TEACHING HUMAN DIGNITY

China's One-Child Policy:

Exponential & Logarithmic Functions

CENTRAL QUESTIONS:

- **How do exponential and logarithmic functions contribute to understanding population growth? How did mathematical models influence China's adoption of the one-child policy?**
- **What was problematic about how the Chinese government achieved the goal of population reduction?**
- **Quantitative reasoning is not necessarily neutral. What role should mathematics play in ethical and policy decisions? What other considerations should be included in such decisions?**

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Developed in collaboration with John Brahier.

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Dear Colleague,

The question of human dignity is essential for a humane and flourishing society. That is why ***Teaching Human Dignity*** takes up issues across the spectrum of life and dignity, ranging from abortion to euthanasia, war, and the ethical treatment of embryos. It is our hope that these resources will allow participants to engage these complex issues from a variety of disciplinary perspectives and inspire creative responses grounded in the inviolable dignity of each human person.

The McGrath Institute for Church Life's ***Teaching Human Dignity*** series is an interdisciplinary educational series that provides high school teachers with units, lesson plans, and resources designed to integrate life and human dignity topics into existing curriculum. The unit contained in this ebook, "China's One-Child Policy: Exponential and Logarithmic Functions" was designed by John Brahier. Mr. Brahier is an alumnus of the University of Notre Dame, where he majored in Theology and Mathematics. He earned his Masters in Education from Bowling Green University. He is currently a high school campus minister in Dearborn, MI.

In this five-lesson unit, teachers will find the framework, activities, in-depth instructional guides, and resources they need to guide students through a mathematical and ethical analysis of China's one-child policy. Due to the mathematical skills required and the nature of the moral questions, this unit is recommended for use in an Algebra II (or higher) course. The unit is designed as an extension for an existing unit on exponential and logarithmic functions, and therefore includes only a review of logarithmic and exponential functions. A teacher utilizing this material will want to ensure that students have developed proficiency with these types of functions prior to proceeding with the unit.

Students begin the unit by reviewing exponential and logarithmic functions and learning about fears of overpopulation and mass starvation in China in the late 1960s and 1970s. Students then examine and develop mathematical models to project population growth and explore both the importance and limitation of the use of mathematical modeling to analyze situations and make policy decisions. It is important for students to understand that mathematical data is not "neutral." In itself it cannot tell us what to do or how to act. We (human beings) are responsible for interpreting and applying such data to promote the flourishing of all. Participation in this unit concludes with an exploration of the ethics and moral implications of China's one-child policy and some possible unintended consequences. Finally, students are asked to evaluate the one-child policy in terms of several factors: the mathematical models likely used in the formulation of the policy, the ethical questions in play, and the policy's consequences. They are asked to bring these individual factors into conversation together to form a judgment about the one-child policy.

Given the scope of the unit and the integration of Catholic ethics, there could be an opportunity for collaborative, interdisciplinary teaching. If desired this unit could be co-taught with a theology teacher or a social studies teacher.

- A social studies teacher could complement the content of the unit by instructing students more deeply on the proper functions of a government in promoting the flourishing of each and every individual within its bounds. Furthermore, a comprehensive understanding of the common good can help students realize more fully the importance of each person's human dignity and the necessary construction of layers of communities that overlap and interact with one another to ensure the flourishing of both the individual and of the whole. (Note: The concept of the common good can be covered by either a social studies teacher or a theology teacher. If materials are needed, consider using the unit "Human Flourishing and the Common Good" within the *Teaching Human Dignity* series.)

- A theology teacher could complement the content of the unit by instructing students more deeply on the theological and philosophical underpinnings of human dignity and a Christian anthropology, most especially noting the unity of body and soul and what it means to uphold human dignity in decisions involving responsible parenthood.
- Recognizing that these types of interdisciplinary collaborations with colleagues are not always possible, there are resources available that will allow the math teacher to be successful in teaching this unit. These resources include:
    - "What is Human Dignity?" - an expert guide by Melissa Moschella in the *Teaching Human Dignity* series.
    - *Humanae Vitae* especially §§ 1-3, 17, and 23
    - "Human Flourishing and the Common Good" (especially videos from Lesson #3) - a unit in the *Teaching Human Dignity* series

All resources for the unit can be found on the McGrath Institute for Church Life website.

We created a Facebook group where teachers can share ideas, tips, lesson modifications, and best practices. We hope you'll join the conversation!

Sincerely,
The Teaching Human Dignity Team

Unit Overview

Unit-at-a-Glance

Curriculum Area:
Mathematics (Algebra II or higher)

Time Requirement:
Approximately five 50-minute class periods

Descriptors:
Exponential functions, logarithmic functions, mathematical modeling, population growth, one-child policy, abortion, China

Unit Objectives

Students will be able to:

- perform basic computations involving exponential functions or equations.
- perform basic computations involving logarithmic functions or equations.
- construct linear and exponential functions.
- understand the inverse relationship between exponents and logarithms and use this relationship to solve problems involving logarithms and exponents.
- interpret expressions that represent a quantity in terms of its context.
- articulate the ethical challenges involved in China's one-child policy.
- integrate different types of knowledge to evaluate China's one-child policy.

Rationale

Understanding mathematics involves more than the accurate computation of functions. It also requires the ability to apply mathematics to real-world situations and events and to evaluate the relevance of computational data when making concrete decisions. In this unit, students review and apply their knowledge of logarithmic and exponential functions to explore China's one-child policy, both in terms of the accuracy of the computations and the ethical application of mathematical analysis to real-world situations. As they engage in mathematical inquiry, students are asked to evaluate how mathematical computations ought to influence governmental policy decisions about population control and to consider other relevant factors in the decision-making process.

Common Core State Standards

The following items are based on Appendix A from the CCSSM. These items are intended to be addressed in Algebra I and Algebra II (depending on the standard). Since most of the math instruction in this unit is intended to be a review instead of the primary instruction, all of the relevant descriptions from CCSSM will be included below.

CCSS.MATH.CONTENT.HSA.SSE.A.1

Interpret expressions that represent a quantity in terms of its context.

CCSS.MATH.CONTENT.HSA.SSE.A.1.A

Interpret parts of an expression, such as terms, factors, and coefficients.

CCSS.MATH.CONTENT.HSA.SSE.A.1.B

Interpret complicated expressions by viewing one or more of their parts as a single entity. For example, interpret P(1+r)n as the product of P and a factor not depending on P.

CCSS.MATH.CONTENT.HSF.IF.A.2

Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context.

CCSS.MATH.CONTENT.HSF.IF.C.8.B

Use the properties of exponents to interpret expressions for exponential functions. For example, identify percent rate of change in functions such as $y = (1.02)^t$, $y = (0.97)^t$, $y = (1.01)12^t$, $y = (1.2)^t/10$, and classify them as representing exponential growth or decay.

CCSS.MATH.CONTENT.HSF.BF.A.1

Write a function that describes a relationship between two quantities.

CCSS.MATH.CONTENT.HSF.BF.B.5

Understand the inverse relationship between exponents and logarithms and use this relationship to solve problems involving logarithms and exponents.

CCSS.MATH.CONTENT.HSF.LE.A.2

Construct linear and exponential functions, including arithmetic and geometric sequences, given a graph, a description of a relationship, or two input-output pairs (include reading these from a table).

CCSS.MATH.CONTENT.HSF.LE.A.4

For exponential models, express as a logarithm the solution to abct = d where a, c, and d are numbers and the base b is 2, 10, or e; evaluate the logarithm using technology.

CCSS.MATH.CONTENT.HSF.LE.B.5

Interpret the parameters in a linear or exponential function in terms of a context.

Unit Summary

Lesson Title	*Description*	*Learning Objectives*
Lesson #1: Introduction and Review of Exponential Functions ***One 50 minute class period***	In this lesson, students are introduced to the main object of study in this unit and will be given an overview of the days to come. Students then review exponential functions in order to build a foundation for the days to come. Pages 2-5 in the **Student Packet**	Students will be able to perform basic computations involving exponential functions and equations. Students will be able to apply the standard exponential equation to a scenario that involves population growth or decline. Students will be able to explore the real life meaning of quantities involved in computations and take these into account when making rounding decisions. Students will be able to understand historical concerns of overpopulation that informed China's one-child policy.
Lesson #2: Review of Logarithmic Functions ***One 50 minute class period***	In this lesson, students engage in a review of logarithmic functions, which will lead to a review game. Finally, students will read historical background about China that will be used to understand the implementation of China's one-child policy. (This last item may be assigned as homework.) Pages 6-8 in the **Student Packet**	Students will be able to identify the logarithm as the inverse of the exponential function. Students will be able to perform basic computations involving logarithmic functions. Students will be able to apply the standard logarithmic equation to a scenario that involves population growth or decline. Students will be able to explore the real life meaning of quantities involved in computations and take these into account when making rounding decisions.

