PROGRAM ANNOUNCEMENT COVER PAGE

Date: _____

Institution:	The College of New Jersey
New Program Title:	Integrative-STEM
Degree Designation:	Masters of Education
Programmatic Mission Level for the Institution	
Degree Abbreviation:	
CIP Code and Nomenclature (*if possible*): *If outside the classification indicate Not*	
Campus(es) where the program will be offered:	Ewing
Date when program will begin (month and year):	May 2016
List the institutions with which articulation agreements will be arranged:	N/A

Is licensure required of program graduates to gain employment? No

Will the institution seek accreditation for this program? Yes

If yes, list the accrediting organization:
CAEP

Program Announcement Narrative

Objectives page(s): 3-4
Need page(s): 5-6
Student enrollments page(s): 6
Program resources page(s): 7-9

Appendix G

NEW PROGRAM CHECKLIST

Institution: The College of New Jersey

Program Title: Integrative-STEM

Degree: Masters of Education

REMINDER: The complete program package of materials should be submitted as an electronic file to the Chair of the Academic Issues Committee.

DESCRIPTION	*Check to Confirm*
1. Program Announcement Narrative Proposal Degree Requirements	☐
2. Consultant's Curriculum Vitae	☐
3. Consultant Report	
* Submission date: October 2014	☐
* On site visit? If yes, date(s): August 26-27, 2014	☐
* Consultant's curriculum vitae	☐
4. Response(s) to Consultant's Report	☐
5. Board of Trustees' Resolution	☐
* Date of resolution: _____	☐
6. Institutional Responses	☐
* Statement of "no objections"	☐
* Objections	☐
* Objecting institutions:	☐
_____	
_____	
* Response to objections	☐
* Information about reconciliation efforts	☐
*Copies of letters of support from responding colleges and universities	☐

Name: _____

Title: _____

Phone / Fax: _____

Email: _____

_____

Signature *Date*

Program Announcement Narrative

Integrative-STEM Masters Program Description

I. Objectives

Introduction:

The Department of Technological Studies at The College of New Jersey (TCNJ) proposes to start a new Masters of Education (M.Ed.) program in integrative Science, Technology, Engineering and Mathematics (STEM) education studies. A focus on STEM education has been building nationally, with recent emphasis on "design pedagogy," which utilizes the Technology and Engineering components of STEM to engage students in a highly integrative, intra-disciplinary fashion with deeply authentic teaching and learning experiences. Recently, the Next Generation Science Standards (NGSS) recognized the value of the T&E of STEM and explicitly included engineering design into both their framework and detailed standards for PK-12 education. The Department of Technological Studies, located within the School of Engineering at TCNJ, has substantial experiences and expertise in K-12 Technology & Engineering education, and integrative-STEM education. TCNJ's Department of Technological Studies has had strong STEM-oriented education programs since approximately 1987, when a strong shift towards ***design*** ("design pedagogy") occurred in the department's teacher preparation curriculum. Also, the Technological Studies Department started likely the country's first integrative-STEM teacher preparation program in 1998: the PK-6(8) "integrative-STEM Education (i-STEM)" program (renamed from "Math/ Science/ Technology"). For the past several years, this integrative-STEM program has been the largest disciplinary major for education teacher candidates at TCNJ. Additionally, TCNJ has been strongly involved nationally, serving on and for important national committees on PK-12 Technology and Engineering Education, has led the development of STEM teaching methods and has published substantially in the field.

The target audience for the proposed M. Ed. in integrative-STEM Education is in-service teachers, persons with a PK-12 certification to teach. The proposed integrative-STEM Graduate Studies Program gives the following three possibilities for students: (i) Masters of Education degree, (ii) TCNJ integrative-STEM Education Methods certificate and (iii) continuing (non-matriculation) education.

Students in this program will follow a curriculum that aligns with recommendations from the National Council for Accreditation of Teacher Education (NCATE) and the more recent attributes contained within Council for the Accreditation of Teacher Preparation (CAEP) accreditation standards. The proposed program will beneficially serve both New Jersey and regional teachers in becoming more effective teachers, using up-to-date integrative, design-centric teaching and learning methods (which are applicable in multiple K-12 disciplines).

Masters graduates from the proposed M. Ed. in Integrative-STEM Education will achieve the following program outcomes:

(A) Integrative-STEM habits of mind, essential skills, and design pedagogies
   a. articulate the use of Technology and Engineering in application to design pedagogy, K-12 engineering education and integrative-STEM.
   b. articulate the benefits and challenges of integrating across the curriculum, including substantial and important linkages to STEM and non-STEM standards and policies.
   c. design and implement effective integrative-STEM educational experiences, taking several key aspects into consideration including construction of appropriate design briefs, creativity, STEM content skills, systems- and quantitative-thinking, collaboration/communication (student work in individual and team formats), optimism, classroom management, impacts on diverse learners/ inclusive environments, assessment for engineering activities, and impacts on teacher evaluation. Ability to effectively implement Problem-based Learning (PBL).
   d. apply design process concepts and skills to their own processes of teaching: thinking of teaching itself as a design process ("Teachers as Designers").

