

Results

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1 Table for Understanding Results

TABLE I. LEGEND TO UNDERSTAND RESULTS

Legend	
FL_LR	Federated Learning using Logistic Regression
FL_SD_LR	Federated Learning using Logistic Regression and Synthetic Data
k	Number of iterations
t	Time in seconds
n	Number of instances/records
p	Number of features
s	Number of clients
LL	Value of Logistic Loss function, whose range is from 0 (least errors) to 1 (most errors)
LLH	Value of the Logarithmic Likelihood function, whose range is from $-\infty$ (worst model) to 0 (best model)
AA	Approximate Accuracy, given by e^{-LL}
$E(*)$	Average of *
$R(*)$	Range of *
$C(*)$	Confidence Interval of * at a 95% confidence level

2 Datasets Description

TABLE II. DATASETS USED FOR THE EXPERIMENTS

Datasets	Symbol	Description	<i>n</i>	<i>p</i>	<i>s</i>	Response Variable	Source
Adult ¹ Income	D1	Adults' annual salaries in US dollars	48,842	14	5	If annual income > \$50k or \leq \$50k	UCI
Automobile ²	D2	Car specifications	205	21	22	If car price is within one of the 11 equally divided intervals from [5118, 45400]	UCI
Heart Disease ³	D3	Main heart disease precursors	303	75	4	0,1,2 indicate no heart disease and 3,4 indicate heart disease	UCI
Diabetes ⁴	D4	Main diabetes symptoms	101,767	49	439	\geq 30% of readmission, < 30% of readmission, or no readmission	UCI
Student Performances ⁵	D5	Students' academic performance in Portuguese and Mathematics	1,044	30	2	If a student passed (50%) or failed (\leq 50%)	UCI
University's Quality of Life ⁶	D6	University metrics that are used to determine average quality of its student body's life	285	17	38	Bad quality of life (0-2) or bad quality of life (3-5)	UCI

¹[Adult Income Dataset Link](#)

²[Automobile Dataset Link](#)

³[Heart Disease Dataset Link](#)

⁴Link Currently Unknown (received folder via email)

⁵[Student Performance Dataset Link](#)

⁶[University's Quality of Life Dataset](#)

3 Results

3.1 Total Number of Iterations for Model Convergence

TABLE III. ITERATION RESULTS FOR EACH DATASET

Datasets	FL_SD_LR			FL_LR
	E(k)	E(k)	E(k)	k
Adult Income	6	4 - 9	(5,7)	108
Automobile	8	5 - 12	(6,10)	168
Heart Disease	5	3 - 8	(4,6)	125
Diabetes	55	32 - 79	(52,58)	753
Student Performance	7	5 - 9	(6,8)	252
University's Quality of life	9	6 - 12	(7,11)	137

The smallest factor of which the number the number of iterations changed from FL_LR to FL_SD_LR was a factor of approximately 14, which was in the Diabetes (D4) dataset.

The biggest factor of which the number the number of iterations changed from FL_LR to FL_SD_LR was a factor of 25, which was in the Student Performance (D5) dataset.

3.2 Total (Computation) Time Taken for Model Convergence

TABLE IV. COMPUTATION (TIME) RESULTS FOR EACH DATASET IN SECONDS

Datasets	FL_SD_LR			FL_LR
	$E(t)$	$R(t)$	$C(t)$	t
Adult Income	29.96839	17.09602 - 43.52939	(23.45782, 36.47896)	272.13762
Automobile	18.09699	10.826 - 26.83907	(15.43236, 20.76162)	610.23627
Heart Disease	14.93217	9.23702 - 21.74821	(11.67568, 18.18866)	213.14715
Diabetes	735.47428	413.7019 - 1057.59356	(710.76486, 760.1837)	3735.32932
Student Performance	27.88597	29.24998 - 34.71514	(24.84305, 30.92889)	426.14308
University's Quality of life	33.42473	28.42473 - 38.92473	(29.65964, 37.18982)	411.62555

The smallest factor of which the total (computation) time changed from FL_LR to FL_SD_LR was a factor of approximately 5, which was in the Diabetes (D4) dataset.

The biggest factor of which the total (computation) time changed from FL_LR to FL_SD_LR was a factor of 34, which was in the Automobile (D2) dataset.