Unit Summary cont.

Lesson Title	*Description*	*Learning Objectives*
Lesson #3: Development of One-Child Policy ***One 50 minute class period***	In this lesson, students put themselves in China in the 1970s and examine the mathematical models being used to project population growth. They will develop simple models of their own and study the actual 1979 projections to understand how the one-child policy was developed. Pages 9-11 in the **Student Packet**	Students will be able to articulate the historical and political concerns that informed China's one-child policy. Students will be able to utilize historical data to build an exponential model and predict China's population. Students will be able to compare the results of computations with models developed by the Chinese government.
Lesson #4: Moral Considerations of the One-Child Policy ***One 50 minute class period***	In this lesson, students review the mathematical concepts from the previous lesson, read about the Catholic Church's stance on appropriate ways to approach population control, and discuss the important moral issues surrounding China's one-child policy. Pages 12-16 in the **Student Packet**	Students will be able to demonstrate understanding of exponential and logarithmic functions. Students will be able to articulate the historical circumstances that led to China's one-child policy. Students will be able to describe the central ethical issues of China's one-child policy, especially the role of the government and human dignity.
Lesson #5: Evaluating the One-Child Policy ***One 50 minute class period***	In this lesson, students will evaluate the one-child policy through a variety of methods, both mathematical and moral. This class period will culminate in the writing of a paragraph that analyzes the one-child policy from a moral standpoint. Students will be assigned a summative task that will ask them to synthesize what they have learned in a creative format. Pages 17-21 in the **Student Packet**	Students will be able to assess China's one-child policy through multiple lenses, including mathematical modeling, ethical reasoning, and social consequences.

Lesson #1:

Introduction and Review of Exponential Functions

Lesson #1 Overview

Subject: Mathematics (Algebra II or higher)

Time Requirement: One 50 minute class

Resources Required:

- Introduction and Review of Exponential Functions PowerPoint
- Exploring China's One-Child Policy with Exponential and Logarithmic Functions Student Packet
- Exploring China's One-Child Policy with Exponential and Logarithmic Functions Teacher Packet
- PBS RetroReport, "The Population Bomb"[1]

Lesson Description: Students are introduced to the main object of study for this unit: China's one-child policy. They begin to explore the fears of overpopulation that motivated China's adoption of a one-child policy in 1979 and review exponential expressions and population growth models, which will significantly factor into their consideration of China's population questions. Several practice problems accompany this launch day.

Objectives:

Students will be able to:

- perform basic computations involving exponential functions and equations.
- apply the standard exponential equation to a scenario that involves population growth or decline.
- explore the real life meaning of quantities involved in computations and take these into account when making rounding decisions.
- understand historical concerns of overpopulation that informed China's one-child policy.

[1] "Population Bomb: The Overpopulation Theory That Fell Flat" by Kit R. Roane and Sarah Weiser *Retro Report on PBS*, October 22, 2019, https://www.retroreport.org/video/the-population-bomb/

Lesson #1 Summary

Time	*Phase*	*Summary*	*Student Work*	*Teacher Notes*
n/a	***Preparation***	Teacher prepares materials for the lesson and thoroughly reviews instructional support materials.		◆ Teacher reviews all materials for Lesson #1, including: • the relevant pages of the **Exploring China's One-Child Policy with Exponential and Logarithmic Functions Student Packet** and **Exploring China's One-Child Policy with Exponential and Logarithmic Functions Teacher Packet** • **Introduction and Review of Exponential Functions PowerPoint,** and the • **PBS RetroReport: "The Population Bomb" video.** ◆ Teacher makes a copy of the **Student Packet** available for each student. ◆ Teacher may find it helpful to familiarize herself/himself with all unit materials prior to beginning Lesson #1.
5 minutes	***Preliminary Problem***	Students complete the preliminary problem. Teacher reviews student answers and encourages students to consider the context of their computation.	◆ Students receive **Student Packet**, which will guide their work for the unit. ◆ Students complete preliminary problem. ◆ Students self-assess and correct mistakes as the teacher reviews the problem.	◆ Teacher distributes **Student Packet** to each student. ◆ Teacher uses the **Introduction and Review of Exponential Functions PowerPoint** to display the preliminary problem *(Note: preliminary problem is also in **Student Packet**).* ◆ Teacher reviews problem with students and draws attention to the context of the problem and the impact this context has for arriving at the correct answer.
10 minutes	***PBS RetroReport: "The Population Bomb"***	Students watch the **PBS RetroReport, "The Population Bomb"** video and briefly discuss in class.	◆ Students watch the video and answer accompanying questions. *(Note: accompanying questions are optional.)*	◆ Teacher uses the **Introduction and Review of Exponential Functions PowerPoint** to introduce the central questions of the unit. ◆ Teacher shows PBS video and leads short class discussion.

Lesson #1 Summary cont.

Time	*Phase*	*Summary*	*Student Work*	*Teacher Notes*
10 minutes	***Review Problems***	Students work on review problems (#1-2) in order to reinforce order of operations and appropriate rounding.	◆ Students complete the review problems in the **Student Packet**. ◆ Students self-assess and correct mistakes as the teacher reviews the problems.	◆ Teacher should circulate during student work time to help students as they work. ◆ Teacher reviews problems and gives correct answers.
5 minutes	***Review of Exponential Functions***	Teacher guides students in a review of exponential functions.	◆ Students take notes in the **Student Packet**.	◆ Teacher uses **Introduction and Review of Exponential Functions PowerPoint** to review exponential functions.
20 minutes	***Practice Problems***	Students work (either individually or in small groups) on the practice problems related to exponential functions (#3-5).	◆ Students complete the practice problems in the **Student Packet**. ◆ Students self-assess and correct mistakes as the teacher reviews the problems.	◆ Teacher should circulate during student work time to help students as they work. ◆ Teacher reviews problems and gives correct answers.
n/a	***Homework***	Students complete any remaining practice problems for homework.	◆ Students complete unfinished practice problems.	

Lesson #1 Instructional Guide: Procedural Notes

Preparation

Timing and pacing of this unit may need to be adjusted based on students' prior knowledge and level of proficiency. This unit is designed for students who have already demonstrated understanding of exponential functions and who have an elementary understanding of logarithmic functions. As such, the following resources assume basic computational abilities and theoretical understandings. If a teacher plans to use this content as an introductory unit on exponential and logarithmic functions, the teacher should supplement the review resources from Day 1 (for exponential functions) and Day 2 (for logarithmic functions).

Introduction

It is important for the teacher to help students recognize that math is based on concrete realities. While students may know the mechanics, or process, of solving a math problem, many may lose sight of the realities behind the numbers, that is, what the numbers actually represent. The introductory problem for this unit should help students recognize the importance of the concrete realities that numbers represent, a skill that is often neglected when performing contextless mathematical drills. This exercise helps students develop a more complex understanding of how to apply mathematics in real-world situations where computations must be interpreted based on exigent realities.

The teacher will display the following preliminary problem for students to complete as they come into class.

Preliminary Problem

There are 103 students in the senior high school class. They are planning a class trip to the zoo. Only 25 students can fit on a bus. How many buses does the principal need to arrange to get all of the students to the zoo?

a) 3.12
b) 4
c) 4.12
d) 5

The teacher will ask students to share their answers. Most students will select either c or d. The teacher should briefly reflect on these two possible answers with students, beginning by asking anyone who selected 4.12 (c) to explain why they chose this answer. (This is the answer that is generated by rotely performing the division problem at hand.) The teacher should then invite students who selected the correct answer, 5 (d), to share their rationale with the class. It is important to note that in this case, fractions of human beings and fractions of buses do not have any contextual meaning. The purpose of this problem is to encourage students to consider the context of their computation before arriving at an answer. In this unit, it will be vital to understand that computations do not exist in a vacuum; they are not merely theoretical calculations. Rather, they involve human lives.

The teacher should explain that when we utilize mathematical data to help solve problems, it's essential to consider the context of the situation. The teacher should also point out that even in this very simple problem, it was necessary for students to do more than rotely compute the numbers to arrive at the correct answer to the question. They had to apply their knowledge in the context of a real-world situation, and round up to account for the transportation of all students going to the zoo. Likewise, in the real world, complex situations require us to use mathematical computation as one (of many) tools in the decision-making process.

