A Statistical Study of the Trivial of Tradeskill Trophies in EverQuest

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2. Abstract

In the game of EverQuest, players can attempt to make items through crafts such as blacksmithing or tailoring. Each item has an associated difficulty level called a "trivial." The trivial for most items is known, but not for all of them. This paper seeks to identify the difficulty level of seven related combines in EverQuest that produce an item called a "trophy" by analyzing the success and failure rates of the attempts to make those trophies. 1144 success/fail results were collected, which translated into 36 useful data points. A linear regression analysis was then run on those data points to determine that the cap was 74.0891% ± 2.788%, or approximately 75%. Linear regression proved fruitless when studying the trivial, so a variant of the regression system was used to determine that the trivial is likely to be 341 ± 1 point, or approximately 342.

3. Introduction

3.1. Background

Have you ever wondered how the world works? The science of physics seeks to explain the nature of the world around us, but reality can be dauntingly complex even for experienced physicists, let alone a typical layperson.

Computer games will sometimes seek to simulate the physics of reality, and in some cases, games can even create a new reality with its own laws of nature. Games can be fanatically accurate – Microsoft's Flight Simulator line of games can be used to supplement training to become a flight pilot, and the Microprose Falcon line of games is as close as you can get to flying an F-15 Falcon fighter jet without joining the Air Force. Other games reduce the physics of reality to a more manageable set of rules that can be modeled and processed by a home computer, and easily understood by a player.

Some games will seek to simulate an entire world (or a portion of a world, such as a city). The player takes the role of one person, or occasionally a small group of people working together, who seek adventures within the world. When the focus of the game is centered upon the progression and growth of your character as he or she progresses through the game and upon the interaction of your character with other characters within the game world, the game is classified as a role-playing game.

Within the context of a game, everything is calculated deterministically. The game uses established formulae and known values to calculate certain events. Those events may contain a random element (such as the chance of a bullet hitting or missing the target), but ultimately, standardized formulae create consistent results. However, to the player, the results appear to be random. Since they cannot see the individual steps of the calculations, only the final results, the game appears to be random. Players can use this data in an attempt to work backwards and determine the underlying formulae and constants that run the game – in other words, players can unravel the physics that hold the world together.

3.2. What is EverQuest?

EverQuest is a computer game that is played online, over the Internet. It is usually classified as a "massively multiplayer online role-playing game" or MMORPG. EverQuest allows the player to take part in a large fantasy world with hundreds or even thousands of other players from all over the world (hence, massively multiplayer). The player creates a character that becomes his avatar in the virtual world. Each player controls his own character, while other characters, animals, monsters, and so on are controlled by the computer server that runs the world.

EverQuest simulates the fictional world of Norrath, its moons, and the ethereal planes surrounding Norrath (which serve as homes for Norrath's various gods). Players start in the game by hunting creatures that threaten the player's home city (ranging from vermin that plague the city like rats and bats to opposing races that seek to exterminate the city's inhabitants), then progressing to more complicated quests and adventures. As characters

progress, they become stronger (represented in the game as "gaining a level"); characters start at level 1 and can eventually become level 70 (as of this writing). They also have opportunities to gain new equipment and "alternate advancement" abilities that increase their power relative to other characters of the same level. Eventually, players can challenge the very gods in combat. EverQuest was first released to the general public in March 1999.

3.3. What are Tradeskills?

One of the alternate methods of play in EverQuest is the ability to craft items, called "tradeskills." There are seven tradeskills that are available to everyone: smithing, tailoring, fletching (making bows and arrows), pottery, baking, brewing, and jewel-crafting. Four additional tradeskills are restricted to certain races or classes; these are poison-making, tinkering (the highly unpredictable art of making magical contraptions), alchemy (potion making), and research (the creation of new magic spells).

The player will typically start a tradeskill attempt (called a "combine") by deciding which item he or she wishes to make. Then the player has to collect the necessary components. Some components are sold by vendors in unlimited quantities; others have to be collected from defeated enemies or through the completion of quests; yet other components have to be crafted using tradeskills (this is referred to as "subcombines").

Once a player has collected all the necessary items, he places them in a "combine container" – this is a tailoring kit for tailored items, a forge for smithed items, an oven for food, and so on – and clicks the "Combine" button. The game then runs a complicated formula that determines whether the player is able to complete the combine successfully (yielding the desired item), or whether the player fails the combine (usually resulting in a loss of the components). To the player, the process appears instantaneous, and the only reported result is whether the player succeeded or failed the attempt.

3.4. History of Tradeskills within Everquest

When EverQuest was first released, tradeskills were not a significant part of the game. Over time, the developers of EverQuest added new items that players could make and new abilities that made tradeskilling easier. As tradeskills became more prominent, players started to investigate the mysterious mechanics behind their chosen profession.