3.3 Logistic Loss Values for Final Model

TABLE V. LOGISTIC LOSS RESULTS FOR EACH DATASET

Datasets	FL_SD_LR			FL_LR
	$E(LL)$	$R(LL)$	$C(LL)$	LL
Adult Income	0.25153	0.22348 - 0.26735	(0.24811, 0.25495)	0.25253
Automobile	0.29734	0.27024 - 0.29999	(0.29511, 0.29957)	0.2958
Heart Disease	0.30411	0.27386 - 0.31903	(0.30184, 0.30638)	0.30432
Diabetes	0.27508	0.23235 - 0.28324	(0.27274, 0.27742)	0.27502
Student Performance	0.25322	0.23235 - 0.28324	(0.25043, 0.25601)	0.25268
University's Quality of life	0.27178	0.23235 - 0.28324	(0.27161, 0.27195)	0.27190

The factors of which the logistic loss value changed from FL_SD_LR to FL_LR were all factors of approximately 1, which implies that the final model's error margins were almost identical between FL_LR and FL_SD_LR.

3.4 Logarithmic Likelihood of Final Model

TABLE V. LOGISTIC LOSS RESULTS FOR EACH DATASET

Datasets	FL_SD_LR			FL_LR
	$E(LLH)$	$R(LLH)$	$C(LLH)$	LLH
Adult Income	-7418.84086	-7679.35477 - -7158.32695	(-7535.75048, -7301.93124)	-7418.04494
Automobile	-809.93967	-896.5046 - -723.37474	(-836.29098, -783.58836)	-810.19597
Heart Disease	-3455.38416	-3826.03508 - -3084.73324	-3568.90049, -3341.86783	-3455.03993
Diabetes	-15460.10069	-15980.44403 - -14939.75735	-15830.19322, -15090.00816	-15460.46884
Student Performance	-4753.44224	-4942.70078 - -4564.1837	-4862.86706, -4644.01742	-4754.18452
University's Quality of life	-737.64251	-774.83249 - -700.45253	-750.03115, -725.25387	-737.12735

The factors of which the logarithmic likelihood value changed from FL_SD_LR to FL_LR were all factors of approximately 1, which implies that the final model's fits to the global data were almost identical between FL_LR and FL_SD_LR.

3.5 Accuracy of Final Model

ACCURACY RESULTS FOR EACH DATASET

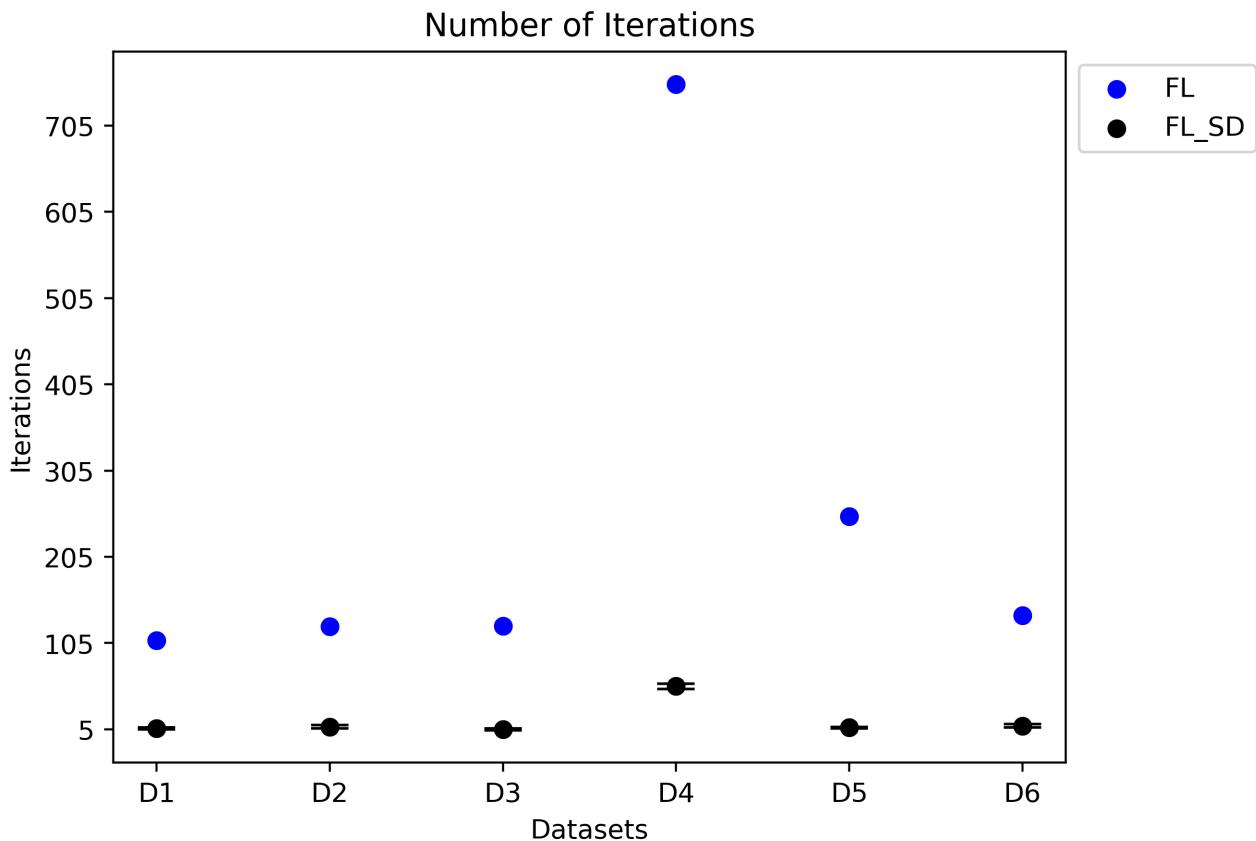
Datasets	FL_SD_LR			FL_LR
	$E(AA)$	$R(AA)$	$C(AA)$	AA
Adult Income	0.77761	0.76540 - 0.79973	(0.77495, 0.78027)	0.77683
Automobile	0.74279	0.74082 - 0.76319	(0.74113, 0.74444)	0.74393
Heart Disease	0.73777	0.72685 - 0.76043	(0.73610, 0.73945)	0.73762
Diabetes	0.75951	0.75333 - 0.76854	(0.75773, 0.76129)	0.75955
Student Performance	0.77629	0.75333 - 0.79266	(0.77413, 0.77846)	0.77671
University's Quality of life	0.76202	0.75333 - 0.79266	(0.76189, 0.76215)	0.76193

