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Article

Teaching the Beauty of God in Computer Programming and Design

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Even though aesthetics is often not explicitly included in computer science curricula, a review of computer science literature shows that incorporating beauty is beneficial in areas such as programming and design. Beauty in the field of computer science unified with a theological view of beauty forms a faith-integrated perspective with vertical and horizontal dimensions. This article shows that a faith-integrated perspective of beauty in computer science adds transcendent meaning and purposes for incorporating aesthetics as part of a computer science academic curriculum. Some examples are also provided for teaching with a faith-integrated perspective of beauty in computer science courses for Christian higher education.

Keywords: beauty, faith integration, computer science, Christian higher education, biblical worldview

In education, aesthetic appreciation is typically not ranked very highly on the priority hierarchy for curriculum.[1] For example, while the Computer Science undergraduate program curriculum guidelines (developed by a joint task force of the ACM and IEEE academic and professional organizations) contain a general reference to the importance of aesthetic values, they do not specifically include aesthetics in the curriculum.[2] However, a review of computer science literature shows that incorporating beauty is beneficial in areas such as programming and design.

This article shows that a faith-integrated perspective of beauty in computer science adds transcendent meaning and purpose for incorporating aesthetics as part of a computer science academic curriculum. A faith-integrated perspective of beauty in computer science is to view beauty in the field of computer science unified with a theological perspective of beauty formed through a biblical worldview. A biblical worldview is a conceptual framework, based on the Bible, for viewing the world; it is a belief system that guides individual behavior.[3] How beauty in computer science might be taught from a faith-integrated perspective stems from the findings in the next two sections on beauty in the field of computer science and a theological perspective of beauty.

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Beauty in the Field of Computer Science

In this article, beauty in the field of computer science refers to ways in which aesthetics is applied in computer science. The examples of beauty in computer science encountered in a review of literature were primarily in the areas of programming and design.

Beauty in Programming or Software Development

Even though aesthetics is not often explicitly included in computer science curricula, one notable exception is the Beauty and Joy of Computing (BJC) launched by the University of California, Berkeley, for high school and undergraduate freshmen. In this curriculum, there is an emphasis on the "beauty and elegance of the code."[4] Donald Knuth, professor emeritus at Stanford University and recipient of the A.M. Turing Award (often referred to as the "Nobel Prize of Computing"),[5] offers some criteria for what makes a program beautiful in his article, "Computer Programming as an Art."[6] His criteria include utility, correctness, robustness, readability, usability, and efficiency.[7] These criteria have remained relevant throughout the years.[8] Knuth says that "computer programming is an art … because it produces objects of beauty."[9]

In contrast, "ugly code … is poorly indented, poorly documented, not robust, uses inappropriate data structures, [and] uses poor identifier names."[10] Ugly code is defined as "programming source code that is either poorly written or so complex that it is extremely difficult to figure out."[11] With ugly code, it is challenging to detect and remove errors or validate correctness.[12] One example of addressing poor indentation in ugly code is the Python programming language interpreter requiring indentation for all blocks in the code.[13] The enforced structure enhances readability, which is beneficial for understanding and maintaining the code.

Edsger Dijkstra, a Dutch computer scientist most well known for his shortest-path algorithm, sought to battle chaos and complexity in mathematics and computer science.[14] Since the theoretical foundations for computer science are based on mathematics, many of the references to beauty by the mathematical community apply to computer science as well. Mathematician G.H. Hardy argues for the value of mathematics based on its beauty, and even says that "there is no permanent place in the world for ugly mathematics."[15] He points to the "simple and clear-cut" elegance of beautiful theorems, such as those of Euclid and Pythagoras.[16] Computer programs often implement mathematics and algorithms to solve problems, and desirable characteristics include correctness, performance, and efficiency.[17] These contribute to the development and design of beautiful code.

