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Mathematics: Always Important, Never Enough: A Christian Perspective on Mathematics and Mathematics Education

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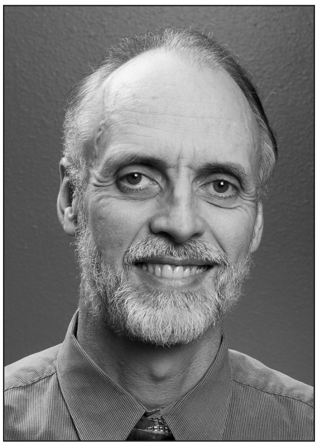
Mathematics: Always Important, Never Enough

A Christian Perspective on Mathematics and Mathematics Education



by Calvin Jongsma

Dear Anneke,[1]

We will soon be coming to your house for the holidays. I know you and Claire are counting the days until Christmas: how many are left? I can hardly wait, either. I think grandma told you that school is out for me now but that I have to spend some of my vacation making a speech for mathematics teachers. We will be talking about what things are important for kids to learn about mathematics.

As you know, I think mathematics is one of the most fun things anybody can do. You probably like art better than math, but I know you enjoy working with numbers and shapes, too. That's what mathematics is all about: finding different numbers and shapes in the world all around us, learning how they are related to each other, and figuring out good ways to use them. It's valuable to learn how to do this because numbers and shapes help us do things that would be difficult or impossible otherwise. I know when you draw pictures you sometimes use circles and ellipses and straight lines to make people and animals and background look real. You use numbers a lot, too, whenever you count things or keep track of time or bake cookies. Which reminds me, are you making enough Christmas goodies for everyone that's coming?

Numbers and shapes are very important parts of the world God created. You can see them everywhere if you know how to look for them. People who know a lot of complicated mathematics helped to figure out how to make computers and connect them together using the internet, how to use numbers to record sounds and pictures on a DVD, and how to fly many big planes in and out of airports without having them crash into each other. We'll soon be driving out to your house, like usual. Isn't it amazing that while we live hundreds of miles away, we can use a map so we don't get lost? Mathematics is important for almost everything we do these days, so everybody should learn a lot of mathematics even if it isn't their favorite

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subject.

Teachers can help you learn about numbers and shapes by asking you to do things with them that you enjoy. Mathematics can be learned using games and other interesting activities. Do you do any of these things in your class? To help you learn things well, teachers may sometimes give you worksheets to do, too, but I hope that's not the only way you learn about numbers and shapes. Eeuww, boringg!! OK; it *can* be fun to do things over and over again when you like to do them and when they can help you learn something really well, but you do need to know why they're important to learn.

God wants us to love Him more than anything else and to care for the people around us just as we do ourselves. Learning more about the world helps us to take good care of what God made – people, animals, plants, and things. Mathematics is part of this care, but of course many times other things are more important. When you or Claire play with little Maddy to entertain her or keep her out of mischief, you're mostly showing how much you love her, even if you're playing with shape blocks or reading a counting book to her.

The world is so full of interesting things to learn about mathematics that you could spend your whole life doing it and still not learn nearly everything. Isn't that amazing?! I always like finding out something brand new about numbers or shapes or other kinds of things – like *algebra*, but that's too complicated to explain until you get older. I get to teach a new course next semester – it's called *Number Theory* – and I'm looking forward to discovering many new things about the counting numbers. God made such a wonderful variety of mathematical things all related to one another in such marvelous ways that I never tire of learning about them. I also *really* like the detective work of figuring out how people did mathematics a long time ago – that's called *history of mathematics*. I studied that when your mom was as old as you and Claire are, and I still do some of this now to help me become a better teacher. Learning how other people worked with shapes and numbers gives me good ideas for how to teach them to others.

It's fascinating to explore how numbers and shapes work. I hope learning mathematics can be as exciting for you as it was for me, even if you never teach it, as I do. And I hope your teachers always try to show you how enjoyable mathematics can be: they have a very important job to do in helping you learn as much as you can about numbers and shapes, having fun while you do it.

Well, this letter is getting awfully long. I'd better send it off so you get it before we arrive. See you soon.

Love you.

Grandpa

Introduction: Aim of This Talk

At this point, maybe I should just quit. Most of the ideas I want to develop in this paper are already present in the letter, at least in germ form, and maybe that's enough. Math professors are, after all, notorious for being blissfully ignorant of ordinary affairs, talking about things nobody else has a clue about.

The B. J. Haan Conference organizers, however, may not think they've gotten their money's worth if I stop here. After all, I've produced only one missive, not a whole book of them,[2] so I'm probably duty-bound to expound further on my letter's themes. This means I'll be getting more philosophical, but I'll try to use illustrations to clarify my points.

My goal is to develop a biblical Christian perspective on mathematics and mathematics education, and to reflect on the practical implications of such a viewpoint for doing and learning mathematics. This is something I've thought about, off and on, for more than two decades as I've taught college-level mathematics to all sorts of students, but it is certainly not something I've been professionally trained to do or have become an expert at doing.

As a matter of fact, the whole thrust of this project probably seems rather silly to most educated people. Isn't mathematics one of those religiously neutral areas of the curriculum where facts are facts, no matter who produces or studies them? What can Christianity possibly contribute to mathematics beyond some window-dressing? Is there any significant way in which we can say mathematics is Christian or not? Isn't the content of mathematics entirely faith-free? There aren't any

Christian prime numbers or biblical algorithms or secular circles or evil proofs, are there? Doesn't Christianity just come into play with how mathematics gets applied and how teachers treat their students, with issues of morality and inter-personal relations?

We shouldn't conceive of mathematics and Christian religion, therefore, as two companion bodies of knowledge that need to be joined in order to make our mathematics Christian. Rather, Christian faith is central and should work itself out in our mathematics.

I'm convinced that more can be said about the relation between religion and mathematics. I, too, think the objects studied by mathematics are (generally) the same for Christians and non-Christians, but they are often interpreted quite differently, based, in the final analysis, on what each person considers to be divine. While there may be a great deal of surface agreement, therefore, this doesn't mean that religious beliefs have no impact on the practice and content of mathematics. I'll try to sketch more precisely what the connections are, but this will require us to view both mathematics and religion differently than many do in our culture.

Religion and Mathematics: How are They Related?

