An Integrated Elementary School Engineering Education Experience

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Abstract

There are many approaches to introducing engineering into the elementary school environment. Many of these pathways have been presented at the American Association for Engineering Education annual conference. One program developed in partnership with the University of South Florida, the National Science Foundation designated Regional Center of Excellence for Advanced Technological Education in Florida, FLATE (www.fl-ate.org) the U.S. Department of Education's Magnet Program, and the School District of Pinellas County in Florida has been implemented in the Douglas L. Jamerson, Jr. Elementary School in St Petersburg, Florida. This K-5 effort is distinguishable from other projects reported in ASEE publications in that it represents an engineering technology elementary education approach that is totally integrated into the school's curricula and implemented throughout every subject taught in every class in the school. Engineering technology and its design process is the focal point for all learning including physical education and music. The program's fundamental strategy provides a foundation for hands-on and contextual learning for all subjects while fostering creative thinking and critical evaluations. This paper outlines the structure of the program, presents impediments to its success, reviews student scores on statewide tests, and indicates the school's ranking over the last 7 years on the State of Florida's school rating scale. This paper also outlines the strategy used for teacher professional development that assured the curriculum would have its maximum impact on the student population. However, the balance of the paper is toward results and not methods.

Background

Douglas L. Jamerson, Jr. Elementary School opened in 2003 in an inner city low-income neighborhood. The school has a K-5 student population with no special restrictions or enrolment criteria. Its location and magnet school status facilitated the creation of a student population that is ethnicity integrated without a district student assignment plan. Although this basically open enrollment practice draws students from the entire school district the school's Title I services still address the free or reduced lunches needs for approximately 65% of the student body. There are more than 600 students and at least 3 classrooms at each grade level. Student talents and abilities are normally distributed and there is no grouping of mainstream students by sections, test scores, and/or perceived ability. Every teacher at each grade level is expected to present the same curriculum in their stand-alone classrooms with the topics framed by state standards and the order of these presentations driven by lesson plans that are horizontally and vertically integrated.

A unique aspect of the curricula which required school wide modifications to its professional development plan is the fact that the school does not have a specific engineering technology instructional period but integrates the engineering content throughout the science, language arts, mathematics, and physical education standards driven components of its educational mission. This approach forces each teacher to find ways to use these subjects to strengthen the understanding of the engineering supported topics being taught which then, in turn, enrich the student's core "reading, writing and arithmetic" learning experiences. Within this structured environment, the individual philosophy of the faculty at D.L. Jamerson parallels the thoughts expressed by Henry Petroski at the 2003 Virginia Children's Engineering Conference;

> "...Grown-up engineering, which is as old as civilization, maintains the youth and vigor and imagination of a child. This is why, when presented to children on their own terms, the excitement of engineering is immediately apparent and fully comprehendible. There is no child too young to play and therefore to engage in engineering…"

and their collective efforts demonstrate these thoughts in practice.

Curriculum Impact Data

The comparative basis for the impact of this engineering technology based curriculum's success is the fact that the neighborhood school that D. L. Jamerson Elementary school replaced was closed in 2002 because of its poor performance. By 2006, Jamerson's program was in place long enough for the third grade classes to be predominately populated by students that began at the K and/or 1st grade with the 4th and 5th grade population increasing in K-3 Jamerson educated students. Table 1 summarizes the school's Florida Comprehensive Assessment Test (FCAT) statewide rating for the last 6 years including the school's grade during its student transition years. (the school also received an "A" rating for 2013-2014.) The table indicates D.L. Jamerson's curriculum success at least in respect to the expectation the State has for its elementary schools. The grades in Table 1 should be reviewed remembering the fact that all students in a school take the FCAT and that D.L. Jamerson Elementary student population has a complete portfolio of students that includes exceptional education students and children with special needs. Thus, Table1 does more that state that D.L. Jamerson Elementary school is better than the school it replaced. It is, in fact, doing as good or better than the top schools in the district.

