Name of Program: Lockheed Martin/ UCF Academy for Mathematics and Science

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Lockheed Martin/UCF Academy for Mathematics and Science

Describe your program, including its mission, goals, and key components.

The Lockheed Martin/UCF Academy for Mathematics and Science (LMA) is an education/industry/community partnership created to improve mathematics and science education in Central Florida. This graduate program for teachers of kindergarten through eighth grades was founded in 1992 by the University of Central Florida (UCF). The LMA was funded through a unique collaboration between the private and education sectors. The Lockheed Martin Corporation donated one million dollars to UCF over a four-year giving period, and Florida's Board of Regents provided matching funds. Furthermore, the National Science Foundation awarded start-up funds that sustained the program during the giving period. The endowment provides one of the unique features of this graduate program; it ensures continuing tuition support (approximately 2/3 of tuition cost of the entire program) for a program that instructs teachers how to become change agents in the teaching and learning of mathematics and science. The University of Central Florida nominated the LMA as a UCF Program of National Prominence in 2002. The benchmarking process for this prestigious nomination resulted in a detailed search for other programs of an integrated nature and has revealed that the LMA is one of the few graduate programs in education that offer enrollees an M.Ed. in integrated mathematics and science education for teachers in grades K-8.

The **mission** of the LMA is to improve the quality of mathematics and science teaching and learning in the schools of Central Florida by providing leadership efforts to:

- Strengthen the quality of teaching and learning in mathematics and science education
- Create a network of school-based leadership in mathematics and science education
- Develop a strong infrastructure of cohorts focusing on long-term impact
- Increase the number of pupils who enter high school and choose to enroll in mathematics and science courses which will prepare them for careers in mathematics, science, and technology fields.

The LMA provides the environment, the challenge, and the theoretical and practical context of education where inquiry and collaboration can occur. This intellectual atmosphere fosters the creation of teacher-leaders and initiation of educational change. The beliefs of the LMA are as follows:

- Mathematics and science knowledge must be constructed by each pupil through active interaction.
- Mathematics and science are learned most effectively through problem solving experiences related to the real world.
- All pupils must have opportunities to learn significant and relevant mathematics, science and technology.
- All pupils can succeed in classrooms where expectations are high and risk-taking is encouraged.
- Mathematics and science curriculum, instruction, and assessment must be sensitive to differences related to socioeconomic backgrounds, gender, culture, and ethnicity.
- Mathematics and science instruction must encourage direct family involvement.

The LMA academic program design is consistent with national curriculum, instruction, assessment, and teacher preparation standards and is based on the conceptual framework of the

teacher as a reflective practitioner. The program emphasizes leadership and pedagogy through collaboration and reflective practices, and is committed to the creation of a network of K-8 school-based leadership in mathematics and science education. Therefore, a major focus of the program is supporting all teachers in their efforts to enhance the quality of mathematics and science education. Teachers in the LMA are referred to as scholars, and from 1993 to 2003 the LMA graduated over 300 scholars. The program awards master's degrees in K-8 Mathematics and Science Education.

The academic program consists of 39 semester hours and requires five semesters to complete. The scholars proceed through the LMA in cohorts of approximately 20. The LMA purposefully creates a risk-free, collaborative environment in which the LMA scholars thrive. The development of a professional community within the cohort supports teacher growth and change. The coursework makes explicit the LMA philosophy of teaching as ongoing self-improvement; becoming better at teaching is seen as an ongoing journey. Self-questioning and reflective practice are crucial aspects of good teaching, and are purposefully fostered within the LMA scholars.

Producing an action research thesis is the culminating activity of the academic program and is required for graduation. The theoretical framework for the action research is one of reflection and action. Action research allows the researcher to focus on his/her teaching practice to improve and learn. While rigorous and systematic, action research is intent on describing, interpreting and explaining events while the researcher seeks to change them for the better.

