

**In Educational Games,  
Complexity Matters**  
**Mini-games are Trivial - but “Complex” Games Are Not**  
**An important Way for Teachers, Parents and Others to Look**  
**At Educational Computer and Video Games**

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**I**n my view, most of the rancorous disagreement about using “games” in – and for – education stems from a fundamental difference across generations about exactly what the word “game” signifies.

This is not surprising, since when today’s adults were growing up games meant one thing, but since that time an entirely new kind of game – I call it the “complex” game – has evolved, about which today’s adults know practically nothing. Aside from watching their kids get absorbed in these games, and hearing things (usually bad) in the press, most adults have no first-hand knowledge of these “complex” games at all. So an understanding of what most kids are talking about when they say “game” that is adequate for judging whether or not these experiences are valuable (and I think, along with many others, that they are) is not only totally absent in most adults, but is also almost totally inaccessible even to those adults that are interested. Precisely *because* of these games’ complexity, such access requires a tremendous effort, which few adults – including, notably, almost all of those who criticize such games – will ever put in.

My goal in this article is to fill in – to the extent one can without actually playing the games – this important “blind spot” in adults’ knowledge of their kids’ games. In doing so I hope to help all unaware parents, and teachers and other adults (whom I often call “Digital Immigrants”<sup>\*</sup> since they were born too early for this technology to be “theirs” in a Native way) understand what these new “complex” games are, and why they are so important to our kids, to education, and, ultimately, to us all.

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<sup>\*</sup> For more on this useful metaphor see my article “Digital Natives, Digital Immigrants” : <http://www.marcprensky.com/writing/Prensky%20-%20Digital%20Natives,%20Digital%20Immigrants%20-%20Part1.pdf> )

## Many Ways to Look at Games

Since video and computer games have emerged (rather stealthily) to become one of our culture's largest forms of entertainment in terms of dollars spent, much is being written these days about them. In addition to the game press and the public press, the study of games is now an academic specialty as well, known as "ludology."

Ludologists point out for us many important things about games, such as the different roles games have played throughout the ages. Ludologists help divide games into "genres," such as adventure, strategy, and puzzle. They search for the "core" elements that make games games, and not something else. And they look at what contributes to game's being fun, and at why people play them.

All of the multiple ways these specialists look at games are useful. But here I am talking much more fundamentally. In this article I make only one distinction – that between "mini games" and "complex" games.

Yet although it may appear a simple distinction at first, the implications stemming from my perspective are not simple at all. They are, in fact, extremely important, particularly for educational games' moving forward in the future.

(If you are interested in learning more about any of the other topics mentioned above, and about ludology in general, please see the bibliography at the end of this article.)

## Digital Immigrants' Games were Trivial Pursuits

Let us go back a moment to the days *before* personal computers – pre-1981. In those days, when most of today's parents and teachers were growing up, the games the kids (who are now today's adults) played were mostly devoid of any great importance, meaning, or learning. In other words, they were trivial. In fact, the last, hugely successful non-computer game, which totally summed up its era, was named *Trivial Pursuit*. Learning, if there was any, was mostly limited to trivia.

Almost all the pre-computer games were card or board games. (I am excepting physical games and sports, which have remained the same pre and post computer – except for their strategies.) The pre-computer games typically took no more than an hour or two to play (and often less.) With only a few exceptions such as *Bridge*, *Chess* and *Go* – which were played seriously by relatively few – games of the pre-computer era gave kids very little to reflect on or learn at a deep, or thoughtful level. Sure, kids may have learned a few economic lessons from *Monopoly*, but games, back then, were mostly games. Distractions, if you will. A way to pass an idle hour on a rainy day. *Trivial pursuits*.

## Consequences

The consequences of this situation are large, and extremely important. *Because of these formative game-playing experiences growing up, when today's teacher (or parent or educator) hears the word game, their first reaction is: "trivial."* And they don't want this "trivial" stuff to be part of their child's, or children's "serious" education. So they reject games out of hand as a serious learning tool. To them, it all makes perfect sense.

