Employing a Rubric to Assess Learner Performance in Calculus and Differential Equations

David Kaplan[1]

Abstract

Among the key measurement tools in Ellis and Apple's (2017) Learning to Learn Mathematics - Why is it Critical? *is a table displaying collegiate learners' mathematics performance across 28 characteristics. Lowest-level learners are said to perform as survival learners, while highest-level learners perform as pioneer learners. Between these extremes are, in order, need-based learners, contained learners, and professional learners. In this research, a classroom rubric measuring 14 of the 28 learner characteristics was created from Ellis and Apple's table. At the beginning of Calculus II and Differential Equations classes, the rubric is discussed with the students, making clear the intent to measure increases in learning levels occurring across these 14 characteristics, from the beginning to the end of the class taught in a flipped-classroom environment. Students self-evaluate their learning level on these 14 characteristics at the beginning and end of each of these courses. The paper analyzes and discusses changes in learning level, how the instructor facilitated them, and compares the progress that first-year Calculus II students make vs. second-year differential equations students.*

Introduction

While there are number of articles in the literature that tout the effectiveness of, and advocate for employing active-learning pedagogies to improve student learning, such as the flipped classroom, there is a clear need for further study using rubrics that measure student learning from the beginning to end of a course using these pedagogies. As Love, Hodge, Grandgennett, and Swift (2013) note in *Student learning and Perceptions in a Flipped Linear Algebra Course*:

> Before a significant number of university faculty will be willing to undertake such a dramatic change in instructional practices, as that represented by flipped classroom strategies, it will be critical to continue to build a foundation of systematic research that investigates the nature, utility, and effectiveness of flipped classroom models. Hence, further research is needed in other disciplines, instructional contexts and by additional STEM educators, to more fully contribute to the instructional decision-making being undertaken on college campuses today related to the use of flipped classroom environments. (p. 337)

Active learning strategies posit that when students are put in *performance mode* in the classroom, they move much more quickly up the initially steep slope of a skill's learning curve; and that this movement occurs most effectively in a classroom under the skilled guidance and encouragement of the instructor, aided by team members. The most commonly employed active-learning model is called the flipped classroom; so-called because weekly deliverables, usually homework, are done in class and the lecture is done outside of class. Typically, students watch a video on theory and methods prior to class and then each team or group is given problems to solve and present during class. The instructor serves as both a resource, helping with missing background skills, and guide. In the heart of each flipped classroom session, when the groups are working intensively to solve their problem, there are a considerable number of back-and-forth dialogues within the teams and with the instructor. The instructor, aided by effective team members, ensures that on the path to the solution, the teams are hitting the intermediate check points.

It takes a couple of weeks for the students to get used to this classroom approach. Indeed, as Missildine, Fountain, Summers, and Gosselin (2013) state in *Flipping the Classroom to Improve Student Performance and Satisfaction*:

> Students were less satisfied with the flipped classroom method than with either of the other methods ($p < 0.001$). Blending new teaching technologies with interactive classroom activities can result in improved learning but not necessarily improved student satisfaction (p. 599).

The author's experience is that the instructor must properly set the stage, especially in the early part of the term. The mode needs to be focused and high-energy; the tone serious, positive and fun; and the expectations set at the challenging level. When the flipped classroom is correctly employed, there are key rewards to be gained as McLaughlin et al. (2014) state:

[1] York College of Pennsylvania

> As class attendance, students' learning, and the perceived value of this model all increased following participation in the flipped classroom, the authors conclude that this approach warrants careful consideration as educators aim to enhance learning, improve outcomes, and fully equip students to address 21st-century health care needs (p. 243).

Although there is evidence of research of the flipped-classroom as a pedagogical approach, an extensive literature search for articles discussing learning rubrics to measure learning yielded no results. A few studies that assessed the efficacy of the flipped classroom reported on student self-assessments of the flipped-classroom compared to the traditional classroom. Huggins and Stamatel (2015) provide a good comparative analysis in their article, *An Exploratory Study Comparing the Effectiveness of Lecturing vs. Team-Based Learning* reporting that learning-level improvements in an active-learning classroom compared to a traditional classroom were not statistically different.

This study examines student learning in the flipped classroom through the use of an assessment tool to measure student performance at the beginning and end of mathematics courses. More specifically, it is hypothesized that in the flipped classroom environment, there will be statistically significant learning-level improvements from the beginning to the end of the class as measured by a learning-level rubric tailored to the specific type of course—here mathematics students in Calculus II and Differential Equations.