Due to the unique nature of the LMA, the National Science Foundation (NSF) awarded $934,081 for a four-year grant to longitudinally evaluate the effectiveness and impact of the LMA in 1999. The grant afforded investigators and NSF the time for a follow-up study of this program to examine its long-term effects. Longitudinal studies of academic programs are unusual; often, investigators have little interest in, or time for follow-up studies of their programs after the primary funding ends. Academic faculty members have multiple demands for their time that seldom include looking back at previous work. The pressures in academe for continued external funding lead investigators to seek additional funds for a new project that capitalizes on what they have learned in the relatively short term of the original project. Thus, the long-term effects of the original projects remain uninvestigated and unknown. As a result of NSF's initiative to look back, the extensive evaluation of the LMA was able to provide a plethora of evidence that the program is meeting its goals.

Lockheed Martin/UCF Academy for Mathematics and Science

A. Describe how the program is a cooperative effort between the college of education, arts and science, and P-12 schools.

Drs. Ventre (Engineering), Chow (Physics), and Armstrong (Mathematics) have taught courses in the program, and members of each of the mathematics and science departments serve on the advisory committee for the academic program. Such collaborations have resulted in the writing of federal grants. Five proposals totaling over 10 million dollars are currently under review, and Drs. Hynes (Mathematics Education) and Morse (Engineering) are completing an NSF Bridging Education and Engineering grant where engineering concepts are being infused into methods classes and the introductory engineering courses are being revamped for on-line delivery with assistance from the College of Education.

Besides collaborating with the Colleges of Arts and Science and Engineering, the LMA program is tightly linked to public school districts. While it targets teachers from the school districts of Orange, Seminole, and Osceola Counties, it is open to K-8 teachers from other school districts. The LMA and Orange, Seminole, and Osceola Counties work together to provide senior interns for the LMA scholars while they are in the program. This arrangement benefits all stakeholders. The development of leadership skills represents a central piece to the LMA program, and mentoring a senior intern provides an arena for the LMA scholars to sharpen those skills. Mentoring a senior intern also helps the scholars to improve their communication skills and the articulation of their teaching practice. Scholars also benefit financially. The state of Florida provides a voucher for up to six semester hours of tuition for each senior intern mentored. The senior interns benefit from learning how to teach under the careful supervision of a LMA scholar. Additionally, the senior interns learn that ongoing professional development is important to the profession since their mentors are participants in LMA's professional development master's program. The school districts benefit from this arrangement because the senior interns have a high-quality internship experience that helps them become successful first-year teachers. The University of Central Florida is a metropolitan research university, and most of the senior interns find a job placement in the school district in which they completed their internship.

Most importantly, the partnership between the tri-county school districts, the College of Arts and Science, and the LMA has resulted in excellence in mathematics and science teaching. The mission of the LMA, as pointed out before, is to strengthen mathematics and science teaching and learning. Data from the longitudinal study illustrate that the LMA has produced a cadre of empowered teachers who teach a standards-based mathematics and science curriculum that has resulted in improved pupil learning. An examination of mobility data illustrate that the majority of graduates of the LMA have remained in education, where they continue to provide their expertise to the pupils of Central Florida and also to their colleagues.

C. Provide examples of evidence that demonstrate the program's positive impact on teacher candidates' learning.

Positive impact on teachers' learning can be shown in several forms of data resulting from the NSF-funded longitudinal study which was recently concluded. A mixed methods design was utilized, providing multiple data sources and a variety of in-depth evidence. Data sources include classroom observations, focus groups, surveys, interviews, teacher work-samples, and document review.