Reporting Year	School State Rating
12 - 13	A
11 - 12	A
10 - 11	A
9 - 10	B
8 - 9	A
7 - 8	B
6 - 7	C

Table 1 School FCAT rating

The three parts of Table 2 provide the 2008 FCAT results for all 5th grade students at D.L. Jamerson Elementary School. The table subsections present the fine structure of the 5th grade student performance levels. The headings in the tables are abbreviated and condensed with the hope that it creates a visual format that allows the reader to easily assimilate a lot of details within isolated data table presentations. Each table provides three columns of separate student information with each student only identified as a number. For example, row one of Table 2(a)

#	Read	Level	Scien	Level	Math	Level	#	Read	Level	Scien	Level	Math	Level	#	Read	Level	Scien	Level	Math	Level
10	237	one	270	one	385	one	37	233	one	299	two	311	two	45	187	one	180	one	100	one
48	159	one	211	one	272	one	60	169	one	167	one	190	one							
2	272	one	304	one	345	one	31	197	one	257	two	290	one	63	185	one	216	one	100	one
64	252	one	349	three	347	three	68	144	one	189	one	100	one			Level	2	→		
9	276	two	277	two	303	two	36	280	two	228	one	315	two	65	285	two	305	two	342	three
							33	265	two	274	two	294	two	50	267	two	224	one	315	two
51	285	two	277	two	295	two	62	260	two	240	one	229	one							

Table 2 (a); Douglas L. Jamerson, Jr. Elementary 2008 5th grade FCAT Results

provides score results for student #10 on the left, student #37 in the middle, and student #45. The middle student, #37, has scores of 233 in Reading, 299 in Science, and 311 in Mathematics. The grade level of comprehension, as determined from FCAT statewide rubric, for this male's reading, science, and math scores are one, two, and two, respectively. Students #2, #31 and #63 are the first three female students listed in Table 2 (a). (Student # 5 is 1st female in Table 2 (b).)

#	Read	Level	Scien	Level	Math	Level	#	Read	Level	Scien	Level	Math	Level	#	Read	Level	Scien	Level	Math	Level
1	288	three	304	two	299	two	3	288	three	260	one	321	two	8	324	three	333	three	297	two
14	325	three	364	three	374	four	17	311	three	246	one	286	one	25	296	three	267	one	280	two
29	305	three	380	four	367	four	34	318	three	370	three	365	four	42	320	three	292	two	328	three
52	298	three	251	one	324	two	53	301	three	275	two	281	one	57	295	three	310	two	316	two
66	329	three	356	three	381	four								5	301	three	307	two	335	three
18	287	three	280	two	346	three	19	305	three	307	two	328	three	23	319	three	311	two	356	four
27	293	three	327	three	347	three	30	295	three	350	three	324	three	47	292	three	298	two	329	three
54	317	three	358	three	365	three	58	307	three	348	three	366	four	61	300	three	330	three	345	three

Table 2 (b); Douglas L. Jamerson, Jr. Elementary 2008 5th grade FCAT Results (continued)

The authors offer the information in Table 2 without presentation or discussion of the rubric used to define the comprehension level of a student. This leveling process was performed by others and is based on a procedure defined by the Florida Department of Education. Since the entire

#	Read	Level	Scien	Level	Math	Level	#	Read	Level	Scien	Level	Math	Level	#	Read	Level	Scien	Level	Math	Level
4	371	four	357	three	350	three	7	353	four	359	three	368	four	13	332	four	374	three	363	four
20	363	four	368	three	404	five	22	348	four	413	four	428	five	24	379	four	365	three	393	four
39	338	four	371	three	370	four	40	360	four	399	four	359	four	44	367	four	390	four	419	five
46	345	four	298	three	329	three								6	338	four	351	three	361	four
15	354	four	358	three	362	four	16	364	four	358	three	355	four	21	341	four	389	four	365	four
26	350	four	408	four	411	four	28	349	four	354	three	397	five	38	331	four	338	three	350	three
43	383	four	408	four	405	five	49	346	four	281	two	290	two	55	365	four	378	four	368	four
	Level	5	→				12	392	five	395	four	385	four	32	386	five	366	three	430	five
69	390	five	395	four	385	four								35	400	five	347	three	368	four
56	385	five	396	four	419	five	59	409	five	382	four	387	four	67	402	five	355	three	350	four

