



Science, Technology, Engineering, Art, and Math (STEAM) Diplomacy: Preliminary Results from an Initial Pilot Course

Dr. Daniel B. Oerther, Missouri University of Science & Technology

Professor Daniel B. Oerther, PhD, PE, BCEE, CEng, D.AAS, F.AAN, F.RSA, F.RSPH joined the faculty of the Missouri University of Science and Technology in 2010 after ten years on the faculty of the University of Cincinnati where he served as Head of the Department of Civil and Environmental Engineering. Since 2014, he has concurrently served as a Senior Policy Advisor to the U.S. Secretary of State in the areas of environment, science, technology, and health (ESTH). Oerther earned his B.A. in biological sciences and his B.S. in environmental health engineering from Northwestern University (1995), and he earned his M.S. (1998) in environmental health engineering and his Ph.D. (2002) from the University of Illinois, Urbana-Champaign. He has completed postgraduate coursework in Microbial Ecology from the Marine Biology Laboratory, Environmental Health from the University of Cincinnati, Public Health from The Johns Hopkins University, and Public Administration from Indiana University, Bloomington. Oerther is a licensed Professional Engineer (PE, DC, MO, and OH), Board Certified in Environmental Engineering (BCEE) by the American Academy of Environmental Engineers and Scientist (AAEES), and registered as a Chartered Engineer (CEng) by the U.K. Engineering Council. He is recognized as a Diplomat of the American Academy of Sanitarians (D.AAS). His scholarship, teaching, service, and professional practice focus in the fields of environmental biotechnology and sustainable development where he specializes in promoting Water, Sanitation, and Hygiene (WaSH), food and nutrition security, energy efficiency, and poverty alleviation. Oerther's awards for teaching include the best paper award from the Environmental Engineering Division of ASEE, as well as recognition from the NSPE, the AAEES, and the Association of Environmental Engineering and Science Professors (AEESP). He participated in both the 2006 and the 2015 conferences of the National Academies Keck Futures Initiative (NAKFI) as well as the 2011 Frontiers of Engineering Education Symposium (FOEE) of the U.S. National Academies. Oerther is a four-time recipient of Fulbright, and he has been recognized with a Meritorious Honor Award by the U.S. Department of State. Due to his collaborations with nurses and healthcare professionals, Professor Oerther has been inducted as a Lifetime Honorary Member of Sigma Theta Tau, the International Honor Society of Nursing (STTI), and he has been inducted as a Lifetime Honorary Fellow of the American Academy of Nursing (F.AAN). Dan is also a Fellow of the Royal Society of Arts (F.RSA) and a Fellow of the Royal Society for Public Health (F.RSPH).

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Abstract

A new course, “Science, Technology, Engineering, Art, and Math (STEAM) Diplomacy,” has been developed at the Missouri University of Science and Technology to introduce engineering students to the field of foreign relations and the tripartite objectives of: 1) science in diplomacy; 2) science for diplomacy; and 3) diplomacy for science. The course employs an available scholarly monograph as a text and integrates materials created by the Center for Science Diplomacy of the American Association for the Advancement of Science (AAAS) as well as publically available materials. The new course employs a previously reported format including blended delivery, a flipped classroom, and mastery learning (D.B. Oerther, “Reducing costs while maintaining learning outcomes using blended, flipped, and mastery pedagogy to teach introduction to environmental engineering,” in *Proceedings of the 2017 ASEE Annual Conference & Exposition, Columbus, OH, USA, June 25-28, 2017*. [Online]. Available: <https://peer.asee.org/28786>. [Accessed April 26, 2018]). Three term length projects are included as part of the class, namely: 1) a model United Nations debate of the use of genetically modified crops as foodstuffs during famine; 2) the preparation of an application for an internship or fellowship in the broad field of science policy (i.e., Fulbright award); and 3) the preparation of an extensive case study using the lessons learned from the Antarctic Treaty as a guide. Although the course is a work in progress, the materials offered in this paper – including course content, pedagogical approach, and the results of initial assessments of student preferences – provide sufficient details that the course may be replicated at other institutions to introduce engineers to foreign relations and diplomacy.