PBS RetroReport: "The Population Bomb"

The teacher should explain that in this unit, students will be exploring a specific historical situation and evaluating a related policy decision that was impacted by mathematical computations. The teacher should emphasize that as part of this work it will be important for students to continue to consider more than simple computation. Just as they did in the warm-up problem (albeit on a smaller scale), they will need to consider how to apply mathematical computations to complex, real-world situations.

After discussing the warm-up problem and before beginning the PBS report, the teacher should communicate the overall goal of the unit. The teacher may say something like this: "In this unit, we are going to be talking about how exponential and logarithmic functions can help us understand population growth and how this understanding influenced China's one-child policy."

Next, students view the **PBS RetroReport, "The Population Bomb,"** which introduces them to the widespread alarm about population growth in the mid-20th century, which influenced the Chinese government's decision to adopt a one-child policy.

The video highlights some dramatic proposals made in the 1960s, based on what was then considered to be a solid scientific hypothesis (though, even at that time, the theory had many critics)[2] It presents Paul Ehrlich's thesis that the world would suffer catastrophically from overpopulation if it continued on its then-current trajectory (e.g., mass starvation, mass pollution, etc.), and his recommendation of zero-population growth. As students watch the video, they may answer the corresponding questions on pages 2-3 of **Exploring China's One-Child Policy with Exponential and Logarithmic Functions Student Packet** or the teacher may wish to have them simply watch the video and answer the questions as a class at the conclusion of the clip. The video does a good job of conveying the sense of panic and need for immediate and potentially compulsory response that resulted from Paul Ehrlich's work and activism. The overall effect of the video may be lost if students are more attuned to answering specific questions than following the narrative arc. The teacher will need to consider the specific group of students in his or her classroom to determine what is best for their learning.

After the students have had time to watch the video as a class, the teacher may debrief the video, asking for student reactions (i.e., was there anything that surprised them, was new to them, or confusing). The teacher may also want to review the specific questions from the packet, although these answers may arise organically as students share general responses to the video.

After the teacher has introduced the basic ideas of fears surrounding overpopulation and population control, the teacher should transition the class to working through a review of exponential functions. The teacher should explain to students that decisions surrounding public policies on population control stemmed directly from scientific research and mathematical modeling. For homework after Lesson #2 the students will have the opportunity to learn more about China's response to fears of overpopulation and mass starvation, which resulted in the one-child policy. For now, however, in order to more thoroughly understand and evaluate China's one-child policy, students need to be able to understand the mathematical models that spurred this decision. Thus, they will turn to some basic math skills, which are the necessary building blocks to more fully understand the population models the Chinese and other governments used. Their math skills are not just going to be directed to made-up story problems but rather to a real situation. Being cognizant of the real-world meaning of numbers will be an important lens for students to have throughout this unit.

Review Problem

Students can begin with the review problems found on page 3 of the **Student Packet** or slide 9 of the **Introduction and Review of Exponential Functions PowerPoint**. Per the teacher's discretion, students can work individually or in groups. The answers to the review problems can be found in the Teacher Packet on page 3. When reviewing the answers with the whole class, there are a few important reminders that the teacher should note:

- Following the order of operations (PEMDAS: Parenthesis, Exponents, Multiplication & Division, Addition & Subtraction) is vital for accurate computation. Students who arrived at incorrect answers likely either did not correctly follow the order of operations or made a simple computational error.

[2] For more information about Paul Ehlrich, his theory about population growth and its effects, as well as contemporaneous critiques of his work, see https://www.smithsonianmag.com/innovation/book-incited-worldwide-fear-overpopulation-180967499/

- Knowing and remembering the context of the situation at hand is vital. In this case, students may present different answers for all three parts of #2 depending on how they chose to round. Since the instructions are purposefully vague and the context is intentionally unclear, this is to be expected. This is an opportunity for the teacher to pose some follow-up questions:
  - What rounding would be expected if these were monetary units? *(nearest hundredth)*
  - What rounding would be expected if these were human beings? *(nearest integer)*

Review of Exponential Functions

The teacher can either ask the students what exponential growth is and then provide a more exact definition or just provide the definition.

Exponential Growth

Exponential growth *is a type of growth in which the increase in size is directly proportional to the size of the current quantity.*

The students should record this definition in their **Student Packet.**

There are several ways to model population growth, including some functions that involve e. For the sake of continuity, this structure will be used consistently.

Practice Problems

The three practice problems should be addressed separately, meaning that students should work on #3 independently or in small groups and then regroup to review the solutions before any students move on to #4. This way, the teacher can facilitate more targeted follow-up conversations since students will be focused on a specific problem or set of problems.

Problem #3

Practice problem #3 is an opportunity for teachers to re-emphasize order of operations. These computations should be relatively straightforward for students.

Problem #4

Practice problem #4 focuses on the meaning of the different parts of an equation that involve population growth. Students will likely need to be reminded of the difference between the growth rate when written as a percentage and the r-value. To express a percentage as a decimal, the number should be divided by 100.

Problem #5

Practice problem #5 gives an applied example of population growth that involves computation. The most challenging part of this question is part (c). This part represents the "bridge" between Lesson #1 and Lesson #2. Unless students use a logarithm, they will likely fall back on guessing and checking, graphing, or using a table to solve this problem. Based on the prior knowledge of the students, the teacher would use the review time of this problem to start to make the transition to the next lesson, in which students will either discover or summarize (based on their prior knowledge) the concept of a logarithm and apply it to this problem. (To emphasize a point made earlier in this instructional guide, if students are unfamiliar with logarithms, the teacher will need to supplement the materials from Lesson #2, which is designed primarily as a review and assumes a basic understanding of logarithmic functions.)

Homework

If students have not finished the practice problems during class time, they may need to complete them for homework.

Lesson #2:

Review of Logarithmic Functions

Lesson #2 Overview

Subject: Mathematics (Algebra II or higher)

Time Requirement: One 50 minute class period

Resources Required:

- War Cards
- War Cards Teacher Edition
- Review of Logarithmic Functions PowerPoint
- Exploring China's One-Child Policy with Exponential and Logarithmic Functions Student Packet
- Exploring China's One-Child Policy with Exponential and Logarithmic Functions Teacher Packet
- Scissors
- Article: "How China's One-Child Policy Started in the First Place"[3]

Lesson Description: Students review logarithmic functions and apply them algebraically to solve problems involving population growth. This lesson includes a fun, interactive game (similar to the game, "War") that helps reinforce the computational skills students have reviewed in Lessons #1 and #2. The lesson concludes with additional background information about China's one-child policy. This historical context will aid in ethical analysis in Lessons #4 and #5.

Objectives:

Students will be able to:

- identify the logarithm as the inverse of the exponential function.
- perform basic computations involving logarithmic functions.
- apply the standard logarithmic equation to a scenario that involves population growth or decline.
- explore the real life meaning of quantities involved in computations and take these into account when making rounding decisions.

[3] "Here's How China's One-Child Policy Started in the First Place" by Tessa Berenson, TIME, October 29, 2015, https://time.com/4092689/china-one-child-policy-history/.

Lesson #2 Summary

Time	*Phase*	*Summary*	*Student Work*	*Teacher Notes*
n/a	***Preparation***	Teacher prepares materials for the lesson and thoroughly reviews instructional support materials.		◆ Teacher reviews all materials for Lesson #2, including: • the relevant pages of the **Exploring China's One-Child Policy with Exponential Functions and Logarithmic Functions Student Packet** and **Teacher Packet** • **Review of Logarithmic Functions PowerPoint**
5 minutes	***Introduction***	Teacher begins class by reflecting on the last practice problem from the Lesson #1 and the role of inverse operations.	◆ Students ask any remaining questions about exponential functions. ◆ Students will discuss their approaches to solving #5c.	◆ Teacher answers any remaining questions about exponential functions. ◆ Teacher asks students to reflect on how they solved question #5c. ◆ Teacher asks students how to undo the operation of addition. ◆ Teacher explains inverse operation and defines a logarithm as the inverse operation of an exponential function.
10 minutes	***Review of Logarithmic Functions***	Teacher guides students in a review of logarithmic functions and problem #6.	◆ Students take notes in the **Student Packet.**	◆ Teacher uses the **Review of Logarithmic Functions PowerPoint** to review logarithmic functions.