Beauty in Design

Human Computer Interaction (HCI) is another area in which interest in the importance of aesthetic value continues to grow.[18] HCI is a field of study focusing on the interaction between human users and computers in technology design.[19]

The study of aesthetics in HCI often refers to visual beauty and sensory appeal.[20] HCI studies by N. Tractinsky and coauthors and Kai-Christoph Hamborg and coauthors show that there is a relationship between beauty and usability, although there are some inconsistent results regarding the exact relationship between the two.[21] In their studies on the impact of beauty on product choice, Sarah Diefenbach and Marc Hassenzahl show that there is "a 'beauty dilemma'—the idea that people discount beauty in a choice situation, although they value it in general."[22] While results confirm that there is a complex relationship between beauty and usability, these studies do corroborate that beauty is appreciated and contributes to a more positive overall user experience. In other research focusing on visual beauty for Web design, Kristiina Karvonen states that "the feeling of trust is promoted through beautiful design."[23] She specifically recommends the beauty of simplicity in design. Carlos Flavian and coauthors similarly affirm the importance of simplicity, particularly for navigation through a website.[24]

Some researchers have explored aesthetics beyond just the visual characteristics and simplicity in design.[25] For example, Mads Nygaard Folkmann evaluated various sources of aesthetic theory, particularly related to philosophical aesthetics and art-related hermeneutics, to find other concepts that might contribute to understanding beauty in the field of HCI.[26] Folkmann determined that reflectivity and representation enable a deeper understanding of the relationship between humans and design. Reflectivity "invites interpretation of its function"[27]; representation "questions what design solutions

mean for the user and how they represent meaning."[28] These indicate an interest in understanding what can be communicated through beauty in design.[29]

In the preceding examples, beauty in computer science is found to be beneficial in the areas of programming and design. Thus, if beauty in computer science is to be incorporated as part of an academic curriculum, it might be included in courses that teach concepts related to development and design. To teach beauty in computer science from a faith-integrated perspective, a literature review was conducted to form a theological perspective of beauty.

A Theological Perspective of Beauty

This section summarizes a review of beauty in scripture and theological literature, presented within a framework of David de Bruyn's classifications of beauty.[30] According to de Bruyn, definitions of beauty can be broadly categorized as theological, classical, subjective, or transcendental.[31]

Theological definitions see God as the source and foundation of beauty.[32] "God's own beauty makes beauty itself objective."[33] Fourth-century bishop Gregory of Nyssa, a theologian of the divine beauty, says Beauty is one of the names of God.[34] In scripture, the psalmist seeks to "gaze upon the beauty of the Lord and to inquire in his temple" (Ps. 27:4 ESV). Thus, the pursuit of God's beauty is an act of Christian worship.[35] Even the beauty in creation is a display of God's "invisible attributes, namely, his eternal power and divine nature" (Rom. 1:20).

Classical definitions of beauty focus on proportion and symmetry, resulting in a sense of order and harmony.[36] A theologically informed description of classical beauty would include "notions of unity, proportion, harmony, order, brightness, clarity, color, and pleasure."[37] Specifically, philosopher and theologian Thomas Aquinas defines a standard of beauty as having conditions of "perfection or integrity, proportion or harmony, and brightness or clarity."[38] He says that "beautiful things are those which please when seen,"[39] primarily due to proportion and form. Some scriptural illustrations of classical beauty are the detailed descriptions given for the structure, unity, and proportion of the tabernacle curtains and frames in Exodus 25–31 and 35–40.

Subjective definitions refer to the experiences of perceiving beauty with our senses. While this perception can also be related to recognizing classical beauty, the emphasis is on the view of the subject or person sensing and perceiving. Some examples in the Bible include 1 Samuel 9:2 where Saul was perceived by Israel as being more handsome than other men, or 2 Samuel 14:25 where Absalom was praised by all Israel for his appearance. Though subjective perceptions of beauty may be influenced by culture and personal preferences, philosopher David Naugle sees these as relative only to the objective beauty of God.[40]

