NCELA
National Clearinghouse for English Language Acquisition and Language Instruction Educational Programs

INTEGRATING STEM TOPICS IN THE FOREIGN LANGUAGE CLASSROOM

Over the next decade, the U.S. government, including the U.S. Department of Education, plans to invest more than $100 million in the preparation of science, technology, engineering, and math (STEM) educators. The goals of these initiatives are to improve the achievement of U.S. students in math and science and to identify effective teaching methods for advancing the quality of STEM education at different levels of study (White House Office of Science and Technology Policy, 2011). In order to compete successfully in a global marketplace, the United States needs a workforce that has skills in the STEM fields and can collaborate across international boundaries.

Integrating STEM content with advanced foreign language instruction provides a unique way for students to gain foreign language capacities directly related to promising career pathways. Content and language integrated learning (CLIL), also referred to as content-based language teaching, simultaneously promotes skills in the target language and advances content knowledge, making this a promising approach for students to gain STEM skills in a foreign language classroom (Brewster, 2004; Mehisto, Marsh, & Frigols, 2008; Smala, 2009).

Project-based learning (PBL) in a CLIL classroom fosters foreign language learning by engaging students in important, real-world projects and having students utilize their first and second language knowledge, skills, and abilities to complete the work. Project-based learning integrates all four language skills (listening, reading, speaking, and writing), incorporates collaborative team work, lends itself to clear outcomes, and challenges learners to use the foreign language in different capacities inside and outside the classroom (Stoller, 1997, 2010; Thomas, 2000).

Successfully planning a thematic unit of PBL to integrate STEM topics into a foreign language classroom involves collaboration with STEM content teachers, identifying final outcome goals, creating guidelines for students, assisting students in gathering, compiling and reporting information in a second language, and creating useful evaluation tools to assess student work. In what follows, we illustrate how a teacher in a high school Russian language classroom might structure a PBL unit centering around creating a report on renewable energy, using authentic Russian language sources, and targeting both students' Russian language skills and STEM knowledge.

Step 1. Identify a relevant theme from the STEM curriculum

Description: There are two components that are addressed in a project-based activity—the content that is being explored and the language that is learned through this exploration process.

Tips to facilitate Step 1:

- Recruit a STEM instructor to collaborate on this project.
- For a list of potential topics to use in the project, consult the STEM instructor to discover the standards and curriculum topics being addressed in the students' STEM classes. The following example comes from Massachusetts' learning standards for high school Earth and Space Science (Massachusetts Department of Education, 2006, p. 34).

2. Energy Resources in the Earth System
Central Concepts: *Energy resources are used to sustain human civilization. The amount and accessibility of these resources influence their use and their impact on the environment.*

> **2.1** Recognize, describe, and compare renewable energy resources (e.g., solar, wind, water, biomass) and nonrenewable energy resources (e.g., fossil fuels, nuclear energy).
> **2.2.** Describe the effects on the environment and on the carbon cycle of using both renewable and nonrenewable sources of energy.

Step 2. Determine the final outcome

Description: The final outcome of the project should be related to the language learning objectives, the students' level of language skills, and their competence in the STEM field. Outcomes can be tied to multiple language standards across the domains of reading (e.g. identifying material from written sources), speaking (giving a presentation) or writing (preparing a summary report).

Tips to facilitate Step 2:

- Consider (authentic) tasks that students are (or will be) expected to perform in the content-area subjects—for example, to write a report synthesizing several sources which discuss renewable energy resources.
- Be prepared to adapt the task/final outcome to match students' levels of language proficiency.

Step 3. Structure the project

Description: Provide students with clear guidelines about the structure of both the activity and the final product. Make students aware of the steps they will take to complete the project, along with information about which parts of the projects will be completed in class (e.g., during computer lab sessions) and what they are expected to do as homework. Students also need to be aware of the language demands of the project—for instance, how a research summary or lab report is typically presented in Russian (or another target language). This information should clearly relate to the language and learning objectives (as determined by the teacher) that were established (and reviewed) prior to the start of the project.