Mathematics and religion aren't two separate realms that Christians need to integrate in order to do or teach mathematics Christianly. We are all called to the vocation of Christian discipleship, to work for the restoration of God's good creation, to seek the coming of his kingdom in whatever we do: that's *religion*. Doing mathematics is one of the ways in which we can show obedience and thanksgiving to God. We shouldn't conceive of mathematics and Christian religion, therefore, as two companion bodies of knowledge that need to be joined in order to make our mathematics Christian. Rather, Christian faith is central and should work itself out in our mathematics. Picture the wheel of life with a hub and various sectors: Christian commitment is at the core of the wheel; mathematics is one of its sectors.

I'll explain further what this viewpoint entails, but first I want to generalize: this set-up isn't just the case for devout Christians or Hindus; it's the way mathematics and religion are related for everyone. By formulating the issue in this way, I am drawing upon the Reformed Kuyperian tradition developed over the last century or so.

Life is religion, in its fullest sense; that is, it unfolds in response to God's Word, which gives structure to all of creation and provides norms for how we should live. Individual human actions, attitudes, and decisions are part of a larger pattern of life that reveals its purpose as being service either to God or to some pseudo-divinity. Religion at its core has to do with our orientation toward what we acknowledge as divine, toward what we believe to be the origin of everything that exists and the source of all meaning and cosmic interconnectedness. We humans are creatures who need to make sense of our experience and existence in terms of something that is absolute and ultimate. We do so because of our religious nature.

Religious commitment is realized in a worldview, in a vision of life that generates answers to the most basic questions about reality: *How did we (and the rest of the world) get here? What's our purpose for being here? What, if anything, is wrong with the way things are now, and how did they go wrong? How can things be fixed or made better?* A worldview gives us a framework for interpreting our experiences, and it gives guidance to our lives, both in our day-to-day activities and in our professional work. Worldviews mold the ways we think about the students we teach and the way they learn. They direct how we think about issues even when we don't explicitly articulate them.

Worldviews also shape traditions within our fields of study. However, unless we have been trained to see matters in these terms, we may not realize what worldviews our beliefs and methodology are promoting. Consequently, we may even be working out of a worldview that is at variance with our stated religious commitment.

Those of us who are professionally engaged with educational or mathematical theories will often be drawing upon something even more systematic than a worldview. We may need more than a basic orientation toward what we take to be divine and some tacit answers about the overall meaning of life. Philosophy can help us here. Religious commitments and worldview sensibilities become philosophically honed as we systematically reflect on how things are inter-related. Christian philosophy can provide a broad meaning-context for theorizing about some aspect of God's creation. It's certainly not the case that you cannot teach or do mathematical research unless you are a philosopher – you obviously can and should – but Christian philosophy provides a conceptual framework for thinking about broader issues, and it can provide fruitful pointers about how to resolve fundamental problems.

To summarize, I believe that religious perspectives are developed into worldviews, which can in turn be sharpened by philosophical positions that have ramifications for a field such as mathematics. The impact of religion on mathematics, therefore, can be characterized as being indirect but structural: not direct or immediate but also not just serendipitous or optional. Religion's role is pervasive and influential, setting the deepest ground of meaning for doing mathematics. A religious outlook, in the sense discussed above, will thus affect educational and mathematical practice, even when different perspectives (seem to) lead to the same technical mathematical procedures and theories. I will discuss this more later, but first I want to sketch the contours of a biblical foundation for mathematics.[3]

A Biblical Foundation for Mathematics: Creation, Fall, Redemption

Protestant Christians have long held that the Word of God should be the basis for every aspect of their lives. The Reformed tradition works with the biblical theme of *Creation-Fall-Redemption*. This compound motif captures the grand sweep and meaning of history, but it also provides us with important ideas about the underlying structure and purpose of the world that is historically unfolding, and it tells us about its relationship to God. We shall look at each of these three components on its own shortly, but I first want to say a few words about their relative roles within the biblical narrative.

Scripture is centrally about God's work of redemption. Of course, the Bible also reveals our great need for redemption; humans cannot extricate themselves from the sinful mess their disobedience set in motion and continues to propagate. As a result, sin and especially salvation are key themes in Scripture, and they are likewise strong emphases of the ecumenical creeds and the doctrinal standards in the Reformed ecclesiastical tradition.

However, notwithstanding their crucial importance, a Christian worldview cannot restrict its attention to these two components of the biblical motif, as the Bible itself makes clear: neither Fall nor Redemption can be fully understood outside the context of Creation. The Fall introduces distortion and brokenness into the Creation, and Redemption is intended to restore Creation and reconcile all things to the Father. Creation itself is the amphitheater in which God's reign is fully realized.

The Creation Motif and a Reformational Perspective on Mathematics

Creation matters: God created everything good in the beginning, He continues to uphold it even after the Fall, and it will one day be fully renewed. This emphasis on the importance of Creation is what distinguishes a Reformational worldview from that of many other traditions.

I will highlight three clustered theses about creation and reflect on their importance for a Christian perspective on mathematics. Two of these will pertain to God as the divine creator; the third will look at human involvement in creation.

1. God is Creator and Sustainer

God is the Sovereign Creator of everything that exists (outside himself). Things exist because God said so, and

He maintains and orders all things through his wise and loving control.

What does this mean for mathematics? First of all, I think we should distinguish two different senses of the term *mathematics*.

Sometimes mathematics refers to what mathematicians study, to the basic objects of their theories (prime numbers, triangles, parallel lines, rates of change), and to the universal patterns (various properties and relations) these abstracted entities exhibit among themselves. In this sense, mathematics is part of what God created. Reality has a definite quantitative and spatial structure, given it by God, that we can discover. Mathematical realities are the way they are whether or not humans are fully aware of them: the constant π in the circumference formula $C = \pi d$ is the same as the proportionality constant needed for expressing the circle's area, though it took a long time for humans to realize this. As a dimension of reality, mathematics functions as it does because God designed the world that way, because of laws he instituted to govern mathematical entities and their interconnections.

However, mathematics is probably more often used in another way, as the symbolism, concepts, and theories *about* the mathematical realities just mentioned. In this sense, mathematics is the result of human theorizing and doesn't exist apart from human activity. Here humans have responsibility and may exercise their creative and inventive capacities. Humans invented exponent notation to capture the notion of repeated multiplication, and they later connected it with other related ideas: this is not something we can derive from the creation, even though the rules that govern exponents hold because of God's laws for multiplication, division, taking roots, and limits. God may be said to "do mathematics" in the first sense (though I think that's a strange way to put it), but I do not believe God does mathematics in this second sense, not even in a non-deductive, immediate fashion.

So, then, do humans invent or discover mathematics? Well, they don't create the things they study, nor do they impose on those things the properties that distinguish them from and relate them to one another; so in this sense humans definitely discover mathematics. Mathematics is not man-made in this sense; it is divinely ordained. We shouldn't find mathematics "unreasonably effective," therefore, even when we are pleasantly surprised by all the many ways it can be applied to physics or economics, for the One who made all things that exist is the One who gave them mathematical features.