(B) STEM subject area content knowledge and practices
   a. acquire applicable knowledge of mathematics, science, engineering and technology in K-12 education experiences.

   b. articulate how i-STEM content/methods impact, and are impacted by, global, economic, environmental and societal contexts. Include knowledge and impact of STEM careers.

(C) Standards and policies related to i-STEM
   a. articulate key connections between i-STEM methods and appropriate educational standards and policies, including Common Core, Next Generation Science Standards (NGSS), Standards for Technological Literacy, Engineering Education guides/standards, and regional education policies (including 21st-Century skills and teacher evaluation).

(D) Safety in i-STEM educational environments
   a. demonstrate the ability to safely use and manage the techniques, skills, and engineering tools appropriate in an i-STEM educational environment.

II. Need

Demand for integrative-STEM educational methods

Numerous studies have cited the weakening of STEM capabilities of K-12 students in the country, and teachers are the strongest influence in the classroom. Hence, an integrative-

STEM education for in-service teachers provides a very high demand service, by having teachers learn new teaching methods/ skills, as well as content. Several studies have shown substantial benefits from an integrative approach to including the T&E of STEM into the K-12 environment.[1-5] Additionally, a grant run out of TCNJ's Center for Excellence for STEM Education for the last ~2.5 years on integrative-STEM methods for in-service teachers has demonstrated a very high demand. TCNJ's Center for Excellence for STEM Education has given integrative-STEM Professional Development (PD) services to well over 500 teachers & administrators in over 70 school districts across New Jersey. TCNJs Center for Excellence for STEM Education has also delivered substantial integrative-STEM professional development in several other mid-Atlantic States. Numerous teachers have also asked about when and if a masters in integrative-STEM education might be available at TCNJ. In a comparable program at VirginiaTech, located in very low population density region, student enrollment is 60-80 students per year. Enrollment in the proposed program at TCNJ, due to its high population density, could attain substantially higher enrollment. TCNJ's elementary education integrative-STEM undergraduates are in high demand, often with districts asking specifically for these integrative-STEM education graduates. Several of our integrative-STEM program graduates are leading STEM education efforts in their schools and districts.

Relationship to institutional master plans and priorities

The proposed degree program fits well into the mission and master plan of the School of Engineering and The College of New Jersey. TCNJ is a highly-selective, primarily undergraduate institution with strategically defined Masters programs. The proposed integrative-STEM Masters of Education program will be a high quality program helping to fulfill TCNJ's strategic mission. Using the College's strategic map as a reference (http://strategicplanning.pages.tcnj.edu/files/2013/12/Strategic-Map-10-03-13-bw.pdf), the proposed integrative-STEM graduate program contributes in the following ways to the strategic plan.

(i) Item-B, "Strengthen TCNJ's Intellectual Community & Focus Academic Programs"
This program will "Foster engaged pedagogies and best practices wherever learning occurs," the fourth item in this section of the Strategic Map. Design-based pedagogies are being effectively implemented across the country, with substantial measured benefits.

(ii) Item-C: "Strengthen the Integrated, Transformative Total Student Experience"
This program will "Enhance 'Entry Point' opportunities for engagement and integration," the second item in this section of the Strategic Map.

(iii) Item-D, "Develop and Implement a Sustainable Financial Model Supporting the Strategic Map"
This program provides a "creative option for revenue enhancement," by providing a high quality and highly needed integrative-STEM professional development for K-12 teachers in the region, with courses offered during currently "lower-usage" terms (i.e.- summers & evenings), which are also beneficial to teachers Several courses could also be effectively run in blended formats.

(iv) Item-E, "Create a Strategically Effective Institution … etc."

This program provides a means to "Expand and Strengthen Faculty and Staff Development," by encouraging current faculty to engage at a Masters-level in their teaching and learning and to hire newer faculty with the ability to engage at both masters and undergraduate levels. A masters program in this vibrant and growing field will also substantially increase scholarship opportunities for faculty and undergraduate students.

(v) Item-F, "Live a Culture of Diversity and Inclusion"

Integrative-STEM methods are exceptionally valuable in applying high quality teaching and learning methods in diverse and inclusive environments, topics that will be purposefully included in the required curriculum.