When this happens, the adults are having what writer Malcolm Gladwell, in his latest book, describes as a "Blink," reaction – one that happens very quickly without conscious thought. Blink reactions, as Gladwell points out, can sometimes be very accurate. But as Gladwell also points out, *"blink" reactions are, in many cases, tragically wrong – especially in cases where people are not fully informed from their background.* And that is precisely what is happening in the case of most adults when they think about games

### What Their Experience Taught Is No Longer True

Without their knowing it, a huge piece of data is missing from the Digital Immigrants' experience and perception of games. What keeps these otherwise bright, perceptive people from seeing the world of games as it actually is? Here's my sense: When these adults look at computers (superficially, to be sure) they often see games being played – such as *Scrabble, Poker, Monopoly, Clue, Mah-Jong* – that are almost the same (again superficially) as the ones they played as kids.

And when these adults look at so-called "educational" games on the computer, (including the hundreds of online games at Web sites such as NASA, UNICEF, National Geographic, the Nobel Prize site, and various math, science and other specialized sites), and at educational games found in stores, such as *Carmen Sandiego, Oregon Trail, Reader Rabbit, and Math Blaster*, they again find games not so dissimilar from the games they already know: games that take less than an hour to complete (often far less), and whose content is simple and one-noted.

While the adults agree that many of these "small" games are fun for kids (and sometimes even fun for themselves) the adults also know that whatever "content" these games contain is narrow and shallow. They know that when compared to what education is all about, the games they are seeing on computers are *trivial*.

And they are right.

*Because they are only seeing half the games.*

### Mini vs. Complex

The games I just described, which are the entertainment games and the so-called educational games that most adults know about, are what I call “*mini-games*.” And mini-games, with rare exceptions, *are* trivial. (My colleague Bonnie Bracey calls them “bubble gum games.”) But today, *mini-games are only a fraction of the games out there*. (The precise fraction is hard to quantify, but it’s maybe one-half in terms of number.) The remaining games – certainly well over one-half in terms of time spent playing – are an entirely new animal, the “complex” game.

### **“Complex” Games**

Complex games developed gradually over the past 25 years, enabled totally by the computer. Unlike mini-games, these “complex” games typically require tens of hours of concentrated attention to master. They demand the learning of multiple skills, as well as the ability research and communicate outside the game. Complex games are almost exclusively what is sold in the game stores.

Most adults, however, *have never experienced a complex game first-hand as a player*. So they don’t know about these games except by hearsay. And what they hear is often wrong. What they especially don’t understand that these “complex” games are *not trivial at all*. In fact, they are among the most non-trivial pastimes ever invented, requiring enormous amounts of effort, skill, and, most important to us, learning.

Importantly, it is complex games – not mini games – that kids mean when they talk about games, and it is complex games – not mini games – are what kids want when they request educational games. One high school student describes what he is looking for as: “Multiplayer, creative, collaborative, challenging, and competitive” In other words – “complex.” Not mini. Not bubble gum.

### **Let’s Speak Correctly**

When talking about “games,” especially in education, we all – parents, teachers, educators, writers, researchers – can raise our level of discourse and cross-generational communication by carefully distinguishing between mini-games, as described above, and the “complex” game, the relatively new animal I will describe in a minute. (Note: while complex games are new for adults – they’ve always been there for today’s kids, who grew up with them.)

When discussing the merits and educational value (or lack of value) of any educational game, we should state up-front whether the game we are talking about is a mini-game or a complex game. Rather than say “Educational Games are trivial”, we ought to say “Educational Mini-games are trivial” (and “Educational Complex Games are not.”)

### **How to Tell**

The distinction between whether a game is a mini-game or a complex game can generally be made *prima facie* (albeit superficially), solely on how many hours it takes to complete or master that game. Mini games take 2 hours or less; complex games 8 hours or more, all the way up to over 100 hours in some cases. A few games fall in the middle, but typically tend to one side or another.

Time to complete or master, though, is really just a proxy for the game's complexity: Mini-games have little complexity – they typically provide one single type of challenge (along with minor variations). Complex games provide a sophisticated mixture of difficult challenges that typically intertwine and support each other. Complex games often have one or several mini-games embedded within them for specific learning purposes.

### Examples I: Mini-Games

Mini-games include almost all 52-card-deck card games, such as *Solitaire*, *Poker* and *Hearts* (*Bridge* is an arguable exception.) They include all quiz and question games, from *Jeopardy*, to *Millionaire*, to *You Don't Know Jack* and *Trivial Pursuit*. They include almost all board games, such as *Checkers*, *Scrabble* and *Monopoly* (*Chess* and *Go* are possible exceptions). Mini Games include the wonderful puzzle games found at [www.popcap.com](http://www.popcap.com), including *Atomica*, *Bejewelled* and *Bookworm*. And mini-games include practically all of the small “learning games” found on a great variety of Web Sites, including the BBC, National Geographic and others. (A great many of the mini-non-entertainment are cataloged on my site [www.socialimpactgames.com](http://www.socialimpactgames.com).)