Lesson #2 Summary

Time	*Phase*	*Summary*	*Student Work*	*Teacher Notes*
15 minutes	***Practice Problems***	Students work (either individually or in small groups) on the practice problems related to exponential functions (#7-8).	◆ Students complete the practice problems in the Student Packet. ◆ Students self-assess and correct mistakes as the teacher reviews the problems.	◆ Teacher should circulate during student work time to help students, as needed. ◆ Using the PowerPoint, the teacher reviews problems, gives correct answers, and emphasizes the importance of context for mathematical computations.
20 minutes	***"War"***	Students solve problems on "War" cards and play "War" using their cards.	◆ Students complete problems on “War” cards. ◆ Students confirm answers with a peer. ◆ Students cut cards apart. ◆ Students play “War” with another student during the allotted time.	◆ Teacher distributes “War” card sheets to students, ensuring a roughly even distribution of “A” and “B” decks. ◆ Teacher explains the rules for War. ◆ Teacher circulates among students, answering questions, as needed.
5 minutes	***Closure***	Teacher reminds the students about the upcoming quiz at the beginning of Lesson #4 and assigns the homework (Note: If there is time, students can begin to work on the assigned reading).	◆ Students may begin working on homework if there is time.	◆ Teacher answers any outstanding questions.
	Homework	Students explore the historical development of China’s one-child policy.	◆ Students read article, **“How China’s One-Child Policy Started in the First Place”** and answer associated questions in the **Student Packet.**	◆ Teacher provides students with either printed handout or electronic version of the article **“How China’s One-Child Policy Started in the First Place.**

Lesson #2 Instructional Guide: Procedural Notes

Introduction

The teacher may need to begin Lesson #2 by reviewing practice problems from Lesson #1 and/or answering any additional questions.

Lesson #1 concluded with a series of practice problems that involved exponential functions and population growth models. The last problem from the previous lesson required students to use an indirect solution method (i.e., guessing and checking, graphing, a table, etc.). Directly solving this question would require a different algebraic tool: a logarithm. The teacher begins Lesson #2 with a simple question: "How do you undo the operation of addition?" Students should answer this question with "subtraction." The teacher reminds students that this "undoing" operation is known as an "inverse operation," so what is needed to algebraically solve the last problem from Lesson #1 is the inverse operation of an exponential function--a logarithm. Depending on prior knowledge, this understanding (that a logarithm is the inverse of an exponential) may or may not be new.

What is a Logarithm?

The inverse operation of an exponent.

Review of Logarithmic Functions

Using the **Review of Logarithmic Functions PowerPoint**, the teacher guides students in a review of logarithmic functions. The teacher begins by helping students fill out the three open-ended statements in the **Student Packet** on page 6 (Note: the questions in the **Student Packet** correspond to the PowerPoint slides).

Simply put, a logarithm ***operates as the inverse operation of exponentiating.***

A logarithm answers a simple question: ***What exponent (x) must I use with base b in order to produce y?***

If $y = bx$, *then* $x = \log_b(y)$.

With the last line in mind, the teacher should direct students to problem #6, which involves converting from exponential form to logarithmic form. Students work individually or in small groups before checking the answers as a class.

Practice Problems

Before introducing the practice problems #7-8 for logarithmic functions, the teacher should offer several reminders:

- Order of operations (PEMDAS) must be consulted at all times in mathematical computation!
- Depending on the calculator students are using, entering logarithmic expressions may involve slightly different keystrokes. It will be important to ensure that students have the appropriate tools (and operational knowledge) to perform calculations.

While students work individually or in small groups, the teacher should circulate and offer support and critique where necessary. Based on the quality of work being performed, the teacher may choose to offer a large group review of the solutions or not (if small groups have collectively reached the correct answers on their own).

Regardless of the extent of the review the teacher conducts in a large group setting, he/she should spend the time contextualizing the questions and answers.

Problem #7

The teacher should ask, "If the directions for #7 did not include instructions about rounding to the nearest tenth, how would you have reported your answer to the three parts?"

Students should acknowledge that they lack context to definitively determine how to round. This is a good opportunity to revisit the importance of knowing and remembering the meaning behind the numbers that are being used in computation.

Problem #8a

The teacher should ask the students how they chose between 2016 and 2017 for their answer. (The correct answer is 2016 and confirms the indirect computation that was completed during Lesson #1.) Based on the algebraic computation involved in #8, students should have arrived at an answer of t = 2,016.23 (rounded to the nearest hundredth). Students might be inclined to round to the nearest integer. In this case, it happens to produce the right answer but does not represent sound mathematical thinking. If this rationale is offered by students, the teacher may ask a follow-up question such as, "If your computation had yielded 2,019.84, how would you have reported your answer?" Following the logic of simply rounding to the nearest integer, students may arrive at a response of 2020, which would be incorrect. This is yet another opportunity for the teacher to emphasize the importance of context for mathematical computation. Any value between 2019 and 2020 simply refers to a time during the 2019 calendar year. Therefore, a computed value of 2,019.84 would simply mean that the desired population (in this case, 2.25 million) was reached 84% of the way into the year 2019.

Problem #8b

Similarly to the previous problem, students will need to consider appropriate rounding for this situation. A strict calculation will yield 2044.265. Many students may be inclined to simply round this value to the nearest integer (2044). In this case, 2044 is the correct answer, but that approach (simply rounding) is misleading. Students need to consider that the population will reach the specified level (10,000) about ¼ of the way into the year 2044.

Problem #8c

This kind of critical thinking, which involves an appreciation of the meaning of numbers, is important for the teacher to continue to emphasize, both for the sake of accuracy but also so that, later in the unit, when these numbers represent human lives, students are more likely to be sensitive to it.

War Game

The teacher should introduce the game of "War" as another opportunity for students to continue to refine their computational abilities through a fun, interactive format. The teacher briefly explains the general concept of the game "War" as follows:

- Students play in pairs.
- Each player starts with a stack of cards.
- At the same time, each player turns over his or her top card.
- Whoever has the higher value on the card wins both cards, which are placed at the bottom of the winning player's stack. The game continues until one player has no cards left.

The teacher then gives the following specialized directions for classroom use:

- Each student is given a sheet of cards labeled either A or B (Note: ideally, A and B cards should be evenly distributed among students).
- The values of the cards that students will use for the game will be determined by calculations involving exponential and logarithmic functions and expressions. Students should complete these calculations before cutting the cards.
- Students should check their answers with someone who has the same set (A or B).
- Students should then cut their cards out using scissors.
- Students then play "War" against a classmate with the opposite set of cards, so that the original cards can be returned to the student at the end of the lesson.
- The teacher should set a maximum time limit (approximately 5 minutes) to actually play the game. The time allotted should be minimal due to the fact that playing "War" does not involve critical thinking or calculation.

- The teacher should explain that if students do end up in a situation of war they should flip over the next card and whoever has the highest value wins all four cards. This is the recommended way to resolve situations of war because the student card decks are much smaller than a full deck of 52 cards.

At the conclusion of play, the teacher should remind students that the types of computations they have reviewed (i.e., exponential and logarithmic functions) will be necessary for the analysis of data from China that will be utilized in subsequent lessons.

Conclusion

In concluding the lesson, the teacher should remind students of an upcoming quiz (at the beginning of Lesson #4) on exponential and logarithmic functions. The teacher should also continue to emphasize the importance of skills students have learned in Lesson #2 for the upcoming exploration of China's one-policy, which will begin in Lesson #3.

Homework

In anticipation of this, students are assigned a short reading about China's one-child policy, "How China's One-Child Policy Started in the First Place." They should also answer questions on page 8 in the Student Packet to ensure basic comprehension of the reading. These answers can be referenced in later lessons and when creating the summative project as students begin to analyze the moral aspects of China's one-child policy.

Lesson #3:

Development of the One-Child Policy

Lesson #3 Overview

Subject: Mathematics (Algebra II or higher)

Time Requirement: One 50 minute class period

Resources Required:

- Analyzing the Mathematical Models of China's One-child Policy PowerPoint
- Exploring China's One-child Policy with Exponential and Logarithmic Functions Student Packet
- Exploring China's One-child Policy with Exponential and Logarithmic Functions Teacher Packet
- Government's Role in Population Control Google Form (Note: this resource is not provided; the teacher will need to create a Google form or its equivalent)

Lesson Description: Students put themselves in China during the 1970s and examine the mathematical models being used to project population growth. They develop simple models of their own and study the actual 1979 projections to understand how the one-child policy was developed.

Objectives:

Students will be able to:

- articulate the historical and political concerns that informed China's one-child policy.
- utilize historical data to build an exponential model and predict China's population.
- compare the results of computations with models developed by the Chinese government.