Similar programs in New Jersey and the Region

To our knowledge there are no similar programs in integrative-STEM methods for in-service teachers in New Jersey or the region. In ~2012 Montclair State University started a dual certification Masters-in-the-Art-of-Teaching (M.A.T.) program with an focus on *inclusive* integrative-STEM, but being an M.A.T. program, that program is designed for career-changers, requiring a substantial curricular emphasis on beginning teaching and learning sciences.

There are two successful programs in the nation that are similar to the proposed program; Virginia Tech and Illinois State University. Virginia Tech was likely the first institution to start a Masters of Education program in integrative-STEM (renamed program in 2007). Illinois State University started a similar "STEM Education and Leadership" program more recently (approximately 2012).

III. Students

Student enrollment in this program is meant to be predominately in-service teachers. Through TCNJ's Center for Excellence in STEM Education, integrative-STEM methods training has been delivered to over 70 school districts in New Jersey in the past ~2.5 years. Due to these experiences, we estimate the number of students to be enrolled in this program to be approximately the following as a function of time: Year-1 (15), Year-2 (30), Year-3 (45), Year-4 (65).

IV. Resources to Support the Program

Faculty and Support of Instruction

There are currently five (5) full time tenure or tenure-track faculty lines in the department. One faculty line is currently filled with a 1-year full time temporary line, but a search is being conducted to fill that line with a full time tenure track personnel (goal of starting Fall-2015). A desired skill set for the new hire is the ability to lead integrative-STEM methods courses. [One department line is currently 100% dedicated to non-program activities (release time for AFT president and teaching liberal learning courses).] Current department offerings are: (i) two undergraduate programs consisting of a total of approximately 190 students [(a) secondary Technology/Pre-Engineering Education and (b) PK-6(8) integrative-STEM Education], (ii) an M.A.T. program in Technology/Pre-Engineering Education supporting between 2-to-6 students per yearly cohort. Our department also supports ~19 sections of Liberal Learning course load per year. Our department currently utilizes a large number of highly qualified adjunct professors for a variety of content and professional courses. A subset of these adjuncts would be highly skilled in integrative-STEM methods, and would be qualified to teach in the proposed integrative-STEM M.Ed. program.

The additional resources needed to support this program would be (i) new and current adjunct faculty, (ii) a coordination function (from a FT faculty member) with appropriate release time, (iii) materials expenses for courses, (iv) training expenses for blended learning formats (v) funds for detailed course development. If the program attains large growth then the following two resources may be needed: (i) new full time tenure track faculty and (ii) capital equipment for labs.

All three of the current full time faculty teaching courses in our academic programs have Ph.D. degrees in STEM fields (engineering, science and/or math) and have been very active in K-12 engineering/ STEM education. Dr. Steve O'Brien has a Ph.D. in Electrical Engineering from Cornell University and undergraduate degrees in both Physics and Mathematics, and would serve initially as the coordinator of the proposed integrative-STEM program. Dr. O'Brien has been active in research in K-12 Technology & Engineering education and has served on several important national committees related to engineering/ STEM education in K-12 [(i) National Academy of Engineering and (ii) American Society of Engineering Educators (ASEE) K-12 Division Executive Board]. Dr. Matthew Cathell has a Ph.D. in Materials Science Engineering from Drexel University and undergraduate degree in Chemistry from LaSalle University. Dr. Cathell has established himself has a premier educator on campus, receiving several recognitions for his teaching acumen. Dr. Cathell has used his teaching expertise to develop a high quality undergraduate integrative-STEM methods course (required for both undergraduate programs). Dr. O'Brien has similarly developed a high quality integrative-STEM methods course that is required for all STEM M.A.T graduate students. Dr. Manuel Figueroa has a Ph.D. in Biomedical Engineering from Drexel University and undergraduate degree in biomedical engineering from Tulane

University. Both Drs. Cathell and Figueroa were active participants in the National Science Foundation GK-12 program during their Ph.D. programs, which gave them excellent exposure to engineering/ STEM education, as applied in practice in K-12 environments. New faculty (adjunct or fulltime) hired to support the new integrative-STEM M.Ed. program will be required to have substantial experience in K-12 integrative-STEM education. Adjunct faculty utilized for this program will not be required to have a terminal degree, but they will require a Masters degree, consistent with TCNJ policy, and several years of experience teaching integrative-STEM methods to teachers or teacher candidates, especially for the proposed program's Teaching & Learning courses. Adjuncts should also have several years of successful K-12 integrative-STEM teaching experience.

Additional Equipment, Laboratory Support, Computer Support, Facilities

Current equipment, combined with budgeted new capital equipment, laboratory support, computer support, and facilities that currently support the department's other programs are adequate to start the proposed program. However, as the program grows additional capital equipment, faculty and facilities may be necessary to support the additional curriculum and students. The capital equipment needs would be tied to total student load, and would center on K-12 engineering education tools, such as three-dimensional printers, desktop computer-aided design, science/ math/ engineering/ STEM educational kits. Additional facilities space, when needed, would consist of primarily intra-disciplinary "multipurpose" spaces where design pedagogies are more effectively taught and experienced.