Tips to facilitate Step 3:

- Prepare a handout for students outlining the phases of the project. Schedule due dates for completing each section. Appendix A includes a sample handout with seven phases to complete a research project on renewable and non-renewable energy sources. The handout also includes suggestions for the focus of a paper (e.g. advantages and disadvantages of nuclear power in Russia) as well as key resources and basic vocabulary).

- Have students examine authentic materials in the foreign language that are similar to the final product. For example, students might read web-based articles in a popular science magazine. Then, have students compare these to similar materials in English, paying attention to the following features of the report: content, sections, visuals, tables, formulas.

Step 4. Information gathering cycle

Description: Prepare students for the language demands of information gathering. Guide students toward appropriate sources in the foreign language and provide constant feedback. Useful sources include encyclopedias, high school science texts in the foreign language, and newspaper or magazine articles covering the thematic topic. Depending on the language levels of the student, the teacher may provide materials directly, or guide students toward finding their own materials on the internet.

Tips to facilitate Step 4:

- To address content-related demands:
  - provide examples of sources, including encyclopedias, textbooks, or media articles and
  - if students are identifying their own sources, provide students with tools to quickly identify the topic, level, and relevance of a text. Strategies might include scanning titles and subheadings, identifying the length of the text, and understanding the audience of the piece (for instance identifying the difference between a technical article in a science journal and a newspaper piece aimed at the general public).
- To address language-related demands:
  - introduce and practice topic related vocabulary.

Step 5. Information compilation and analysis cycle

Description: Prepare students for the language demands of compiling and gathering information and work with students on analyzing information from their sources and incorporating it into their projects.

Tips to facilitate Step 5:

- Provide students a template for taking notes from sources (Appendix B) and synthesizing information in their own words (Appendix C).
- Help students analyze authentic materials to identify linguistic devices employed to present ideas. For example, examine the component parts of a description of an experiment in the foreign language, and point out the language used to introduce the necessary equipment, to describe the method used, and to report the results (for an example of vocabulary items compiled on renewable and non-renewable energy sources as well as transitional phrases commonly used in research papers, see Appendix D).

Step 6. Information reporting cycle

Description: Prepare students for the language demands of finalizing the project.

Tips to facilitate Step 6:

- Provide a detailed template for the final product, and instruct students on expectations such as page length, number of sources, and the structure of the report.
- Tap into students' experiences in their STEM classrooms by activating their knowledge of similar projects that they have done in English.
- Make information available for students to guide them in addressing the linguistic demands of the project.

Step 7. Evaluate the project

Description: Evaluate students on their use of language, content, and strategies used to complete the project. Ideally, every aspect of the project activity needs to be evaluated. It is also useful to elicit feedback from the students about their experiences while working on the project.

Tips to facilitate Step 7:

- Create evaluation form(s) and discuss the criteria with students (see Appendix E for an example of an evaluation form to grade students' final research synthesis projects).
- Consider evaluating the project activity on various levels (e.g., student self- and peer-evaluations, content area teacher's feedback).

Synthesizing content and language learning into a single project gives students experiences which mimic the real-world experiences of professionals working in a second language, and allows them to combine language learning goals with other content area learning. Carefully constructed project-based learning lets students explore content in a foreign language while supported in a classroom environment. Key elements to structuring such a thematic unit include identification of relevant topics, setting goals for the final product, ensuring students are aware of their role in the project, helping students navigate finding, analyzing, and reporting information in a foreign language, and providing students with feedback and assessment.

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Prepared by Tatiana Nekrasova-Beker, Ph.D. and Anthony Becker, National Clearinghouse for English Language Acquisition/Second Language Testing, Inc.