Transcendental definitions relate beauty to truth and goodness, all three of which form the Platonic triad. Truth and goodness are qualities that are not visible to sight, but, since God is beautiful and invisible, beauty is not limited only to what can be seen.[41] Swiss theologian Hans Urs von Balthasar wrote a fifteen-volume trilogy on beauty, goodness, and truth as being anchored in and inseparable from theology.[42] He recognizes that beauty is not just in the visible form, but that the actual content lies within, radiating God's glory.[43] He says that beauty through faith, from a theological perspective, enables the perception of the glory of God revealed to us.[44] For example, Psalm 19 describes creation as declaring God's glory. God creates with beauty, and in Genesis 1, everything that God made was declared to be "good." Thus, beauty in this definition has to do with "fittingness and excellence,"[45] according to God's design.

De Bruyn says that Jonathan Edwards synthesizes the theological, classical, subjective, and transcendental categorizations of beauty into a consolidated definition, which essentially says that beauty is inseparable from God, in that "the large varieties of beauty are emanations of God's beauty."[46] So, even the classical, subjective, and transcendental categorizations of beauty are related to the theological,

because all beauty is a reflection of God's beauty. Thus, a summary theological perspective is that beauty is inseparable from God, and that which is beautiful is a reflection of God's beauty. The next section will unify the previous examples of beauty in computer science with this theological perspective of beauty to form a faith-integrated perspective for computer science curricula, particularly in Christian higher education.

Integrated Perspective of Beauty in Computer Science

The earlier examples of beauty in the field of computer science incorporate characteristics from de Bruyn's classical, subjective, and transcendental categorizations of beauty.[47] Classical qualities such as structure and order are important in program code for practical purposes. Not only do they make code easier to read, understand, and maintain, they are also recommended as best practices.[48] Subjective qualities, particularly in design, can improve user experiences and product appeal, often generating increased usage, which can sometimes result in financial gain.[49] Transcendental characteristics such as correctness and robustness are found to be important for product quality.[50] These indicate that beauty is incorporated in computer science for practical and functional benefits, such as improved maintainability, increased usage, or enhanced product quality. However, discussions of beauty in the field of computer science do not typically make associations between beauty and God, even though from a theological perspective, beauty is inseparable from God.

Therefore, an integrated perspective is needed because beauty is best understood in connection with God. As Paul Spears and Steven Loomis point out, integration (which is to unite into one whole) is required for complete understanding in any discipline.[51] The next two sections show that a faith-integrated perspective of beauty in computer science has a vertical dimension relating to God and a horizontal dimension relating to others, which then lead to implications for a Christian higher education computer science curriculum.

Vertical Dimension

The earlier summarized theological perspective is that beauty is inseparable from God, and that which is beautiful is a reflection of God's beauty. Psalm 19:1 says, "The heavens declare the glory of God, and the sky above proclaims his handiwork." Through general revelation in the "book of nature,"[52] the world is able to perceive the beauty of the Creator. God's beauty in design is not only revealed in nature but also in scripture, such as in passages on the tabernacle and all its furnishings (Exodus 25–31 and 35–40). God includes beauty in the tabernacle design, as he incorporates classical qualities such as colors, structure, and proportion. The artistic craftsmanship of the ornaments and the use of precious metals such as gold also contribute to the aesthetics. The lampstand has crafted "almond blossoms, each with calyx and flower," which are designs that reflect those in creation. These demonstrate that the tabernacle is not just for utilitarian functionality but that it also reflects divine beauty, thus enhancing worship.[53]

However, minister Lisel Joubert points out that in the time between the giving of instructions for building the tabernacle and its completion, the incident of the golden calf occurred (Exodus 32).[54] This is an example of focusing on the created object, which indeed has some elements of visual beauty, rather than on God, who is the source of that beauty. The first chapter in the Book of Romans warns against confusing beautiful objects with beauty in the Person of God himself.[55] Whenever encountering beauty, we are to look to God, the source and foundation of beauty, because all that is beautiful is a reflection of God's beauty. For example, mathematics professor Jason Wilson notes that while math itself is beautiful, Christians in the mathematical community have written about mathematical beauty pointing to God and inspiring worship of him.[56] Thus, through the eyes of faith, beauty in computer science should point to God as the source of beauty.