Resources for the integrative-STEM Masters in Education

All of the departments and School's current courses, equipment, laboratory support, computer support, facilities, and faculty will be useful in supporting the start of the proposed program. Similarly, the faculty has determined that the library resources, services, and facilities are sufficient to support the proposed program.

V. Degree Requirements

The proposed integrative-STEM M.Ed. degree requirements are as described below.

Integrative-STEM Teaching & Learning Core	15 credits
STEM Education Content & Research	9 credits
Electives (as defined in program description)	12 credits
Total	**36 credits**

All Masters students will be required to complete (i) an integrative-STEM Teaching and Learning Core, (ii) two STEM Education content courses, (iii) an education research methods

course and (iv) four program-approved electives. The curriculum details are shown in two attachments. Attachment A is a 2-page graphical representation of the program. Attachment B consist of the course descriptions of the new i-STEM courses.

TCNJ integrative-STEM Methods Certificate:

After students complete the integrative-STEM Teaching and Learning Core plus an approved STEM education course (a total of 18 cr), they will be eligible to receive a TCNJ integrative-STEM Education Methods graduate certificate.

VI. Transition Related Issues

As the proposed program grows additional faculty support may be needed. However, in the growth "transition" period, all Core courses and other required courses will be offered by current full-time or adjunct faculty.

For accreditation purposes, TCNJ intends to add the proposed integrative-STEM M.Ed. program to other education Masters programs in the first appropriate CAEP review.

References

[1] Brophy, S., Klein, S., Portsmore, M., Rogers, C. (2008). Advancing engineering education in P-12 classrooms. Journal of Engineering Education. July, 369-387

[2] Koch, J., Feingold, B. (2006). Engineering a Poem: An action research study. *Journal of Technology Education*, 18(1), 54-65

[3] Lachapelle, C. P., Cunningham, C. M., Engineering is elementary: children's changing understandings of science and engineering. (2007). *Proceedings of the American Society for Engineering Education Annual Conference*, Honolulu, HI

[4] Lachapelle, C. P., Cunningham, C. M., Jocz, J., Kay, A. E., Phadnis, P., & Sullivan, S. (2011). Engineering is Elementary: An evaluation of year 6 field testing, *NARST Annual International Conference*, Orlando, FL

[5] Zubrowski, B. (2002). Integrating science into design technology projects: using a standard model in the design process, *Journal of Technology Education*, 13(2), 48-67

[6] Parry, E. A., Hardee, E. G., Day, L. D. (2012). Developing elementary engineering schools: from planning to practice and results, *American Society for Engineering Education (ASEE) Annual Conference* San Antonio, TX, June, 2012)

Attachment-A **Attachment-A**

TCNJ integrative-STEM Masters Program

TCNJ is a recognized national leader in integrative-STEM (i-STEM) educational methods. In 1998 TCNJ's Dept. of Technological Studies, housed within the School of Engineering, established a formal elementary i-STEM pre-service teacher preparation program, which is currently one of the largest education majors on campus. Many recent standards (Common Core, Next Generation Science and 21st Century skills) are highly consistent with the design pedagogy philosophy used in i-STEM methods. Design pedagogy uses the T&E components of STEM to set valuable educational contexts. For example, concepts such as authentic problem-based learning, engineering (design under constraints), teamwork, creativity and integrative/ cross-curricular connections are key attributes of TCNJ's i-STEM programs. TCNJ's i-STEM Masters program is geared for certified teachers and consists of 3 categories of requirements: (I) i-STEM Teaching & Learning Core (15 cr.), (II) STEM Ed. Content & Research courses (9 cr.) and (III) Electives (12 cr.). A total of total of 36 credits is required to complete the Masters degree. College certificates and NJ State certifications are also possible, (see page 2).

(I) i-STEM Teaching & Learning Core

- STEM 510: Foundations in i-STEM [3 cr]
- STEM 520: i-STEM Pedagogy [3 cr]
- STEM 530: i-STEM Curriculum [3 cr]
- STEM 610: Emerging Trends & Issues in i-STEM Ed. [3 cr]

- [STEM 660: Creativity/Systems [3 cr]
- [STEM 700: i-STEM Ed. Capstone [0 cr]

Taken together

15 Credits

(II) STEM Ed. Content & Research

- STEM 631*: Applied math & statistics for i-STEM Ed. [3 cr]
- STEM 6XX*: (See STEM Ed. Content courses) [3 cr]
- EDFN 508: Intro. to Research [3 cr]

9 Credits

* STEM Education content courses purposefully integrate Science, Math, Engineering and Technology [Ex. STEM 671 & 681 cover various physics topics, while STEM641 covers various biology & chemistry content.]