Non-educational mini-games are often referred to as “Casual” Games. Whatever you call them, casual/mini-games have tremendous popularity as pastimes, and will be continuing to grow in numbers. Recently, cell and mobile phones have emerged as an important new platform for this type of game.

In education, thousands of mini-games exist, many of them built by teachers.

When transferred to the computer, many of today's mini-games gained some complexity. The computer keeps track of multitudes of details better than human players, allowing *Solitaire*, for example, to be played with multiple decks. The computer enables more graded variations on a particular play type, allowing one to move through 50 levels of *Bookworm*.

***But even with all this, the important thing to remember about mini-games is that they are always “mini.”*** They treat only one subject, puzzle or gameplay type in a small way. They are (almost) always trivial.

### Useless?

However the fact that mini-games are trivial does not by any means make them useless. Mini-games are good for good for relaxation and breaks, as in *Solitaire*. They are good for exercising the brain, as in *Scrabble* or *Bejewelled*. They are good for making specific points, as in *September 12*, and for accomplishing specific tasks, as in *The ESP Game*. In education, mini-games are good for providing motivation to practice particular focused skills. But *individual mini-games don't educate. They lack the breadth and depth necessary to do so.*

Digital Immigrants understand mini-games. Although sporting new features, these are often the same games (and certainly the same size games) that the Immigrants grew up with.

This is why most of the educational games found on the Web (and even in stores) are mini-games, **designed and built by Digital Immigrant teachers and educators.**

And it is also why many parents, teachers and educators see “games” as essentially trivial – mini-games are. *But people who think all games are trivial are ignoring half the picture.*

### The “Complex” Game

An entirely new type of game has emerged since the advent of the mini-processor and personal computer – the “complex” computer and video game. And what this is is something that most adults – parents, teachers and others – don't “get,” although they have probably paid for most of the ones sold.

One reason this knowledge has been so hidden from them is that there is no generally accepted term for what I call the “complex” game. “Complex” is my own suggestion, although I'm not sure it completely does the job. Some use the term “hard core,” as in “hard-core gamers” and “hard-core games,” (but that term also has some unfortunate connotations.) Games are usually described by their “genre,” but complex is a descriptor that crosses, and exists in, all genres.

The “complex” game, in the sense that I mean it here, *did not exist* when Digital Immigrants (most of today's parents and teachers) were growing up. It is a new animal. It is different even from the advanced games of the past, *Chess*, *Bridge* and *Go*, which are, comparatively, really “mini games on steroids” in that their game play is simple and repetitive, but in those special cases it leads to enough variety and difficulty to make those games challenging and hard (or impossible) to fully master.

*Chess*, *Bridge* and *Go* are not what I mean by today's “complex” games. ***Today's “complex” games are something else – a new species of game. And unless you, as a parent, teacher or educator understand this, you will never understand why kids love these games, learn so much from them, and clamor to have them as a basis for their school learning.***

## What Makes a Complex Game?

What makes a “complex” game different from a mini-game is that a complex game requires a player to learn a *wide variety of often new and difficult skills and strategies*, and to *master these skills and strategies* by advancing through dozens of ever-harder “levels.” Doing this often requires both *outside research* and *collaboration with others* while playing. (Is this starting to sound like something that might work in education?)

The “levels” in a complex game may consist of building bigger, more complex cities or civilizations (e.g. *Sim City*, *Civilization III*, *Rise of Nations*), conducting harder and more challenging campaigns (e.g. *Age of Empires*, *Age of Kings*), confronting harder and more challenging enemies (e.g. *Harry Potter*, *Lord of the Rings*), solving harder and more challenging puzzles (e.g. *Myst*, *Riven*), completing more and more challenging quests (e.g. *EverQuest*, *City of Heroes*, *World of Warcraft*) or meeting other challenges of increasing subtlety and complexity.

For your game “character,” in complex games you must often choose among dozens of professions and races. You must choose how your skills are distributed among different abilities. You must choose a religion, a gender, and a guild, and whether you are on the good or the “dark” side of things, which determines your ultimate goals. All these choices determine the kind of experience you will have when you play the game. Actual play involves interacting with a wide variety of people, both simulated and real, and building up a variety of different skills.