Also, just as HCI studies explore communication through design aesthetics, an integrated perspective might view designing with beauty as a means of pointing others to God, since "beauty is a medium for knowing God."[57] There is even a connection

between beauty and doxology.[58] Since "the concepts of design and purpose are closely related,"[59] products can reflect the purpose of the designer. For example, the beauty in the design of the tabernacle was a visible reminder that it was to represent God's earthly dwelling place.[60] Thus, creative works can potentially have the ability to communicate God's presence.[61] Church websites listed as "beautiful" or "well designed" on ChurchThemes.com often include beautiful designs depicting biblical content or people in worship, which help point to God and communicate purpose.[62] An analogy may be made to stained glass windows in cathedrals that present content within beautiful designs. Using Notre Dame de Paris as an example, architectural engineering professor Nelly Shafik Ramzy describes how designers of cathedrals intentionally incorporate elements of beauty to enhance worship: towers and spires are vertical elements symbolizing aspirations to be united with God, canopies point heavenward, light passing through stained glass is likened to the Light that came to the world through the Virgin Mary, and the windows depict theological images and events related to the Bible.[63] Intended results are that the beauty incorporated in the cathedral would point to God and inspire worship of him.

To summarize the vertical dimension of a faith-integrated perspective, it is beneficial to recognize that designing and developing with beauty is a reflection of God's creative processes. Also, whenever incorporating beauty into the design and development of computer systems, it is important to look beyond the beauty in the product, and instead focus on God, the source of beauty. Furthermore, intentionally incorporating beauty in programs and designs, such as developing simple elegant code that resolves a complex problem, may have the effect of pointing others to God. This leads to the horizontal dimension of integration, focusing on those who see, use, or work with the resulting computer products or technologies.

Horizontal Dimension

God deliberately created the world with aesthetic qualities, and human beings appreciate beauty as a result of being created in the image of God.[64] Sin and brokenness after the Fall have darkened the beauty in the world, but the beauty of Christ has redeemed what was disintegrated in the Fall.[65] Thus, beauty can transform society and lead it toward shalom, which is a state reflecting truth, goodness, and beauty.[66]

In the horizontal dimension of the faith-integrated perspective, beauty would be incorporated into computer science not only for practical and functional benefits but also to reflect God's love to others. Programming with structure, order, readability, and simplicity would benefit anyone who needs to maintain the program code. Similarly, improving product appeal, correctness, robustness, and user experience could be viewed as reflecting God's love through these enhancements. Related to Aquinas's view that beauty brings pleasure, providing an overall enjoyable user experience can be an expression of care for the user.

In the earlier examples of beauty in the field of computer science, simplicity is often cited as important. A simple design is easy to understand, comprises only the essential, and is free from elaboration.[67] This reflects the quality of fittingness according to design because there is nothing extra added. Since simplicity as a transcendental quality reflects truth, goodness, and beauty, it is consistent with the research in computer science showing that beautifully designed products have positive effects on users, such as promoting feelings of trust.[68]

Overall, these vertical and horizontal dimensions of the faith-integrated perspective illustrate that beauty contributes to focusing on God and others when designing and developing. Ignoring the importance of aesthetics when teaching computer science could result in neglecting a significant aspect of an integrated curriculum.[69]

Implications for a Computer Science Curriculum

Integration of faith and learning is a distinctive of Christian higher education, so the integrated perspective is essential.[70] Professor Octavio Esqueda says that education should be grounded in a biblical worldview, and that the creation, Fall, and redemption metanarrative of the Bible is a framework for

integrating faith and learning.[71] When God created the world, he declared all to be "good," and there was complete integration.[72] "Because everything that existed came from God, there was really no distinction between sacred and secular; everything was sacred."[73] However, after the fall, when sin entered the world, there was complete disintegration.[74] Christ's redemption is what enables reintegration.[75] So, faith and learning in computer science should not be viewed as separate, but must be integrated because God is the source of all truth.[76] As seen with the vertical and horizontal dimensions of a faith-integrated perspective, the aim of incorporating beauty into computer science as part of the curriculum would be to reflect the creative processes of the Creator, point to the beauty of God, express God's love, and make a positive impact on others. Neglecting beauty, on the other hand, can have detrimental effects, because that which is ugly can obstruct the restorative process.[77]