(III) Electives

Four approved electives**

12 Credits

**With appropriate elective choices there are several possible pathways, leading to either college (TCNJ) certificates and/or NJ State certifications. Choosing any particular pathway is optional. (see page 2 for more details)

Pathways:

(A) Supervisor Cert.
(B) Design
(C) Research
(D) Inclusion Practices/ Special Ed.
(E) Middle School Math
(F) Self-Defined
{Ex.: Sci. Concentration … etc.}

TCNJ integrative-STEM Masters Degree Requirements

Complete: (i) Teaching & Learning Core (15 cr.), (ii) STEM631, one STEM Ed. content course and EDFN 508, (iii) 4 approved electives, (vi) a min. of a B- grade in all courses and (v) a minimum cumulative GPA of 3.0 in Program courses.

i-STEM Courses (3 cr. each):

(i) i-STEM Teaching & Learning

Core

- STEM 510: Foundations in iSTEM Education
- STEM 520: i-STEM Education Pedagogy
- STEM 530: i-STEM Education Curriculum
- STEM 610: Trends & Issues in STEM Education
- STEM 660: Creativity & System Thinking in Education
- STEM 700: i-STEM Education Capstone

STEM 680: Research Methods in STEM Education

(ii) STEM Education Content Courses*:

STEM 631: Math/Statistics for i-STEM Education
STEM 635: Data Visualization & Analytical Information Design
STEM 641: BioTech Systems and Sustainable Design
STEM 661: Architecture/Civil Technology Systems
STEM 671: Mechanical Technology Systems and Design
STEM 681: Electronics Technology Systems and Design

* STEM Education content courses purposefully integrate Science, Math, Engineering and Technology [Ex. STEM 671 & 681 cover various physics topics, while STEM641 covers various biology & chemistry content.]

Attachment-A **Attachment-A**

TCNJ i-STEM Masters Program- Electives/ Pathways

The i-STEM Masters program is designed with 4 electives, enabling the completion of more specialized curricular pathways, culminating in a TCNJ college certificate and/ or a NJ State certification. It is not required to choose any specific pathway. All courses below are 3 cr. Each.

Pathways:

(A) Supervisor

+ SUPV520: Super. & Instruct. Leadership
+ CURR514: Curr.: Theory & Practice
+ EDAD617: Seminar in School Leader.
+ ELEM/CURR555: Adv. Curriculum

(B) STEM Ed. Content

+ STEM 6XX
+ STEM 6XX
+ STEM 6XX
+ STEM 6XX

(C) STEM Ed. Research

+ STEM680: Res. Methods in STEM Ed.
+ STEM6XX* (STEM Ed. Content Course)
+ STEM6XX* (STEM Ed. Content Course)
+ STEM710: Thesis

(D) Inclusive Practices/ Spec. Ed. [Three possible options]

(i) Inclusive Practices- <u>English Language Learners</u>

Three required courses:
ESLM 577 (F)
ESLM 579 (F)
ESLM 587 (Sp)
Choose one of:
EDUC 513 (F, Sp, & Su)
EDUC 614 (F, Sp, & Su)
EDUC 501 (F, Sp, & Su)

(ii) Inclusive Practices- <u>Students w/ Disabilities</u>

Three required courses:
EDUC 513 (F, Sp, & Su)
EDUC 614 (F, Sp, & Su)
SPED 501 (F, Sp, & Su)
Choose one of:
RDLG 579 (F, Sp, & Su)
SPED 624 (once per year, F?)
SPED 648 (once per year, Sp?)

(iii) <u>Inclusive Literacy Practices</u>

Three required courses:
RDLG 579 (F, Sp, & Su)
[note: Prereq. of a course in teaching reading (undergrad. or graduate level)
RDLG 673 (Sp)
SPED 624 (F)
Choose one of:
EDUC 513 (F, Sp, & Su)
EDUC 614 (F, Sp, & Su)
SPED 624 (once per year, F?)