In the first year of the study, a Professional Impact survey was completed by 73 LMA graduates. On the specific topic of increasing teacher learning, the data show that:

- "the LMA has helped increase my job satisfaction" (79%).
- "the LMA increased my content knowledge" (85%)
- "the LMA increased my pedagogical knowledge" (93%).
- "the LMA increased my leadership skills" (85%)

During the first year of the study, a fidelity study was also initiated. Fifty-five LMA graduates were observed teaching a mathematics or science lesson. Two or three observers were present for each observation; tests of inter-rater reliability were conducted. The *Local Systemic Change* protocol developed by Horizon, Inc. was used. During the second year, 28 graduates were observed teaching a mathematics or science lesson two times in a one-week time frame. In year three, observation data collection focused on the classrooms of 13 graduates who had been rated very highly by the evaluation team in previous years; these observations were longer in duration, with each session lasting about three hours, and four or five sessions were observed for each teacher. The results of the first year's observations showed that 100% of the graduates' work was highly aligned with Florida's Sunshine State Standards (which are largely based on the NCTM Principles and Standards and National Academy of Science Teaching Standards). The majority of classrooms observed reflected an excellent classroom environment; 75% of observations in years one and two rated a 4 or 5 on a 5-point scale for class climate. A high degree of respect for pupil ideas, questions, and contributions were noted in 86% of the observations. Because a purposeful sample of accomplished teachers was used in year three, results are not reported in this document.

Focus groups of LMA graduates took place at various points of the longitudinal study. Evidence of impact on graduates' learning can be seen in the themes which emerged consistently throughout the years:

- Participants agreed that their classroom practices had moved to more inquiry-based actions, with a focus on pupil collaboration (rather than traditional paper and pencil drill tasks, which tend to foster isolated learning).
- A more pupil-centered approach was reported as a result of lessons learned in the LMA program; teachers had changed so as to encourage more pupil input.
- LMA graduates had learned to employ cooperative grouping strategies in their classroom, largely because they had worked this way in the LMA program.

- Graduates had learned to use constructivist ideas, a more integrated curriculum, hands-on discovery, and brain-based learning strategies. The LMA had given them practical classroom applications of these results of recent research studies.

A notable example of the impact of the LMA program on the learning of teachers is the high rate of success LMA graduates have had in achieving the recognition of National Board Certification. To date, 37 graduates have applied for, and been granted, this distinction. This represents 12% of the LMA graduates, as compared to the Florida state percentage of Nationally Board Certified teachers of 1.5%.

Another focus of teachers' learning in the LMA program is the development of the confidence and "know-how" to become a teacher-leader. The taking on of leadership roles was a constant theme of the focus groups and of interviews—expressed in mentoring, presentation of professional development to colleagues, participation in committee work, appointments as team leaders or simply in acting as role models. Many graduates expressed gratitude that the professors of the LMA provided exemplary models of leadership. The graduates further articulated a conviction that the effects of enhanced leadership skills increased their willingness to take risks and their desire to make changes in their teaching practice. One graduate had been featured in a PBS *Scienceline* program on the strategy of inquiry teaching; in the program, LMA was identified as crucial to the graduate's expertise in this approach. The evidence of leadership learning illustrated by this media appearance is supported by the statistic that currently, 17% of graduates have been promoted to leadership positions (such as district curriculum specialists), and 11% have pursued further graduate education. Survey data (n = 64) indicate that 99% of the respondents were active professionally, from serving on committees to providing professional development for other teachers. One open-ended survey item asked how the graduate benefited from the program. Forty-seven percent of the responses centered on improved leaderships skills and confidence, and 60% wrote about improved classroom teaching practice as evidenced by the following comments taken directly from the survey:

- "Personal growth. Made me a better teacher. I'm a better person and therefore a better teacher."
- "[The] program pushed me and encouraged me to take my teaching a step farther. Learned new teaching methods for science."
- "…improved my science (& math) knowledge, research and teaching skills. I do more cooperative learning [sic] Better teacher now. Continued learning—increased knowledge and ideas. "
- "…have been able to use a lot of the theory and skills in my classroom and have seen an increase in enthusiasm from my students and within myself."