Concepts related to programming and design in computer science might be taught in courses such as Introduction to Programming, Data Structures, Algorithms, User Interface Design, or Software Engineering. Teaching with a faith-integrated perspective of beauty in computer science would include the practical and functional benefits of incorporating beauty, viewed through both the vertical and horizontal dimensions. Some practical exercises when integrating aesthetics into computer science courses might include students reflecting on scripture passages and then relating them to computer science design and development. Several examples are provided below, along with anecdotal observations from experiences in the classroom.

In courses such as Introduction to Programming, Data Structures, or Algorithms, having students reflect on the creation account in Genesis may help them to recognize that order and structure, as seen in the process of creation, are important. It has been observed that students enjoy seeing the connection to God through similarities between computer programming and God's creative processes. Also, as God gave humans stewardship care over creation, students may be reminded to consider those who will use or maintain their program code. Students have also been able to recognize that debugging programs or removing errors can be part of the restorative process, as an analogy to God's redemptive work. Bugs in programs are ugly because they prevent the program from functioning according to design. Some students have commented on experiencing the enjoyment of "good" code, which shows that beauty in programming can have a restorative effect on the programmer or designer as well.

Another curriculum example would be for students in a User Interface Design course to reflect on the biblical narratives for the building of the tabernacle, and particularly on Exodus 31:1–5. This passage describes the Spirit of God filling Bezalel with "ability and … all craftsmanship to devise artistic designs" (Exod. 31:3–4), and indicates that the ability to create with beauty comes from the Holy Spirit. Students have been able to see that incorporating beauty in their designs is a reflection of God's design processes and to recognize that their ability to do so comes from the Holy Spirit. In addition, just as the beauty in the design of the tabernacle enhances the experience of the worshipper, students may reflect on how the beauty in their designs will enhance user experiences.

Yet another example would be for students in a Software Engineering course to reflect on the Psalm 19:1–6 passage, on what creation communicates about God. They may also reflect on the Exodus 25–31 and 35–40 passages, on what the tabernacle design communicates. Students may then be asked to consider what they would want their software engineering products to communicate about God or what message content they want to share with others through beauty in their designs.

As illustrated through these examples, aesthetics may be incorporated in Christian higher education computer science curricula with a faith-integrated perspective. The practical and functional benefits from the earlier examples of beauty in the field of computer science can be taught through the lenses of the vertical and horizontal dimensions of the integrated perspective. Some goals in teaching a

faith-integrated perspective of beauty in computer science courses related to development and design would then be to manifest the beauty of God, incorporate God's design processes, reflect God's love to others, bring enjoyment to users, and point to God.

Conclusion

We conclude that a faith-integrated perspective of beauty in computer science has vertical and horizontal dimensions that provide transcendent meaning and purpose for incorporating aesthetics as part of a computer science curriculum. Professor Michael Lawson says, "An integrated life should be taught through an integrated curriculum in order to reflect the integrated nature of truth found ultimately in God himself."[78] Just as the aesthetics of cathedral buildings can "express spiritual aspiration,"[79] it may be possible to produce a similar effect when beauty is intentionally incorporated in computer science design and development from a faith-integrated perspective. David Dockery says that the Great Commandment (Matt. 22:36-40) to love God and to love others may be used as a framework by those called to be Christian educators.[80] Thus, a faith-integrated perspective of beauty in computer science education adds the transcendent meaning and purpose of aspiring to obey the Great Commandment through utilizing intentional creative processes with vertical and horizontal dimensions.

Notes

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