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Appendix A

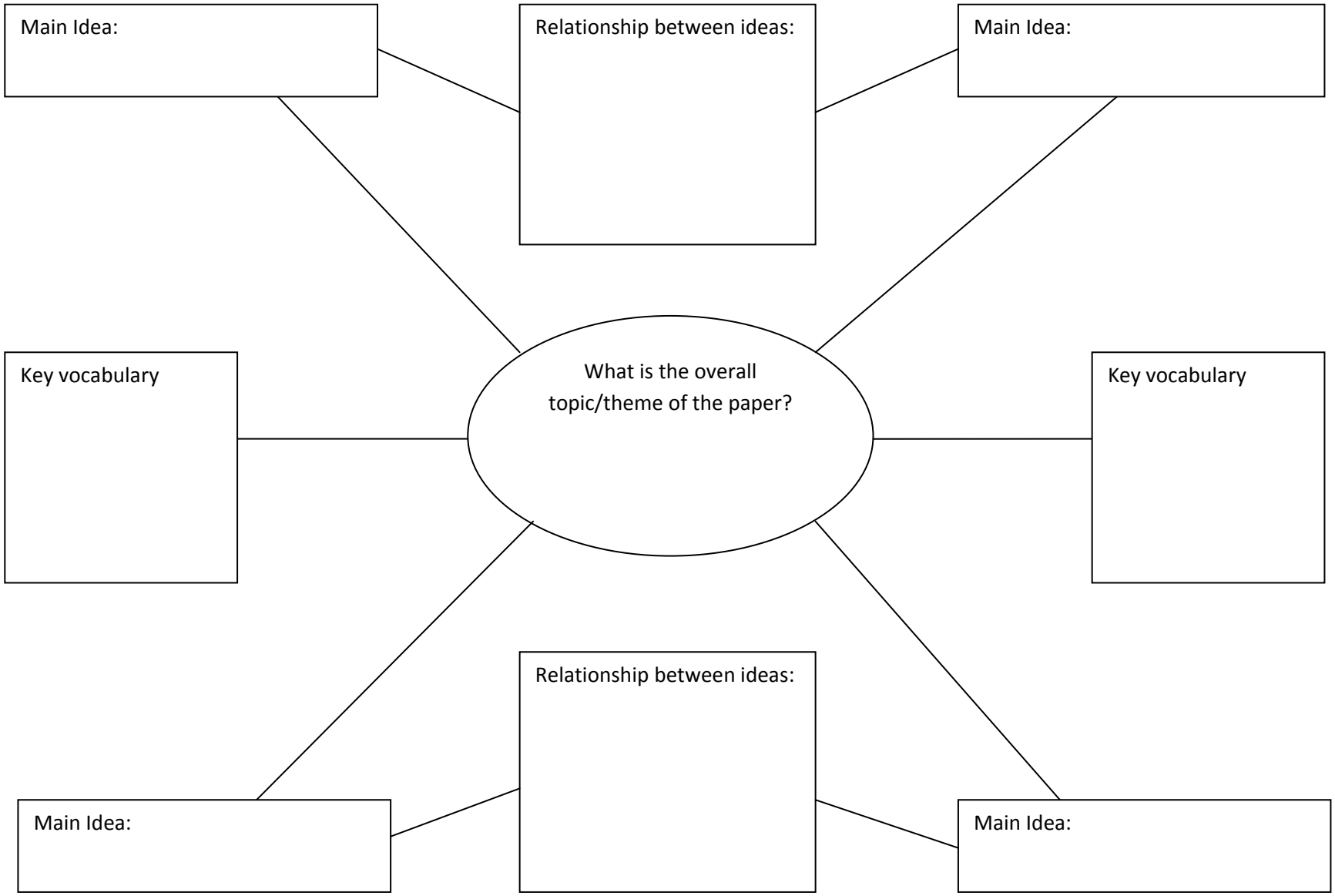
Phases of the project

Phases		Examples
Phase 1	**Identify a theme** Decide on the focus of the paper Decide whether you complete the project individually/ in group and assign tasks	**Topic:** Renewable and non-renewable energy sources **Focus:** Synthesis research paper **Format:** Completed individually **Sample topics**: •Future of non-renewable energy sources. •Advantages and disadvantages of using nuclear energy in Russia. •Exploring alternative energy sources.
Phase 2	**Prepare to gather information** Identify the types of sources and web-sites to research Identify Key Terms to use in the search Identify the inclusion criteria for sources	**Available websites in Russian:** Виртуальный музей истории энергетики Северо-Запада (virtual museum of energy development in Russia's northwest): http://energomuseum.ru/ Карта крупнейших ГЭС России (the map of Russia's largest hydro-power plants): http://geo.1september.ru/2005/09/24-1.gif Образовательная программа по использованию энергетических ресурсов (SPARE--School Project for Application for Resources and Energy) http://spareworld.org/rus/about-us Источники энергии (energy sources): http://spareworld.org/rus/energy_ist **Key Terms to use in the search**: Возобновляемая (регенеративная) энергия, энергия ветра, гидроэнергия, энергия приливов и отливов, геотермальная энергия, энергия солнечного света, биоэнергетика, невозобновляемые ресурсы энергии. (Renewable (naturally replenished) energy, wind power, hydroelectric energy, tide power, geothermal energy, solar power, biomass and biofuel, non-renewable resources.)
Phase 3	**Gather information** Identify 3-5 sources Review each source and take notes.	
Phase 4	**Synthesize information** Compare and contrast ideas, discover meaningful connections among ideas, and develop a unique perspective on a topic	
Phase 5	**Write the first draft of the paper**	
Phase 6	**Review the draft**	
Phase 7	**Prepare the final draft**	