Complex games are filled with ethical dilemmas and choices – What side do I take? Am I better off talking a direct aggressive path or a circuitous stealthy one? Just because I can hurt a player, should I? What are the consequences of my choices? (Anyone who thinks the choices in games have no meaningful consequences should find a kid who, through bad choices, lost a long-developed character! “Inconsolable” is the word that comes to mind.)

Complex games offer the player anywhere from ten to over 100 hours of game time, all the while building toward a climactic finish. Obviously the time to learn and beat a game varies with a player's experience, but it is not uncommon for a player to spend 20 to 60 hours mastering a single game. No wonder kids spend so much time in front of the screen! They're not just playing *Solitaire* over and over (as their parents often do.)

## Why They Play

Adults who wonder why kids are so driven to get back to their computer and video games (almost all of which are “complex”) and why kids don't easily abandon them to go do another activity as the adults do with their mini-games, should consider the following features of complex games.



The most important feature of these, and the one most often cited by players, is getting better through “leveling-up.” Leveling-up literally means getting to the end of one level and starting another. *Emotionally*, though, it means *feeling yourself getting better at the game*. In the words of one young gamer: “I *love* getting level-ups – knowing I’m getting better. I started at level one and now I’m on 40. Now I can do more things. I can keep going and it’s really fun.” Players of all ages and sexes invariably give similar answers – they love the feeling of “getting better” at something, of achieving mastery over something difficult and complex – something they couldn’t do at all when they started. Very often a player who has just taken one character to a very high level in a complex game will start another from scratch – just to show him or herself how much faster they can do it – i.e. how much they have learned.

This should not surprise us. It is the same feeling we get from getting better at our sports, our hobbies, and (if we are lucky) our jobs. Mihaly Csikszentmihalyi, a professor at Claremont Graduate University is well-known for describing the pleasure from this type of mastery at successively higher levels as the feeling of “flow,” or of being in a “flow state.”

Achieving a true “flow” experience, however, requires yet another factor besides “leveling up,” a factor that complex games also provide. That second factor is remaining in a narrow zone between things being too hard (“I give up”) and things being too easy (“I’m not challenged at all.”) As long as the game remains constantly just hard enough to make the player feel challenged, while also providing the feeling of “I can do this if I really try,” people will want to continue playing. Complex games do this extremely well – it is what they are designed to do.

### **Adaptivity**

And, since the “flow zone” is obviously different for each person, complex games employ yet another important strategy to keep their players in the zone – something called “adaptivity.” A complex game adapts to each player’s skills and abilities through highly advanced artificial intelligence programs that sense just how a player is doing, and then change the game slightly whenever the player leaves the “flow zone” in order to move that player back into it.

Adaptivity happens both when players are ahead (i.e. finding the game easy) and when they are behind (i.e. finding the game hard.) Examples of adaptivity when a player is behind include making navigation (e.g. steering) easier, giving the player more “power-ups,” offering the player easier quests, providing the player with computer-generated “buddies” to handle some of the more dangerous characters or situations, and giving the player more powers or ammunition. When a player is doing well, and the game is becoming too easy, adaptivity includes automatically increasing the difficulty on many fronts, and limiting or eliminating things like free power-ups.



This “adaptive” feature of complex games is something that was difficult or impossible to achieve in popular games before the advent of computers (although conceptually it has been around forever in the form of “handicaps.”)

Modern complex games adapt automatically, “on the fly” to every player, individually. Having your game set itself precisely to your specific abilities is a very powerful attraction.

### **Worthwhile Goals**

In addition to “leveling-up” and adaptivity, a third distinguishing feature of complex games is having worthwhile goals, goals that players really want to achieve. Unlike the goal of, say, “learning geometry,” the goals in complex games are goals kids can relate to, often requiring the player to “be the hero” and take the role of someone accomplishing many difficult and demanding tasks. The game *City of Heroes* invites kids to “a place we can all be heroes.” *Harry Potter and the Prisoner of Askaban* reminds players “Harry Needs His Friends!” The game *Rise of Nations* informs them that “The entire span of human history is in your hands.” Again, powerful stuff.

Making sure the player’s goals are clear and compelling is a major piece of game design. Goals are provided on several levels, including very short-term goals, such as “I need to get to place X and do such and such” or “I need to beat this puzzle, monster or boss;” medium-term goals such as the now-famous “Just give me just one more hour, Mom, I want to finish the level;” and of course long-term goals such as really wanting to “beat” (i.e. win) the game, or to reach particularly high levels.