On the other hand, as humans explore the creation, they certainly do generate the concepts and notation used in mathematical theories, they determine effective algorithms for computing various things, and they decide how to arrange mathematical propositions in a deductive order, providing the arguments that connect them all together. In this sense mathematics is not divinely decreed, even when there may be better or worse ways to do things. It is not freely invented by mathematicians constrained only by logical consistency, but neither does it come down to us like manna from heaven. Mathematics is developed by humans from the (creaturely!) intellectual materials available to them as they explore aspects of the reality God made.

As a dimension of reality, mathematics functions as it does because God designed the world that way, because of laws he instituted to govern mathematical entities and their interconnections.

The discovery vs. invention dilemma trades, at least in part, I think, on the confusion between these two senses of mathematics. These are often insufficiently distinguished because mathematical entities are not concrete things; as a result, it is easier for people to hold that everything about mathematics is due to human convention.[4] In the end, I think we need to say that mathematics is both discovered and invented, though we may still argue about which is which.

2. God Alone is Divine

God transcends creation[5]*: nothing created has divine status. Everything depends upon God for its being and functioning. Nothing besides God has nondependent existence, and nothing creaturely provides the ultimate meaning for the rest of creation or the glue that holds all things together. All things exist to give glory and delight to God, and they are held together by Jesus Christ.*

One thing this means is that mathematics is not absolute; we ought to reject mathematical imperialism. There is far more to meaning than what can be measured. As Einstein once quipped, "Not everything that counts can be counted, and not everything that can be counted counts." Mathematics is neither the source nor the epitome of absolute certainty and truth. Humility is called for, not aggrandizement or special-interest gerrymandering.

Pushing to mathematize reality has been a major preoccupation of Western Culture, going all the way back to the Greeks.[6] This does have some positive aspects to it: mathematics *is important*, even foundational, for much of what we do. Everywhere we look, we see mathematical features to explore, abstract, interconnect, and apply: As the TV show *Numb3rs* argues,"We all use math every day**."** God imbued creation with a rich diversity of numerical and spatial properties, structured in complex and elegant patterns, and related to a wide variety of different things.

Still, mathematics is never all there is; it is *never enough*. It is full-bodied reality that provides the context for our abstracted mathematics. Reality has many qualitative elements that cannot be simply reduced to quantitative ones; recognizing this irreducibility is important to any situation we may want to model with our mathematics. Yet too many in our culture think mathematics is all that matters in science or everyday life. This belief borders on ascribing divinity to mathematics, seeing it as the source of order and meaning, the reason why everything behaves the way it does.

This mindset originated with the Greeks – the Pythagoreans, Plato, and Archimedes – but it has become deeply ingrained in modern Western thinking. It gets its classic articulation in the works of Kepler, Galileo, Descartes, Newton, Leibniz, and others, who believed that the world is written in the language of mathematics and that number, shape, size, mass, velocity, and other measures alone are objectively real; nothing else needs to be taken into account to explain the natural world. Postmodern challenges seem to have done little to shake us of this notion. Mathematical modeling and statistics are deemed as important as ever in our world by decision-makers; if you want to prove anything conclusively, you need to use mathematics as your basis.[7] A reductionist outlook will obviously concentrate strongly and programmatically on mathematics' value for other things and so will often discover genuine foundational connections; but it will also tend to distort the relationships and shrink the rich variety of meaning that is present in creation.

Some Christians, such as Kepler, have thought they could adopt this modern Western approach, provided they gave proper credit to God as the Supreme Mathematician. Thus, mathematical ideas get located in the Mind of God or even become part of God's Nature[8] instead of being seen as aspects of the created universe. As such they supply God with the blueprint for making creation or with the conceptual materials for structuring it. This God uses mathematically formulated laws, such as the Pythagorean Theorem or Newton's Universal Law of Gravitation, to govern what he has made. Mathematics (often with its rational sidekick, deductive logic) thus becomes co-eternal with God and, containing necessary truths, provides constraints on what God can and cannot do. Humans, being created in God's image, can think God's thoughts after him in their mathematics, and so they should give glory to God for what they learn about him and his laws for creation. In the final analysis, though, this point of view treats mathematics as divine or central to the divine order of creation; it is no longer a part of created reality subject to God.

Attractive as many Christians find this solution, I believe it is at odds with what Scriptural revelation says about God's transcendence and divinity and creation's total dependence upon God. In essence, it elevates something creaturely to the status of God. Even when it has a pious motivation, as is the case with Kepler and others, it still concedes too much to a dominant non-Christian worldview, forging an unstable synthesis between such a viewpoint and a more biblical outlook.

There are, of course, things that mathematics and the structure of mathematical states of affairs do reveal about God to a Scripturally enlightened mind. They show us a Creator who values quantitative and spatial realities, who declared them good along with everything else he made. They demonstrate God's majesty and greatness: he is the Creator of mathematical features that are wonderfully intricate and richly interconnected with other things. They give us a glimpse of God's faithfulness through the comforting consistency we experience in our mathematical work. The beauty and magnificence of these things prompt admiration and awe; they inspire worship of the Creator.

Mathematical expertise, properly employed, can glorify and serve God, benefit the human race, and enable us to rule as wise stewards over the rest of creation as we develop culture.

3. Humans are God's Image Bearers

Humans were created to be God's representatives on earth, his image bearers. We have been given a creational mandate, to be stewards, caretakers of the earth, whose task and joy it is to exercise dominion over and cultivate what God has created so that it may be fruitful and better fulfill its own calling before God.

Mathematics is part of our collective responsibility as God's image bearers to cultivate the creation. It is an honorable calling and a source of pleasure for those gifted to take up the task. Mathematical expertise, properly employed, can glorify and serve God, benefit the human race, and enable us to rule as wise stewards over the rest of creation as we develop culture.

Pursuing mathematics is one way we can seek to better understand how God has ordered our world and knit it together. Focusing somewhat narrowly on the mathematical characteristics of a concrete situation and generalizing them, we can discover essential properties and relations embedded within the full reality we are studying. Mathematical ideas and procedures can usually be further abstracted and interconnected, leading to a complex network of mathematical procedures and theories. This knowledge can then be applied to the setting that motivated it, but we are often pleasantly surprised that the core mathematical abstractions also apply to many new situations. For example, ideas and techniques in calculus developed for the physics of motion turn out to have application in mathematical biology and economics. Again, symbolic algebra, which was initially developed for problem-solving purposes, gets modified 250 years later and put forward as a mathematical analysis of deductive reasoning; about a century later, other mathematicians discover that this form of algebra can also be used to design machines for computation. This sort of multiple interconnectedness in creation seems to be typical, not unusual; it is something mathematicians experience over and over again with amazement as they pursue their fields of study.