Introduction

The emergent topic of “Science Diplomacy” is important for institutions of higher education with a global worldview. Science Diplomacy includes: 1) training scientists to serve as diplomats (i.e., integrating the “art” of political science into the STEM – science, technology, engineering, and math – disciplines to create STEAM), 2) empowering countries to collaborate on scientific advancement through diplomacy (i.e., CERN – European Organization for Nuclear Research – and the international space station), and 3) building cross-cultural relationships among scientists from different countries (i.e., Fulbright exchange in STEM disciplines) [2]. Because science diplomacy occurs at the nexus of diverse disciplines, it is simultaneously difficult for a single individual to learn the full range of topics necessary to offer such a course, and it is structurally problematic for two or more faculty from diverse academic departments – often in different colleges – to co-teach such a course. Nonetheless, training students in science diplomacy is critically important to manage the global environment (e.g., polar regions, oceans, transnational freshwater, biodiversity, atmospheric quality, and climate) [3], to protect global health (e.g., biodefense, pandemics, and emergent infections) [4], and to share human-made technological ecosystems (i.e., infrastructure, energy production, space, and the internet) [5].

Recognizing the need to bridge science and diplomacy, the American Association for the Advancement of Science (AAAS) created the Center for Science Diplomacy in 2008 [6], launched the quarterly publication, *Science & Diplomacy* in March, 2012 [7], and has begun to offer short courses and research gatherings to facilitate discussion within an emerging community of educators and practitioners (e.g., the Fourth Annual Conference on Science Diplomacy scheduled for 14 September 2018).

A limited number of institutions have also begun to offer courses on science diplomacy including: Tufts [8]; Columbia [9]; and NYU [10], among others. Recently, SUNY has created a massively online open course (MOOC) in science diplomacy with a specialization in health [11], and in February 2017, the AAAS launched the, “SciDipEd page... as a platform to bring together educators and students in the United States and around the world interested in science diplomacy education,” [12]. In 2017 a monograph originally prepared in French was translated into English and is being marketed by Springer as a “text book” for science diplomacy instruction [13]. These educational materials draw from primary sources and supplement reports and summaries of “Science Diplomacy” strategies published for national audiences including France [14], the United States [15] and Germany [16], as well as for regional bodies such as the European Union [17].

Currently, there are no science diplomacy courses offered within the State of Missouri. In contrast, the State of Missouri – through its leadership in agriculture, human health, and advanced manufacturing – is intimately connected to the global marketplace [18]. Furthermore, as the birthplace of J. William Fulbright [19] and the lifetime home of President Harry S. Truman, who signed the Fulbright Exchange Program into law [20], the State of Missouri shares a legacy of contributing to the advancement of foreign policy and international affairs. The current lack of course offerings that bridge engineering and public policy may be an impediment to the creation of jobs and economic opportunity for the citizens of the State of Missouri. The development of a course in Science Diplomacy within the State of Missouri is envisioned to contribute to achieving the FY 2014-2017 Mission Statement of the US Department of State and USAID, namely, “... to shape and sustain a peaceful, prosperous, just, and democratic world, and foster conditions for stability and progress for the benefit of the American people and people everywhere,” [21].

In the pilot offering of, “STEAM Diplomacy,” to a total of 9 students in the Spring Semester of 2018, a blended format, a flipped classroom, mastery learning, and a buffet of optional summative assessments used to assign a final grade has been utilized to teach science diplomacy following a previously published approach [1]. Assessment of student demographics included the performance of an online Myers-Briggs test [22] and an online Learning Styles Inventory [23]. During the course, student satisfaction was assessed using anonymous, online course evaluations administered after the fourth week of the course – via SurveyMonkey – and administered after the fifteenth week of the course – using a campus-wide system. The purpose of this paper is to provide sufficient details – including course content, pedagogical approach, and the results of initial assessments of student preferences – such that the course may be replicated at other institutions to introduce engineers to diplomacy.