The factor of which the accuracy of the final model changed from FL_SD_LR to FL_LR were all factors of approximately 1, which implies that the final model almost identical in accuracy between FL_LR and FL_SD_LR.

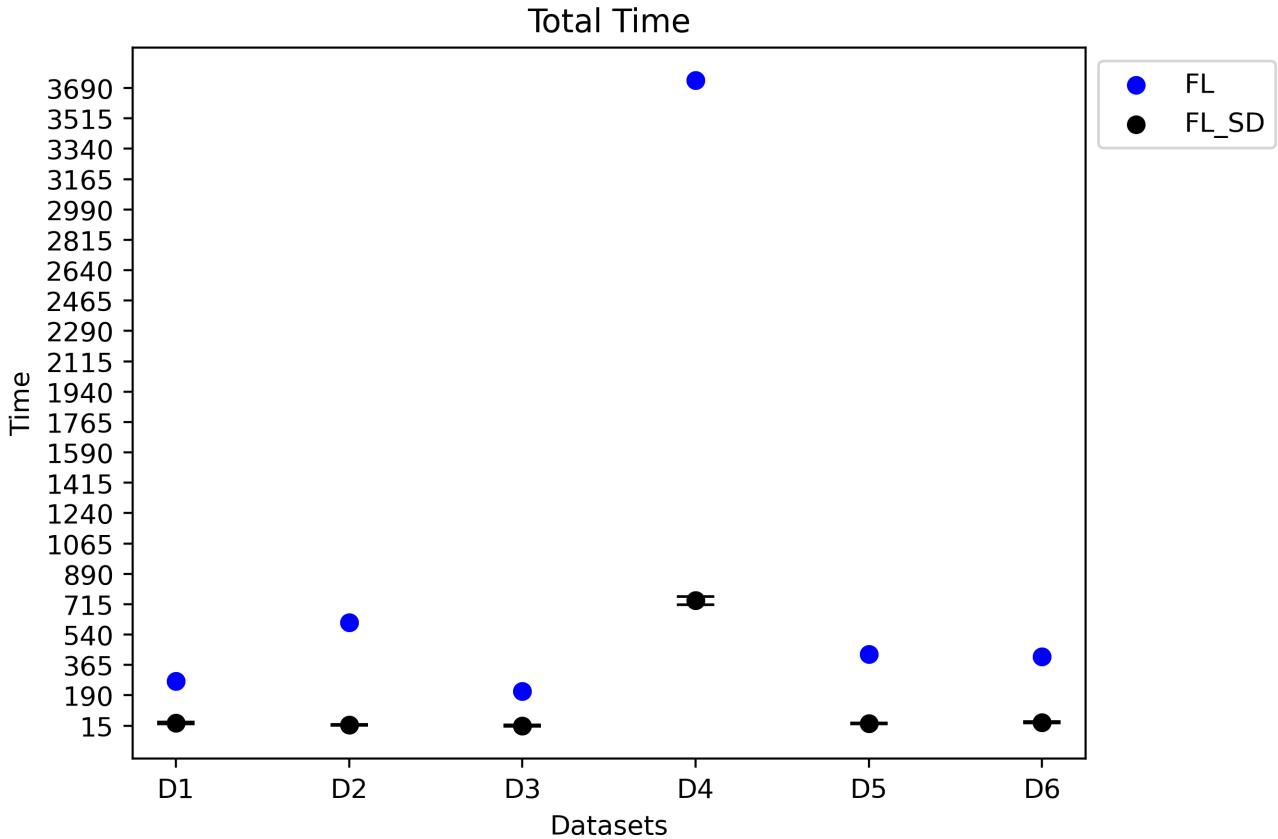
4 Graphs

4.1 Error Bar Graphs

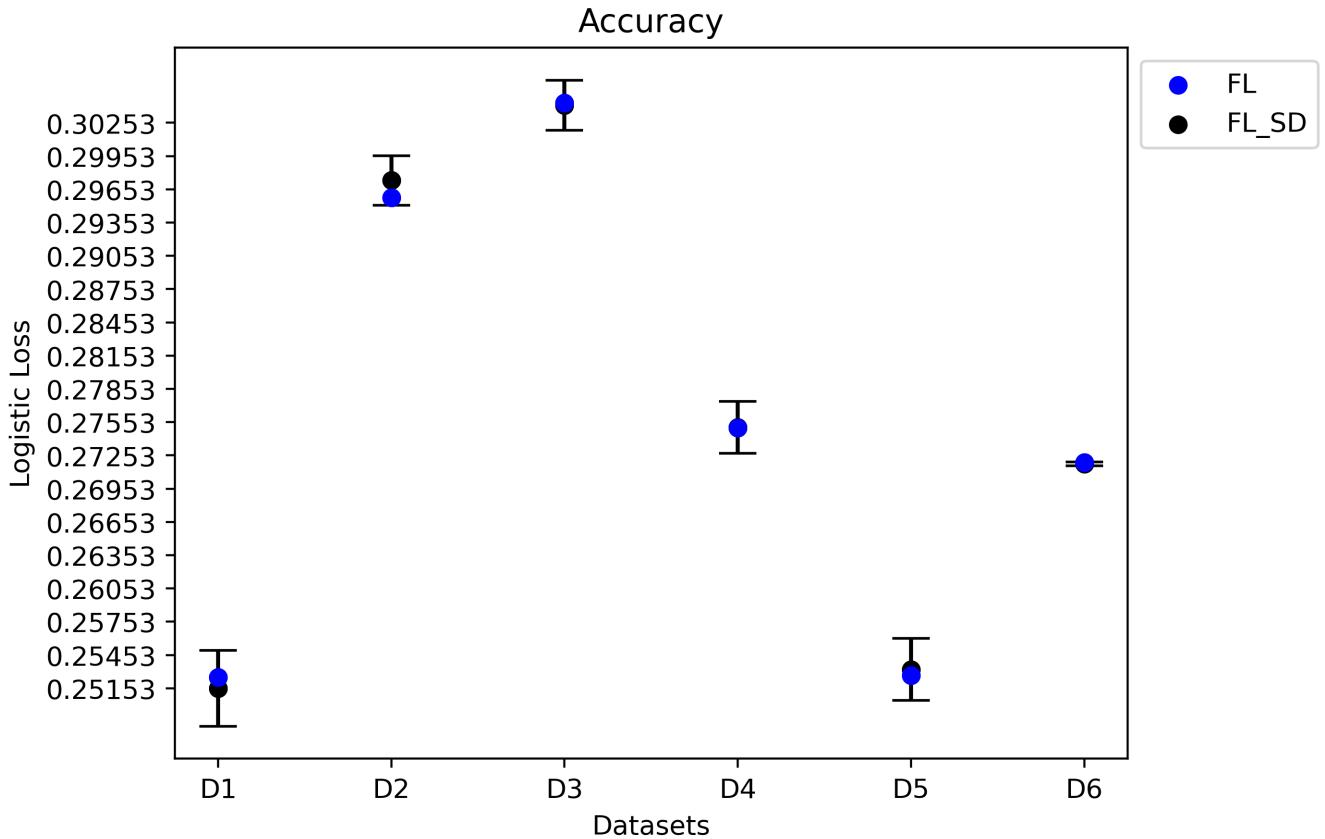