Lesson #3 Summary

Time	*Phase*	*Summary*	*Student Work*	*Teacher Notes*
5-8 minutes	***Introduction***	Teacher reviews homework with students.	◆ Students review homework questions and ask any additional, clarifying questions.	◆ Teacher reviews the article students read for homework and the associated questions. ◆ Teacher answers any additional questions. ◆ Teacher launches lesson.
20 minutes	***Creating Expoential Model of Population Growth***	Students work in small groups to write and apply an exponential model based on Chinese population data from 1978.	◆ Students work in small groups on problems #9-11 in **Student Packet.**	◆ Teacher should circulate during student work time to help students as they work. ◆ Teacher leads a large-group check of content after problems #9-11.
15 minutes	***Analyzing Chinese Models of Population Growth***	Students work in small groups to analyze models used by the Chinese government and compare with their own exponential model.	◆ Students work in small groups on problems #12-13 in **Student Packet.**	◆ Teacher should circulate during student work time to help students as they work. ◆ Teacher leads a large-group check of content after problems #12-13.
5 minutes	***Closure***	Students should answer the following questions in either a Google form or equivalent method: "Based on your learning so far, what do you think some ethical objections to China's one-child policy might be?"	◆ Students answer question about possible objections to China's one-child policy.	◆ Teacher provides a Google form or equivalent means for students to easily answer question about potential objections to population control. ◆ Teacher answers any clarifying questions.
	Homework	Students finish answering the question: "Based on your learning so far, what do you think some ethical objections to China's one-child policy might be?" Students study for upcoming quiz.	◆ Students study for quiz. ◆ If they have not done so, students answer question about ethical objections to population control.	◆ Teacher reviews students' answers to the final class question. ◆ Teacher makes answers readily available for the entire class to review prior to or at the start of Lesson #4.

Lesson #3 Instructional Guide: Procedural Notes

Introduction

The teacher begins Lesson #3 by reviewing homework and asking students if they have any questions from the reading. This first article about China's one-child policy is a short historical piece without much ethical analysis or mention of the moral issues pertaining to China's one-child policy. This will help students not get ahead of themselves in a moral analysis before the teacher is able to lay the groundwork in Lesson #4. The teacher should transition to the math problems for the day by explaining that the Chinese government developed its policies based on mathematical projections of population growth and the fears articulated in Paul Ehrlich's book, *The Population Bomb.* The teacher may choose to use or not use the corresponding PowerPoint during class to display the math problems.

Analyzing the Mathematical Models of China's One-child Policy

For problems #9-11, students are asked to put themselves in the place of China's government in 1979, trying to protect the future of the Chinese population. The teacher may split the class into small groups to work on problems #9-11. Students then work to write and apply an exponential model based on Chinese population data from 1978. For problems #12-13 students will analyze models used by the Chinese government and compare them with their own exponential model.

Creating an Exponential Model of Population Growth: Problems #9-11

For problems #9-11, students use data from 1978. The teacher may even want to ask students what year the data is from and why they think the data is from 1978. Some students may think the data should be from 1979 if they are in the year 1979. This can be a good opportunity to again draw students' attention to the meaning of the numbers being used. If we are currently in the year 1979, then we would not yet have numbers for the population of China in 1979, therefore government officials had to use data from 1978. If officials were to use numbers from the 1960s, while the population numbers would be accurate from those years, the growth rate may have shifted by the late 1970s.

Problems #9-10

In problems #9-10, students use the data provided to build an exponential model and then use that model to estimate China's population in future years. This function can be adjusted and be written in terms of millions or hundreds of millions or otherwise depending on how students want to set it up. This is yet another important opportunity to remind students to keep the context in mind. The difference between 1 billion and 1 million is significant, and simple misrepresentations can result in major errors.

Problem #11

In problem #11, students are asked, according to their model, when would the population of China reach 1.2 billion. Students will use a logarithm to solve the exponential equation.

After the students have had the time to complete problems #9-11, the teacher should bring the class together to review the math problems and discuss the answers.

Analyzing Chinese Models of Population Growth: Problems #12-13

Problems #12-13 should be addressed one at a time so that ample conversation and follow-up can occur immediately after the completion of each problem.

Problem #12

Problem #12 is a graph-reading exercise that utilizes projections that were compiled in the 1970s and presented to Chinese governmental officials. The packet and answer key provide helpful notes about the meaning of the graph and data points (such as the meaning of β). When reviewing part (b) of #12, it is important that the teacher draw students' attention to the comparisons between the estimation based on this graph and the computations using exponential models.

The answer key points out two possible explanations regarding the reason for these differences. A teacher may choose to use this kind of question ("Why do you think there are differences between our computations in #10 and our estimations in #12?") as a follow-up to part (c).

Problem #13

Problem #13 establishes the "need" for a one-child policy; as such, it is a pivotal moment in the unit. This problem sets the stage for a student to come to the conclusion that a ß-value between 1.0 and 1.5 would be necessary to achieve the population goal; with the context of this number (total fertility rate) in mind, students will see the "necessity" for the one-child policy.

Conclusion

To conclude Lesson #3, the teacher should remind students about the upcoming quiz at the beginning of Lesson #4. In order to prepare students to consider the ethical implications of China's one-child policy, the teacher should conclude by inviting students to review their collective input on the question:

Based on your learning so far, what do you think some ethical objections to China's one-child policy might be?

(Note: the teacher will want to display a summary of student answers)

Inviting students to reflect on this question prior to Lesson #4 will provide the teacher insight into student readiness to engage the ethical implications of China's one-child policy, their ability to bring mathematical computation into dialogue with ethical considerations, and make any necessary adjustments to Lesson #4.

Homework

For homework, students review exponential and logarithmic functions and prepare for the quiz at the beginning of Lesson #4.

Lesson #4:

Moral Considerations of the One-Child Policy

Lesson #4 Overview

Subject: Mathematics

Time Requirement: One 50 minute class period

Resources Required:

- "The Dignity of a Human Person: A Catholic Doctrine" by Cardinal Timothy Dolan, *Church Life Journal,* April 4, 2016 (for teacher background; optional)[1]
- Copies of Quiz
- Moral Considerations of China's One-Child Policy PowerPoint
- *Catholic Teaching on Population Control Issues*, section II: "The Teaching of the Church on Population" (pages 3-5) Handout (not provided)[2]
- "The ghost children: In the wake of China's one-child policy, a generation is lost" by Nathan Vanderklippe, *The Globe and Mail,* March 31, 2015 (not provided)[3]
- Exploring China's One-Child Policy with Exponential and Logarithmic Functions Student Packet
- Exploring China's One-Child Policy with Exponential and Logarithmic Functions Teacher Packet

Lesson Description: Students complete a short quiz designed to assess student understanding of logarithmic and exponential functions. After the quiz, Lesson #4 makes a shift in content to allow the students more time to focus on the moral and ethical aspects of China's one-child policy. This day, undoubtedly, will be the most difficult for a teacher, especially one with little experience bringing ethics to bear on the numbers calculated. At the same time, this day will encourage students to grapple with the appropriate role of the government and policy. Students will read excerpts from Church documents about the purpose and role of the government and reflect on what this means in relation to efforts to control population growth. In the summative task, students will be asked to integrate the Catholic Church's understanding of the appropriate role of government in their evaluation of China's one-child policy.

Objectives:

Students will be able to:

- demonstrate understanding of exponential and logarithmic functions.
- articulate the historical circumstances that led to China's one-child policy.
- describe the central ethical issues of China's one-child policy, especially the role of the government and human dignity.

[1] https://churchlifejournal.nd.edu/articles/the-dignity-of-a-human-person-a-catholic-doctrine/
[2] https://www.usccb.org/committees/pro-life-activities/population-control-materials
[3] https://www.theglobeandmail.com/news/world/the-ghost-children-in-the-wake-of-chinas-one-child-policy-a-generation-is-lost/article23454402/

Lesson #4 Summary

Time	*Phase*	*Summary*	*Student Work*	*Teacher Notes*
n/a	***Preparation***		◆ Students study for quiz.	◆ Teacher prepares quiz. ◆ Teacher prepares and reviews **Moral Considerations of China's One-Child Policy PowerPoint.** ◆ Teacher may also want to read the Cardinal Timothy Dolan article, "The Dignity of the Human Person: A Catholic Doctrine" (optional)
5-10 minutes	***Quiz***	Students take quiz.	◆ Students complete short quiz. ◆ After students complete the quiz, they read the excerpt from "Catholic Teaching on Population Control Issues" and answer the corresponding questions on page 16 in the **Student Packet.**	◆ Teacher monitors quiz. ◆ Teacher provides excerpt from "Catholic Teaching on Population Control" for students to read. ◆ Teacher prepares **Moral Considerations of China's One-Child Policy PowerPoint.**
5 minutes	***Introduction***	Teacher transitions from quiz/reading to lesson and shares the general objectives.	◆ Students listen and ask clarifying questions as needed.	◆ Teacher launches **Moral Considerations of China's One-Child Policy PowerPoint.** ◆ Teacher should remind students that up to now, they have been focusing on the mathematical accuracy of China's one-child policy, and that now they are going to explore an equally important set of questions about the ethics and morality of the policy.