More quantitative details of the graduate leadership activities garnered from survey data are illustrated in the following table:

Leadership Activities for LMA Graduates (2002-2003)*

Provided professional development to other teachers	71%
Authored grants	66%
Attended conference without conducting a presentation	64%
Conducted presentations at professional conferences	30%
Received honors or awards	30%
Authored papers/articles	15%

*N=64

In the fourth year of the longitudinal study, additional evidence of teacher learning was collected in the form of Teacher Work Samples (TWS). This tool provides a rich, detailed picture of a teacher's practice and underlying philosophy; the format used here follows that developed by the Renaissance Partnership for Improving Teacher Quality. LMA graduates were invited to provide studies of their practice; the four that created finished products looked at three-to-five week units of their curriculum, focusing on plans and assessments relating to learning outcomes (which are discussed in the following section of this submission). The teachers revealed a great deal about what they had learned through their LMA experience. The components of the format are: contextual factors, learning goals, assessment plan, design for instruction, instructional decision-making, analysis of pupil learning, reflection, teacher beliefs and philosophies, and planning and resources. A rubric system applied a three-point rating to each of several indicators for these components: one point for "indicator not met", two for "partially met", and three for "indicator met". Average scores for the TWS's on the components ranged from 2.5 to 3; overall average score was 2.82 which is quite high. It is true that the TWS study is a highly qualitative one, and therefore these numbers are presented as indicators rather than as evidence. However, the rich description of the teachers' practice does reveal the impressive repertoire of teaching strategies and techniques that these LMA graduates have mastered, as well as their infectious enthusiasm for guiding pupil learning.

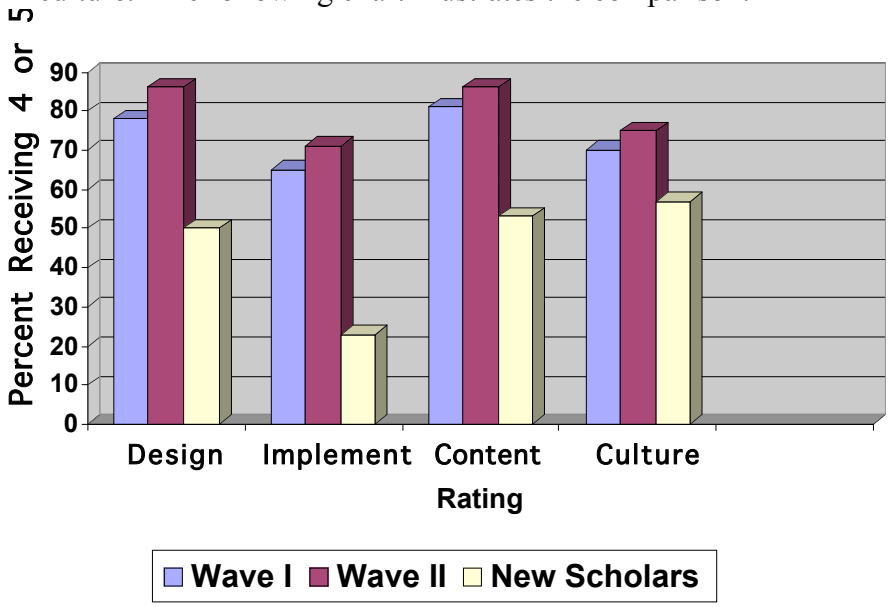
The LMA works hard to purposefully create a sense of community within the program and its participants. This sense of belonging results in numerous scholars keeping in touch with program personnel. It is not uncommon for graduates to contact program personnel to expand upon their achievements and comment on the LMA's impact on their achievements. Once such unsolicited communication was made via e-mail on May 12, 2004 and illustrates the impact of the program on this graduate, his teaching skills, and his pupils' performances. It reads:

> Dear Dr. Hynes,
> I graduated from your math and science program in 2003. Ever since then, I have been using the ideas and learning to help me become a better science teacher. Your program forced me to objectively analyze how my teaching influenced my students' learning. It was a painful process, but worthwhile.
>
> Since I graduated, my principal at my school put me in the position of teaching all of the 5th grade students science at my school. I had around 117 students in all. We are a Title I school with around 40% free/reduced. Well, I wanted to share with you the FCAT results that were attributed to

your program because I was the only teacher responsible for science this year.