Without mathematics, our ability to control and take care of our world would be severely hampered. Particularly today, life without mathematics is unthinkable. Mathematical ideas and procedures permeate all parts of contemporary life; the fabric of our technological culture is thoroughly interwoven with mathematical threads. During the twentieth century, and especially the last half, we have witnessed an explosion in mathematical applications and the creation of mathematics-based artifacts, even though the supporting mathematical substructure for most of these things remains hidden below the surface, unknown to few beyond the specialists involved with them. There has thus developed a stark disparity between the reality of mathematics' presence in society and the public's perception and understanding of this fact. Those who look more closely, however, find mathematics nearly everywhere.

The Motif of the Fall and a Reformational Perspective on Mathematics

Now that we have looked at some implications of the Creation motif, let us turn to the second component of the biblical theme: the *Fall*. As before, I will first state a more general biblical thesis and then look at its implications for mathematics. We will consider the Fall from both the human and the divine sides.

1. Human Pretension to be as God

Sin entered the world as a result of humans aspiring to be divine, to be like God. The sinful desire to replace God with something creaturely is roundly and repeatedly condemned by Scriptural injunctions against idolatry: nothing in creation is divine.

In Western culture we see our first-parents' sin reflected in the urge to fully control and reconstruct creation in our own image, using science and technology. Current developments in biotechnology, informatics, nanotechnology, and robotics are pushing the envelope to help us gain ever greater mastery of nature and control over our own destiny; some even hope one day to re-engineer human beings using such tools. I believe this is a sinful vision of reality that will not be blessed by God. Moreover, the ideal of quantifying reality has been complicit in this program all along, even if the field of mathematics per se can be considered apart from this involvement. As Christians we should be aware of the larger context of our mathematical research, and while this awareness might not deter us from pursuing a particular line of research, we should become advocates for good uses of what we discover, and we should oppose those applications that would promote harmful or evil consequences.

However, mathematics is affected by the Fall in more ways than just in how its results are taken up into a larger program. Our participation in mathematics can also be wrongly oriented and reflect a sinful attitude toward God. This point touches on our personal motivation for doing mathematics: do we exhibit arrogance by seeking to enhance our own reputation and bring glory to ourselves, or do we have an attitude of humility and service to others, seeking to give glory to God for the gifts he has given us?

And more than human motivation is at stake. The Fall may affect our global view of mathematics: how is mathematics related to other areas of life? As we already noted, mathematicians and others have at times elevated mathematics to the level of divinity in their drive toward greater mathematization, seeing reality as essentially determined by mathematical results while mathematics itself is nondependent on other things, being true, regardless of what the physical universe is like or whether it even exists.

On the other hand, mathematics is sometimes seen as a pure discipline, defining its own problems and developing its own theories with no input or necessary connection to anything else. In an extreme form, it may even be considered a purely formal system of human conventions, having no intrinsic meaning whatsoever. Those who hold this view believe that while others are welcome to borrow mathematical results to model real-world situations, mathematics is a pure human creation. The only time there is an intimate connection to external reality is when humans impose mathematical ideas on the world of their experience. Humans, so it is thought, create abstract mathematical realities, and they develop mathematical models to organize the chaos of their everyday experience, which has no God-given structure. It should be fairly clear how this viewpoint corresponds to a deeper human longing to be like Creator God, though we can also point to historical developments in mathematics itself that seem to encourage such an approach.

Finally, the Fall may affect our perspective on mathematics in a more local way. What do we see as all-important within mathematics? What is the nature of mathematical entities and mathematical truth? Are numbers and shapes eternal realities? Is mathematical truth absolute? What unifies mathematics and makes it coherent? Can we reduce everything in mathematics to number, as the Pythagoreans thought? To logic, as Frege and Russell claimed? Or to axiomatic set theory, as many twentieth-century practitioners working in the foundations of mathematics believed?

Such systematic attempts at reductionism within mathematics also usually indicate a desire to idolize something creaturely, making it more than it should be.

2. God's Curse and Blessing after the Fall

God cursed creation on account of human sinfulness; distortion and brokenness now pervade our human experience. Yet God continues to uphold creation by his ordinances, by providing environments of blessing, and by restraining evil.

What about issues that go beyond philosophical perspective, matters that are more technical in nature? Are there parts of mathematics (taken now in the sense of what humans develop) that might be distorted due to our sinful nature? This idea makes some sense to me, though it's not glaringly obvious. One could argue that this distortion happens in the case of a reductionistic treatment of mathematics: some technical results may make no sense to mathematicians who dispute the overall approach being taken, either because they take issue with the existence or definition of certain entities or because they dislike the methodology being used. In good tolerant fashion, however, mathematicians generally tend to let different approaches flourish side by side, the tares with the wheat, avoiding those they think are seriously misguided. Eventually, it is thought (to use another metaphor) that if you allow a thousand approaches to bloom, the problems with a genuinely bad approach will become manifest – as they were, for instance, to the Pythagoreans – and then that approach will fade away or go out of fashion.

There seems to be something to this idea, that mathematics has a self-correcting mechanism of sorts on some level. Creation seems to kick back when one insists on making it out to be something it really isn't. In the field of mathematics, this self-correction shows up when valid results are achieved that don't mesh well with or that even contradict one's perspective. For example, the existence of incommensurable magnitudes demonstrated to the Greeks that not everything could be handled by relations among counting numbers; Russell's Paradox demonstrated to Frege that reducing everything to logical notions leads to insurmountable difficulties. It may take some time before the difficulties show up, but once they do, mathematicians are forced to deal with them.

Is this the way God restrains evil in mathematics? I think this is at least part of the story. Also, does God send rain on the believer and the unbeliever alike by making central mathematical realities so transparent that one can't get them too wrong? By making ordinary methods of deductive reasoning acceptable for everyone under normal conditions? Is this what common grace means in the field of mathematics? Perhaps. I don't have definitive answers to these questions. Nevertheless, differing viewpoints about the nature of mathematical entities and proper mathematical methodology show that mathematics cannot be conceived of as a religiously neutral affair, unaffected by one's worldview orientation.

Nevertheless, differing viewpoints about the nature of mathematical entities and proper mathematical methodology show that mathematics cannot be conceived of as a religiously neutral affair, unaffected by one's worldview orientation.