4.1.1 Total Number of Iterations



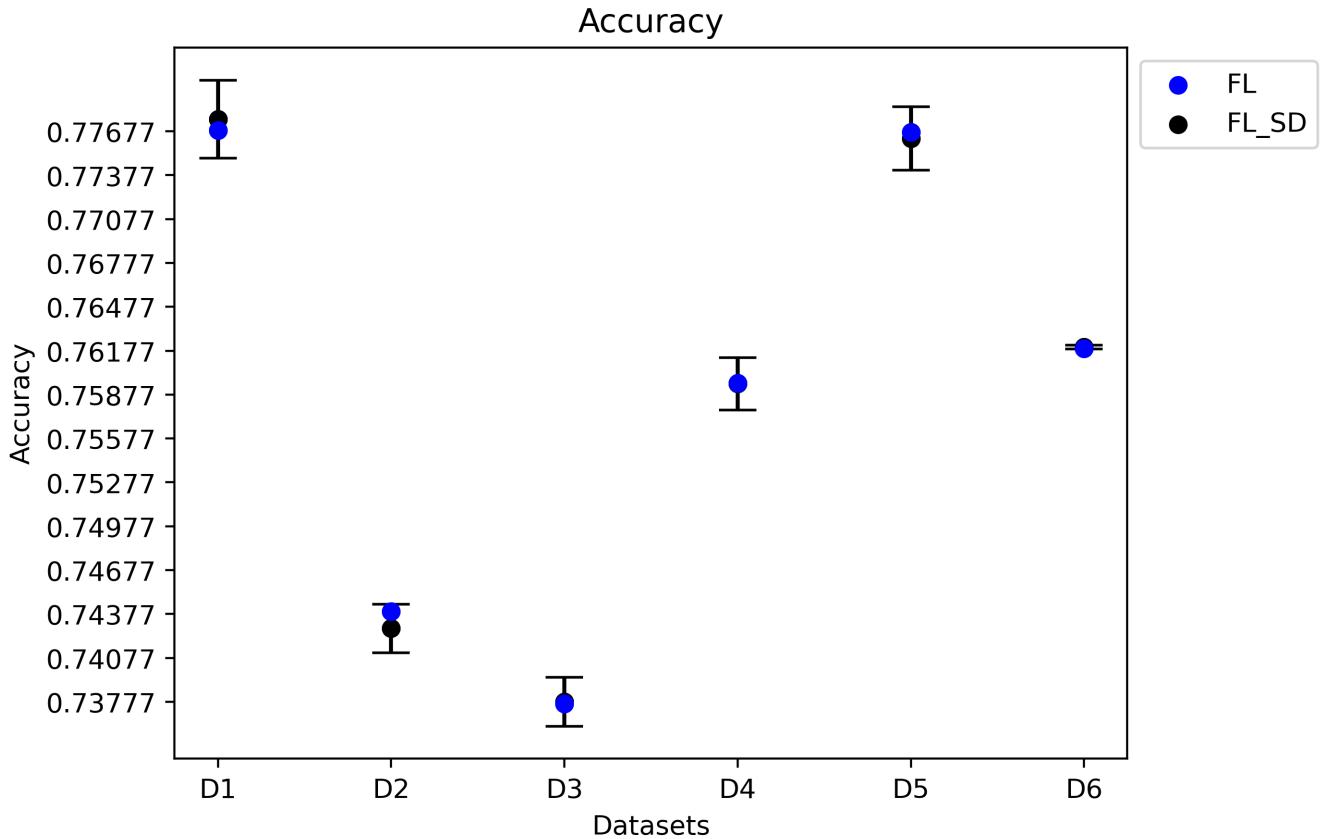
4.1.2 Total (Computation) Time



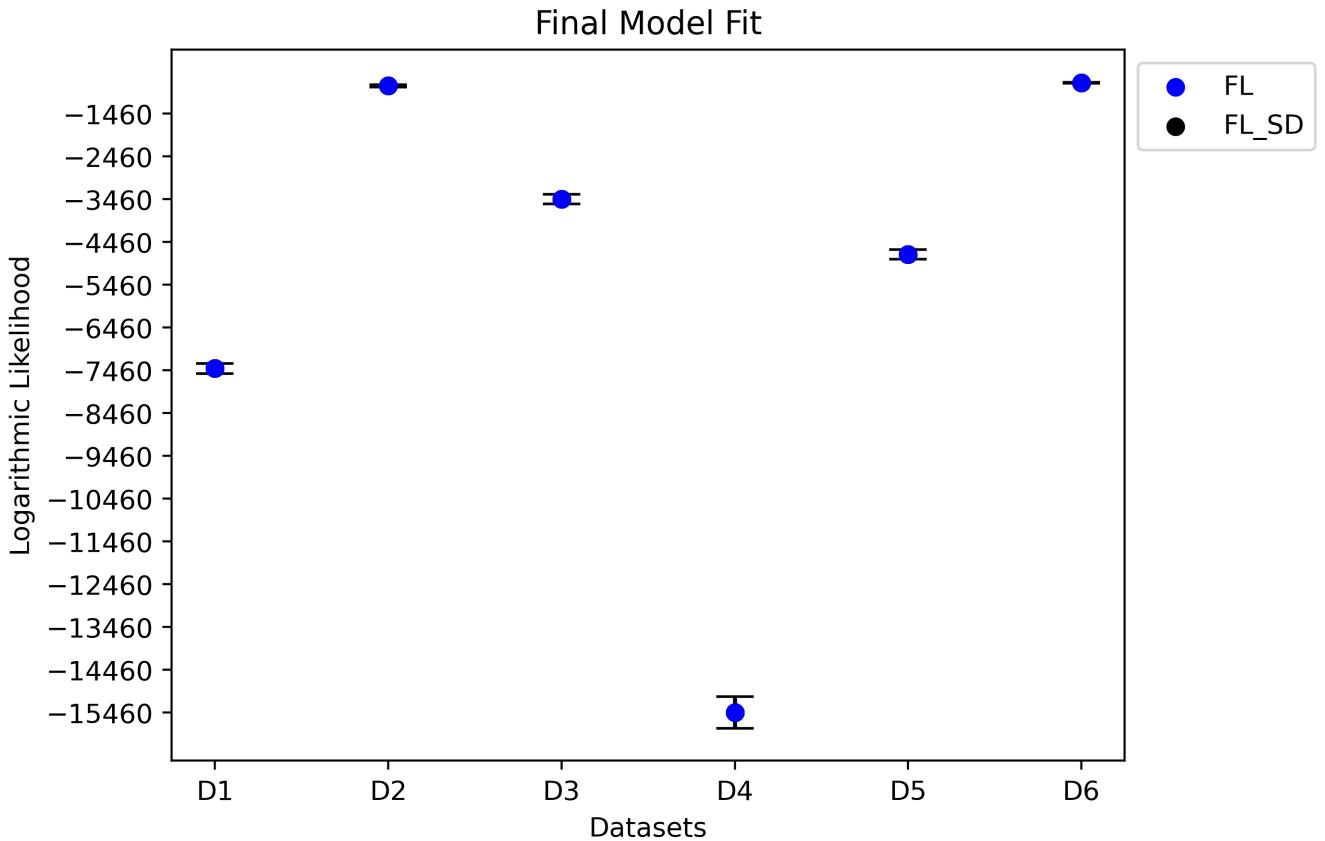