Table 2 (c); Douglas L. Jamerson, Jr. Elementary 2008 5th grade FCAT Results (continued)

FCAT examination and the school rating process are well beyond our expertise to comment on, the exams' content, structure, execution as well as the school rating process were simply accepted as a statewide standard best practice. From this perspective, the information in Table 2 simply reflects the 5th grade Jamerson population response to a set of identical examinations that were administered under state guidelines at the same time points in their 5th grade academic year as all of the other 5th graders in Florida. Thus, the results do reflect on the impact of the integrated engineering based curriculum practiced at D.J. Jamerson Jr. Elementary school relative to the desired performance of students in public and private schools in Florida.

There is an abundance of information to contemplate within Table 2. The reader is encouraged to explore the table in-depth with the following observations provided to stimulate that activity. Table 2(a) lists scores for students that read one (level 2) or two (level 1) levels below 5th grade. Table 2 (b) provides score information for students reading at a 5th grade level, (level 3). Table 2(c) reports scores for students that read one (level 4) or two (level 5) levels above 5th grade. No student scored two levels above 5th grade in all three tests (reading, science, mathematics) ; however, female student #56 scored level 5 in reading (385) and math (419) and level 4 in science (395). Reading scores were selected as the bench-march because language art skills are the cornerstone for information transfer in elementary school.

#	Read	Level	Math	Level	#	Read	Level	Math	Level	#	Read	Level	Math	Level	#	Read	Level	Math	Level
1	256	one	283	two	29	223	one	212	one	39	349	one	369	four	42	186	one	230	one
46	248	one	268	two	53	220	one	228	one	66	225	one	287	two	69	242	one	291	two
70	168	one	168	one	77	170	one	292	two	80	250	one	328	three	83	252	one	239	one
89	251	one	377	three	90	203	one	329	three						**21**	258	one	265	two
35	245	one	262	two	**63**	228	one	240	one	**64**	168	one	201	one	**67**	255	one	275	two
91	194	one	219	one		**Level**	**2** →			44	275	two	300	three	60	270	two	301	three
65	277	two	218	one	72	373	two	435	five	74	279	two	328	three					
19	283	two	267	two	**50**	259	two	260	two		**Level**	**3** →			12	313	three	309	three
22	301	three	317	three	23	313	three	315	three	30	313	three	396	four	41	305	three	301	three
57	326	three	400	five	82	314	three	354	four	88	286	three	367	four					
18	314	three	373	four	**33**	300	three	159	one	**38**	316	three	297	three	**43**	301	three	306	three
49	298	three	283	two	**54**	308	three	308	three	**61**	309	three	315	four		**Level**	**4** →		
25	340	four	357	four	34	345	four	346	four	52	333	four	345	three	81	344	four	381	four
87	350	four	340	three						**32**	384	four	320	three	**48**	343	four	415	five
58	343	four	295	three	**59**	386	four	375	four	**62**	345	four	388	four	**75**	344	four	427	five
78	353	four	381	four		**Level**	**5** →			11	448	five	355	four	24	404	five	428	five
86	409	five	338	three	**68**	394	five	380	four	**84**	446	five	469	five	**85**	413	five	500	five