Can mathematical reality (now taken in the sense of what God has created) also be warped in some way? I admit that I find this notion harder to grasp. Are there mathematical properties or relationships that are different after the Fall than before it, things that depend in some way upon a distorting human formation? I don't think so; I frankly don't know what this might be. Weeds sprang up to thwart agricultural efforts; but are there any thistles growing in the field of arithmetic – non-standard models, perhaps? Maybe mathematical ideas are more difficult to comprehend than they might have been if the Fall hadn't occurred, so that math anxiety, for instance, is due to the Fall, but it seems to me that this problem has mostly to do with our understanding of the ideas, not with the ideas themselves.

One might, of course, point to certain limitation results discovered in twentieth century foundations of mathematics – Gödel's Incompleteness Theorem, for example, or the existence of non-standard models for first-order theories – but these simply demonstrate the creaturely limitations of deductive mathematical theories, not something that might have been different if sin hadn't entered the world. As mathematics becomes more general and abstract, however, it becomes increasingly difficult to distinguish between what human beings contribute to the field of study and what realities are given; at times, mathematicians may merely postulate the existence of entities with certain properties to see what consequences this might have, to see what new problems can be solved.

The Motif of Redemption and a Reformational Perspective on Mathematics

Finally, let us briefly explore the third component of the biblical theme: Redemption. Here, too, we can consider the theme both from the human and the divine sides.

1. God's Reclamation Project

God so loved the world that he sent his Son to save it from destruction. Christ's death and resurrection redeems his people and the entire cosmos, and he will one day fully restore the fallen creation to what it was meant to be, enfolding and redeeming its historical development in the process.

All aspects of life are touched by God's act of salvation, including mathematics. In one sense, redemption makes all things new, but in another sense, it doesn't. It frees things to be themselves once again, but it doesn't add a spiritual dimension that was previously missing. The same is true of mathematics. You won't discover a Christian perfect number any more than you will find a Christian songbird in your backyard. Yet mathematics can now become what it was meant to be, an exploration of various dimensions of the creation that God made, used to develop his creation in fruitful ways. Since this use of mathematics occurs through human activity, let us move to the second thesis and say a little more about it there.

2. Human Participation in Reconciliation

As ambassadors of the Kingdom, humans are involved in the process of reconciling all things to God. The creational mandate given in the beginning now includes sharing the good news, striving to relieve brokenness and distortion, and working to bring about harmony and shalom.

Redemption is more than a one-time event in history or our lives. It is also an ongoing process, and here all things human have a role to play, including mathematics. Mathematics can contribute to combating evil and developing our world in healthy ways – its applications can help us better understand and care for the environment, develop responsible technology, and create normative social structures such as more just voting procedures. Whatever has mathematical features, which is just about everything, can benefit from mathematical knowledge, offered in the context of a kingdom vision and a broad understanding of how these features fit into the whole. To underscore what has been said thus far, let me quote the title of my talk: *mathematics is always important but never enough.* We must develop and use mathematics in ways that promote what is good and that reveal a balanced and integral view of its place and meaning within our world.

Reformational Perspective on Mathematics and Religious Neutrality

We've spent long enough expounding a biblical-worldview basis for doing mathematics. Now it is time to zero in on the significance of religious faith for doing mathematics in a more technical sense. We can no longer put off the burning question Christian mathematicians and mathematics teachers everywhere get asked by the skeptics: *Is there a Christian way to brush your teeth?* Well, that's not quite the question we get asked, but it is pretty close.

Let's think about this issue for a minute before we get back on track. It would seem obvious that your faith doesn't make any difference in how you hold a toothbrush or how you move it around in your mouth. Don't non-Christians and Christians do it in the same ways? Furthermore, aren't there variations between how different Christians brush their teeth? Some use their right hand, some their left; some go straight back and forth, others oscillate up and down. Whatever small differences there are surely can't be due to one's religious outlook. Your faith just doesn't dictate how you brush your teeth.

Well, hold on a minute. I can't speak for others, but the tooth-brushing habits in our house have changed over the decades, based on what we have learned. We now use a less commercial toothpaste because of health and environmental concerns: we don't want fluoride or artificial sweeteners or harsh abrasives in our toothpaste or aluminum in the tubes it comes in. In addition, we want our toothbrushes constructed in a way that fits well with their main purpose and that uses resources responsibly. We don't want to knowingly buy a product from a company that uses questionable manufacturing or management practices or that supports causes we think are wrong. Finally, we also want the technique we use for brushing our teeth to be part of an effective program in preventing cavities and plaque buildup. Educating ourselves on this last matter has also introduced changes in our brushing technique over the years, as it may into the future.

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Why do we do all this? What are our motives? Deep down we believe we are supposed to take good care of our teeth, a wonderful gift of the Lord, so that we may use them well for a long time. We also believe that we should do this in a way that contributes to a life of stewardship overall. Naturally, we don't want to obsess so much about caring for our teeth that we fail to do other important things, like socializing with good friends for a while after a meal, but we do want our tooth-brushing to be an integral part of our overall Christian lifestyle and an expression of obedient discipleship.

Does the Bible prescribe, then, a holy technique for brushing one's teeth? I'm positive it doesn't; but that's neither the right question about tooth care nor the right context in which to answer it. Brushing one's teeth is tied up with personal hygiene, environmental considerations, and social responsibility. It has *got* to be part of one's religion, one's life lived obediently before the face of God and in response to creational norms in this time and place. Agreed?

Now back to the task at hand. Is there a Christian way to add 5 + 7 or to apply the quadratic formula or to prove the Pythagorean Theorem? Sure. In the way it was meant to be done! In a way that contributes to a larger pattern of obedient living. Is there only one way to do it, stipulated by the Bible or our theological doctrines? No; but some ways may be more in tune with how God structured this aspect of creation or may be more appropriate in one context or time than another. Will the ways these things are done clearly demonstrate a religious core or a worldview foundation or a philosophical outlook? Possibly not. For one thing, it is not the role of religious commitment or worldview or philosophy to prescribe the content of our knowledge. Like everyone else, Christians need to diligently study God's creation to learn how it works. For another thing, a religiously oriented worldview provides the overall framework and deep-seated motivation and broader meaning for directing what we do; it is not something that we normally embroider on the surface of our results. Will we be able, then, to see a difference in the technical details of our mathematics or our educational practices? Perhaps not, especially if we are going to be myopic about it and insist that adding 5 + 7 or applying the quadratic formula or proving the Pythagorean Theorem must be treated in isolation from the larger context of mathematics and everyday life.