Background

In their paper, *Learning to Learn Mathematics – Why is it Critical*?, Ellis and Apple (2017) build on the limited existing scholarship about learning mathematics by developing a comprehensive set of mathematical-learner characteristics as well as a set of tools for measuring mathematical learner performance. Table 7, *Measuring Mathematics Collegiate Learner's Performance*, is a highly-applicable tool for assessing student learning level improvements. Working with the paper authors, I helped hone the language and terminology used to create a rubric that collegiate-level mathematical learners could use to self-assess their learning-level in the various math learner characteristics as depicted in Table 1.

A classroom experiment was designed using an assessment tool created from Table 1 to measure whether there were learning improvements in two Calculus II classes and one Differential Equations class, in the spring 2018 term. A subset of fourteen of the 28 mathematical learner characteristics presented in the first column of Table 1 were chosen because in mathematics classes at the first- and second-year level, these 14 learner characteristics are regularly accessed, whereas the remaining 14 characteristics are less frequently needed until the students are in upper-level mathematics courses. The fourteen chosen characteristics, highlighted in Table 1, were: *Skeptical, Precise, Productive Struggle, Self-reliant, Abstract, Visualize, Tool Usage, Interprets Data, Interprets Notation, Identifies Key issues, Reuse Solutions, Translator, Teacher,* and *Quick-thinking*.

A form was developed for students to assess their mathematical learner level at the beginning and end of the course. The form tallied each student's initially-assessed learner level (in order): **Survival, Need-Based, Contained, Professional,** or **Pioneer** across each of the 14 characteristics. These learner levels were assigned point values of 2, 3, 5, 6, and 7 respectively. So, if a student initially assessed themselves as a need-based learner across all 14 characteristics, they would have an initial score of 42; and if they assessed themselves at the end of the course as a professional-level learner across all categories, they would have a score of 84.

At the beginning of each course, the instructor gave a 45-minute explanatory session on understanding and using the form. A hypothetical student at each of the learner levels across the 14 characteristics was discussed. After a brief question and answer with the students about the learning levels, the instructor was convinced that the students understood how to use the rubric to self-assess. Students who submitted consent-to-participate waivers were then asked to fill out and submit the form with their initial learner-level assessment. Approximately 50 students submitted the initial form out of 77 students enrolled in the three classes. In addition to the student's self-assessment, the instructor also completed an assessment of each student using the rubric.

Implementation

The flipped-classroom pedagogy was employed in all three classes: two Calculus II courses and a Differential Equations course, with the assumption that the learning level would improve most when students were *put in performance* during each class. Prior to class, students watched a video on the day's material, which discussed the theory and showed how to solve example problems. At the beginning of class, the instructor spent 15 to 25 minutes reviewing the material from the video, focusing on the problem-solving approach.

The students were put into four-person groups on the first day of class. Each group was assigned a problem to present at the board every class. The groups worked among