Table 3 (a); DLJ 2008-2009 3rd grade FCAT results

Table 3 (a) and Table 3 (b) provide information analogs to the content of Table 2 but with respect to the 2008-2009 3rd grade FCAT scores. Table 3 (a) shows score information for all the 5th grade students that started at D.L. Jamerson Elementary as Kindergarten students in the 2004-2005 school year. The reading level distribution levels in Table 3 (a) indicate that level 1 has the highest population (33%) followed by level 3 (25%), level 4 (20%), level 2 (12%), and level 5 (10%). Table 3 (b) reports on students that did not start as Kindergarten students. Twelve of the students represented in Table 3 (b) started in the third grade while 10 students started in second grade. Table 3 (b) reading level distribution indicates that most students are at level 3 (36%) followed by level 1 (33%), level 2 (18%), level 4 (13%) and level 5 (0%).

#	Read	Level	Math	Level	#	Read	Level	Math	Level	#	Read	Level	Math	Level	#	Read	Level	Math	Level
4	256	one	271	two	8	227	one	218	two	9	180	one	242	one	14	214	one	267	two
17	245	one	246	one	40	175	one	201	one	53	220	one	228	one	64	168	one	201	one
83	252	one	239	one						5	164	one	271	two	27	229	one	234	one
31	237	one	263	two	56	253	one	217	one		Level	2 →			20	264	two	315	three
37	259	two	307	three						6	280	two	312	three	16	260	two	259	two
28	273	two	306	three	50	259	two	260	two	71	270	two	305	three		Level	3 →		
13	315	three	359	four	36	316	three	340	three	41	305	three	301	three	45	328	three	350	four
76	302	three	320	three	79	242	three	340	three						15	313	three	364	four
23	313	three	315	three	26	289	three	277	two	30	313	three	396	four	33	300	three	159	one
49	298	three	283	two	55	396	three	400	five	82	314	three	354	four		Level	4 →		
10	337	four	382	four						3	383	four	500	five	32	384	four	415	five
47	382	four	268	two	51	336	four	375	four		Level	5 →							

Table 3 (b); DLJ 2008-2009 3rd grade FCAT results (students not starting in Kindergarten)

Rational

Why an integrated engineering curriculum? From the very first meeting in 2002 the founding faculty at DLJ made it clear that their priority was to teach the children to read well. Although temped to dissuade them, the authors made their first great decision; "just go with the flow". Thus, the decision was to develop the engineering, with its supporting science and math into the school's reading curriculum first, and to implement these changes immediately in the K-3 grade levels. However, this approach is not without its challenges. Elementary school language arts teachers have a lower interest and considerably less background in math and science. His or her initial perspective of engineering's role was simply an assigned project or non-mainstream filler activity supervised by someone else. In addition, the expansion of primary students' (K-2) appreciation of mathematics to include scalars and vectors required considerable professional development of primary faculty and then additional workshop activities to distill their new knowledge into the students' reading environment. Finally, the primary faculties initial mindset when projects were used was to fall back on low implementation energy standard book company examples that either matched the season, plants on the window sill, or general science themes with some version of a volcano model the most popular selection.

Results

Table 4 provides, at least for DLJ, the overview results in FCAT reading scores and accents the wisdom in the "put engineering into the reading curriculum first" strategy. Table 4 (a), Table 4 (b) and Table 4 (c) present summary information, relative to the students' reading levels, for the 5th grade and 3rd grade FCAT scores, respectively. Two extreme facts are not incorporated in these table summaries;

(a) The lowest individual 3rd grade student FCAT score sets are level one scores for reading, and mathematics.
(b) The lowest individual 5th grade student FCAT score sets are level 1 score in science and level 2 scores in reading and math.

As a base point for review of the results in Table 4, Table 3 data indicates two things.

(a) Three 3^{rd} grade students had FCAT scores of five and five in reading and mathematics.
(There was no science FCAT for 3^{rd} graders in 2008-2009.)

(b) The single highest 5^{th} grade FCAT scores set of five, four and, five was achieved by two students.

