A Latent Element of Alice's Agency in Wonderland: Conservative Victorian Mathematics

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Overview and Dodgson as a Mathematician

This thesis[1] will include an examination of the underlying mathematical concepts in Charles Dodgson's (Lewis Carroll's) 1865 novel *Alice's Adventures in Wonderland* and how they contribute to a feminist understanding of Alice's character in the context of the Victorian Era. This thesis will further address Alice's status as a woman/child and how it is a dynamic force throughout the novel. Because Alice's exact age is not given, historical and feminist theoretical lenses will be used to help define what women and children were during this period.

When *Alice's Adventures in Wonderland* was published, Charles Dodgson was an instructor of mathematics at Christ Church College, Oxford. As a mathematician, Dodgson had rather conservative beliefs about mathematics, -- adhering to the notion that Euclidean geometry, and its derivatives, were the only type of mathematics worth exploring. In fact, Dodgson not only rewrote books of Euclid's *Elements* to be more accessible to a wider audience, but he was so familiar with Euclidean geometry that he could "actually see the figures [from it] before him in the dark" (Beale 297). Because Victorian mathematics involved the advancement, acceptance, and formalization of many concepts that could easily be mistaken as nonsensical by the mathematically conservative, it is no surprise that Dodgson chose to satirize them in his novel (Pycior 163).

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[1] This writing sample is a condensed version of my senior literary studies thesis.

In the novel, Alice navigates Wonderland as a Euclidean geometer. Because Alice is well equipped with a Euclidean geometrical background similar to that of Dodgson, she is able to work through the mathematical challenges presented to her by approaching them conservatively. Despite Dodgson's traditional approach to mathematics, his approach to feminism was not. Because Alice is able to internalize appropriate mathematical concepts that align with Dodgson's conservative views, masculinist forces are unable victimize her (Kincaid 65) – resulting in her agency in Wonderland.

The Victorian Woman and the Victorian Child

As a result of the social innovations occurring in Victorian England, Alice's status as a child or woman fluctuates throughout the novel – giving Alice's agency in Wonderland fluctuating levels of significance. One of the most important social innovations was the attempt to mark a distinction between childhood and adulthood. Before the seventeenth century, there was no schema of a child; this schema "flowered" in the nineteenth century (Kincaid 61). Though conceptualization of children underwent several important changes in the Victorian Era, it was still contested, so a consistent definition of the Victorian child did not exist.

For instance in Victorian England, people under the age of seven were not considered capable of committing a felony; people between the ages of seven and fourteen were generally not considered capable of committing a felony, but it could be contested; and after fourteen, people could be convicted of felonies (Kincaid 68). Analogous laws existed in regards to employment (Kincaid 68). Because there were inconsistencies in the Victorian law regarding people between the ages of seven and

fourteen, people in this age cohort fall into a liminal space; they could be considered adults or children – it just depended on the scenario at hand.

Although Alice is not given a definitive age in *Alice's Adventures in Wonderland*, it is clear that she falls into this liminal space, so it is necessary to address the role of both women and children in the Victorian period. This way, she can be analyzed on a point-wise basis throughout the novel to get a better understanding of how significant her agency is at different points in her journey through Wonderland.

The Victorian Child

Despite the developing concept of the Victorian child, it is important to understand the reasons behind its delayed development. During the Industrial Revolution, the child mortality rate was high as a result of malnutrition, hazardous working conditions, and disease (Rogers 42). Because of this high mortality rate, it was difficult for parents to develop a deep connection with their children (Rogers 42). Following the Industrial Revolution, the Pre-Raphael Revolt served as the "wake-up call" to define childhood, the child became idealized, and was allowed to act as a child (Rogers 42).

The Victorian Woman

A term closely associated with the conservative middle and upper class Victorian woman is "angel in the house." To make this idea more precise, it is important to place this belief in its historical context. The origin of the traditional Victorian roles for men and women was heavily based on the ideas presented in Coventry Patmore 's 1851 poem "Angel in the House." In "Angel in the House," Patmore argues that "[the] [m]an must be pleased; but him to please / Is woman's pleasure; down the gulf" (303-304) and the wife

must be "[d]early devoted to his arms; / She loves with a love that cannot tire;" (321-322). The poem further elaborates on the socially conservative's ideal woman.