Lesson #4 Summary cont.

Time	*Phase*	*Summary*	*Student Work*	*Teacher Notes*
25 minutes	***Presentation of new material***	Teacher guides students through an ethical analysis of China's one-child policy.	◆ Students listen and participate.	◆ Using the lesson PowerPoint, the teacher introduces the information presented in the slide notes and Procedural Notes. ◆ Teacher engages students in structured conversation at various points throughout the presentation. ◆ Teacher solicits questions and provides clarification
5 minutes	***Closure***	Teacher wraps up lesson and asks students to complete a 3-2-1 Exit Ticket.	◆ Students complete a 3-2-1 Exit Ticket indicating 3 new things they learned in the lesson, 2 things they want to know more about, and 1 question they still have about China's one-child policy.	◆ Teacher summarizes the main points of the presentation and explains that during the next class period students will have the opportunity to evaluate the mathematical and ethical considerations of the one-child policy. ◆ Teacher asks students to fill out a 3-2-1 Exit Ticket.
5 minutes	***Homework***	Students will gain a deeper understanding of the social and ethical implications of China's one-child policy by finishing their post-quiz reading and one additional short reading assignment, and completing the corresponding questions in the **Student Packet** (pages 15-16).	◆ Students ask any final clarifying questions. ◆ With any remaining time, students may begin homework.	◆ Teacher launches homework and answers any clarifying questions.

Lesson #4 Instructional Guide: Procedural Notes

Preparation

This lesson begins to address the moral and ethical concerns underlying China's one-child policy. The **Moral Considerations of China's One-Child Policy PowerPoint** slides and teacher corresponding notes should be sufficient for a math teacher to offer a brief lecture on the moral elements of China's one-child policy. The issues raised in this lesson can be complexified and scaffolded to cover more elements, if desired. Additionally, this lesson provides a unique co-teaching opportunity and collaboration with a theology teacher and/or a social studies teacher. A theology teacher should be able to address the moral questions at stake and speak to critical insights from the social teaching of the Church regarding the nature of the human person and the role of the government. If co-teaching with a theology teacher, including material from *Humanae Vitae* would also be appropriate (especially paragraph §§ 1-3, 17, and 23). A social studies teacher should also be able to address the role of the government in supporting the flourishing of its citizens. Even a conversation with colleagues in theology and/or social studies may help in teaching the lesson. Partnering with a teacher from a different subject area also has benefits beyond content coverage. In particular, it allows students to see the integration of different disciplines in action.

It is important to note that there are two different levels of concern when discussing China's one-child policy. First, there is the question of the role of the government and whether a population control policy like the one-child policy accords with the role of the government. Second, there is the issue of basic human dignity and the limitation of governments in creating policies that don't violate the human dignity of its members. It will be helpful for the teacher to review the **Moral Considerations of China's One-Child Policy PowerPoint** prior to the start of the lesson in order to make notes or to consult a colleague. The teacher may also find it helpful to read the short article from Cardinal Dolan, "The Dignity of a Human Person: A Catholic Doctrine" for a concise presentation of the Catholic Church's understanding of human dignity.

It is important for the teacher to recognize that there may be students in the class who are Chinese or have family members living in China. It may be especially troubling for them to hear about practices in China. Or they may have been raised to strongly support China's one-child policy. It is important for the teacher to remember and convey to the students that the Chinese government had legitimate concerns about the welfare of its people. Yet these legitimate concerns can not justify the policies that violated the human dignity of millions of individual citizens.

Quiz

To begin the lesson, students take a short quiz to assess their understanding of exponential and logarithmic functions. The quiz assesses students' abilities to perform computations with exponential and logarithmic functions, which were reviewed in Lessons #1 and #2 and then were applied in Lesson #3. Depending on time and teacher preference, once students have completed the quiz, the teacher may choose to review the questions and answers or move on with the content of the lesson for the day.

Modification:

The topics covered in this lesson are complex. If it is possible to integrate parallel teaching on these topics in theology or government class, that would be ideal, especially for students who are unfamiliar with the ideas, but it is strictly not necessary.

After students turn in their quizzes, they should begin reading the excerpt from "Catholic Teaching on Population Control Issues" and answering the questions in the **Student Packet** on page 16. Due to copyright restrictions we are unable to provide the reading in the packet, so the teacher should print copies of Section II: "The Teaching of the Church on Population" (pages 3-5) and make them available for students when they finish the quiz.

What is Human Dignity?

Some students may disagree with the idea that abortion violates the human dignity of the unborn child. They may have heard that early on "it" is just a clump of cells, or the fetus doesn't have a heartbeat, can't feel pain, etc. For a more detailed explanation of the concept of human dignity, the teacher may consider reading: "What is Human Dignity?" Expert Guide, part of the *Teaching Human Dignity* series. The short explanation below sketches some key points from the Expert Guide that focus on a philosophical understanding of human dignity:

- What is the basis of this fundamental dignity of human beings? Why can't we treat a fellow human being the way we would treat a fly? From a philosophical perspective, human dignity is grounded in the fact that humans are beings with a rational nature. To say that all humans possess a rational nature is to say that all humans, because of the type of creature we are, possess the basic natural capacity for rationality. Because dignity is based on the type of being we are, on our nature as rational beings – rather than on what we can do – it is equal and unchanging for all human beings, even those who might not yet be or may never achieve full rationality.
- Rationality encompasses two, closely related capacities: the capacity for conceptual thought (intellect) and the capacity for free choices (will).
- Only rational beings are agents capable of free actions for which they are morally responsible.
- How do we know that all humans possess a rational nature? What about those human beings who do not manifest their rationality, like embryos or babies, the severely mentally disabled, or those suffering from advanced dementia? Answering this question requires recognizing that the nature of a species is revealed in the capacities of the mature, healthy adult. Like other animals, our capacities unfold over time. Consider the analogy of Polaroid photos. When the photo first comes out of the camera, all you see is a dark black square. Over time, however, the image – which was there all along – begins to reveal itself until it can be seen clearly. The same is true with human beings, whose rational nature is present from the moment when sperm and egg fuse to form a new human life, even though it will take many years for that nature to fully reveal itself. For all human beings, if not prevented from doing so by some external cause such as illness or injury, do begin to manifest rational capacities once they have reached a certain level of maturity. This means that the root capacity for rationality must have been present all along. Otherwise the regular and predictable manifestation of rational capacities in humans at a certain stage of development – but not in cats, dogs, dolphins or any other animals – would be quite mysterious and inexplicable. But there is nothing mysterious about the fact that humans (like other living things) have a determined and predictable nature that unfolds and manifests itself gradually.

Introduction

After all students have completed the quiz, the teacher transitions to the content for the day. The teacher should remind students that they have spent the past several days examining the mathematical models the Chinese government used to develop the one-child policy. But the development and implementation of the policy raises serious ethical and moral questions that are as important to examine as the accuracy of the mathematical computations.

The remainder of the class will be spent exploring these questions. The slide deck and notes are available in the **Moral Considerations of China's One-Child Policy PowerPoint.**

In terms of content, the PowerPoint presentation covers a review of historical events that led up to China's implementation of the one-child policy.

Slide #2 references content students were introduced to when watching "The Population Bomb" video during Lesson #1. In addition to the general fears worldwide of massive starvation and destruction of the planet, China, specifically, had fairly recently experienced a massive famine during which millions of its citizens perished. Given these very real experiences and fears, China implemented the one-child policy in 1979. The teacher may ask students what they remember from their reading homework after Lesson #2 or just remind students of the basic structure of China's one-child policy: The policy stated that families could only have one child. In addition to propaganda, the one-child policy was enforced through economic penalties (fines) and coercion (forced sterilization and forced abortion). The policy was also modified several times. For example, in the mid-1980s, the policy was modified to allow couples in rural areas to have a second child if their first child was a girl.

Once the teacher has given the basic background and context of China's one-child policy, the teacher invites students to think about the possible ethical problems. The teacher should pose the following question to the students: "What might be some objections about China's one-child policy?" This question can be addressed in a number of ways: students can break into pairs for a few minutes to discuss and then report back to the class (Pair and Share) or the teacher could directly solicit student responses. The goal of the discussion is to begin to contextualize the math by activating student interest in the ethical/moral dimensions of the one-child policy.