Below Level 3 readers

5 males and 5 females read two levels below 5^{th} grade level
3 males and 4 females read one level below 5^{th} grade level
All but 2 below grade level readers scored below grade level in science and mathematics

Level 3 readers

8 male 3^{rd} grade level readers are below grade level in math
No female 3^{rd} grade level readers are below grade level in math
10 males and 10 females are one level above grade level readers
2 males and 5 females are two levels above grade level readers

Level 4 readers

10 of the 20 level 4 readers were female
No level 4 readers was below grade level in science or math

Level 5 readers

5 of the 7 level 5 readers were female

Table 4 (a); 2008-2009 highlights for 5^{th} grade FCAT results

Below Level 3 readers

11 males read 2 levels, level 1, below 3^{rd} grade readers
5 females read 2 levels, level 1, below 3^{rd} grade readers
5 males and 2 females are one level below expectations for 3^{rd} grade readers
3 of the below grade level readers scored at 3^{rd} grade level in math

Level 3 readers

8 males and 7 females are at the 3^{rd} grade reading level
Two 3^{rd} grade readers scored below grade level in math
Six 3^{rd} grade readers scored above grade level in math
One 3^{rd} grade reader scored two levels above grade in math

Level 4 readers

7 of the 12 level 4 readers were female
No level 4 reader was below 3^{rd} grade in math
2 male and 2 female level 4 readers scored at grade level in math

Level 5 readers

1 of the 6 level 5 readers scored at grade level in math
3 of the 6 level 5 readers were female

Table 4 (b); 2008-2009 highlights for 3^{rd} grade FCAT results (students starting at DLJ)

Vertical Alignment

Realizing the value in reinforcement of the engineering elements over a student's time period at D.L. Jamerson, the faculty put an engineering based elementary education plan in place that also assured vertical alignment and spiral learning. Although every grade level was expected to develop engineering based content for all subject strands taught, each grade level had the leeway to structure how to go about teaching to State defined standards connected to each strand. As the curriculum developed and the elementary engineering education expertise in the faculty matured,

Below Level 3 readers	9 males read 2 levels, level 1 below 3rd grade readers 4 females read 2 levels, level 1, below 3rd grade readers 2 males and 4 females are one level below 3rd grade readers 5 of the below grade level readers scored at 3rd grade level in math
Level 3 readers	6 males and 8 females are at the 3rd grade reading level Three 3rd grade readers scored below grade level in math Six 3rd grade readers scored above grade level in math One 3rd grade reader scored two levels above grade in math
Level 4 readers	4 of the 12 level 4 readers were female 1 level 4 reader was below 3rd grade in math No level four readers scored at grade level in math
Level 5 readers	No student scored at level 5 in reading

Table 4 (c); 2008-2009 highlights for 3rd grade FCAT results (students not starting at DLJ)

this spiral alignment was refined and fortified. Table 5 provides the fundamental vertical alignment for the Gravitational Force and Resultant Motion unit in the physical science subject strand. This force field to motion alignment was one of the first developed.

The rudimentary concepts in this topic area are immediately familiar to the students and lessons developed have a tactile nature that reinforces learning. For example, the students in the kindergarten classes certainly read about Goldilock's adventure and the chair construction activity was absolutely grade appropriate but they were also asked to predict what would happen to the chairs when there were two choices of dolls that looked the same but had different mass. The dolls were attached to spring scales and the children had to notice the needle positions before they could pick up the dolls. Thus, the visual position of the scale needle with its alternative non-standard units (high, low) reinforced the child's own measurement system units (heavy, light) to collaboratively predict which doll would break the chair.

The "weight" theme continued in first grade via the reading of folk tales. This reading progression reflected the increased skills in the first grade reader and also provided an avenue to bring the work concept into their reading experience. This, in turn, lead to energy conversations and the required lessons on healthy diet. By 2nd grade math skills allowed a shift from a just reading focus to a few design challenges that demanded the dexterity and patience of an older child. From third grade on, the math skill set drove the engineering technology activities to a higher plane with reinforcement about work, simple machines, mechanical advantage and calculations that connected those reading efforts to scalar quantities. By the 4th and 5th grades, reading for comprehension is the focus and students have district assigned science texts and word problem math programs that can be supported by relatively sophisticated engineering technology based projects.