Science Mean score for 2003 - 298
Science Mean score for 2004 - 325

Additionally, to help determine the program effect on the graduates, thirty teachers who were newly admitted to the LMA were observed using the same *Local Systemic Change* protocol that was used with the graduates. This comparison provides striking evidence of the differences between program graduates and the control group of 30 teachers who had yet to experience any program effect. The graduates received higher ratings on a 5 point Likert scale for all four sections of the observation protocol: lesson design, lesson implementation, content, and classroom culture. The following chart illustrates the comparison:



Finally, principals were surveyed to determine their perceptions about the graduates. One hundred and twenty surveys were sent to principals with a response rate of 55% (n=66). It is notable that their responses were overwhelming positive. Details of that data are below:

Principal Perception of LMA Teacher Quality

Question	Response
If you have LMA graduates teaching math, how would you rate their effectiveness in math instruction?	84% effective or very effective
If you have LMA graduates teaching science, how would you rate their effectiveness in science instruction?	86% effective or very effective
Overall, to what extent do LMA graduates serve as instructional leaders in your school (i.e., mentors, workshop facilitators, role models, etc.)?	84% to a great extent
Would you like to have more LMA graduates on your faculty?	91% yes
Have you recommended the LMA program to your teachers?	77% yes

D. Provide examples of evidence that demonstrate the program's positive impact on graduates' ability to improve P-12 pupil learning.

The gold standard of evidence of improvement in pupil learning, currently, seems to be standardized test results. In Florida, this means the Florida Comprehensive Assessment Test (FCAT). Data collected and analyzed to date does provide evidence of the effects of the LMA program on the pupils of its graduates. Academic year 2002 mathematics FCAT scores were obtained for 476 pupils of LMA graduates; their mean scores (normed and/or criterion) were compared, by grade, to statewide mean scores. As can be seen below, the LMA-related scores were significantly higher than the state scores in all grades except fifth (and those fifth-grade LMA related scores were higher than the district means for fifth grade).

2002 FCAT Scores for Students of LMA Teachers Compared to State Means

Comparison to State Mean Criterion Scores				**Comparison to State Mean Normed Score**			
Grade	df	p=	Mean Difference	Grade	df	p=	Mean Difference
3	44	.033	20.3	3	44	.023	14.4
4	145	.000	28.7	4	105	.00	13.5
5	49	.623	<-3.6>	No Data Available for Normed 5th Grade			
7	118	.000	32.3	7	115	.00	18.5

A recent dissertation (Woolridge, 2003) studied the performance of pupils on the FCAT relative to the certification level and educational background of teachers. Pupils of the graduates of the LMA program teaching in elementary schools scored significantly higher on the test than students of other teachers. When compared to the subgroup of teachers with master's degrees but not the LMA master's, the result was the same. The pupils of LMA graduates scored significantly better that students of other teachers with other masters degrees.

A 2004 study (Hirumi) relating the Florida school grades to the number of LMA scholars employed at the school, provides further evidence of the program's positive impact on graduates' ability to improve pupil learning. The state of Florida grades its schools A, B, C, D, or F, according, primarily, to the FCAT scores achieved by each schools' pupils, as well as the history of changes in the scores from year to year. A clear positive correlation was found to exist between the number of LMA graduates serving in a school, and its grade. Of schools that employ one graduate, 83% are rated A, B, or C. Of schools employing two graduates, 90% are rated A, B, or C. In schools that employ three or more graduates, 93% are rated A, B, or C. Overall, 87% of schools that employ graduates are rated A, B, or C; while statewide, 85% of all schools are rated A, B, or C.