(E) Middle School Math

Pick any four of the following:
+ MATH 591: Number Theory & Systems
+ MATH 592: Data Analysis & Probability
+ MATH 594: Patterns, Functions, Algebra
+ MATH 595: Geometry
+ MATH 597: Discrete Math
+ MATH 598: Calculus
+ STEM 635: Data Visualization
[*MATH59X courses are designed specifically for Middle School math teaching]*

(F) Self-Defined

+ Four approved courses with advisement

F: Fall, Sp.:Spring, Su: Summer

<u>TCNJ integrative-STEM Education Certifications</u>:

(1) <u>NJ-State Supervisor Certification:</u> NJ requirements are (i) Masters degree from a regionally accredited institution, (ii) NJ instructional cert., or its out-of-state equivalent, (iii) 3 yrs. of successful full-time teaching/educational experience (with approp. NJ cert., if in a NJ public school), (iv) 12 cr. of grad. study [(a) 3 cr. general K-12 staff supervision, (b) 6 cr. curr. design & dev., and (c) 3 cr. K-12 staff dev. and/or curr. design & dev.].
(2) <u>NJ-State Middle School mathematics endorsement</u>: Complete the MS math pathway and pass the MS mathematics Praxis exam.
(3) <u>TCNJ i-STEM Educational Methods Certificate:</u> (i) Complete 15 cr. Core and (ii) Any other STEMXXX course, or any pre-approved grad. course.
(4) <u>TCNJ i-STEM Special Ed. Certificate:</u> (i) Complete requirements for the i-STEM M.Ed. and (ii) complete an Inclusion/Special Ed. Pathway.
(5) <u>TCNJ i-STEM Engineering/ Design Education Certificate:</u> (i) Complete requirements for i-STEM M.Ed. and (ii) complete Eng./ Design Ed. Pathway.
(6) <u>TCNJ i-STEM STEM Ed. Research Education Certificate:</u> (i) Complete requirements for i-STEM M.Ed. and (ii) complete STEM Ed. Research Pathway.

Attachment-B

Integrative-STEM Masters of Education Course Descriptions

TCNJ, Dept. of Technological Studies, School of Engineering

Course Descriptions;

(1) Integrative-STEM Teaching and Learning Foundations:

a) Foundations in integrative-STEM; STEM510 [3 cr.]

This course is a graduate level introduction to integrative-STEM educational philosophy and methods. This course assumes that students have substantial experience as a K-12 teacher. A summary of the topics covered in this course are: (i) an in-depth review of Learning Theories (including Behavioral, Sociocultural, and Constructivist) as well as a review of Zone of Proximal Development / Scaffolding, (ii) review of signature teaching methods and curriculum in context of the reviewed learning theories, (iii) historical review of the development of integrative-STEM approach, including discussions on the basic principles of the T&E of STEM including the iterative design process, (iv) substantial hands-on experiences with the design process (with associated focused discussions of teaching methods, curriculum, assessment and teacher evaluation), (v) an introductory study of, and experiences with, design-focused Problem-based Learning (PBL), (vi) the pedagogical impacts of the T&E elements [ex.- context with Depth-of-Knowledge / Blooms taxonomy, integration and context-setting capabilities including influences of global, economic, environmental, personal and societal contexts.] (vii) put "Engineering Habits of Mind" into a K-12 educational context and (viii) put integrative-STEM methods into context with several contemporary educational standards (i.e.- Common Core, NGSS and 21st –Century Skills …etc.). {Integrative-STEM educational methods in the context of this course is "the purposeful integration of STEM content with each other, and/or with non-STEM content, to achieve a deeper level of learning/ skills due to the need of students to utilize higher depths of knowledge, multiple learning modalities, multiple content disciplines and a diverse set of skills/ capabilities to successfully accomplish design-centered activities."] Prereq. i-STEM graduate student

b) Integrative-STEM Pedagogy; STEM520 [3 cr.]

This course is a graduate level course centered on pedagogies used in STEM education, separately and as an integrative method. This course assumes that students have substantial experience as a K-12 teacher. A summary of the topics covered in this course are: (i) historical perspective of signature pedagogies used in Math, Science, Engineering/Technology, (ii) contrast and compare these pedagogies, (iii) investigate specific examples of Pedagogical Content Knowledge (PCK) in the STEM disciplines, (iv) put the reviewed pedagogies into context with current integrative-STEM educational methods and the philosophical basis of the Understanding-by-Design curricular development model, (v) investigate the impacts of pedagogy on curriculum, classroom management/practice, assessment and teacher evaluation methods and (vi) develop a deeper understanding and complete in-depth experiences with design-centric Problem-based Learning (PBL), including safety considerations. Coreq. STEM510.

c) Integrative-STEM Curriculum; STEM530 [3 cr.]