The investigation basically boiled down into attempts to guess or predict the chance to succeed at making items and the chance to increase your skill. Initial estimates and guesstimates were made for these formulae; and as changes were made to the game, these were updated or refined. In addition, the makers of EverQuest would hold a periodic gathering called a Fan Faire at which players of the game could meet and interact with the developers. At these Fan Faires, tradeskillers would often ask for confirmation or verification of guesses or estimates by the player community.

3.5. What are Trophies?

Each tradeskill except research has an item called a trophy. This item is intended as a prize for achieving high skill within the matching tradeskill. It costs a significant amount

of in-game money (platinum pieces, or plat for short; gold, silver, and copper pieces are sub-denominations, with each piece being worth ten of the next-smaller denomination) and time to acquire the components, and it has a very high complexity level to make successfully. Players do not know the exact difficulty level.

4. Description of the problem

4.1. Objective

The objective of this paper is to determine the difficulty level (called the "trivial") of the tradeskill trophies and the cap on the chance to succeed at a trophy combine, if any.

It is important to players to have accurate information regarding their tradeskill combines. This information is used by players to estimate their costs for making items or for increasing their skill. Inaccurate or missing information makes this harder. In addition, there is always a sense of elegance associated with having complete information.

4.2. What factors affect success rates?

There are five factors that affect a player's chance to succeed a particular combine. These are as follows:

- The item's trivial
- The player's skill
- Any skill-modifying items the player may use
- "Mastery" abilities
- Upper and lower caps on the chance to succeed

4.2.1. Changes in 2004

Between September 2004 and March 2005, the developers of the game implemented a number of substantial changes to the mechanics that underlay tradeskills. Three particular changes are of relevance to this study. Each will be discussed more thoroughly under the appropriate section below. First, the cap on unmodified player skill was raised from 250 to 300, and the cap on modified skill was removed entirely. Second, the cap of 250 on item difficulty was removed. Third, the developers gained the ability to impose a cap on the chance to succeed for any particular combine, regardless of player skill. (For simplicity, these changes will be referred to as the 2004 changes.)

4.2.2. Item Trivials and Difficulties

Each item a player can make has an associated complexity level called the "trivial" (for reasons that will soon become apparent). Some items are easy to make, meaning they have a low trivial; while others are much harder, meaning they have a high trivial. In general, items that are more useful or more powerful will have a higher trivial; thus, it is more difficult to make these items successfully. Trivial values typically range from 15 to 404 (the highest trivial currently confirmed).

When the game was first released, the trivial values of each item you could make were not known. Instead, they had to be discovered by players. Once a player's skill exceeded the trivial of the item, the game would give the message "This item is trivial for you to make" when the player successfully made the item – hence the origin of the term "trivial." This message was later changed to a clearer one ("You can no longer advance

your skill by making this item"), but the term "trivial" is still used to describe the complexity level of a tradeskilled item.

For example, if you successfully made an item with skill 200 and did not get a trivial message, then succeeded on the same item with skill 201 and received a message that you could no longer advance your skill by making this item, then you could conclude that the item had a "trivial" of 201 – this is the highest value to which you could raise your skill by making this item.

Players collated this information and shared it with each other. The majority of such information was gathered at a Web site called EQ Trader's Corner (www.eqtraders.com).

Around February 2004, the game's interface was changed so that players could see the actual trivial of the combine they are attempting. However, not all items were visible in this manner; the trivial of items not listed remained a mystery to players. The trophies are the most prominent of these mystery items.

As discussed under the Derivation of Formulae section, each trivial is stored internally within the game as a number called the "difficulty." Ordinarily, players would never have direct interaction with item difficulties; instead, the game would invisibly convert the difficulty to a corresponding trivial. The highest difficulty known at that time was 250, which corresponded to a trivial of 335. Not coincidentally, this difficulty yielded a success rate very close to 50% at the then-maximum skill of 252 (discussed below).

After the changes in 2004, new items appeared in the game that had trivials far in excess of 335. As of this writing, the highest confirmed trivial is 404, which corresponds to a difficulty of 302.

4.2.3. Player Skill

In EverQuest, players increase their skill in each tradeskill by attempting combines whose trivial is above their current skill level. On each such attempt, the player has a chance of getting a "skill-up" and increasing their skill in the corresponding tradeskill by one point. For example, if a player has a skill of 200 and attempts a combine with trivial 252, that player has a chance to get a skill-up, regardless of whether the player successfully makes the item or not.

Initially, a player's unmodified skill within a particular tradeskill could not exceed 250. Players assumed that skill was stored as a one-byte unsigned integer, giving a possible range of 0 to 255.