What, then, should we expect a biblical worldview to do for mathematics? Among other things, it ought to set the deepest meaning-context for our engagement with and perspective on mathematics. It ought to give us a strong sense of how mathematics fits into the overarching cosmic drama of Creation-Fall-Redemption. It ought to help us discern whether certain ways of relating mathematics to the rest of life are good or bad. It ought to give us a vision of how mathematics can contribute in an integral cooperative fashion with other disciplines to open up various areas of life in fruitful ways. It ought to provide us with rudimentary intuitions about whether certain ways of viewing mathematical content overall will be productive or will end up distorting the field. A biblical worldview, I have been arguing, will treat mathematics as a field that investigates certain important but limited aspects of creation structured by God, not as a field dealing with eternal truths or parts of God's nature or the central structure of all reality or purely human conventions or any other alternative proposed by thinkers inspired by non-Christian beliefs or the desire to accommodate them. Framed this way, I'd say a biblical worldview is very important for developing a Christian perspective on the field of mathematics.

Worldviews and broad philosophical perspectives set implicit agendas for mathematical development: they give underlying direction to research programs, they define the conceptual frameworks in which questions arise, and they predispose us to look for certain types of answers and not for others. They also guide our overall approach: they bias us more towards some methods of inquiry than others or to more readily accept or reject certain notions and principles in technical matters. These things are so, I think, whether or not the formal mathematical superstructures look deceptively the same for mathematicians having very different outlooks. Delving into the history of mathematics can help us uncover some of these worldview connections and milieus. Divergent attitudes toward deductive thinking by the Greeks and the Chinese in ancient times led them to value and use reasoning differently as a method for establishing mathematical results.[9] Concern for the lack of rigor and precision of algebraic procedures evidently led the Greeks to turn away from incorporating them into their system of mathematics: number theory rated treatment alongside geometry but not computational arithmetic or algebra. Similarly, the Greek point of view that only whole quantities measured by some unit are numbers and that fractional parts of quantities belong to the sordid practice of everyday life led them and later mathematicians to work only with ratios of whole numbers; the arithmetic of fractions needed to wait for a culture that valued such practical commercial matters.

As we begin to ask questions about the broader context and deeper meaning of mathematics, differences between mathematical traditions become apparent. Will these be differences in mathematics? I'd say yes; but my saying so depends on a more holistic notion of mathematics. If mathematics is restricted to the sterile Euclidean litany of axiom-definition-theorem-proof, to the surface-level of formal statements, most of what we see in core mathematics will be the same for everyone. However, as soon as we inquire about underlying meaning and interpretation – something many mathematicians seem trained to ignore – sharp differences appear, ones that reveal divergent worldviews and beliefs about what should be taken as ultimate or divine. Thus, if we broaden our definition of mathematical discourse to include motivation and organization of ideas, applications, methodology, and broader contexts of meaning, and if we also include typical mathematical practices as they occur in everyday life, the differences we find will be integral to the field of mathematics.

Lest we lose our focus in all this, however, the main objective, as Nick Wolterstorff once said about Christian scholarship in general, is not to be different but to be faithful. I believe that differences will show up in the area of mathematics, as elsewhere, both when we dig deeper to ferret out what various results really mean for the person or school of thought developing them and when we zoom out to take in the broader picture, but this difference is only a byproduct of what we should be doing. Our calling is to pursue mathematics obediently – in a way that will please God, do justice to what he has created, and be of benefit to others. It should not be our goal to look strange while we do this.

Reformational Perspective on Mathematics Education

How, then, *do* we teach mathematics Christianly on the various educational levels we represent? My reflections about how to do this go back to my college days, but they intensified when I was in graduate school. It was 1970, and I was studying mathematical logic and axiomatic set theory at the time – technical foundations of mathematics – but I had a strong interest in history and philosophy of mathematics, something that had been kindled by my college courses in history of philosophy. One day I was in a used bookstore, browsing through their mathematics section, when I came across a booklet put out by a group of new math educators in the greater Cleveland area. As I paged through their proposal for the primary grades, I was dumbstruck. They suggested teaching children about sets and one-to-one correspondences before moving on to deal with numbers. The number of a given set was then introduced not via counting but as the essential property that all the collections in one-to-one correspondence with that set had in common. Well, if that wasn't mashing up the logicist foundations of mathematics (due to Frege and Russell – then already discredited, by the way) to make mathematical pablum for young children! That was the first time I saw concretely that a highly developed philosophical viewpoint, grounded in a worldview (in this case, an outlook that deified logic), could help set the agenda for an entire mathematics curriculum. It made a strong impression on me. Why couldn't a Christian worldview and philosophy of mathematics give the same sort of direction for developing a mathematics curriculum?

Consequently, when I was asked to be a part-time consultant for the Curriculum Development Centre in Toronto for their elementary school mathematics program, I agreed, even though I didn't really know what I had signed on for. Over the next few years I became much more familiar with both pedagogical and curricular issues in mathematics. The tangible outcome of this work was a co-authored companion volume to CDC's *Joy in Learning*, a book called *The Number and Shape of Things*. I don't know how influential that work was – it's no longer available in print, and few people I know have ever heard of it – but working on it was formative for me; it shaped my views on mathematics education ever since.

We operated with a number of key principles in that program, insights I still hold as central to Christian mathematics education. These are not earthshaking or brand new, but since they are also not the status quo in today's textbooks and classrooms, we should talk about their validity and how to put them into practice. For organizational convenience, I will collect my thoughts under two main theses – the first related more to curriculum, and the second more to pedagogy.

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1. The Study of Mathematics Should be Reality-Oriented.

This is the most basic educational principle. Since mathematics arises from our everyday experience of certain aspects of creation, it should be taught and learned in a *reality-oriented* way. How this idea builds upon the perspective that I've already outlined should be fairly obvious. Let me spell out a few of its implications for the mathematics classroom, as I see it.