This course is a graduate level course centered on curriculum used in STEM education, separately and as an integrative method. This course assumes that students have substantial experience as a K-12 teacher. A summary of the topics covered in this course are: (i) philosophical and historical perspective of signature curricula and curricular frameworks used in Math and Science [curriculum/curricular frameworks could include New Math, Everyday Math, Singapore Math, Philips-Exeter math, NCTM curricular frameworks, various science curricular frameworks and curriculum (AAAS's Project 2061, including Science for All Americans and Benchmarks for Science Literacy)], (ii) contrast and compare these Mathematics and Science curricula/ curricular frameworks, (iii) complete a philosophical and historical perspective of Technology/ engineering education/ integrative-STEM curricula, including actual teaching experiences with these curricula [Engineering is Elementary, Engineering byDesign, Project Lead The Way or Teach Engineering), (iv) complete the design/ implementation of an integrative-STEM curricular unit (including safety considerations) using the Understanding by Design curricular development philosophy and model, (v) articulate how integrative-STEM content/methods impact, and are impacted by, global, economic,

environmental, personal and societal contexts, (vi) articulate how knowledge of careers can be gained through integrative-STEM curriculum. Prereq. STEM510, Coreq. STEM520

(2) Supplemental Teaching & Learning:

a) Emerging Trends & Issues in integrative-STEM Education; STEM610 [3 cr.]

This course is a graduate level course centered on emerging trends and issues in STEM education locally, regionally and nationally. This course assumes that students have substantial experience as a K-12 teacher. A summary of the topics covered in this course are: (i) review of current research that impact STEM pedagogy, curriculum/ programs-of-study, classroom management/practice, assessment or teacher evaluation [STEM "theory-to-practice"], (ii) review emerging trends/issues in STEM-advocacy/ Teacher-leadership, including (a) impacts on students, teachers and community and (b) structure (classroom, School, District, State, Regional or National). Prereq. STEM530.

b) Creativity & Systems/ Critical Thinking in Education; STEM660 [3 cr.]

Important aspects of current K-12 educational goals/ standards are Creativity and Systems Thinking and "Critical Thinking," each of which can be largely impacted with integrative-STEM education methods. This course is a graduate level course centered on effectively impacting creativity and systems/ critical thinking. This course puts creativity and thinking processes into context with the elements and principles of design of common products (widgets/ processes/ services). The course introduces the creative process practiced by artists, designers, engineers (& teachers), and how this knowledge is valuable in the K-12 classroom. The course uses recent research into the creative process of humans to set a context. Content includes processes/ methods of creative thinking, drawing and modeling skills commonly used by designers; development of a design vocabulary; the nature and evolution of technological design; the impacts of design on the individual, society, and the environment (global and economic impacts); human factors; team formation/ design; and appropriate educational technology. This course ties systems thinking to creativity, across the STEM (and non-STEM) K-12 curriculum. This course also has students experience methods for assessing creativity and systems thinking. Prereq. STEM610. Coreq.: STEM 700

c) i-STEM Education Culminating Experience; STEM700 [0 credit]

A capstone project requires the student to design, organize, deliver and assess a "substantial" i-STEM curricular unit or a "substantial" i-STEM PD event(s). The "audience" of the event could be students (formal or informal setting), parents, teachers, administrators or other important education stakeholders. Students will work with faculty in defining the i-STEM event/ curricular unit. The i-STEM event will demonstrate the student's in-depth understanding of i-STEM methods and content. This course is required to be taken together with STEM 660. Prereq. STEM610 Coreq.: STEM 660

d) Research Methods in STEM Education; STEM680 [3 cr.]

This course is an introductory graduate level course on research methods used in the field of education, with emphasis on STEM education. This course assumes that students have substantial experience as a K-12 teacher and have knowledge of basic statistics (averages, Normal distributions … etc.), t-tests and correlation tests (via the prerequisite of STEM631). This course takes an active approach to learning, with students often acquiring and analyzing data from a variety of self-collected or professor-provided sources. A summary of the topics covered in this course are: (i) an in-depth review of general educational/ social science research methods, including quantitative, qualitative and mixed research methods, (ii) a review research from both the contexts of a STEM educational researcher as well as a user or consumer of STEM education research, (iii) analyze strengths and weaknesses of published STEM educational research and (iv) writing of well-defined research questions (and matching to potentially effective research methodologies). As a culminating experience students will complete a written plan for a STEM research project (but not conduct the research during the semester). [Note: This course is an elective for the integrative-STEM program, but is a required course if the Research Pathway is chosen.] Prereq. STEM510, STEM520, STEM631, EDFN508

e) Integrative-STEM Research Thesis; STEM710 [3 cr.]
This course is where a student completes a previously well-defined research plan, likely as a result of taking STEM680, as part of the Research Pathway. The final deliverable is a written thesis, describing the research work. Prereq. STEM680