In many of today’s complex games, such as *The Sims*, precise goals are not provided, but are rather left for players to set for themselves. It hardly needs mentioning that the goals we set for ourselves are the ones we are most motivated to reach!

While I have described a few of the most important factors driving kids to play their complex games for hours on end (maybe you thought it was the graphics – well it’s not) there are many additional factors as well, including: struggle, cooperation and social interaction with others, and the ability to create, and to share (or even sell) one’s creations. (And note, by the way, that being “driven” to play is far different, in almost all cases, than the derogatory and inaccurate term “addicted.” Think, for example, of golf, or even shopping. Many of us are driven to do these things, and we do them quite a lot, often neglecting other responsibilities. But very few of us are actually “addicted” to them, other than metaphorically.)

Note also that some of the same factors that make complex games so engaging also exist in some of the best mini-games, such as those from Pop Cap ([www.popcap.com](http://www.popcap.com)) . But the complex games employ them in much broader, deeper, and complicated combinations of story, skill, and required mastery.

## Examples II: Complex Games

I have already mentioned games such as *Sim City*, *Civilization III*, *Rise of Nations*, *Age of Empires*, *Age of Kings*, *Harry Potter*, *Lord of the Rings*, *Myst*, *Riven*, *EverQuest*, *City of Heroes*, *World of Warcraft*, but there are hundreds more. “Complex” games includes almost every game that comes in a box, whether for PC, or for console (i.e. Playstation2, Game Cube or X-Box.) The category also includes a great many of the games for handhelds (GameBoy, PSP.) Most simulation games, including *Sim City*, *The Sims*, and all the “Tycoon” Games (*Airport Tycoon*, *Cruise Ship Tycoon*, *Mall Tycoon*, *Roller Coaster Tycoon*, *Zoo Tycoon*, etc.) are complex games. So are historical strategy games such as *Civilization III* and *Rise of Nations*. So is *John Madden Football*, in which you not only play the players, but also the team manager and team owner. So are military-themed games such as *Medal of Honor*, *Full Spectrum Warrior*, and *America’s Army*. And, finally, so are the much-criticized (although usually wrongly) games such as *Grand Theft Auto*, *Vice City*. In fact, these are among the *most* complex of games, meaning that they have the most to offer.

(One type of game that is *not* complex, however, is the type fighting game where the player presses button combinations to put moves against those of an opponent. These kinds of fighting games are really glorified mini-games. But other kinds of fighting games such as *Ninja Gaiden*, which involve a deeper mix of more complicated skills, are complex.)

One irony that drives kids crazy is that some of the most complex games – and therefore the most interesting games to play – contain violence in their story lines and are therefore derided by critics, parents, and the general press. Many parents, who typically focus only on the violence and ignore the complexity in these games, actually think they are doing their kids a favor by not letting the kids play them. But in reality they are doing their kids no favors. The *New York Times* game reviewer did an excellent job recently of debunking the “violence” objection to video and computer games. See <http://www.nytimes.com/2005/03/24/technology/circuits/24game.html?adxnml=1&adxnmlx=1111760665-sY1bDimqhgZBFJq3rVJNHg>) My intention here is neither to justify nor excuse the violence (which can, and should, be a great topic for an ethical discussion between adults and children), but rather to point out the games’ complexity and therefore total value.

## Decisions, Decisions

Returning to the notion of game complexity, another way it is often expressed is through the number of choices, or decisions, the player must make in the game. While school and other forms of entertainment typically involve a participant making few decisions or none at all, complex games force players to make interesting and important decisions during every second of play. In fact, many designers of complex games see their games as “a series of interesting and important decisions, leading to a satisfying conclusion.” In classrooms, of course, the time between decisions can often be measured in hours.

### And Now Back to Education (and Serious Games in General)

Why – parents teachers and educators – have I told you all this? And why am I insisting you make a clear distinction between mini-games and complex ones?

The reason is this, and it is important: *When most teachers and parents think of, and express an opinion about games in education, they are thinking only of mini-games. Carmen Sandiego is a mini game. Oregon Trail is a mini-game. Almost all the science, math, social studies and other educational games on the Web are mini-games. Quiz games are mini-games.*

And as we have seen, most *mini-games are trivial*. They are “bubble gum games.” Bubble gum may be fun, tasty, and even occasionally useful, but it really has no place in serious education, except for motivation (in the right circumstances mini-games, including quiz games, can be terrific motivators.)