Table 1 Measuring Mathematics Collegiate Learner's Performance

Math learner characteristic	Trained: Survival Learners	Learned: Need-Based Learners	Learners: Contained Learners	Enhanced Learners: Professional	Self-Growers: Pioneer Learners
Mindset	**As taught**	**When prompted**	**When useful**	**Conscious integration**	**Intrinsic integration**
Skeptical	Often accepting	Accepts experts	Questions inexperienced	Until fully convinced	Questions even self
Precise	Lay-level accuracy	Somewhat accurate	Working-level accuracy	Polished accurate work	Removes ambiguities
Productive struggle	Easy solutions	Known approaches	When In expertise area	When gain is great	Process 1st, results 2nd
Self-reliant	Minimally	In simple practice	In areas of confidence	In areas of responsibility	When others have failed
Reasoning	**One-step arguments**	**Basic arguments**	**Complex arguments**	**Proves theorems**	**Creates mathematics**
Makes conjectures	When forced to	In areas of interest	In area of expertise	All daily life challenges	Ground-breaking areas
Counter examples	When pointed out	Detects weak premises	Most issues challenged	Rarely fail to find	Challenges conventions
Logical	Frequent logic errors	No basic logical errors	Errors in intricate cases	Very rarely makes errors	Sees errors others miss
Rules out paths	Sees when pointed out	Sees obvious dead ends	Sees common dead ends	Sees most dead ends	Sees unseen dead ends
Thinking	**Memorizes**	**Follows explanations**	**Analyzes**	**Elevates Understanding**	**Integrates expertise**
Abstract	Needs concrete cases	For basic abstractions	When needed to think	To enhance thinking	Develops abstractions
Visualize	When obvious	Sees object in context	Sees object & contexts	Sees changing context	Paints pictures for all
Representations	The one and only	Illustrated alternatives	When confused	To increase richness	Continually varies
Makes connections	Only if fully elucidated	Obvious ones	Many connections made	Develops concept maps	Multi-level and visionary
Modeling	**Concrete only**	**Uses other's models**	**Develops basic models**	**Advancing models**	**Develops new models**
Builds models	Only uses tangible	Uses diagrams & images	Builds math models	Applicable new models	Innovative new models
Tool usage	Tool use w/ guidance	Common-use tools	Recommended tools	Comprehensive tool set	Extends, develops tools
Innovates	If nothing else works	In areas of keen interest	In professional expertise	When productivity stalls	Continuously
Interprets data	When essential	In commonly seen cases	To answer inquiries	To give insights	To broaden perspective
Learning	**Regurgitate as given**	**Can explain basics**	**Can teach others**	**Can generalize**	**Expertise and extension**
Interprets notation	Only after explained	As used commonly	Across most math fields	In new situations	Creates new notation
Uses examples	Uses when explained	Readily available	Creates simple examples	Plays with & modifies	Develops to test bounds
Thinks analytically	Sees obvious, if shown	Some distinctions	Sees details	Can explain details	Sees how to extend
Transfers knowledge	To same case	To cases practiced	To analogous cases	To new applications	To widely-varied cases
Problem Solving	**Formulaic problems**	**Complex exercises**	**Uses PS methodology**	**Real world problems**	**W/in & interdisciplinary**
Identifies problems	If others point it out	In area of concern	In common situations	Reveals target	Gain consensus
Identifies key issues	The most obvious	Many key	Most key	Ranked list	Includes unforeseen
Reuse Solutions	Mostly one time use	Very frequent problems	Most common problems	For most sub-solutions	Generalizes solution
Notices Assumptions	Perhaps, if challenged	Critical ones	Most used	For perceived use	For future uses also
Communication	**Often vague**	**Basic math language**	**Translates for audience**	**Explain math reasoning**	**Educates audience**
Vocabulary builder	Only if needed	Functional usage	Versed	To share ideas	To develop ideas
Translator	Struggles to be clear	Not always understood	Makes basics clear	Clarifies all details	Clarifies big picture
Teacher	Re-explains basics	Teaches as taught	Develops understanding	Develops math learners	Develops self-growers
Quick-thinking	Struggles with basics	In scripted situations	In expertise areas only	In professional discourse	In any situation

Source: *Ellis and Apple (2017)*

themselves to solve a given problem, sometimes consulting members of other groups. When a group had misunderstandings they could not overcome, or background deficiencies, they would call the instructor over for a consultation. Sometimes the resolution required the instructor to ask just a convergent question or two; sometimes a hint using an analogous problem was enough to get the group on track. Other times it was necessary to sit down with the group in an intervention-like fashion for as much as 10 minutes, instructing through background deficiencies because the groups had widely varying background skills in algebra and calculus. Early in the course, most groups needed guidance, in varying degrees, about how to initially approach, and set up, the solving of the problem.

About halfway through the semester, the learning-level rubric was put up on the overhead again and further discussed, with the instructor pointing out examples of learning-level improvements the class had been making as evidenced through the daily problem-solving sessions and the presentations at the board. As the course progressed, the nature of the instructor consultations changed considerably. Whereas the consulting sessions were extensive at the beginning of the course, as the course moved closer to the end, most groups became significantly more self-reliant, with many groups just checking their process and final answer with the instructor. Not all groups became fully effective, though, about 20% of each class did not make significant improvements in their learner level, based on instructor assessment. And, even at the end of the course, most groups still needed guidance when the techniques were completely new or especially complex.

