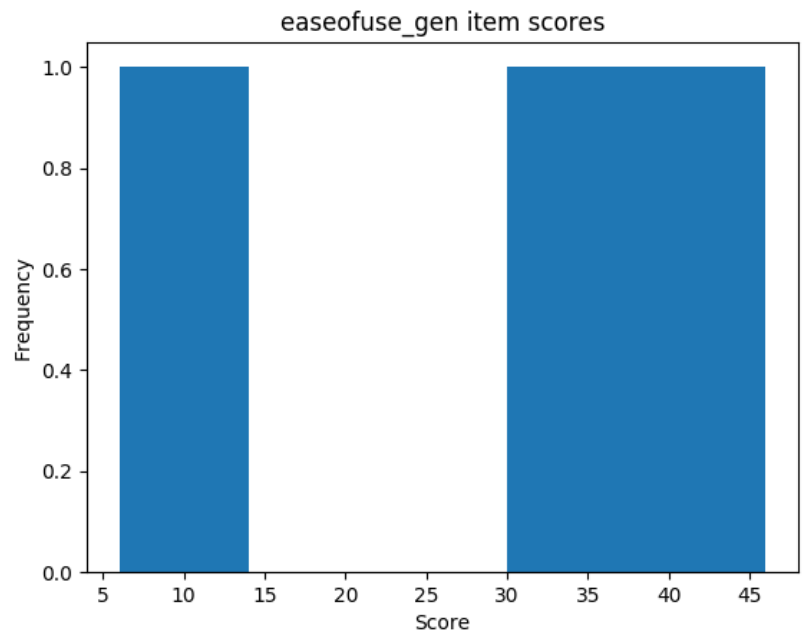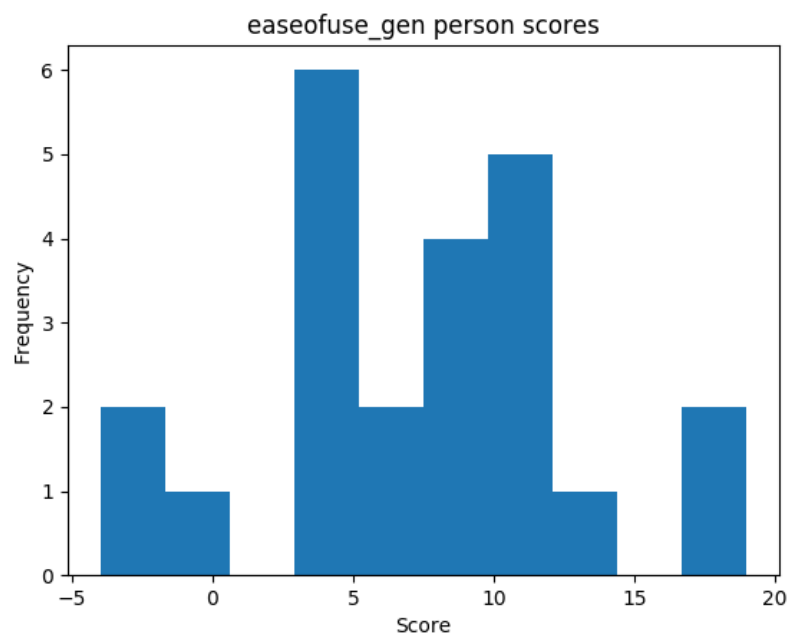
Comparisons

Perceived usefulness questions

	Mann-Whitney-U k	Mann-Whitney-U p	Welch's t-test k	Welch's t-test p
ctt	-1.196	0.2449	-1.212	0.2395
irt	-0.014	0.9891	-0.014	0.9889

usefulness item scores

usefulness person scores
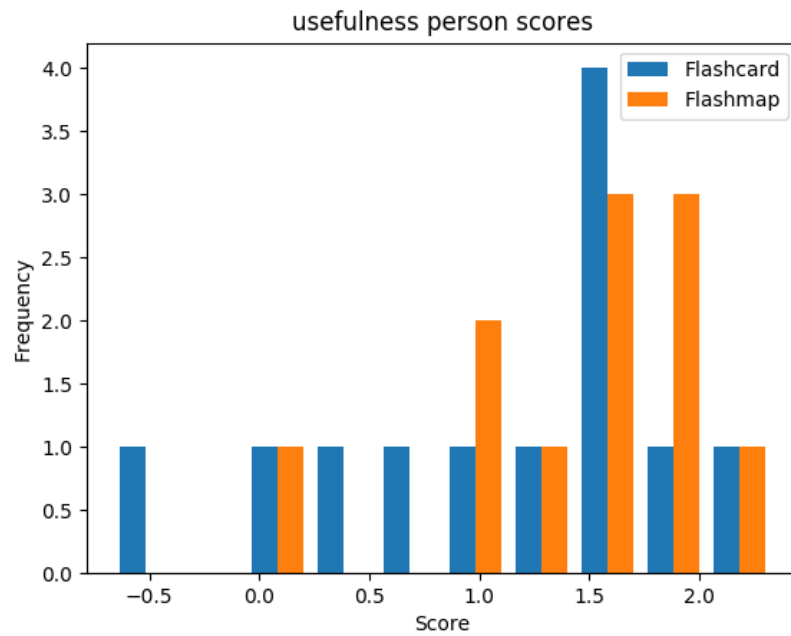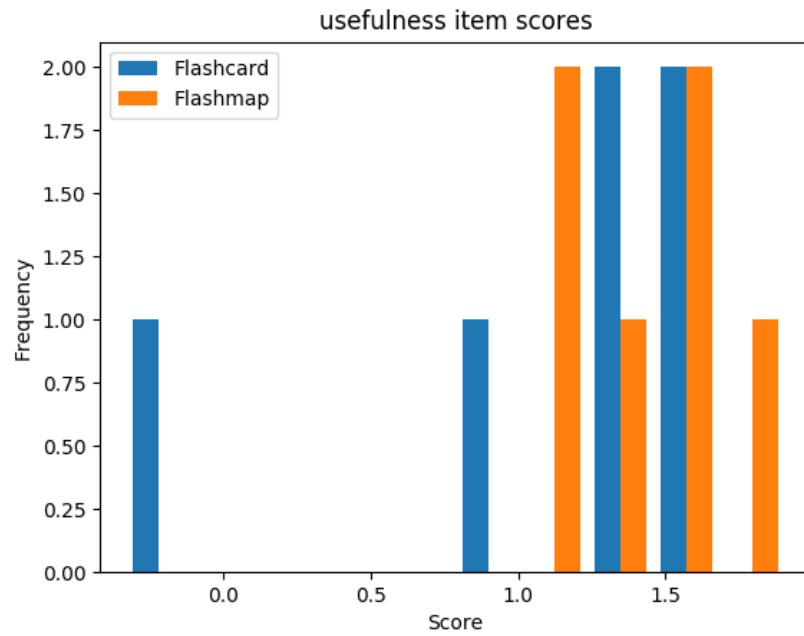
Perceived ease of use questions

	Mann-Whitney-U k	Mann-Whitney-U p	Welch's t-test k	Welch's t-test p
ctt	-0.711	0.4851	-0.717	0.4816
irt	1.206	0.2411	1.206	0.2412

easeofuse item scores

easeofuse person scores