Although reading was the Jamerson faculty designated path to the engineering activity The school year at D.L. Jamerson is sectioned to cover specific science areas by school district design. Thus, the faculty developed a learning Strands for physical science (Table 5), earth science and life science. Themes were developed in each of these Strands that vertically carried through each grade level in a manner analogous to the forces and motion theme reviewed above.

Gravitational Force and Resultant Motion Strand		
Grade	**Engineering Science Concepts**	**Examples**
Kdgn.	Introduces **forces as a push or pull** through fairy tales such as *Goldilocks and the Three Bears* and *Humpty Dumpty*.	□ Building chairs to support the mass of 2 different Goldilocks dolls. □ Finding ways to prevent Humpty from falling off the wall, to protect his body, and to protect his landing.
1st	Introduces **work** through the folk tale of *John Henry*.	□ Building puff “steam engines” □ Building a lunch box with foods that would provide energy for John Henry.
2nd	Introduces **potential** and **kinetic energy** as well as **friction.**	□ Building a marble drop that meets specific design criteria.
3rd	Introduces **mechanical advantage** of **work** through **simple machines** as well as finding **mass in grams** and **weight in Newton’s.**	□ Designing a pulley system with specific mechanical advantage requirements.
4th	Introduces **calculations of the scalars; volume, density, power**, **live load and dead loads** and the **buoyant force vector** as well as the introduction of **free body diagrams** and **technical drawings.**	□ Building and testing clay dugouts. □ Calculating buoyant force and creating free body diagrams. □ Sketching technical drawing of a K’Nex car. □ Building K’Nex cars to test and complete calculations.
5th	Introduces **various types of bridge designs**, various forces acting on a bridge (**tension**, **torsion**, and **compression)** and how to **calculate their strength**, **distributive load,** state of **failure** or **equilibrium**.	□ Calculating forces and showing applied forces through free body diagrams. □ Designing and building a model bridge that will meet specific design criteria. □ Completing a cost analysis of their bridge design.

Table 5; the vertical alignment in the physical science subject strand

Summary

In 2003 Douglas L. Jamerson, Jr. Elementary School was created in a predominantly ethnically isolated inner city neighborhood. The school's magnet and neighborhood K-5 student population is blended without special enrolment or classroom assignment criteria. Every teacher at each grade level presents curricula topics in an order driven by a school wide horizontally and vertically integrated lesson plan grid. Since the curriculum is designed not to have a separate specific engineering instructional period there was an initial intensive 2 year professional development plan executed at Jamerson that facilitated faculty efforts to integrate the engineering content throughout the science, language arts, mathematics, and physical education standards driven component of its educational mission. The 2008-2009 FCAT data represent the first "graduating class" at D.L. Jamerson. These scores plus the extensive list of honors the school continues to collect confirm the merit and success of Jamerson's approach to elementary education. Table 6 (a) and Table 6 (b) summarize the elementary education FCAT experience

#	Read	Level	Scien	Level	Math	Level	#	Read	Level	Scien	Level	Math	Level	#	Read	Level	Scien	Level	Math	Level
2	272	one	304	one	345	one	10	237	one	270	one	385	one		Level	2	→			
33	265	two	274	two	294	two	62	260	two	240	one	229	one	65	285	two	305	two	342	three
	Level	3	→				23	319	three	311	two	356	four	34	318	three	370	three	365	four
42	320	three	292	two	328	three	52	298	three	251	one	324	two							
5	301	three	307	two	335	three	61	300	three	330	three	345	three		Level	4	→			
16	364	four	358	three	355	four	21	341	four	389	four	365	four	22	348	four	413	four	428	five
26	350	four	408	four	411	four	49	346	four	281	two	290	two							
12	392	four	396	four	385	four	28	349	four	354	three	397	five	43	383	four	408	four	405	five
44	367	four	390	four	419	five		Level	4	→				56	385	five	396	four	419	five