The quality of the student presentations also noticeably improved. For the first few weeks after the student presentations, the instructor would take the time to carefully point out what would have made them professional-level presentations: proper use of terminology, more thorough and in-depth explanations of each step, or explaining why a technique was used and how to use that technique properly. By the end of the course, some presenters were as polished as the instructor. All presenters made significant improvements. In the last week of the course, students' final learner-level assessments were submitted. While 50 students had submitted the initial survey, only 36 students submitted usable final surveys.

Results

What do the initial vs. final data say; were there learning-level improvements as perceived by the students in their self-assessments? **Yes.** The average initial student assessment score was approximately 60, indicating that the average student entered the class assessing themselves about halfway between a **Need-Based** and a **Contained** learner according to the rubric. At the end of the class, the average student self-assessment score was a 77, which is about halfway between a **Contained** and a P**rofessional** learner. Thus, there was a 17-point improvement, about one-and-a-half category levels. Furthermore, the nine strongest students in the classes, assessed themselves at the **Professional** level or higher.

Looking at the individual characteristics: *Visualize, Interpret Data, Interpret Notation, Reuse Solutions,* and *Quick-Thinking* had the largest increases, about one-and-a-half category levels increases, from below the **Contained** level to halfway between the **Contained** and the **Professional** level. The *Precise* characteristic had the smallest increase, at slightly less than one category level, 0.8. The remaining characteristics, *Skeptical, Productive Struggle, Self-Reliant, Abstract, Identify Key Issues,* and *Teacher*, all had more than a one learner-level improvement, from a learner-level lower than **Contained** to a learner level less than halfway between **Contained** and **Professional**.

As a cross-check on validity, a comparison of the student's initial and final assessment were made to the instructor's initial and final assessment. The differences in the assessment scores are indicated by boxes in Table 2. Six (14%) of the initial scores were lower (two in Calculus II, four in Differential Equations), but the average initial score only changed (decreased) about 4 points, remaining about halfway between the **Need-Based** and **Contained** learner levels. Twelve (33%) of the final point assignments were different, (eight in Calculus II and four in Differential) but the average score of 75 only changed slightly and remained higher than the **Contained** learner level and approaching the **Professional** level as depicted in Table 2 .

Columns 5 and 6 from Table 2 were compared, that is the instructor delta (final minus initial score) was compared to the students' delta (final minus initial score). It increased slightly versus the student delta, from 1.3 learner levels to 1.5 learner levels (from 18 to 20 points overall) for Calculus II and was equivalent for Differential Equations, further confirming the learning-level gains made. The correlation between course grade percent and either the students' or instructor's final score, or the student or instructor delta, was weak (0.07 to 0.14). A significant number of students achieved large learning-level improvements, but not the highest course grades, having started the course with lower mathematical skill levels or lower learning levels. Finally, it is noted that the p-values for each course, whether coming from the students' or instructor's learning-level assessment, were well above 99.9% confidence level (For ANOVA analyses see Appendix 1).

Table 2 Assessment Scores by Course

CALCULUS II						
	Student Assessment		Instructor Assessment		Student Delta	Instructor Delta
Major	Initial	Final	Initial	Final	Final-Initial	Final-Initial
Math	82	93	82	93	11	11
Non	42	76	42	76	34	34
	54	75	54	75	21	21
CE	51	81	51	81	30	30
Bus	39	74	39	74	35	35
CS	50	74	50	74	24	24
CE	46	60	46	75	14	29
CE	46	50	46	60	4	14
ME	89	95	56	75	6	19
ME	67	75	67	75	8	8
ME	49	83	49	83	34	34
Math	67	80	67	80	13	13
CE	62	81	62	85	19	23
UND	78	81	56	75	3	19
ME	55	66	55	70	11	15
ME	61	77	61	77	16	16
CE	69	71	69	71	2	2
CE	36	54	36	65	18	29
CE	71	83	71	83	12	12
2-math	32	54	32	54	22	22
FC	64	86	64	86	22	22
FC	54	91	54	78	37	24
Average	57	75	55	76	18	21
Learner Level	4.1	5.4	3.9	5.4	1.3	1.5
Changed			9.10%	31.80%		