Methods

Course Catalog Description. As published by the Missouri University of Science and Technology, the offering is described as, “An experimental course, Science, Technology, Engineering, Art, and Mathematic (STEAM) Diplomacy aims to excite interdisciplinary students to consider diplomatic craft and foreign policy to further professional business interests as well as to contribute to creating a more secure, democratic, and prosperous world for the benefit of the American people and the international community. While STEAM Diplomacy is inherently global, to facilitate the introductory nature of this course, the materials will be discussed with an emphasis on American foreign policy approaches.”

Course Delivery. The offering includes: a blended format; a flipped classroom; mastery learning; and a buffet of optional summative assessments used to assign a final grade [1]. Briefly, content delivery via both online digital media and via face-to-face lecture is known as a “blended format”, and some of the benefits include accommodating diverse learning styles (i.e., listening or reading) while improving student satisfaction with content delivery [24] [25]. A “flipped classroom” enhances the opportunity to use inductive learning strategies (i.e., think-pair-share) in the lecture because students preview course content before meeting face-to-face with the instructor [26] [27]. As students struggle to “grok” complex concepts, “mastery learning” – where students demonstrate knowledge of a concept before moving on to the next concept – provides an opportunity for self-pacing to accommodate individual variation among students and among concepts [28]. And finally, offering a buffet of optional summative assessments – after minimum mastery has been achieved – provides a means of informal grade contracting where students opt to demonstrate their knowledge – and earn a grade – in a manner most consistent with their personal preferences (and likely their perception of the path of least resistance) [1].

Course Content. The course consists of ten units divided into three categories (a, b, and c), including:

- a) required introduction to blended, flipped, mastery learning and buffet assessment (U 0);
- b) six required fundamental units (U 1 to U 6); and
- c) three optional term projects (U 7, U 8, and U 9).

The three optional term projects are selected to provide a hands-on application of the content introduced in the required fundamental units by leveraging the instructor’s prior experience completing Diplomacy Lab projects provided by the United States Department of State [29]. One optional term project (U 7) employs an adaptation of the Model United Nations program Human Right lesson [30] to allow students an opportunity to explore international negotiations on a common topic, namely: agricultural productivity incorporating the use of genetically modified organisms, sustainable intensification, and agro ecology. One optional term project (U 8) offers students an opportunity to submit an application for a national or international fellowship opportunity in the broad area of “science policy” (i.e., Fulbright program, [31]) to allow students an opportunity to explore alternative career paths beyond the traditional engineering approach of working for a company, consulting firm, or regulatory agency. And one optional term project (U 9) offers students an opportunity to write a case study of science diplomacy on a topic of their choosing using the lessons of the Antarctic Treaty of 1959 as a

guide [32] to allow students an opportunity to synthesize the complex concepts introduced throughout the course. The content of the six required fundamental units (U 1 to U 6) correspond to the chapters of Science and Diplomacy: A New Dimension of International Relations [13], and include: U 1) introduction to science diplomacy; U 2) what is science diplomacy?; U 3) science diplomacy as a national issue; U 4) science in diplomatic apparatus: the diversity of national approaches; U5) science in the vanguard of diplomacy; and U 6) multilateral science diplomacy. Additional required online media were selected as supplemental lectures to five of the six required fundamental units, including: U 1) “Science Diplomacy: An Introduction,” created by the AAAS [33]; U 2) “A New Beginning,” speech delivered by United States President Barack Obama on 4 June 2009 from the Major Reception Hall at Cairo University in Egypt [34]; U 3) Remarks by the Queen Letizia of Spain and remarks by Pope Francis to the Second International Conference on Nutrition at the headquarters of the UN FAO in Rome, Italy on 20 November 2014 [35]; U 4) two brief videos entitled, “Germany’s Education Minister Johanna Wanka talks to DW about Brexit,” [36] and the, “10th Anniversary Celebration of the Italian Scientists and Scholars in North America Foundation,” [37]; and U 5) brief videos on the topic of *Schistosomiasis* [38] [39]. To facilitate the development of the longer optional term-length case study, a series of five shorter optional case studies were included as part of five of the six the fundamental units, including:

- U 1) New Frontiers in Science Diplomacy: Navigating the Changing Balance of Power, 2010, The Royal Society [2];
- U 2) “The Lower Mekong Initiative,” announced by United States Secretary of State Hilary Clinton in 2009 [40];
- U 3) “The Antarctic Treaty,” case study created by the Royal Geographical Society [41];
- U 4) the French campaign to “Make the Planet Great Again,” by attracting climate change scientists to relocate and conduct research in France [42]; and;
- U 5) “The South Africa AIDS Controversy: A Case Study in Patent Law and Policy,” published by the Harvard Law School [43].

As part of these shorter case studies, students learning was assessed through rubric grading of Pechu Kucha presentations where twenty slides were presented for twenty seconds, each, as part of an overall presentation lasting six minutes and forty seconds.

Course Assessment. Student demographics were collected using online Myers-Briggs testing [22] as well as a Learning Styles Inventory [23]. Student satisfaction was collected using anonymous, online course evaluations administered using SurveyMonkey after the fourth week of the course (results reported), and using a campus-wide system after the fifteenth week of the course (results not available at the time of publication). Mastery learning was assessed using a mixture of instruments including multiple-choice vocabulary quizzes and true/false statements from the required online media. Students received a minimum grade of “C” for the course when they demonstrated full mastery of required materials before the deadlines stated in the syllabus. To earn a higher grade, a buffet of optional summative assessments was utilized. The three optional term projects were assessed using rubric grading. Optional summative assessments for the five shorter case study examples included in the fundamental units were assessed using rubric grading. As discussed previously [1], the use of a modified, mastery learning approach allows the instructor to identify knowledge that “must-be-learned”, and to separate this required knowledge from the optional knowledge that “can-be-learned”.

Detailed description of pilot course syllabus

The monograph Science and Diplomacy: A New Dimension of International Relations [13] was used as the primary text for the course. One benefit of a text translated from French is that the examples and the perspective are offered based upon science diplomacy as practiced by France. This varies considerably from the approach to science diplomacy as practiced by the United States (i.e., as reflected in the material published by AAAS, [33]), and it also varies considerably from the approach to science diplomacy as practiced by the United Kingdom (i.e., as reflected in the material published by The Royal Society, [2]). One drawback of a text translated from French is poor translation in various places throughout the monograph and the need for the instructor to assist primarily American students to understand examples from a French foreign policy perspective.

A detailed course calendar is included in Appendix 1. The course includes a number of required lectures during the first two weeks to help to set the tone and pace for the course. Throughout the remainder of the semester, required lectures are reduced to approximately once every two weeks, and the remainder of the optional lectures are used for students to complete optional assignments associated with the required lecture modules (e.g., to present a Pecha Kucha talk) or for students to work on optional assignments associated with the three term-length projects.

As part of the required lectures during the first two weeks of the course, a number of topics are introduced, including:

- Students are introduced to the concept of Science, Technology, Engineering, and Math (STEM) through a review of Science, Technology, Engineering, and Mathematics (STEM) Education: A Primer published by the Congressional Research Office in 2012.
- Students are introduced to the concept of STEAM through a review of Art, Design and Science, Engineering and Medicine Frontier Collaborations: Ideation, Translation, Realization: Seed Idea Group Summaries published by the National Academies Press in 2016.
- Students are introduced to the differences among “science diplomacy” and “engineering diplomacy” through a comparison of U.S. and International Perspectives on Global Science Policy and Science Diplomacy: Report of a Workshop published by the National Academies Press in 2012 and the two articles: 1) “Engineering Diplomacy: An Underutilized Tool in Foreign Policy” which appeared in the June, 2012 issue of *Science & Diplomacy*; and 2) “Engineers Outside the Box: Pathways to Global Impact,” which appeared in the March, 2018 issue of *Science & Diplomacy*.
- Before the lecture introducing the model UN term length project, students are exposed to the long-standing issue of women’s rights and leadership within the UN including an in-class discussion of a video of Eleanor Roosevelt interviewing President Kennedy on the status of women (available online at: <https://www.jfklibrary.org/Asset-Viewer/Archives/JFKWHA-085-005.aspx>), and an in-class discussion of a video entitled, “Saving France’s Secular Identity” (available online at: <https://youtu.be/jsZgpNqkmyc>) which discusses law 2004-228 of 15 March 2004 commonly known as the French law on secularity and conspicuous religious symbols in schools.