Victorian social critic John Ruskin adds to this definition in his 1856 essay "Of Queen's Gardens" where he explicates more traditionalist expectations and views toward the middle and upper class Victorian woman. Conservative middle and upper class women were not expected to "guide, nor even think for [themselves]." (Ruskin 26). It was also believed that because "the home is always around the wife, . . . it's best that she is physically in the home" (Ruskin 68). By placing the woman in the home, it was believed that "she is protected from all danger and temptation," she could have children, and care for her family (Ruskin 68).

Not only did conservative Victorians expect the middle and upper class woman to be the "angel in the house" and not be capable of thinking for herself, but also "it was widely recognized that the mother was the 'pivot' of the household, on whom the comfort and integrity of the family depended." (Lewis 5-6). She would want to be this way because "achieving such domestic qualities as modesty, frugality, and purity were seemingly attainable to any woman regardless of religion, wealth, or status" (Armstrong 3-4).

While it was tradition for women to be placed in the home and many conservative Victorians argued that the status quo regarding women's rights was acceptable, Victorian women also gained several rights (Youngkin 1). In 1847, the *Factory Act* gave females between the ages of thirteen and eighteen the right to work ten hours a day. Also, in 1857, the *Matrimonial Causes Act* gave women the right to repossess their property after becoming legally separated, and Elizabeth Garrett Anderson became first female doctor

in 1865 (Youngkin 1). Although women were traditionally placed in the home, these gains toward social equality were an important step.

Because these political changes regarding the status of women were beginning to take place around the time of *Alice's Adventures in Wonderland*'s publication, it is unsurprising that Alice, as a woman,[2] remains unvicitimized by the masculinist forces of Wonderland. Although some women embraced these changes, many middle and upper class women chose to continue fulfilling their role as the "angel in the house," because it signified their social status. By remaining in the home, a desirable image of themselves and their family in Victorian society was maintained.

Since some Victorian women were leaving the home and the traditional roles that conservatives placed upon them, success in the workforce and/or academia is especially commendable. Because Alice is able to demonstrate that she is one of these progressive women who acquires an education that is as strong as a typical Victorian male college student's[3], her journey and agency in Wonderland are quite remarkable when considering the nature problems she encounters as an adult.

The Mushroom, the Caterpillar, and Euclidean Geometry

One of the most hotly debated scenes within the feminist body of research is Alice's encounter with the Caterpillar. According to feminist critic Carina Garland, Alice is given vague instructions regarding the proper use of the mushroom, which is "another way for the male author to control her" (32). However, fellow feminist critics Nina Auerbach and Judith Little contend that "[a]lthough her size changes seem arbitrary and

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[3] For an outline of the Victorian college math curriculum, see *Mathematics in Victorian Britain*.

terrifying, she in fact directs them," (Auerbach 35) and Alice controls her own destiny. By examining these arguments, it is blatant that there is not a clear consensus among feminist scholars as to whether Alice can be read as strong and heroic or not.

However, when taking Dodgson's mathematical background into consideration and examining the mathematical connotations presented here, this scene can be better understood. The Euclidean geometry of Dodgson's background is based on, but not limited to, the following definitions and postulates:

> Definitions
> 1. A point is that which has no part.
> 2. A line is breadthless length.
>
> Postulates
> 1. A straight line can be drawn from any point to any other point.
> 2. A finite straight line can be produced continuously in a line.
> 3. A circle may be described with any center and distance.
> 4. All right angles are equal to one another.
> 5. If a straight line falling on two straight lines makes the interior angles on the same side less than two right angles, then the two straight lines, if produced indefinitely meet on that side on which there are angles less than two right angles. (Burton 139-140).

Although Euclidean geometry is axiomatic, it was critiqued for being based on vague definitions (Burton 141). This usage of vague language in Euclidean geometry is paralleled in the Mushroom and the Caterpillar scene.