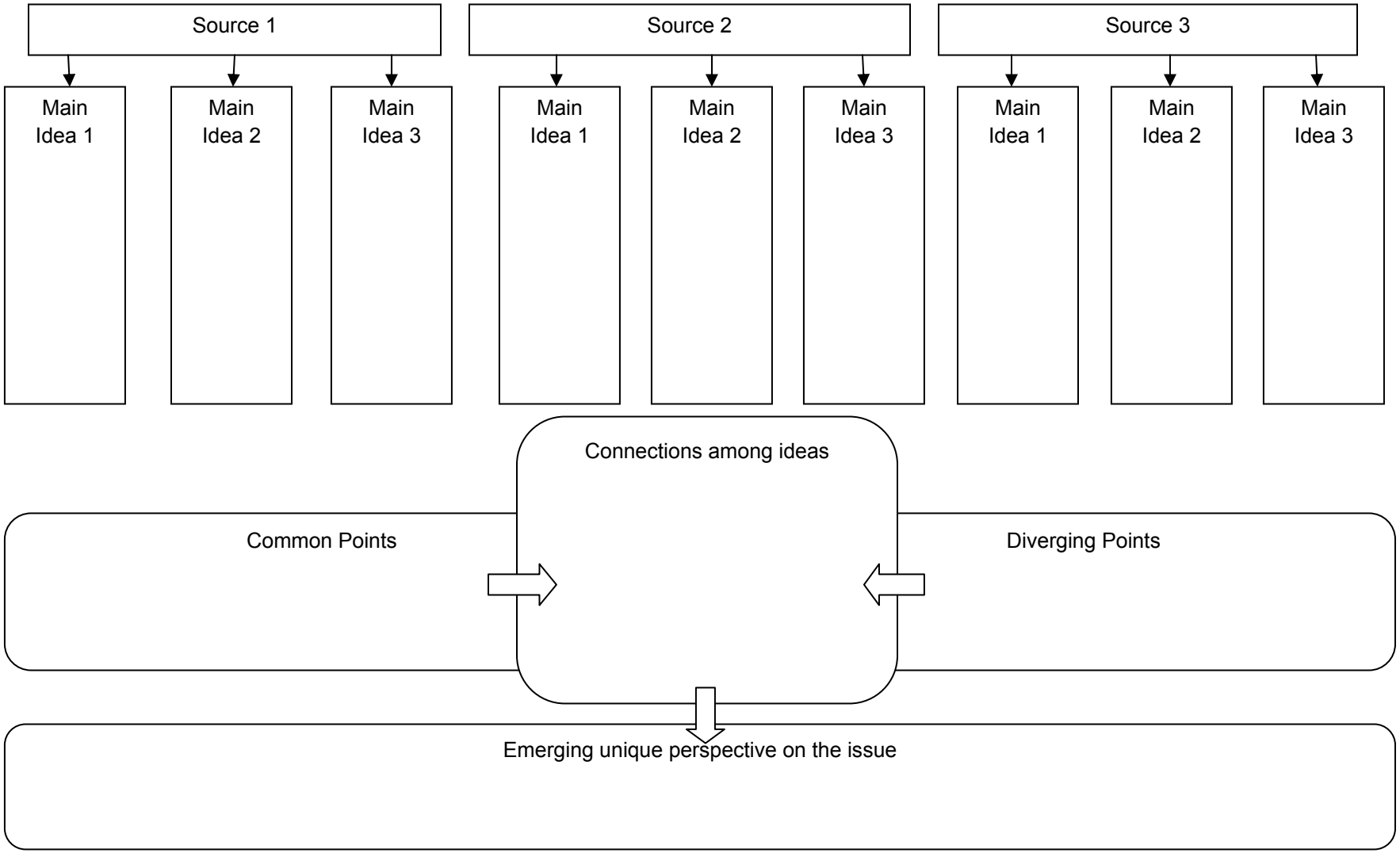
Appendix B: Note-taking organizer

Student name: _____ Date: _____

Source: _____ Good to use? (circle one): YES / NO



Appendix C: Synthesis Chart



Appendix D

Linguistic Resources

Вокабуляр по теме (Thematic Vocabulary)

available	доступный
bioenergy	биоэнергетика
blended	смешанный
charcoal	древесный уголь
coal conversion	переработка угля
coal deposit	угольное месторождение
coke	кокс
commercial	промышленный, коммерческий
crude oil	сырая нефть
to damage	повреждать
decay	распад
distribution	распределение, размещение
eject	выбрасывать, выпускать
emergency	авария
exhaust	выхлопная труба, выхлоп
extensive	обширный, пространный
fossil fuel	ископаемое топливо
geothermal energy	геотермальная энергия
harmful	вредный
hydropower	гидроэнергия
inflammable	легко воспломеняющийся
instantaneously	мгновенно
manufactured	промышленного производства, искусственный
non-renewable energy sources	невозобновляемые ресурсы энергии
ocean energy	энергия приливов и отливов
peat	торф
petrochemical	нефтехимический
pile	отвал, отвал грунта
plant	растение
pollutant	загрязняющее вещество, примесь
raw material	сырье
renewable energy	возобновляемая (регенеративная) энергия
solar energy	энергия солнечного света
steel industry	сталелитейное производство
strip mining	открытая разработка
to concentrate	сосредоточиваться
to design	разрабатывать, конструировать, проектировать
to divide	делить
to furnish	поставлять, снабжать

to haul	перевозить, транспортировать
to include	включать в себя
to increase	возрастать, увеличиваться, усиливаться
to pipe	пускать по трубам
to refine	очищать
to spill (spilled, spilt)	проливаться, разливаться
trial	испытание, опыт
wind energy	энергия ветра

Речевые клише для оформления академической письменной речи (transitional phrases)