If the teacher is unsure of a student answer or how to respond, the teacher may choose to thank the student for his/her contribution and ask for another thought, or the teacher may want to ask the student to say more or clarify their point. The level of discussion and contribution will in part depend on the level of comfort of the teacher to engage this material.

After students have had an opportunity to engage the question, the teacher will want to transition to discussing the two main points: (1) appropriate role of the government and (2) human dignity. The teacher may say something like, "As you've noted, China's one-child policy is not simply a matter of mathematical accuracy; it also has ethical implications that range from the proper role of the government to personal freedom to the dignity of human life. These are not mathematical questions, but they do relate directly to how a government ought to use such data. We might pose the question this way: 'Can a government use whatever means necessary to achieve a desired goal, even if that means violating human dignity?' These kinds of questions are philosophical questions about the meaning and value of human life, so it's not surprising that the Catholic Church has wisdom to offer to the conversation."

The teacher should display the quote on slide #7 for the students to read. The teacher should give students a moment to process the quote and jot down some notes. The same quote and questions can be found on page 12. Once students have had time to jot down some notes, the teacher can either ask them to share aloud or to share in pairs and then with the whole class. As students share their answers to the questions, the teacher should encourage the students to refer to the quote to support their answer, rather than just thinking abstractly about the question based on their personal opinions.

At this point in the discussion, the teacher may guide students to articulate that governments have a positive role to play in society and elaborate the following responsibilities that flow from this role:

Governments have a responsibility to:

1 **Serve the common good (the flourishing of all people!)**

a. Protect basic rights such as access to education, food, water, housing, healthcare, freedom of religion, dignified work, a living wage, etc.

b. Governments cannot promote the good of most individuals by sacrificing the good of others.

2 **Care for the poor and vulnerable.**

3 **Overcome structures of injustice.**

a. Governments have the responsibility to protect people from injustices, discrimination, and abuse of powers.

4 **Ensure equal opportunity for human flourishing.**

a. The government has a responsibility to address problems that cannot be addressed by individuals or communities. Notice that this means the government does not control everything, but it does have the important role of maintaining the conditions for all human beings to flourish.

5 **Protect human life and defend human dignity of all.**

How a government fulfills its responsibilities may vary depending on the time period, the place, the culture, etc., but all governments have the responsibility (i.e., duty) to promote human life, defend human dignity, and ensure necessary conditions for all human beings to flourish. Although human dignity is only named in the fifth point, all of these responsibilities are based on the inherent dignity of the human person.

The teacher may even go so far as to ask students if they think the Chinese government was attempting to fulfill these responsibilities when it constructed the one-child policy. Although students will have the opportunity to think through these points again in their final assessment, it would not hurt to begin to help them make connections between China's one-child policy and these positive roles as detailed in the provided quote.

Once the class has the opportunity to discuss the role of the government, the teacher should transition to the concept of human dignity. The teacher may say something like: "We recognize that governments have a duty to protect and defend human dignity, but we have probably heard many different ideas about what human dignity is, so let's clarify exactly what we mean by using the phrase human dignity and how it relates to China's one-child policy."

The teacher should display the quote from the Catechism on slide #9 for the students to read. Students should have a few moments in silence to process the quote and jot down their notes to the bulleted questions on the slide. The same quote and questions can be found on page 13.

Once students have had time to jot down some notes, the teacher can either ask them to share aloud or share in pairs first and then with the whole class. As students share their answers to the questions, the teacher should encourage the students to refer to the quote to support their answer, rather than just thinking abstractly about the question based on their personal opinions.

How does this quote describe human beings?

There are many different points students may raise from reading the text. All of these points speak to the uniqueness of human persons. Students may offer the following responses:

- This quote starts off saying that "man" (which, in this context, refers to all human beings) is called to share in God's life. This sharing in God's life is a sharing in the knowledge of God and a sharing of love between God and the human person.
- The quote says that the human person is created in the image of God. We believe that God is a communion of persons, Father, Son, and Holy Spirit. This is what we mean when we say we believe in the Trinity. As human persons created in the image of God, we are created to be in loving communion with one another and with God.

- The human person is capable of self-knowledge, of knowing himself or herself. Humans can reflect on their actions, feelings, motivations, choices, etc. Given this unique ability to reflect on and know oneself, the human person is able to freely enter into relationships with other persons.

As the students start to name what it means to be a human person, the teacher may lead to the third question, which asks what it means to be a human person as compared rather than a rock, a book, a pencil, etc. (i.e., someone rather than something).

What does it mean to be a someone rather than a something?

The teacher will want to guide students to the conclusion that human beings, no matter who they are, are never simply objects that can be used or disposed of – they are not things (like the chair students are sitting or the desk they're working on). They are distinct from mere objects and can never be used or disposed of in order to achieve a certain outcome.

The final question asks students:

With whom are we called to be in relationship and what does this quote imply about what our relationships should look like?

The quote specifically names God and others. The teacher might ask students to offer suggestions about types of relationships they have (siblings, parents, friends, etc.). The quote doesn't explicitly say what our relationships should look like. This gives students the opportunity to think critically about what is implied in the text. The teacher will want to lead students to recognize the following features of human relationships: love, self-gift, commitment, communion, respect, honor, and care, etc.

Human Dignity

The teacher should read aloud or have students read aloud the quote from Cardinal Timothy Dolan about human dignity.

After giving students a few moments to internally process the quote and then the teacher may ask the students a few prompting questions to help unpack the quote:

How does this quote describe human beings?

- "temples of the Holy Spirit"
- "vessels of the Divine"
- "Icons of the Trinity"
- "Reflections of God"
- "Created in the image and likeness of God"

The teacher will sum up these basic points: When we say human beings have dignity, we mean that each person has unique value or worth simply because he/she is a member of the human race. Each human being is created in the image of God to share in God's own life.

The teacher may also want to solicit students' insights about the following open-ended question:

How would we treat people if we really believed this?

Finally, if time permits, the teacher can display the final quote from *Gaudium et Spes (Joy and Hope): Pastoral Constitution on the Church in the Modern World* found on slide #11, and share that because each human being has dignity, they cannot be treated in ways that violate their dignity. There are no accompanying questions for this quote. The teacher may wish only to display the quote for students to read or ask students about their reactions to this quote. This will depend on the discussion up to this point and the amount of class time that is left for the day.

The teacher will want to conclude by tying the class discussion back to the question of China's one-child policy. It is important to emphasize the reality of human dignity and the positive role of the government and how these impact how governments can and cannot treat their citizens. The reality of human dignity means that governments cannot support, let alone mandate and coerce, abortion.

One good analogy to help students think about human dignity is to consider a twenty dollar bill. The teacher can ask the students, if the teacher were to go to the bank and take out a brand new crisp twenty dollar bill, who in the class would want it. All of the students should raise their hands. Then the teacher can ask, what if the twenty dollar bill was crumpled in a ball, who would want it? All of the students should raise their hands. What if the twenty dollar bill was dropped in a puddle of mud? What if the twenty dollar bill was cut in half and then taped back together? In each instance, all of the students would still want the twenty dollar bill because regardless of how it appears on the outside, it has the same worth. (Now eventually the analogy can break down, say for example, if the twenty dollar bill was burned or ripped into a hundred tiny pieces that couldn't be taped back together.) In the same way, one can begin to understand human dignity. Each and every human person, no matter the age, sex, race, disability, etc. has the same inherent worth.

Closure

The teacher concludes the lesson by explaining that apart from the moral and ethical issues of China's one-child policy, there were also unintended consequences (see slide #12). Today, China has too few younger people to support its aging population. Given the cultural preference for males, the country also suffers from severe gender imbalance. There is also a large population of undocumented children (i.e., those born illegally under the one-child policy). For homework, students will read more about some of the unintended consequences of China's one-child policy. The teacher may encourage students to consider the points discussed in class and how they relate to the article they will be reading for homework.

Finally, the teacher should ask students to complete a 3-2-1 Exit Ticket, listing 3 new things they learned in the lesson, 2 things they would like to know more about, and 1 question they still have about the ethics of China's one-child policy.

Homework

Students complete the short reading from "Catholic Teaching on Population Control" and "The Ghost Children of China" and answer the associated questions in the **Student Packet** (pages 15-16). These readings are not included in the **Student Packet** and will need to be provided by the teacher.