(3) STEM Education Content Courses*

**{STEM Education courses are content courses that purposefully integrate Science, Math, Engineering and Technology [ex. STEM 671 & 681 cover a variety of physics topics, while STEM641 covers a variety of biology & chemistry content.] }*

a) Math/Statistics for i-STEM education; STEM631 [3 cr.]
An important and often overlooked aspect of technolgy/engineering education, and STEM education in general, has been quantitative bases for design decisions. This course assumes that students have substantial experience as a trained teacher. An outline of the outcome expectations for students in this course is as follows: (i) become skilled with contemporary grade-appropriate computational methods as a tool for engineering/ design analysis and (ii) be able to use math/ statistics in design projects and in educational research methods contexts. The course will cover the grade-appropriate analysis of experimental data and include the concepts of averages, absolute value, error analysis and standard deviation. Applications may also include quantittive anaysis for teacher evaluation processes. Computational methods will include basic application of grade-appropriate quantitative methods. For secondary levels mathematical principles will include algebra, basic statistics, numerical integration and differentiation (via simple geometric-based Excel tools). Prereq. STEM510.

b) Data Visualization and Analytical Information Design; STEM635 [3 cr.]
This course explores topics relating to the visual and graphical presentation of technical, scientific and mathematical evidence, through the lens of analytical reasoning and information design. Teachers have a special need to well-represent information/ knowledge through graphical means since these means may establish more effective cognitive connections to students. Students will examine and critique examples of professional quality data visualizations, and will design and create their own visual representations of STEM-related knowledge. Students will use industry-standard software ("Educational technology") for 2D graphical design, 3D design, and statistical analysis. They will also explore best practices for creating professional level data representations in the form of graphs, tables, plots, and illustrations. Specific course topics will include information graphics, photo- and video-based evidence, computer slide presentations, technical reports and posters. An overarching focus will be the preservation and promotion of complexity and nuance, in forms that possess clarity and coherence. Among the expected outcomes of this course are that students will increase proficiency in critically analyzing complex information and designing high-quality graphical representations that successfully convey knowledge to others. This course is appropriate for those who wish to improve their ability to both process and present STEM knowledge, and is particularly intended for those who teach STEM disciplines. Prereq. STEM510, STEM631

c) Biotechnology Systems and Sustainable Design for Educators; STEM641 [3 cr.]
This graduate level course introduces students to the world of environmental and biotechnology systems for K-12 STEM/ engineering education, at the intersection of the designed and natural worlds. Assuming that students have substantial experience as a trained teacher, this course includes the design and concepts behind important bio-technology systems such as: agricultural technologies, genetic biotechnology, energy systems, knowledge of chemical and biological processes, sustainable design, analytical medical technologies and waste remediation. Lecture topics are supported by pertinent laboratory and field experiences. Students will implement a bio-technology lesson. Prereq. STEM510.

d) Architecture/Civil Technology Systems & Design for Educators; STEM661 [3 cr.]
This advanced course is intended for K-12 teachers and focuses on the design of structures with an emphasis on the principles of Residential design. A main focus will be placed on understanding the historical and contemporary influences on architecture and society. Content includes key architectural styles, architects, architectural computer aided drafting (CAD), green/sustainable architecture, traffic circulation, civil engineering and structural analysis. Architectural style and architect research projects are used to better understand the influence of human design on the individual, society, and the environment. This course employs an interdisiciplinary approach with mathematics and science through problem-based learning opportunities as well as design and build activities. Students will implement an architecture/civil engineering lesson. Prereq. STEM510.

e) Mechanical Technology Systems and Design for Educators; STEM671 [3 cr.]
This course is a synthesis of concepts covered in traditional engineering courses of Statics, Strength of Materials and Machine Design, and is intended for teachers of K-12 STEM/ engineering content. The lecture portion of the class contains ample real-world examples to illustrate the applicability of the STEM concepts in mechanical systems. The course contains substantial hands-on activities and includes instruction on the safe and effective use of tools and materials. This course also requires students to use contemporary 3-D modeling software, and materials processing tools (including 3D printers) in their design activities. Students will implement a mechanical engineering/physics lesson. Course material is appropriate for both elementary and secondary teachers. Prereq. STEM510.

f) Electronics Technology Systems and Design for Educators; STEM681 [3 cr.]
This introductory course provides the student with an overview of the fundamental concepts of the science of electricity, electrical circuits and how electrical technologies have substantially influenced society. This course is intended for teachers of K-12 STEM/ engineering content and will cover both analog and digital electronics [including robotics and Stored Program Control systems (microprocessor systems)]. The course is lecture-based but requires the student to design, build and test a wide range of electrical circuits. Analog electronics topics covered include the physics and chemistry of conductors/insulators, Ohm's law, resistor networks and basic magnetism concepts, as well as measurement, simple RC circuits, and semiconductor devices (LEDs, transistors). Digital electronics topics include Boolean algebra (AND, OR and NOT gates), control functions based on Boolean logic, and how these logic systems relate to cognitive abilities/ intelligence. Building on the basic digital logic concepts, microprocessors are discussed and used to achieve "state machines." Students will implement an electronics/ sciecne-of-electricity lesson. Course material is appropriate for both elementary and secondary teachers. Prereq. STEM510.