For one thing, this means that mathematical constructs should be drawn from and linked to numerically and spatially rich experiences appropriate for the students' ages. This linkage should certainly occur on the lower elementary levels but also at higher levels. Mathematical ideas are embedded in and can be applied to concrete experiences. They do not simply arise from the pages of a textbook, to be drilled into the students with worksheets. If we don't connect the mathematical concepts and algorithms that we teach to things that are important in students' lives, we are depriving them of some essential motivation for learning the material. The traditional textbook approach is too narrowly tied to the structure of the discipline and is too cook-bookish. The conventional method of first illustrating a problem-solving technique by means of several examples, with or without some general explanation of the process, and then asking students to mimic that technique in their homework develops terrible habits for learning mathematics, and it undoubtedly contributes to math-phobia and bad attitudes toward mathematics. Students begin to think mathematics has everything to do with filling in templates and little to do with anything else; yet the whole point of studying mathematics is to develop new and deeper insights into the creation we live in, not to get the answer in the back of the book using a prescribed method. Sure, students need to practice and even automate certain skills to become mathematically competent, and that may take some extended disciplined effort on their part. Even here, however, we can use concrete manipulatives (a half-way house between full-blooded reality and abstract mathematics) for as long as they are needed. And we should be creative enough to incorporate more than worksheets – games and puzzles, for instance – into our diet of exercises. Having students succeed at timed multiplication tests is no accomplishment if they don't know which situations require multiplication and why. They should see that what they are learning helps them to better understand and interact with the world around them.

Older students can learn that there are both good and bad ways to use mathematics and that mathematics should be used to help them become more obedient disciples of Jesus Christ. This is where we can go beyond the theme of creation to consider how mathematics ties in to fall and redemption. How has measurement or statistics been developed and used by various people, and how might we use it to interact with others in wholesome ways, work for justice, and strive to be stewards and earth-keepers of the resources God has given us? These goals cannot be accomplished if mathematics is taught in isolation from other areas of the curriculum and abstracted from life. Measurement needs to be concerned with more than simply measuring and converting units; statistics needs to be more than abstractly learning about different means and notions of variability. Mathematics needs a context. Let me repeat the title of my talk once more in this context: mathematics is *always important* but *never enough*.

Mathematics can become a full partner in the school curriculum in several different ways. It might make a contribution to a bigger topic that is being studied from many different angles. For example, a social studies unit on Egypt might focus on its culture and daily life, its climate, geography, and agriculture, its government and society, its religion, its art and architecture, its astronomy and science, and so on. Someone who has explored the mathematics developed by the Egyptians will be able to pull a number of related mathematical topics into the mix, depending on the mathematical preparation of the students. Interdisciplinary units can also be developed that look at how mathematics relates to other fields. For example, a simple study of moving bodies might be a cooperative effort between physical science and mathematics, incorporating notions of heterogeneous ratios or rates of change, direct proportionality, and linear graphs. Or, mathematics might venture out more on its own, looking at how a big idea such as numerical coding gets implemented in different ways in a variety of everyday applications: bar codes, zip codes, UPC codes, ISBN numbers, etc.

Focusing on connections between mathematics and other things doesn't mean we should never pause to take stock of what we've been doing or spend time developing the essential ideas and procedures more systematically. But it does mean that the mathematical systematization we do should build on the students' familiarity with the everyday value of those mathematical topics. Before we try to consolidate their mathematical knowledge, we should make sure students have explored the ideas in ways that develop genuine mathematical intuitions as a solid foundation on which to build the conceptual superstructure.

2. Mathematics Instruction Should Actively Engage Students and Strive for Understanding.

We unavoidably strayed into pedagogy as we talked about the curricular focus of mathematics. But now let us more intentionally examine the process of learning mathematics. I'll divide this into three stages.

Students should begin to learn about a new mathematical idea in an *exploratory stage*. As teachers, we should structure concrete situations to motivate important mathematical topics; students should investigate them at some length in a rather open-ended way before beginning to firm up their ideas. Using a variety of word problems instead to introduce a concept (or even to practice a process) may be too abstract and insufficiently real for students. If they never explore larger contexts in any depth, students will soon conclude that mathematics is all about following rules and picking up verbal clues from word problems to see what to do with the numbers mentioned. Then whether their answer makes sense or not isn't that critical: after all, it's only a problem in the book used for practicing a skill. That's definitely not the message we want to get across! Students need to be actively engaged in concrete projects so that they get to experience for themselves that mathematics is meaningful. They also need to experience the excitement and joy of discovering some procedures and properties and connections on their own.

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While we may be tempted in the cause of efficiency to force students into the mold of doing things the right way early on, we should, instead, encourage them to develop valid methods of their own during the exploratory stage. Toward the end of first grade, my youngest son invented his own method of adding two-digit numbers to one another. Essentially, he used counting to add the tens before adding on the ones. Being a mathematics professor, I tried to show him a method that added the tens and the ones independently in order to move him more toward the standard addition algorithm. He considered it briefly but decided his way was just as good as mine: and it was, so I didn't press the point. (However, he now adds in his head roughly the way I suggested then, from left to right, as do many mathematicians. History of mathematics teaches us that people have always done things in many different ways.) Naturally, there will never be sufficient time for everyone to discover everything, and the discovery process should always be teacher-directed to some degree, but whatever students learn through their own exploration will be better learned than if they do it by rote memorization.

Once students have explored a topic, they need to study the ideas more systematically to fill out their understanding and fix the ideas and procedures. Here textbook materials and direct teaching can play a larger role than in the exploratory stage, though students must still be active participants in the process. The primary aim of this more *conceptual stage* should be genuine understanding of the various aspects of the mathematical topic. This means that students should learn more than simply *that* a statement is true or *how* an algorithm works. They should understand, at their level, *why* it is true and *why* it produces the correct answer. This kind of understanding requires a growing understanding of connections, of the bigger picture as well as the linkages. In addition, then, to helping students see how mathematics relates to real-life situations, we must work to help them see how mathematics itself is interconnected and meaningful, how it ties into and extends what they already know. These links can be explored and explained, by us and our students, using reasoning and writing – again, on an appropriate level. Mathematics is not the magic art of formula incantation and should not be studied as if it were. It is the premier discipline of interconnected ideas; to ignore these inner relationships is to gut the discipline and cheat students out of perceiving its amazing coherence and unity. Without seeing the web of connections, inside and out, students perceive mathematics as an unmanageable mass of disjointed facts needing to be memorized. Students can cope with mathematics using a rote approach only so long; eventually they suffer memory-overload. Some may even make it as far as college, but then this approach fails them, something I've seen happen. For one thing, mathematics becomes too rich to memorize all the possible permutations needed for problem-solving (Saxon notwithstanding), but for another thing, at advanced levels mathematics becomes explicitly focused on deductive explanations (proofs), the very thing that has been avoided all along by the coping mechanism.

Once students demonstrate facility with mathematical ideas and procedures, they should be asked to extend these ideas and procedures into new situations – to reintegrate and apply them in other concrete situations, and to relate them to new mathematical ideas. This *extension stage* may trigger a whole new round of mathematical learning: exploring, conceptualizing, and extending. Harro Van Brummelen includes a nice discussion of this learning cycle in *Walking with God in the Classroom* (1998). He breaks the cycle up into four main phases: setting the stage, disclosure, reformulation, and transcendence. His second and third phases pull my second stage apart into two components that are more instructor-weighted and more student-weighted respectively, but otherwise they're about the same.