4.1.3 Logistic Loss of Final Model



4.1.4 Approximate Accuracy of Final Model

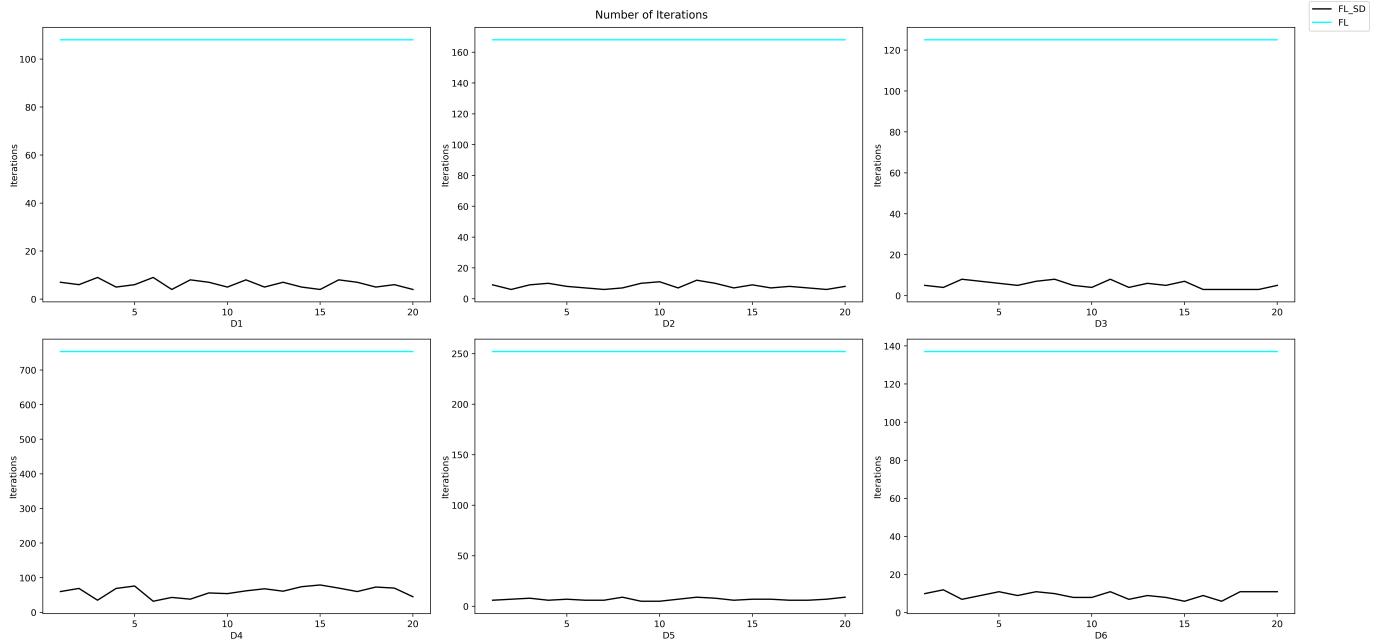


4.1.5 Logarithmic Likelihood of Final Model