Program graduates' abilities to improve pupil learning are related to the climate of the classrooms in which they work. Observational classroom data strongly supports the contention that these climates are positive. Using the *Local Systemic Change* protocol described in the

previous section, findings in years one and two were that 63% of lessons observed found pupils working collaboratively. Pupils were active in their learning, talking with each other to make sense of the learning activity in which they were engaged. Observations also showed that the majority of these classroom climates were relaxed and comfortable places to work, which aligns with findings by brain researchers Caine & Caine (1991) that a risk-free environment is a requirement for optimal learning.

Graduates' abilities to facilitate learning are also impacted by the program's emphasis on NCTM and NSTS standards. In year-one classroom observations, the overall synthesis ratings for content of lessons meeting the national standards were high, as mentioned above. Learning is promoted, according to Caine & Caine's brain research, when it is connected to previous learning. LMA graduates excelled at this type of connective teaching. Even at a time when Florida's high-stakes test, the FCAT, did not assess science learning, 40% of elementary school lessons observed were in the area of science. Interestingly, 35% of the science lessons observed integrated mathematics to a high degree.

The classroom observational data also provides an instructive contrast with wider studies of teachers concerning their mathematics and science teaching practices. A 1994 study by Weiss found that about half of elementary teachers and two thirds of intermediate teachers heavily emphasized the learning of facts and terminology in their science and mathematics lessons. The observations of LMA graduates in years one and two, using the *Local Systemic Change* protocol, found that the most frequent purpose of the lessons was the development of conceptual understanding and rather than the memorization of facts (74% and 71% of the time, respectively).

The classroom observations further provide evidence that the pupils of LMA graduates have a positive attitude towards mathematics and science. In the "overall ratings of the lessons" that are made at the end of the protocol, observers rate pupils' self-confidence in doing mathematics and science. In 75% of the observations the rating was "having a positive effect"; in 64% of the observations, and overlapping the previous category, the lessons were rated positively on the question of whether pupils appeared to have an interest and/or appreciation for the topic (mathematics or science).

Evidence of the impact of the program on teachers' ability to improve pupil learning may also be found in a comparison of observations between graduates of the program, and newly admitted scholars at the beginning of their program. The *Local Systemic Change* protocol used for years one and two observations on graduated scholars was applied to incoming scholars. This part of the protocol was designed to indicate if the lessons contribute to five key indicators of long-term effect. A three point scale is used for this section, 1 (negative effect), 2 (mixed or neutral effect), and 3 (positive effect). The table below lists the percentages of graduates and scholars that received a positive effect rating for each item.

Impact of Lessons on Students

Item: Lesson contributed to:	Year 1	Year 2	New Scholars
Students' demonstrated knowledge of mathematics/science concepts.	82%	64%	33%
Students' capacity to carry out their own inquiries.	56%	57%	13%
Students' ability to generalize skills and concepts to other areas of mathematics/science, other disciplines, and/or real-life situations.	51%	46%	10%
Students' self-confidence in doing mathematics/science.	75%	68%	47%
Students' interest in and/or appreciation for mathematics/science.	64%	61%	47%

The protocol culminates in a final, summary rating on a five-point Likert scale for each lesson observed. At least two observers, tested for inter-rater reliability, rated each classroom session. The findings clearly demonstrate a difference between those teachers who had graduated from the LMA program, and those teachers who were just entering it: 77% of the graduates were rated four or five (with five being the high score), while only 42% of the new scholars were rated four or five.

The evidence provided by research on the FCAT scores, school grades as well as that of the classroom observations discussed here, provides support that graduates of the LMA are providing a rich curriculum where children are learning mathematics and science. In fact, they are learning better than their peers in classes with non-LMA graduates and schools where there are no LMA graduates.

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