- Before the lecture introducing the term length project that involves the preparation of an application for a fellowship in science policy, students are exposed to five types of interactions (e.g., exchange, competition, cooperation, conflict and coercion) and three types of social groups (e.g., primary, secondary, and reference) using Introduction to Sociology (Tenth Edition) by Giddens et al.
- Before the lecture introducing the term length project that involves the preparation of an extensive case study, students are exposed to the 13 dimensions of a Foreign Service Officer using online materials from the U.S. Department of State (available at: <https://careers.state.gov/work/foreign-service/officer/13-dimensions/>).

As part of the required lectures throughout the remainder of the semester, details of the textbook [13] are discussed using a didactic lecture format supplemented with active learning including the use of peer instruction (i.e., think-pair-share) to confirm the understanding and application of vocabulary and concepts as described in the following paragraph. From chapter 1, *Introduction* [13], important vocabulary terms and key concepts are introduced to the students including: bi lateral and multi lateral negotiations; non-state and state actors; hard-, soft-, and smart-power; natural science and social science. From chapter 2, *What is Science Diplomacy* [13], the terms and concepts introduced to students include: détente; science in diplomacy; science for diplomacy; and diplomacy for science. From chapter 3, *Science Diplomacy as a National Issue* [13], the terms and concepts introduced to students include: attraction; cooperation; influence; expatriate; diaspora; constructive ambiguity; balance of power; and strategic reasoning. From chapter 4, *Science in Diplomatic Apparatus: the Diversity of National Approaches* [13], the terms and concepts introduced to students include: scientific attaché; environment, science, technology, and health officer (ESTH Officer); Global Science Program for Security, Competitiveness and Diplomacy proposed legislation of 2012; and a variety of national scientific organizations that operate around the globe including: Centre National de la Recherche Scientifique, Max Planck Society, Alexander von Humboldt Foundation, Deutsche Forschungsgemeinschaft, Swissnet, UK Science and Innovation Network, the Japanese Ministry of Education Culture Sports Science and Technology, the US Bureau of Oceans and International Environmental and Scientific Affairs, and the Ministry of Science and Technology of the People's Republic of China. From chapter 5, *Science in the Vanguard of Diplomacy* [13], the critical concepts introduced to students include: détente among the US and former USSR, the US and China, and the US and Muslim majority nations; the European Organization for Nuclear Research (CERN) and the Synchrotron-light for Experimental Science and Applications in the Middle East (SESAME); the Antarctic Treaty of 1959; and the Agreement on Enhancing International Arctic Scientific Cooperation of 2017. From chapter 6, *Multilateral Science Diplomacy* [13], the critical concepts introduced to students include: global public good; the United Nations Educational, Scientific, and Cultural Organization (UNESCO); the High Level Panel of Experts of the Committee (HLPE) of the Committee on Food Security (CFS) of the UN Food and Agriculture Organization (UN FAO); and the Intergovernmental Panel on Climate Change (IPCC).

Results of partial assessment of pilot course

A new course, “STEAM (Science, Technology, Engineering, Art, and Math) Diplomacy,” is being offered in the Spring of 2018 to a total of 9 students. Table 1 presents a summary of

course demographics. The results were captured as part of a required exercise for U 0, and additional student demographic data were collected from information provided by each student and cross-referenced with the database maintained by the Registrar.