As mentioned previously, it has been argued that Caterpillar's vague language is a method of asserting masculine dominance over Alice (Garland 32). Particularly, in Garland's analysis, two critical points are overlooked. Garland overlooks the fact that Alice uses vague language before the Caterpillar does when she asserts that she "should like to be a *little* larger" (Dodgson 53). "A *little* larger" has unclear social and literal connotations. Analogously, in Euclidean geometry, the definition of a line is vague because it is not precisely defined. Intuitively in terms of Euclidean geometry, a

breadthless length is the thinnest length that can be drawn with a pencil and a straight edge. Alice asking to be a "*little* larger" has a similar effect. She is not specifying a height because of her good social etiquette, but it is understood what she means by wanting to be "a *little* larger," and similarly to the definition of a line in Euclidean geometry, this vagueness does not interfere with Alice and the Caterpillar's mutual understanding of each other.

Historically, Euclid's axiomatic approach has not only been critiqued for being vague, but others have attempted to improve upon it by giving precise definitions. As a result, modern Euclidean geometry has become much more rigorous. Many of Euclid's actual "proofs" relied on assumptions appearing in his diagrams, and several mathematicians have rigorously proved that his assumptions actually hold. Similarly, Alice is assuming that the Caterpillar can fill in the gaps to deduce a coherent understanding of what she means by becoming "a *little* larger." By using this vague language, she exhibits agency in Wonderland because she is able to effectively communicate with the Caterpillar. In a similar fashion to Euclid, she knows that her language will convey its intended message and instead focuses on her more important goal of arriving at the garden.

Another point Garland overlooks is the Caterpillar's comment to Alice regarding her temper. At first glance, it appears as though the Caterpillar is appealing to Alice's emotional status by telling her to "keep [her] temper" (Dodgson 49). However, Dodgson is famous for his use of the double entendre, and upon a closer examination of the mathematical properties of the term temper, this scene is more telling (Gardner 2). "In Dodgson's day, intellectuals still understood 'temper' to mean the proportions in which

qualities were mixed," and the concept of proportions is critical to Euclidean geometry[4] (Bayley 3; Devlin 3). When considering this definition alongside the modern definition of temper and Alice's frustration in this scene, it is apparent that the Caterpillar's advice is more valuable than it appears on a surface level. The Caterpillar's advice here is twofold; not only is he trying to remind her that becoming overly emotional will prevent her successful journey through Wonderland, but he is also educating her on proportions. The conciseness of his lesson enable Alice to not only get a lesson in a topic that is critical to her successful journey through Wonderland, but she is also able to do so in a manner that does not slow her progression. Though Garland indicates that the Caterpillar attempts to control Alice, when considering the mathematical connotation in conjunction with a modern interpretation of this scene, it becomes clear that the Caterpillar attempts to help Alice control her surroundings in Wonderland.

Following the Caterpillar's instructions, Alice proves herself as a Euclidean geometer when she begins her experimentation with the mushroom. At first, Alice does not succeed in getting her proportions correct because "her chin: it had struck her foot," and her neck becomes long like a "serpent's" (Dodgson 54). Because the mushroom controls her bodily proportions, it is acting as a transformation within the Euclidean geometrical plane. However, it is not acting in a way in which she is accustomed.

In terms of Euclidean-plane geometry, Alice is undergoing both uniform and non-uniform (similarity) transformations when she eats the mushroom.[5] When Alice eats a disproportionate amount of the mushroom, her neck becomes long like a "serpent's,"

[4] A proportion in terms of the Euclidean geometry discussed here refers to Euclid's study of commensurable numbers.

(Dodgson 54) and she undergoes a non-uniform scaling. That is, her body is no longer in proportion because not every part of her body is being stretched or compressed by the same factor. On the other hand, when she eats the correct portion of the mushroom, she undergoes a uniform scaling. Since the other food items resulted in a uniformly scaled version of Alice, she is expecting the mushroom to behave analogously. However, the mushroom only does so when equal proportions from each side of the mushroom are taken, so Alice must experiment to find the correct proportions. This is crucial because it demonstrates that Alice is working as a mathematician. Proportionality is something that she only has a superficial understanding of when she enters Wonderland, but she has enough experience in Euclidean geometry to deduce from her previous encounters with food that the mushroom does work, as she would expect in the Euclidean plane. In order to use it correctly,[6] she employs the method of exhaustion (trial and error), which has aided in making many mathematical discoveries from antiquity. Understanding and utilizing this concept gives Alice agency in Wonderland because she gains confidence in her ability to overcome mathematical challenges.