Table 6 (a); DLJ 2008 5th grade FCAT results for students starting at Kindergarten

#	Read	Level	Scien	Level	Math	Level	#	Read	Level	Scien	Level	Math	Level	#	Read	Level	Scien	Level	Math	Level
Started in first grade								Level	1	→				37	233	one	299	two	311	two
45	187	one	180	one	100	one	48	159	one	211	one	272	one	60	169	one	167	one	190	one
64	252	one	349	three	347	three		Level	3	→				14	325	three	364	three	374	four
27	293	three	327	three	347	three	29	305	three	380	four	367	four	53	301	three	275	two	281	one
57	295	three	310	two	316	two								30	295	three	350	three	324	three
54	317	three	358	three	365	four		Level	4	→				20	363	four	368	three	404	five
							7	353	four	359	three	368	four	55	365	four	378	four	368	four
	Level	5	→				35	400	five	347	three	368	four							
Started in second grade								Level	1	→				68	144	one	189	one	100	one
	Level	2	→				50	267	two	224	one	315	two		Level	4	→			
6	338	four	351	three	361	four								40	360	four	399	four	359	four
46	345	four	298	three	329	three		Level	5	→				67	402	five	355	three	350	three

Table 6 (b); DLJ 2008 5th grade FCAT results for students starting at 1st or 2nd grade

for students that started elementary school in DLJ's Kindergarten and the students that started at first or second grade. Table 6 (c) provides the same report information for the students that started at third or fourth grade. Data in Tables 6 (a) and 6 (b) indicate that 66% of the level 1 readers based on the 5th grade FCATs did not attend Jamerson's Kindergarten. However, 73% of the level 4 readers did attend Kindergarten at Jamerson.

Students that started in 3rd or 4th grades, Table 6 (c) had no FCAT score down side because of Jamerson. Only 3 of the 15 students in this group scored below level 3 in reading.

#	Read	Level	Scien	Level	Math	Level	#	Read	Level	Scien	Level	Math	Level	#	Read	Level	Scien	Level	Math	Level
Started in third grade							Level 1 →							63	185	one	216	one	100	one
Level 2 →							36	280	two	228	one	315	two							
9	276	two	277	two	303	two	Level 3 →							17	311	three	246	one	286	one
							18	287	three	280	two	346	three	25	296	three	267	one	280	two
58	307	three	348	three	366	four														
Started in fourth grade							Level 2 →													
51	285	two	277	two	295	two	Level 3 →													
3	288	three	260	one	321	two	8	324	three	333	three	297	two	11	311	three	246	one	286	one
47	292	three	298	two	329	three	66	329	three	356	three	381	four	Level 4 →						
39	338	four	371	three	370	four	Level 5 →							32	386	five	366	three	430	five

Table 6 (c); DLJ 2008 5th grade FCAT results for students starting at 3rd or 4th grade

Table 7 suggests the level of recognition Douglas L. Jamerson, Jr. Elementary school's approach to elementary education has achieved. The list indicates that the engineering with its supporting mathematics focus has made its mark with the federal government, the City of St. Petersburg, and parents. Recognition by the Parent Teacher's Association is a significant community achievement since this award is governed by the school meeting detailed expectations in six nationally based categories; Student Learning, Communicating, Parenting, Volunteering, School Decision Making, Advocacy, and Collaborating within the community. In the 2012-2013 academic year Jamerson lead the Pinellas School District (the 9th largest school district in the country) with learning level gains in its lowest level student population. In addition, Jamerson's 3rd, 4th and 5th graders continue to increase their scores in reading and mathematics. All of these accomplishments still include the school running Autistic, Communication Disorders, and Specific Learning Disabilities Exceptional Education Programs. Collectively, these recognitions of excellence combined with student FCAT scores and the faculties continuous improvements approach to education demonstrates that D.L. Jamerson Elementary School's use of engineering as the basis for student learning is working effectively and does meet if not exceed societies expectation for elementary education.