Connecting Ideas	
So Therefore As a result Accordingly, Thus, Hence, Consequently In other words However Nevertheless In spite of that	таким образом поэтому в результате соответственно, в итоге, следовательно другими словами однако тем не менее несмотря на
Describing	
First Then, Next Finally Comprise(s),Consist(s) of, Constitute(s), Is composed of	во-первых затем в конечном счете, наконец состоит из…, охватывает
Defining	
Means Describes Is defined as Is used Relates to Involves	означает описывает определяется как используется относится к вовлекает, включает в себя
Exemplifying	
Shown by Exemplified by Illustrated by	представленный, показанный приведенный в качестве примера представленный кем-либо
Summarizing and Concluding	
In short, in brief In a word To sum up In conclusion On the whole Altogether, in all	кратким образом, кратко одним словом подводя итог в заключение в целом в конечном счете

Appendix E

Synthesis Paper Scoring Rubric

Student Name: _____ **Date: _____**

Category	Points (out of 100)	Teacher Notes
A. Introduction • States the thesis of the paper. • Provides an overview of the points to be discussed in the body of paper.	___/20	
B. Body of Paper • Parallels the order of ideas discussed in the introduction. • Includes 3-5 main points related to the topic. • Compares and contrasts ideas from different sources. • Supports ideas with references.	___/30	
C. Conclusion • Reviews major points of paper • Offers conclusion about thesis.	___/20	
D. Language Use • Uses correct vocabulary. • Uses transitional phrases. • Uses correct grammar and spelling.	___/20	
E. Format • Shows evidence that student has edited paper. • Paper is 3-5 pages long. • Correctly cites sources.	___/10	

Total Score: _____/100 points