DIFFERENTIAL EQUATIONS						
	Student Assessment		Instructor Assessment		Student Delta	Instructor Delta
Major	Initial	Final	Initial	Final	Final-Initial	Final-Initial
Math	82	93	82	93	11	11
ME	58	78	58	78	20	20
CS	70	76	36	54	6	18
CS	69	61	46	61	-8	15
EM	73	78	73	78	5	5
Math	76	75	56	68	-1	12
CS	59	98	59	68	39	9
Chem	55	85	55	75	30	20
FC	31	78	31	78	47	47
2-math	40	86	40	86	46	46
2-math	75	80	70	80	5	10
Chem	69	79	69	79	10	10
Chem	58	84	58	84	26	26
Chem	62	72	62	72	10	10
Average	63	80	57	75	18	19
Learner Level	4.5	5.7	4.1	5.4	1.3	1.3
Changed			28.60%	28.60%		

There was little difference in learning-level increase between the first-year Calculus II students and the second-year Differential Equations students. About a third of the way through the term the instructor found that in order to keep the challenge-level high for the most ambitious students, it was necessary to define the higher learning levels, **Professional** and **Pioneer**, within the context of each course, so that in each characteristic any learning level was achievable. While students cannot reach the commensurate **Professional** or **Pioneer** level of a mathematician working in the field, some students did reach the highest learning levels, if **Professional** is defined as the level the professor models and if **Pioneer** is defined as 'regularly queries and postulates about additional problem situations, beyond those modeled by the professor'.

Conclusions and Future Study

Before implementing this rubric into their mathematics course, instructors need to choose learner characteristics best-suited to the class they are delivering from the large set of 28 contained in Table 1. It is necessary to give considerable thought at the beginning of the course to creating concrete examples for each learning characteristic they choose, at each of the learning levels, and to spend 30 to 45 minutes discussing each learning characteristic with their class, so the students fully understand how to self-assess.

Even with the higher student-expectation levels required to successfully implement this rubric, the student observations in these three classes were very positive. Thus, the use of this rubric in a flipped classroom, when introduced and explained properly by an instructor with the necessary pedagogical skills, is practicable even in lower-level mathematics classes, without concern that the students are challenged beyond their capability.

By continuing to discuss the learner characteristics as the course progresses, the instructor can interweave a meta-framework into the course, to focus each student on their learning level. The instructor (ideally, an active-learning instructor) can keep reinforcing how the students are improving their learning level with respect to any of their chosen learner characteristics. For example the following were used in this research:

- *That was an excellent example of productive struggle today, class.*
- *In the class discussions today, I heard many of you acting ably as teachers.*
- *I noticed that the class is more efficiently developing quick-thinking skills each day,*
- *Compared to a month ago, all of you are much more self-reliant.*
- *Now that you have a larger repertoire, notice that you can reuse methods more often.*
- *The notation was pretty tough today, but now you are all better translators.*
- *You are all much better at using the computer tools after three classes using them.*

For instructors of lower-level mathematics courses for technical majors, a good outcome is having the average student at the end of the course beyond the **Contained** learner level and approaching the **Professional** learner level, such as occurred in this study. For courses with upper-level mathematics students, a good outcome would be for students to be at least at the **Professional** learner level, with many approaching the **Pioneer** level.

It is necessary to blind-test the extent to which the learner-level improvements seen in the flipped classrooms of this study are also seen in traditional lecture-based classrooms. This comparison will help differentiate the extent to which the incorporation of the learning level rubric itself leads to learning level gains, or whether it is the flipped-classroom pedagogy that is leading to learning level gains. Such an experiment with these controls is already underway.

The learner-level rubric is extendable to other disciplines. A variant of the rubric is being tested in an Organic Chemistry flipped-classroom. As well, the rubric is being employed in a Mathematical Structures class (borderline between lower- and upper-level) and in a lecture-based College Algebra class, where it's serving as a control. There is no reason that a suitably-crafted learning-characteristics rubric, with equivalent learning-levels could not be used in any college-level course.

References

Ellis, W., & Apple, D. K. (2017, November 11). *Learning to learn mathematics: Why is it critical?* Paper presented at the 43rd AMATYC Annual Conference, San Diego, CA.