United States Department of Education
Magnet School of Excellence Awards- 2014, 2013, 2010, 2008
Magnet School of Distinction Awards- 2012, 2011, 2009
City of St. Petersburg
Top Apple Awards- 2014, 2013, 2012, 2009, 2008
United States Parent Teachers Association
PTA Logo Awards- 2013, 2012, 2011, 2010
(2014 awards not announced as of paper submission)

Table 7; Douglas L. Jamerson, Jr. Elementary program related awards

Finally, the authors appreciate that most of the creation, operation, and faculty development details needed to successfully execute the engineering curriculum at D.L. Jamerson are not provided in this paper. The paper provides a great deal of data to emphasis the success of the program but not much information on how this was done. These details are important but extensive. As the curriculum was being developed that progress was reported as papers and presentations at the ASEE annual meetings. To facilitate readers that want these details, those key publications are isolated below in Table 8 as a list in reverse chronological order. Thus, the methods used in the earliest stages of the project are reflected in the content of the Table 8(e) listed paper while the curriculum structure, philosophy, and maturity are indicated in the other table listings.

Title	**ASEE Conference & Exhibition**	**Paper Listing**
(a) Engineering an Elementary School Environment to Enhance Learning	2008	-1487
(b) Integration of Elementary Engineering Elements into the Language Arts Program	2007	-1901
(c) Supporting Math and Science through Elementary Engineering in Elementary Ed.	2007	-1857
(d) Engineering is Elementary; An Engineering And Technology Curriculum for Children	2007	-8
(e) Essential Element Examples of Elementary Engineering in Elementary Education	2006	-1158

Table 8; Content resources for the D.L. Jamerson integrated engineering curriculum

Conclusion

Engineering faculty, secure in the validity of the premise that engineering technology education elements within the elementary school environment can make a systemic impact; need to engage in elementary engineering education. Of the many viable options for action, the commitment to help integrate engineering into a public school has the highest probability of triggering system changes in the way K-5 grade level children are taught. The pitfalls and rewards for these efforts are clear.

Perspective adjustments of the interested members of the engineering educator community will increase the likelihood of the long term success of engineering education in elementary schools and also remove a major pitfall. It is important to avoid the "Little League" approach. In their model, the expertise required is gleamed from an adult with a vested interest; the parent of current player. Thus, the needed long term adult commitment to Little League, or youth soccer, scouting, etc continues even after, in a year or so, individual parents move on with their child to the next activity level. This model with its sincere but short term personnel investment will not sustain a systemic infusion of engineering technology based principles into the dynamic elementary school education environment.

In addition, it is certainly true that the engineering faculty member knows tons more about engineering than the elementary school teacher. However, it must be remembered that the elementary school teacher knows kilotons more about K-5 teaching and age appropriate learning as well as being a smart dedicated professional willing to take on new challenges to improve student performance. Any integration effort using grade level adjusted engineering technology applications will work when the teachers lead the way and an engineer those teachers have come to know and trust is always there to design and shape the process but remains in the background.

An elementary school can teach engineering principles as the basis for the child's learning experience. However, the engineering faculty member(s) involved must have a long term commitment to that school and there will initially be a very large time, talent, and tenacity investment on the engineers' part. Unfortunately, that investment will, in most engineering colleges, not have much impact on that engineer's tenure and promotion.

The engineering faculty member's major reward is obvious, but ironic. As it did at D.L. Jamerson, the impact of a successful effort will ripple through the school's community and district as well as verify the curious fact about working very hard on something you like that is difficult. That type of work, especially when it has a significant social impact, is really just fun and the harder the work the more fun!

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