Lesson #5:

Evaluating the One-Child Policy

Lesson #5 Overview

Subject: Mathematics

Time Requirement: One 50 minute class period

Resources Required:

- Exploring China's One-Child Policy with Exponential and Logarithmic Functions Student Packet
- Exploring China's One-Child Policy with Exponential and Logarithmic Functions Teacher Packet
- Evaluating the One-Child Policy PowerPoint

Lesson Description: In this class, students evaluate the one-child policy through a variety of methods, including mathematical and moral. This class period will culminate in the writing of a paragraph that analyzes the one-child policy from a moral standpoint. (This paragraph may need to be assigned as homework.) Students will also be assigned their summative assessment project.

Objectives:

Students will be able to:

- Assess China's one-child policy through multiple lenses, including mathematical modeling, ethical reasoning, and social consequences.

Lesson #5 Summary

Time	*Phase*	*Summary*	*Student Work*	*Teacher Notes*
5 minutes	***Return Quiz***	Teacher will pass back graded quizzes and will review the correct answers and any common mistakes.	◆ Students review their quizzes and ask any clarifying questions.	◆ Teacher returns quizzes to students. ◆ Teacher answers any questions the students may have about problems they got wrong. The teacher may also review any problems that were particularly difficult for students.
15 minutes	***Analyzing the Mathematics***	Students work in small groups to evaluate the one-child policy from a mathematical perspective.	◆ Students solve problems #14 - #17 in the **Student Packet.** They may do this individually or in groups.	◆ Teacher should ensure students are on track and able to successfully answer the problems.
15 minutes	***Debriefing Homework/Class Discussion***	Using the questions from the Student Packet, students discuss their insights from the readings that they completed for homework.	◆ Students may initially debrief their insights from the homework assignment in pairs or small groups. ◆ Students share their insights with the class.	◆ Teacher may choose to have students do an initial discussion round in pairs or small groups. ◆ Teacher guides students through a class discussion of central ideas from the homework readings.
10 minutes	***Synthesizing Paragraph***	Students will bring together the readings and discussions along with the class lecture from Lesson #4 to analyze China's one-child policy from a moral perspective.	◆ Students work individually to write a paragraph analyzing China's one-child policy from a moral perspective.	◆ The teacher should be available to answer questions or clarify points if students need assistance while writing.
5 minutes	***Summative Assessment*** *(potentially assigned the following day)*	The summative task that combines both the historical facts, mathematical analysis, and moral analysis of China's one-child policy is assigned.	◆ Students will work to complete the summative assessment, most likely outside of class time.	◆ The teacher should introduce the summative task, to be due at a later date.

Lesson #5 Instructional Guide: Procedural Notes

Introduction

During this lesson, students will have the opportunity to continue evaluating (both mathematically and morally) China's one-child policy along with the time and space to begin synthesizing the material from the unit for their summative assessment.

Return Quiz / Analyzing the Mathematics

The teacher should begin the lesson by returning the quiz from the previous day and giving students the opportunity to ask any clarifying questions. The teacher can then turn to the mathematical questions in the **Student Packet** on pages 17-18. These questions will lead students through a numbers analysis of China's one-child policy. Students may work in small groups or with a partner at this point.

Problem #14

Problem #14 reminds students that one of the original goals of the scientists in their data analysis from the 1970s was to keep China's population below 1.2 billion. As history revealed, China did not meet this goal. The table in the **Student Packet** shows China's population along with other statistics from the 1990s. Problem #14 is a simple question asking students to read the table and to note and what year the Chinese population actually reached 1.2 billion, which is sometime during 1994 because by 1995 the population was over 1.2 billion.

Problem #15

The next two questions are both based on the next table which essentially gives the population growth rate on a year-by-year basis. Notice the negative growth rate for the nation in 1961. This may be a good time to remind students about the great Chinese famine which caused a significant drop in the population. This table can be used to help students reflect on what they noticed in #14 and earlier in the week. In #9-11 in the **Student Packet**, students were asked to create an exponential model for China's population.

Based on the work they did in #11, students should have found that by 1995, according to their simple exponential model, the population hit 1.2 billion. In reality this actually occurred in 1994, so their rough exponential model was actually pretty accurate. As a follow-up question to this, students are asked – what does this tell you about the average population growth rate between 1978 and the year in which the population reached 1.2 billion?

Students should be able to recognize that the average growth rate didn't really change from 1978 to 1994 or in other words that the average population birth rate between 1978 and 1994 was the same. The fact that the population growth rate was still basically the same for roughly the next 15 years seems to imply that even with the one-child policy the population growth rate remained relatively consistent.

Problem #16

Problem #16 asks students to think about what might be coming in the future. It has students construct a linear model of the population growth rate over time. Students can use the line of best fit using Excel, Desmos, graphing calculator, etc., from 1960 to 2018 to predict when China's growth rate will be 0%. Students may struggle with the linear modeling. The Desmos resources are very helpful and will guide them through the process. It may also be useful to provide students with an electronic version of this data set so that it can easily be copied and pasted.

Problem #17

Problem #17 is a little bit more open. It is not a simple calculation or reading but rather encourages the students to think a little bit more. The table provided has a variety of different data points for students to consider. This question provides a good hinge point for the teacher to bring the students' awareness back to the fact that numbers in this context are not just data points empty of meaning but actually stand for real human lives.

It is important to bring back this thread for students–that they need to consider the meaning of the numbers, what the numbers represent. It's important to humanize the numbers and not just look at things as a simple calculation.

Debriefing Homework/Class Discussion

Regardless of the policy's mathematical/economic success it is necessary to remember that the numbers represent families. A class discussion could occur at this point about viewing the world through mathematics and a data-ONLY perspective. It is important not to minimize the real good and value of math and science in these discussions or to give students the sense that math/science are problematic. They become morally suspect when they are divorced from the full context from which they are derived. When the mathematician looks at a problem and no longer remembers what the numbers are for and the implications of her calculations then problems can arise. These concepts are important for students to be able to wrestle with as they prepare to complete the final assessment.

The teacher now shifts focus so that students can have the time and space to process their reading homework **(pgs. 15-16 in Student Packet)** which includes both reading about China's one-child policy and the Catholic Church's teaching on population control. Given that the content of the reading was probably new for most students in the classroom, it is probably best to consider having students pair off and discuss their reactions to the article.

> While it is likely that many or most students have generally heard about China's one-child policy, it is possible that students will have learned new information, some of it potentially difficult, from the homework reading. A partner discussion will allow everyone the opportunity to share with another person. The teacher can walk around during this time to monitor the students' discussion.

The teacher should be aware of students with insights or helpful reactions that would be good to share with the whole class. Depending on how long the paired conversations continue, the teacher may or may not ask for a few students to share their thoughts or reactions with the whole class.

Catholic Church's Teaching

It is helpful for the teacher to be aware of a few common areas of misconceptions and confusion that may arise from the homework or during the course of conversation.

- Responsible Parenthood: The Catholic Church teaches that couples are called to actively discern each month whether or not to try and conceive a child. This discernment should consider the emotional, social, financial, and spiritual well-being of the entire family. If the couple discerns that it is not in the best interest of the family to conceive then the couple are encouraged to abstain from sexual intercourse during the woman's fertile days.
- Natural Family Planning: The Catholic Church encourages the use of natural family planning methods for couples to understand the cycle of the woman and be able to recognize the days of fertility. There are various different methods, including the Creighton Model, the Marquette Method, and the Billings Method. These are scientifically grounded with high rates of success, and are not comparable to the rhythm method which was used in the past.
- Role of Women: The Catholic Church does not teach that women are only to remain at home raising children. The Church does recognize that, biologically, women are more likely (not always) predisposed to nurturing children. Women should not be forced by society's structure to work outside the home but rather should have the freedom to choose to work or stay at home or some combination of the two.

Synthesizing Paragraph

Once students have had the opportunity to debrief the homework articles, students can turn to completing the synthesizing paragraph (pg. 19 in the **Student Packet**). In writing this paragraph, students are able to start integrating various facets of the moral and social dimension of China's one-child policy, including the role of the government, the meaning of human dignity, the use of force and coercion, the Church's understanding of population control, etc. Students can start this in class but will probably need to finish it for homework. This synthesizing task will help set the necessary foundation for the summative assessment.

Summative Assessment

It is recommended that the teacher wait until the following day to hand out the summative assessment assignment to the students. This will give students more time to process and think through their own moral and mathematical analysis of China's one-child policy before focusing on the final assessment. The grading rubric for the summative assessment can be found on page 21 in the **Student Packet**.

Closure (optional)

As a final closure to the material, the teacher may consider allowing the students an opportunity to present their summative assessment either to the class or to other students in the school. Students may also reflect on their new understanding of the themes covered in the unit and their enhanced appreciation of the relationship between mathematical modeling and other forms of knowledge, a thread that can be carried forward for the rest of the year.

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