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[8] Another question that comes to mind is why Dodgson would want Alice to find just one factor in which she is scaled, since non-uniform scaling transformations are still acceptable in Euclidean geometry. One of Dodgson's few non-recreational mathematical papers published was on condensation. Condensation is a method of finding the determinant of larger matrices. Determinants are scalars that give information regarding the size of a matrix (Lay 183). Because Alice is able to discover the correct scaling factor, she is clearly working exclusively within Dodgson's realm of mathematics. Once she does understand how to make the scaling transformation uniform, she is able to restore herself to her normal height.

Pig, Pepper, and Projective Geometry

Chapter VI: Pig and Pepper is an example of a scene about which little debate exists within feminist body of scholarly research. Most feminist critics argue that this scene demonstrates Alice's agency in Wonderland, because she rejects the traditional role of Victorian motherhood.[7] When considering the mathematical significance of this scene, a similar reading of Alice's agency in Wonderland can be deduced. In this scene, Alice is once again faced with a mathematical challenge. However, there are a couple of significant differences in comparison to the mathematics presented in the Mushroom and Caterpillar scene. In this scene, Alice's mathematical endeavors are no longer Euclidean, and now she can be considered a woman, rather than a child, as a result of the duties that she is expected to fulfill.

Several feminist scholars have noted Alice's agency in this scene, because she rejects her role of traditional Victorian motherhood. Because the Duchess "flings the baby at Alice," motherhood is quickly thrust upon her, and she immediately begins her role as a Victorian woman. However, according to Judith Little, after the Duchess flings the baby at Alice, she "is at first quite willing to rescue it. Once in her arms, however, the baby turns into a pig, and Alice loses no sentiment over the transformation," and this "experience with the baby leads her to the unmotherly speculation that some children would really be better off as pigs" (Little 197; 199). This demonstrates Alice's immediate rejection of herself as the ideal conservative middle or upper class Victorian woman.

As Dodgson describes Chapter VI: Pig and Pepper, it is clear that the child transforms into a pig rather slowly, but it is questionable why it is possible for a baby to

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[7] The concept of Victorian motherhood is further explicated in my senior thesis.

transform into a pig and its significance to the novel. According to mathematical scholars Melanie Bayley and Keith Devlin, "Pig and Pepper parodies the principle of continuity, a bizarre concept from projective geometry, which was introduced in the mid-nineteenth century in France. This principle involves the idea that one shape can bend and stretch into another, provided that it retains the same basic properties" (3;41).

In order to better understand Bayley and Devlin's arguments regarding Dodgson's choice to parody this idea, it is necessary to note the differences between Euclidean geometry and projective geometry. Projective geometry can be considered a type of non-Euclidean geometry, because it satisfies the first four of Euclid's postulates, but the fifth postulate is replaced with the Projective Axiom (Burton 531; University of Toronto). The Projective Axiom states, "[a]ny two lines intersect[8] (in exactly one point), " which contradicts the notion of parallelism. (University of Toronto).

The main concept from projective geometry that Dodgson parodies in Chapter VI: Pig and Pepper is credited to Jean-Victor Poncelet. His theorem states, "[l]et a figure be conceived to undergo a certain continuous variation, and let some general property concerning it be granted as true, so long as the variation is confined within certain limits; then the same property will belong to all the successive states of the figure" (Devlin 3). Dodgson takes this notion to an extreme when parodying it by slowly transforming the baby into a pig. This is an extreme because a baby does not have enough of the same features to transform into a pig feasibly through Poncelet's theorem. A baby is missing the correct skin type, bone structure, and pigmentation, which indicate that the successive states of the transformation lack these same basic properties. In considering whether or

[8] Depending on how Euclid's other axioms are worded, this definition is subject to change (University of Toronto).