Table 1. Demographics of 9 students enrolled in “STEAM Diplomacy” in the Spring semester of 2018.

	Spring 2018
	N = 9
Gender	
Male	6
Female	3
Learning Styles Inventory	
Visual	3
Auditory	3
Kinesthetic	0
V, A, K all equal	1
Two higher than third	2
Jung Typology	
Extrovert (E)	5
Introvert (I)	4
Sensing (S)	4
Intuition (N)	5
Thinking (T)	5
Feeling (F)	4
Judging (J)	7
Perceiving (P)	2
Enrollment status	
Distance	0
Face to face	9
Graduate student	2
Senior standing	6
Junior standing	1
Architectural Engineering	0
Civil Engineering	2
Environmental Engineering	7
Architectural and Civil Engineering	0

Of the 9 total students, three were female. Visual and Auditory were the preferred, single strongest Learning Styles, but the sample size is small. Among the results of the Myers-Briggs Personality Test, the Jung Typology for “source of energy”, “gather information”, and “make decisions” were approximately the same for each of the two types. The only significant difference for Jung Personality Type was observed in a strong preference for Judging over

Perceiving (i.e., 7 individuals versus 2), which likely indicates a strong preference for “order” and “instructions”. These trends have been reported previously for students [1], and based upon these trends in Jung Personality Type, clear instructions have been included with each course unit.

Although the original intent was to enroll students via distance, unfortunately, no distance students opted to take the course. Future offerings will continue to provide an option for distance student to enroll in hopes of intercampus course sharing within the University of Missouri System including Mizzou, the University of Missouri Kansas City, Missouri University of Science and Technology, and the University of Missouri St. Louis.

The majority of students held Senior status (6 individuals) and were enrolled in “STEAM Diplomacy” in their final semester of baccalaureate studies. Therefore, the student responses to course evaluations conducted during the fourth and fifteenth week of the semester may be influenced by both a sense of “maturity” (i.e., Seniors who have participated in numerous courses with a variety of different instructor types) as well as a sense of “apathy” (i.e., Senior slide before spring graduation and subsequent career placement).

And finally, the majority of the students were enrolled in the baccalaureate degree program of Environmental Engineering (i.e., 7). Therefore, the student responses to course evaluations conducted during the fourth and fifteenth week of the semester should be interpreted as a mixture of “tangentially interested” and “fully engaged” with the course description (i.e., some students may have been enrolled simply because the timing of an elective course was convenient).

A summary of student satisfaction for Spring 2018 is presented in Table 2. The data include results to five questions administered via SurveyMonkey after the fourth week of instruction. Data intended to be collected after the fifteenth week is not yet available at the time of publication. First, the response rate (N=9) was equal to the full course enrollment (N=9) after the fourth week, but the utility of these results may be limited because they do not represent the full semester. Although the data to be collected after the fifteenth week is not available at the time of publication, the preliminary results from the first offering of, “STEAM Diplomacy,” are encouraging because they suggest that the students are excited about the course and are responding positively to the course format and the efforts of the instructor. No comments were available as the survey intended to be completed after the fifteenth week of class has not been completed at the time of publication.

Table 2. Summary of student satisfaction for Spring 2018 collected using anonymous, online course evaluations administered using Survey Monkey after the fourth week of the course (Wk4). No data are available for the fifteenth week of the course at the time of publication. Questions 1, 2, and 3 are included by the campus, and questions 4 and 5 are required by State law. Students are asked to provide a response using a Likert scale from 1 – poor to 5 – excellent. The number of responses (N) and the average response (Average) are included in the table. No “additional comments” have been collected at the time of publication.

	1		2		3		4		5	
Likert	Wk4	Wk15	Wk4	Wk15	Wk4	Wk15	Wk4	Wk15	Wk4	Wk15
1 poor	0	ND*	0	ND	0	ND	0	ND	0	ND
2	0	ND	0	ND	0	ND	0	ND	0	ND
3 avg	0	ND	0	ND	0	ND	0	ND	0	ND
4	4	ND	3	ND	2	ND	3	ND	1	ND
5 excl	5	ND	6	ND	7	ND	6	ND	8	ND
N=	9		9		9		9		9	

* ND, No data: student satisfaction surveys collected after Week 15 were not available at the time of publication.