But now that we are all aware there are complex, non-trivial games, we can ask “Do *they* have a place in education and learning?” And the answer is “*You bet they do!*”

Unlike mini-games, complex games are *not* trivial, and are not limited to one small topic or skill. Complex games are deep – the time kids spend playing a complex game (on average about 40 hours) is the same as they spend in class in an entire course in school. Complex games have the potential to teach, and teach well. They are big enough to include and teach entire bodies of material, and even entire courses.

Complex games, if used correctly, have the potential to be a huge boon to education. That is why it is so important that teachers, parents and educators learn about them. It is silly for something with so much potential to be dismissed out of hand just because the people dismissing it are only familiar with its simple cousin (i.e. the mini-game.)

So let’s get way from focusing on mini-games as the “games” we are talking about using for education. Mini-games may have their place, but they will always be mini, and therefore mostly trivial.

Let’s re-focus the discussion on whether “complex” games are good for education. And there is really no doubt that they are. That is why the U.S. military uses over 50 of them, (mostly for teaching thinking skills, not weapons use.) It is why professors and students at MIT, Harvard, and the Universities of Wisconsin, Texas, and other places are busily engaged in designing and testing various forms of complex custom educational games, as well as the possibility of using certain off-the-shelf games in class. It is why I and others are currently engaged in producing “complex” games for learning math, history, science, English, and foreign languages. (Not that this is by any means easy. As talented game designers from Will Wright to Eric Zimmerman remind us, making a great game about “whatever” is really hard. Making a great game about prescribed educational “content” is much harder. But that, in my view, is what makes it a worthwhile endeavor.)

More and more writings by professors, ludologists, players and observers document why games are great teachers (*see bibliography*.) But one has to understand that all the theory about why games teach is for *complex* games, and not mini-games. And one has to really start to understand just how complex the “complex” games really are, and precisely what they have to offer, in order to fully understand their educational potential. One way to do this is to go to the site [www.gamesparentsteachers.com](http://www.gamesparentsteachers.com), where you can find information on specific complex games and advice on how to discuss these games with your kids. Another way is to read books like Jim Gee’s *What Video Games Have To Teach Us About Learning and Literacy* and my upcoming *Don’t Bother Me, Mom – I’m Learning*.

My strong sense is that if educators and designers focus on the complex (and not the mini) games for education, and if parents, teachers and educators really come to understand what complex games are capable of and why the kids love them so much (which they can do best *by talking to, listening to, and even playing the games with their kids*) a great many of today’s resistant adults will come around and embrace “complex” games, in their many forms, as a key educational tool for today’s students and for kids in the future.

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In a technical interview, both space and time complexity matter. Even if space is available in plenty in modern days, we must understand the time vs space trade-offs. Sometimes, we focus on optimizing space complexity as well. Imagine a graph of s... The building blocks of economic growth Complexity matters. A new Atlas reveals the building blocks of economic growth. Using this analogy, the question of economic complexity is equivalent to asking whether we can infer properties such as the diversity and exclusivity of the Lego pieces inside a child's bucket by looking at the models that a group of children, each with a different bucket of Legos, can make. Cyclomatic complexity was coined back in 1976, so, needless to say, it wasn't meant to capture the complexities of today's programming languages. However, it does a great job at telling just how bad your if-else or switch is. You typically see cyclomatic complexity skyrocket when using traditional branching. So, it often makes sense to remove branches altogether. Follow the writers, publications, and topics that matter to you, and you'll see them on your homepage and in your inbox. Explore. Write a story on Medium. Why g Matters: The Complexity of Everyday Life. Linda s. gottfredson. University of Delaware. Personnel selection research provides much evidence that intelligence (g) is an important predictor of performance in training and on the job, especially in higher level work. This article provides evidence that g has pervasive utility in work settings because it is essentially the ability to deal with cognitive complexity, in particular, with complex information processing. Complexity matters. Jimmy Shen. Dec 18, 2019. 1 min read. Bitwise ORs of Subarrays - LeetCode. We have an array A of non-negative integers. For every (contiguous) subarray B = [A[i], A[i+1], ..., A[j]] (with i ≤ j) leetcode.com. Complexity is O(30N). How to get 30 is important.