not two figures are topologically equivalent, their surfaces cannot change this significantly. For instance, a circle and a square are considered topologically equivalent, because the same line in a circle can be stretched to make a square, and the basic properties are all preserved.[9] The baby and the pig do not have the same basic properties nor are they geometric figures in a two-dimensional plane, so the transformation is an extreme compared to the way in which Poncelet intended for it to be understood. It may be questioned why Dodgson would make such an unconventional and seemingly unfair parody. These concepts were considered the cutting edge of Victorian mathematics, so in order to be comprehensible enough for a general audience to understand his frustration with his perceived absurdities of this theorem; the parody must be this extreme.

Because Alice "felt it would be quite absurd to carry it [the baby who transformed into a pig] any further," (Dodgson 62) she is rejecting this new practice in geometry and remains a strict Euclidean geometer. By rejecting the results of projective geometry, she attains agency in Wonderland because the absurdities deduced by the newer mathematical concepts are not prostrating her. Since she is not disconcerted about not understanding why the baby transformed into a pig, she is able to continue through Wonderland, which makes her a stronger mathematician in this moment as a woman than she was in the previous scene as a child. In this scene she not only proves that she is capable of learning Euclidean geometry, but she is able to apply her knowledge of Euclidean geometry to discern between which mathematical concepts are feasible versus which are absurd.

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[9] In fact, Dodgson critiqued the idea of squaring a circle (or equating a circle to a square) in a pamphlet called "Plain Facts for the Circle-Squarers" (Coveney 312).

Because the concepts from projective geometry are radical and Alice has a strict Euclidean geometrical background, projective geometry is a situation where Dodgson would not want to encourage Alice to think much about it beyond dismissing it. In earlier scenes, such as the Mushroom and the Caterpillar, Alice is able to understand geometrical concepts, mentioned in Euclid's *Elements*, so it is clear that she is not incompetent and understands as much as a typical Victorian college junior or senior math student, despite being a woman. By rejecting the transformed child, she is not only rejecting motherhood, but she is also rejecting the obscure mathematical practices of the time period, which demonstrates the potency of her agency in Wonderland.

The Mad Tea Party and Quaternions

Another radical concept from Victorian mathematics that Alice disregards and Dodgson chooses to satirize is quaternions. Quaternions were considered groundbreaking in their applications to electricity, magnetism,[10] and the algebraic representation of rotations in three and four dimensions (Gallian 524; Rice 5). However, they were also controversial.

Quaternion multiplication is not commutative, and they were the first "consistent algebra system to break [this] inviolable la[w] of arithmetic" (Rice 5). Not only is non-commutativity radical, but quaternions also contain three imaginary (or complex) parts. In the Victorian Era, "there was growing acceptance -- or at least use -- of 'imaginary numbers,'" and Dodgson saw using these concepts to discuss the world from a mathematical standpoint as lacking rigor, since he believed that everything could be attributed to concepts from Euclidean geometry (Bayley 38, Devlin 4).

[10] Maxwell's equations were first stated in terms of quaternions (Rice 5).

Dodgson satirizes quaternions in The Mad Tea Party scene. Because "the Hatter, the Hare, and the Dormouse are stuck going round and round the tea table . . . [they] are forced to rotate forever[11] in a plane around [this] table," which is similar to Hamilton's use of quaternions (Bayley 40-41). Historically, Hamilton attempted to use the quaternions to model motion and rotational phenomena in physics. However, when he only had three imaginary parts they just moved in circles and were ineffective. It was only after he added the real term, which represented time, that the quaternions properly modeled rotational motion phenomena (Devlin 3).

In this scene, Alice is continually questioning what is happening and why, which shows her curiosity. However, she is doing so in an important way. Though she is questioning the occurrences of the Mad Tea Party, she is doing so in a mathematically conservative and dismissive manner. "Alice's prudence and desire for order are blasted again and again, but here . . . she is [un]educable and she disrupts the comic joy with her linear perspective of finality" (Kincaid 97). Similarly to the Pig and Pepper scene, Dodgson would not encourage Alice to be educable here due to his conservative mathematical background.