Huggins, C. M., & Stamatel, J. P. (2015). An exploratory study comparing the effectiveness of lecturing vs. team-based learning. *Teaching Sociology*, *43*, 227-235. Retrieved from: https://doi.org/10.1177/0092055X15581929

Love, B., Hodge, A., Grandgennett, N., & Swift, A. (2013). Student learning and perceptions in a flipped linear algebra course. *International Journal of Mathematics Education in Science and Technology*, *45*, 317-324. Retrieved from: https://doi.org/10.1080/0020739X.2013.822582

McLaughlin, J. E., Roth, M. T., Glatt, D. M., Gharkholonarebe, N., Davidson, C. A., Griffin, L. M., ... Mumper, R. J. (2014). The flipped classroom: A Course redesign to foster learning and engagement in a health professions school. *Academic Medicine*, *89*, 236-243. Retrieved from: https://doi.org/10.1097/ACM.0000000000000086

Missildine, K., Fountain, R., Summers, L., & Gosselin, K. (2013). Flipping the classroom to improve student performance and satisfaction. *Journal of Nursing Education*, *52*, 507-599. Retrieved from: https://doi.org/10.3928.01484834-20130919-03

Appendix

Data from Calculus II Course

ID	Major	Initial	Final	I:Inst	F:Inst	F-I	I:F-i
a1	Math	82	93	82	93	11	11
a2	Non	42	76	42	76	34	34
b1		54	75	54	75	21	21
b2	CE	51	81	51	81	30	30
b5	Bus	39	74	39	74	35	35
c1	CS	50	74	50	74	24	24
c3	CE	46	60	46	75	14	29
d1	CE	46	50	46	60	4	14
d3	ME	89	95	56	75	6	19
f2	ME	67	75	67	75	8	8
i1	ME	49	83	49	83	34	34
l1	Math	67	80	67	80	13	13
l2	CE	62	81	62	85	19	23
m2	UND	78	81	56	75	3	19
m3	ME	55	66	55	70	11	15
o1	ME	61	77	61	77	16	16
s1	CE	69	71	69	71	2	2
s2	CE	36	54	36	65	18	29
s3	CE	71	83	71	83	12	12
w4	2-math	32	54	32	54	22	22
s5	FC	64	86	64	86	22	22
w6	FC	54	91	54	78	37	24
	Average	57	75	55	76	18	21
		4.1	5.4	3.9	5.4	1.3	1.5
	Changed			9.1%	31.8%		

ANOVA	Calculus 2 *Student* Assess Scores			
Groups	*Count*	*Sum*	*Average*	*Variance*
Initial	22	1264	57.5	225.8788
Final	22	1660	75.5	152.0693

Source	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between	3564.0	1	3564.0	18.8597	0.0000870	4.07
Within	7936.9	42	189.0			
Total	11500.9	43				

ANOVA	Calculus 2 *Instructor* Assess Scores			
Groups	*Count*	*Sum*	*Average*	*Variance*
I:Inst	22	1209	55.0	152.0455
F:Inst	22	1665	75.7	73.6558

Source	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between	4725.8	1	4725.8	41.8767	0.00000008	4.07
Within	4739.7	42	112.9			
Total	9465.5	43				

Data from Differential Equations Course

Name	Major	Initial	Final	I:Inst	F:Inst	F-I	I:F-i
a1	Math	82	93	82	93	11	11
b4	ME	58	78	58	78	20	20
c2	CS	70	76	36	54	6	18
d2	CS	69	61	46	61	-8	15
f1	EM	73	78	73	78	5	5
h1	Math	76	75	56	68	-1	12
j1	CS	59	98	59	68	39	9
j2	Chem	55	85	55	75	30	20
m1	FC	31	78	31	78	47	47
p1	2-math	40	86	40	86	46	46
t1	2-math	75	80	70	80	5	10
w1	Chem	69	79	69	79	10	10
w2	Chem	58	84	58	84	26	26
w3	Chem	62	72	62	72	10	10
	Average	63	80	57	75	18	19
		4.5	5.7	4.1	5.4	1.3	1.3
	Changed			28.6%	28.6%		

ANOVA **Differential Equations *Student* Assess Score**

Groups	*Count*	*Sum*	*Average*	*Variance*
Initial	15	940	62.6	184.0867
Final	15	1203	80.2	74.8827

Source	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between	2315.7	1	2315.7	17.8837	0.00022682	4.2
Within	3625.6	28	129.5			
Total	5941.2	29				

ANOVA **Differential Equations *Instructor* Assess Score**

Groups	*Count*	*Sum*	*Average*	*Variance*
I:Inst	14	795	56.8	212.0275
F:Inst	14	1054	75.3	102.8352

Source	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between	2395.8	1	2395.8	15.2177	0.00060492	4.23
Within	4093.2	26	157.4			
Total	6489	27				