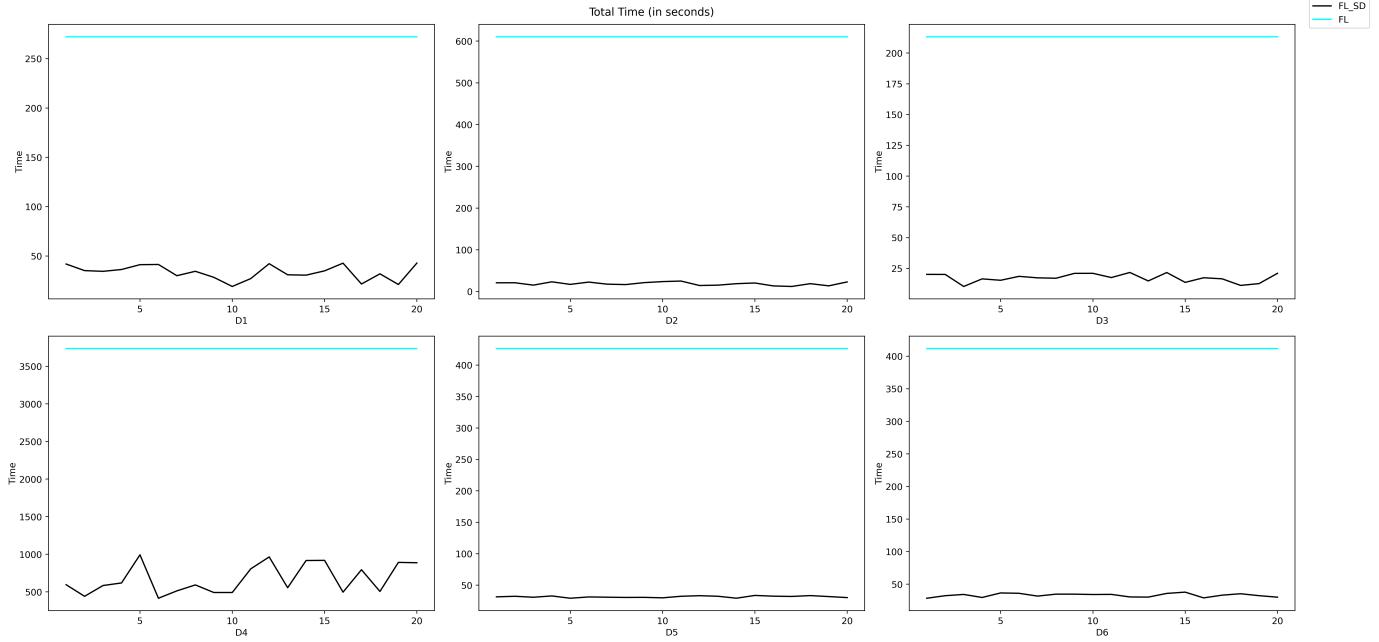


4.2 Linear Graphs

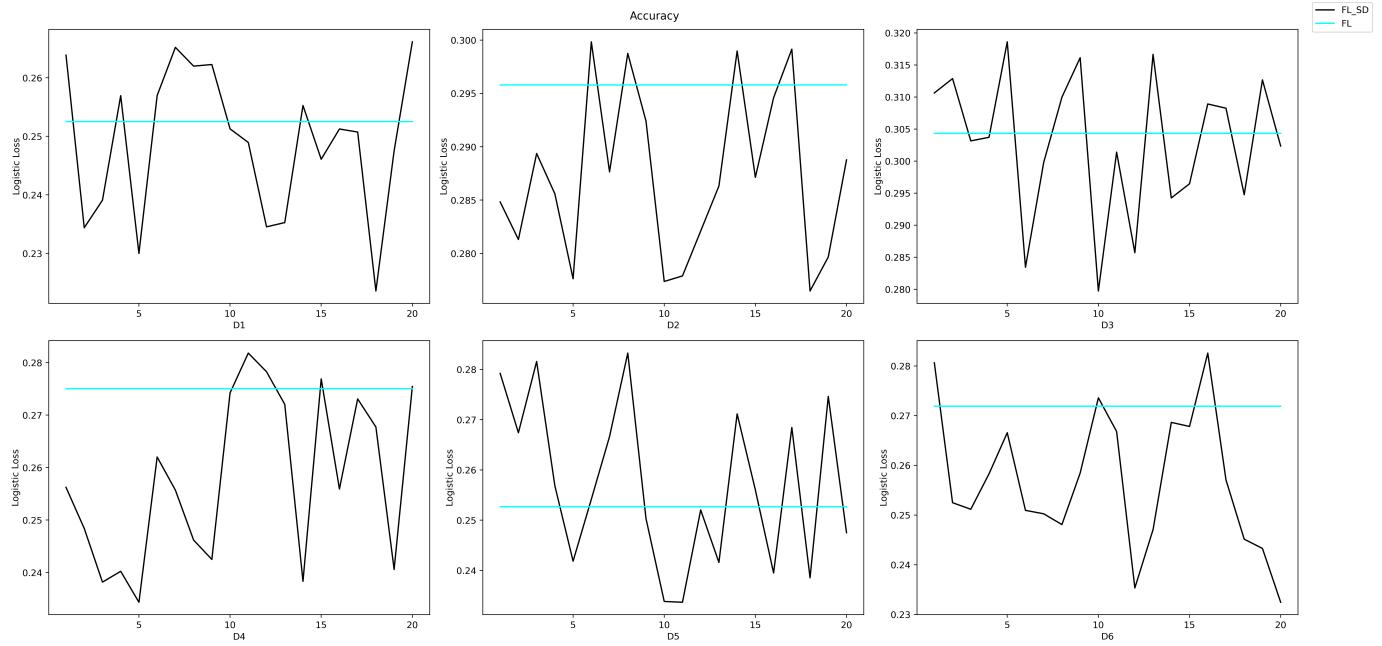
4.2.1 Total Number of Iterations



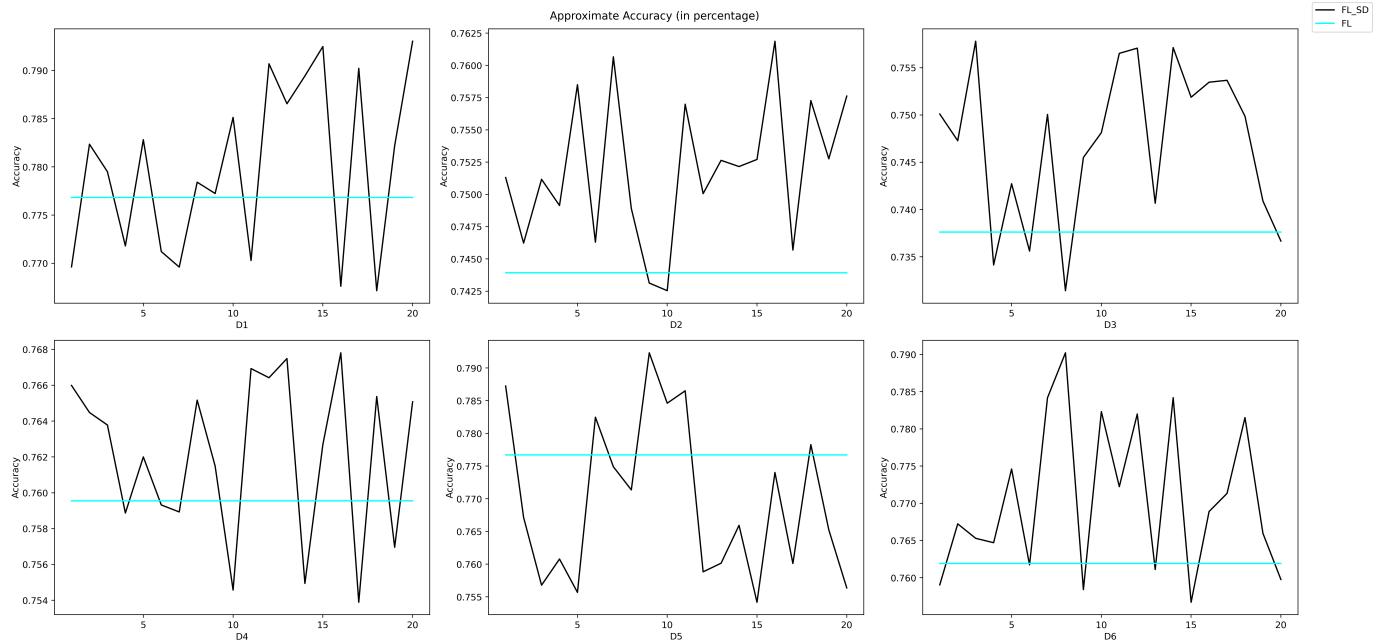
4.2.2 Total (Computation) Time



4.2.3 Logistic Loss of Final Model



4.2.4 Accuracy of Final Model



4.2.5 Logarithmic Likelihood of Final Model