This model of learning makes good sense to a mathematics teacher, something Harro knew first-hand. However, I'd like to add a brief postscript in order to emphasize the importance of the larger setting of education. We can construe this cycle in too pragmatic a fashion so that we end up focusing rather narrowly on the content of mathematics and its problem-solving capabilities. Doing this would be better than what is often done, but mathematics is still richer if its broader context is taken into account. Soon after I started teaching, I committed myself to designing my mathematics courses so that they would pay balanced attention to four things: theoretical matters (definitions, theorems, proofs), algorithmic procedures and technology, significant applications, and broader contexts (relevant religious, historical, and philosophical issues). After working on Dordt College's *Educational Framework Document*, I now conceptualize this slightly differently. I want the mathematics I teach to touch on what we call, in-house, the *four curricular coordinates*: *religious orientation* (basic perspective and worldview matters, as in the first part of this talk), *creational structure* (theoretical elements, procedures, and methods, as well as any intrinsic connections with other areas), *creational development* (the historical origin and development of the topics being studied, along with the broader culture of mathematical practice), and *contemporary response* (applications and discipleship implications). As my students will no doubt attest, I succeed in this to different degrees in the various courses I teach. However, given my particular training and interests, I do seek to draw upon the history of mathematics wherever it fits. This is a focus that probably doesn't make much sense for mathematics until the middle school and high school levels, but I think it has great potential to enrich and inform what we do there as well as on the college level.[10]

As mathematics teachers, we get excited when we see how mathematical ideas are applied to the world around us, and we feel deep satisfaction when we see our students discovering things on their own and gradually improving their abilities, and we really enjoy explaining something so it becomes transparent to our students. The whole point of what we do, though, of including various stages in our teaching and placing them within a broader context, is to help our students become more mature competent disciples of Jesus Christ. To use the terminology of John Van Dyk in *The Craft of Christian Teaching* (2000), we want to *guide* our students as we *open* them *up* to the world of mathematics so that they are *enabled* to do works of service in God's kingdom, using the knowledge and competencies they have developed in our classrooms and elsewhere.

Let me close by issuing a challenge. Maybe some of what I've written suggests a new way to think about the relation between Christian faith and mathematics or mathematics education, but I don't consider myself a grand innovator. Mainly, I'm a teacher. I'm trying to take some basic ideas that I've learned from others over the years and shape them in such a way that their value and relevance for mathematics becomes clearer. Especially as I was developing this last section on mathematics education, however, I began to doubt whether I was saying anything you wouldn't already know. I know it doesn't really go much beyond what I already said in a CDC newsletter of 1980. So how will we get anything to change? I think we all agree, however, that the reality of our classrooms still falls short of the ideal. Why is this? I know the reasons as well as anybody else: this approach is far from being mainstream, so it would take a massive amount of work to revamp the curriculum to make it consistent with our principles. And who has the time for this, especially given the press of class preparation and grading and meetings and . . . I think family and other things are supposed to come in there somewhere, too, aren't they? We just do the best we can with commercial textbooks created by people with an entirely different vision of the importance and role of mathematics, knowing that most of our students are still developing mathematical competencies they can use in a variety of contexts. Where we can, we enrich the classroom by bringing something in that fits better with our perspective of what mathematics ought to be. Maybe it is not much, but it is something. Each of us develops an idea or a unit for our own class, but usually nobody else knows what we've done or why.

We have an opportunity to start changing that isolation.[11] Maybe we're not ready to publish our own textbook series implementing the sort of vision I outlined above (is this because mathematics isn't as important as "more religious" subjects in our schools?), but with a network of teachers interested in this topic, across all levels of education, we ought to be able to share ideas with one another. Let's encourage one another to do professional good works as we teach mathematics to our students. Maybe something bigger than what any of us has done can eventually come from all this.

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Endnotes

1. This opening letter tells my granddaughter (and the conferees) in simple language what I think the main points of my talk are going to be.
2. John Van Dyk, the central organizer of the B. J. Haan Conference, is the author of the 1997 Dordt Press book *Letters to Lisa: Conversations with a Christian Teacher.*
3. The biblical viewpoint I'm developing here is in line with the reformational tradition stemming from the thought of the Dutch Christian philosophers Herman Dooyeweerd and Dirk Vollenhoven, a tradition with its roots in the writings of their predecessor Abraham Kuyper and even further back in the work of John Calvin and St. Augustine. Al Wolters' *Creation Regained* (2005) gives a good exposition of the contours of a Reformational Christian worldview, as do Walsh and Middleton in *The Transforming Vision: Shaping a Christian World View* (1984); Roy Clouser's *The Myth of Religious Neutrality* (2005) argues the philosophical case for why all theories are religiously grounded. A confessional summary of this worldview can be found in the *Contemporary Testimony* of the Christian Reformed Church, *Our World Belongs to God.*
4. This view can also be explained partly by the way modern mathematics and philosophy of mathematics has developed since the middle of the nineteenth century, but we won't pursue this topic further here.
5. Except, of course, where God has chosen to take on creaturely form, such as in the incarnation of Jesus Christ, a mystery we will never fully comprehend.
6. I develop this theme of the mathematization of reality in more historical detail in *Mathematics in a Postmodern Age: A Christian Perspective.* See especially chapters 5 – 7; chapter 7 was co-authored with James Bradley, one of the book's editors.
7. This outlook is explored and strongly criticized in *Descartes' Dream: The World According to Mathematics* (1986) by Davis and Hersh.
8. A more contemporary example of this approach is found in Alvin Plantinga's 1980 book *Does God have a Nature?* See especially the concluding pages (140ff), where he argues that affirming the existence

of mathematical objects (construed as uncreated necessary beings) is an essential part of God's nature. Thus, in a real sense, mathematics and logic can be considered parts of theology.

9. Glen Van Brummelen develops this and related ideas in his contribution (chapter 2) to *Mathematics in a Postmodern Age: A Christian Perspective*.

10. The college course I regularly teach to prospective middle school mathematics teachers takes such an historical approach to standard topics on this level. In the coming years Dave Klanderman and I hope to develop curricular materials suitable for such a course and as supplementary material for middle school teachers.

11. Other developments, such as the Kuyers Institute Math Curriculum Project (see http://www.calvin.edu/kuyers/), which was represented in a workshop at the B. J. Haan Conference, likewise offer hope for change.

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