In the Euclidean geometry in which Alice is accustomed, multiplication is commutative, so it seems nonsensical that it would not be so in another consistent algebraic system.[12] Because this concept is absurd in the Euclidean sense, Alice intentionally disregards it. Alice's disregard of the quaternions, which are nonsense and

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[11] This is assuming that wind resistance, friction, and other forces are not acting upon the tea table to slow it down. Otherwise, continuous rotation would be impossible.

[12] Other than matrices, of course. Dodgson's main works were in condensation -- the technique of computing determinants of 2×2 matrices within a square matrix to find the determinant. This is one place where Dodgson would not question the non-commutativity of multiplication, but this does not imitate the real number line.

too difficult to comprehend in Dodgson's view, advocates her success in "aiming for her goal of getting into the beautiful garden" (Little 198).

Though the tea party serves as a platform for Dodgson's critique of the radical concepts emerging in Victorian mathematics, Alice's agency as a conservative mathematician is heightened in this scene because it begins to affect Wonderland. "When Alice leaves, they [the Hatter, the Hare, and the Dormouse] try to stuff the Dormouse in a tea pot so they can exist as an independent pair of numbers – complex, still mad, but at least free to leave" (Bayley 41; Devlin 3). Clearly, Alice's questioning has affected them. Before Alice begins questioning them, they have endured the six o'clock hour for quite some time (Dodgson 74) and do not question it. It is only after Alice asks, "what happens when you come to the beginning again?" and the Hatter does not have an answer (Dodgson 74) that anyone begins questioning the system and acts to change it. Their solution is a far cry from what Dodgson would consider acceptable, but it is certainly closer to the mathematical practices that he does endorse.

Another key element of this scene occurs after Alice has left and has made it into the hall. She asserts

> "Now, I'll manage better this time," . . . began by taking the little golden key, and unlocking the door that led into the garden. Then she set to work nibbling at the mushroom . . . till she was about a foot high: then she walked down the little passage; and then – she found herself at last in the beautiful garden, among the bright flower-beds and the cool fountains (Dodgson 76).

This is important because it juxtaposes the types of mathematics that Alice encounters. Alice encounters and dismisses quaternions and reverts back to the mushroom, which serves as a Euclidean transformation. Because Alice remembers it immediately and completes the appropriate transformation quickly, she is able to obtain her goal of getting

into the beautiful garden. This demonstrates the extent of her agency in Wonderland, because it is the final test to get to her desired destination.

Contrarily to the conservative Victorian woman, whose knowledge of mathematics was superficial, Alice rises above this and exhibits a greater agency in Wonderland. Here, Alice is faced with arguably the most absurd Victorian mathematical innovation, quickly dismisses it (while influencing others to do the same), and reaches her ultimate destination in Wonderland without hesitation.

Conclusion

Alice's Adventures in Wonderland serves as a medium to both critique Victorian mathematics and explore the undefined boundary between childhood and womanhood. Because Alice makes mathematical decisions that align with Dodgson's traditionalist view of mathematics, she has agency in Wonderland. Alice is able to establish the existence of her strength as a mathematician by learning to use the mushroom and communicating with the Caterpillar. Although she has a background in Euclidean geometry that allows her to make certain assumptions as to how the mushroom works, she is faced with a new problem in Euclidean geometry that she cannot immediately solve. However, after some experimentation, she is able to overcome this obstacle and is given one of her first tastes of agency in Wonderland.

Alice's success does not end here – her Euclidean background serves her well when she encounters non-Euclidean geometry. Here, Alice is faced with a new challenge from projective geometry when the Duchess thrusts motherhood upon her, and she must decide how to respond to the physical embodiment of projective geometry. By choosing to dismiss the child who transforms into a pig, she is not only choosing to reject non-

Euclidean geometry but is also choosing to reject Victorian motherhood – giving her a more potent agency in Wonderland.

Evidently, Alice has experienced significant obstacles in Wonderland. Rather than becoming victim of the absurd mathematical forces in Wonderland, she pushes through them while keeping her goal in mind. By doing so, at the end of each trial, she is attains a graduated agency until she is finally seen as a leader.

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