- 1 Evaluate this course, independent of the instructor's effectiveness, in terms of its educational value to you.
- 2 Rate the instructor's concern for your understanding of the material.
- 3 Rate the overall teaching effectiveness of this instructor.
- 4 I would tell other students that the instructor was effective in communicating the content of the course.
- 5 I would recommend this instructor to other students.

Additional comments:

- No data available at the time of publication.

Discussion

Although a work in progress, the new course, “Science, Technology, Engineering, Art, and Math (STEAM) Diplomacy,” shows early promise for introducing engineers to foreign policy and diplomacy. Because no similar courses have been developed previously, the presentation of the material in this manuscript has tremendous value to the membership of the American Society for Engineering Education (ASEE) by raising awareness of the topic of “Science Diplomacy” and providing an example of course content, pedagogical approach, and the results of initial student assessment with a pilot cohort.

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Appendix 1. Course calendar for STEAM Diplomacy for Spring Semester 2018. The 3-credit hour course was scheduled for three, fifty-minute meetings each week. RF2F represents required face-to-face class meetings. OPT represents optional class meetings. Due dates (DD) for required assignments associated with seven units (U 0 to U 6) are indicated. PK represents oral presentations following the Pechu Kucha format (20 slides for 20 second each, on a timer).

Week	Monday Lecture	Wednesday Lecture	Friday Lecture
1	1/15/18 MLKJr Holiday	1/17/18 RF2F (St. Syllabus Day)	1/19/18 RF2F (U 7 Model UN)
2	1/22/18 RF2F; U 0 DD (blended, flipped, mastery)	1/24/18 RF2F (U 8 Fellowship application)	1/26/18 RF2F (U 9 Case study development)
3	1/29/18 OPT; (last day to add)	1/31/18 OPT	2/2/18 RF2F; U 1 DD
4	2/5/18 OPT – present PK U 1	2/7/18 OPT– Model UN 3 ideas due	2/9/18 OPT – Model UN brainstorm topic, countries, and committee
5	2/12/18 OPT; (last day to register for Spring grad)	2/14/18 OPT	2/16/18 RF2F; U 2 DD
6	2/19/18 OPT – present PK U 2; Model UN country and cmte charts due; (Career fair TOMORROW!)	2/21/18 OPT	2/23/18 OPT – Fellowship 3 ideas due
7	2/26/18 OPT; (last day to drop without WD on transcript)	2/28/18 OPT	3/2/18 RF2F; U 3 DD
8	3/5/18 OPT – present PK U 3; Model UN 1,000-word paper due	3/7/18 OPT – Model UN oral negotiation part 1	3/9/18 OPT – Model UN oral negotiation part 2
9	3/12/18 OPT – Model UN final position paper	3/14/18 RF2F; U 4 DD	3/16/18 St. Pat's holiday
10	3/19/18 OPT – present PK U 4; Fellowship draft application due (Advising week)	3/21/18 OPT; (Advising week)	3/23/18 OPT; (Advising week)
11	3/26/18 Spring break	3/28/18 Spring break	3/30/18 Spring break
12	4/2/18 OPT – Fellowship feedback due; Case 3	4/4/18 OPT – Case present PK	4/6/18 RF2F; U 5 DD
13	4/9/18 OPT – present PK U 5	4/11/18 OPT	4/13/18 (last day to drop)
14	4/16/18 OPT	4/18/18 OPT	4/20/18 RF2F; U 6 DD ; Case draft due
15	4/23/18 OPT – Case draft returned	4/25/18 OPT	4/27/18 OPT
16	4/30/18 OPT – Case final due	5/2/18 OPT	5/4/18 OPT – review for final exam
Finals		As scheduled by Registrar	OPT – Fellowship submitted; Case review classmate