The changes in 2004 allowed players to raise their unmodified skill to 300. Player skill levels in each tradeskill can currently range from 0 to 300.

4.2.4. Skill-Modifying Items

Certain items in the game grant a bonus to the player's skill in one particular tradeskill, expressed as a percentage. For the purposes of the chance to succeed or fail, the player's skill is increased by this percentage. For example, if a player has a base skill of 200 and a

5% skill-modifying item, the player's effective skill would be 210. Known skill-modifying items range from 1% to 15%; by far the most common are 5%. Modified skills are always rounded down to the nearest integer.

When the cap on unmodified player skill was 250, a modifier would raise this skill to a cap of 252. For example, if you had a skill of 200 and a 5% modifier, your effective skill would be 210. However, if your skill was 250 and you used a 5% modifier, your effective skill was not 262 as you might have expected. The cap would limit your effective skill to 252. Skill values of 253-255 were presumably reserved values with special meanings in the game.

The cap on unmodified skill was removed entirely with the changes in 2004; players could now get the full benefit of any modifier they had. For example, the highest known modifier is 15%. A person with this modifier and a raw skill of 300 would have an effective skill of 345. The formerly-reserved values from 253-255 no longer hold any special meaning; they represent just another skill level.

4.2.5. Mastery abilities

As discussed previously, players can choose to work on their alternate advancement abilities in lieu of normal progression in the game. One line of alternate advancement abilities reduces the chance to fail in a particular tradeskill by a set percentage. This is *not* the same as increasing the chance to succeed by that percentage. The specifics of how Mastery affects the chance to succeed or fail are discussed under "Simplified Formulae" below.

The individual abilities are called Tailoring Mastery, Pottery Mastery, and so on. They all function identically, save for which tradeskill they affect. For this document, they will all be referred to generically as Mastery abilities.

The first rank of each Mastery ability reduces the chance to fail a combine in a particular tradeskill by 10%. The second rank increases that to 25%, and the third and final rank reduces the chance to fail by 50%. These are referred to as Mastery 0, Mastery 1, Mastery 2, and Mastery 3.

4.2.6. Caps

The chance to succeed is capped at 5% at the low end and 95% at the high end. This overrides even the reductions of mastery abilities. The low cap means that regardless of your skill or the item's trivial, you always have at least a 1 in 20 chance of succeeding any combine attempt.

The upper cap of 95% is raised by 1% for each 40 points your skill is above the trivial. For example, if an item has trivial 200 and your skill is 240, your maximum chance to succeed is 96%. At skill 280, this chance is 97%. At skill 279, your chance is 96% -- the cap is only raised for whole increments of 40 points.

In addition, certain items have an individual item cap that overrides the default upper cap. Normally, this cap is significantly lower than the default maximum of 95%. For example,

an item might have a cap of 60%. So, even if your skill and other factors would predict a success rate of, say, 75%, the individual item cap of 60% would override. However, if your predicted success rate is 50%, then the cap would do nothing – it is a maximum on the chance to succeed, not a set value. Individual item cap values are not precisely known by players.

4.3.   What Is the Issue?

Players have very little firm information regarding the trophies. All that is known for certain is that the trophies are not trivial at a player skill of 300. The trivial for the poison making trophy (which is not one of the tradeskills included in this analysis) is visible in the in-game interface, and has a value of 335. This would be in line with the age of the trophies; they were introduced at a time when this was the maximum trivial.

However, the observed success rates at very high skill levels do not match what would be expected given the formulae. An item with trivial 335 should succeed the vast majority of the time if the person attempting the combine has a high skill (over 280 or so), and should reach the maximum success rate of 95% at a modified skill of 295 (or skill 289, with Mastery 3). Therefore, we must conclude that either the trivial value of the trophies being studied differs from the poison-making trophy, or else the game's developers must have implemented a cap on the chance to succeed at a trophy combine.

4.4.   Discussion of the Formulae

4.4.1. Derivation of Formulae

Around 2002, a number of players collaborated on the EQ Trader's Corner message boards to generate a tremendous amount of data regarding player skills and success rates. Then, some statistically-knowledgeable players used that data to derive a best-guess estimate of the formulae. Some of the assumptions that underlay these estimates were that skill and difficulty were stored as one-byte unsigned integers (hence the limits of 250 or thereabouts). The formulae showed that the most popular item trivials corresponded directly to round difficulties, and the estimates matched closely to results observed in game. At a Fan Faire in 2005, the developers confirmed that the derived formulae were correct.

Also at that Fan Faire, the developers revealed the existence of per-item success caps. There was significant community outcry about these caps because they meant that the reward for having higher skill (namely, a better chance to succeed, leading to less wasted expense on failed attempts) was effectively negated. However, the developers view the caps as a way to control the rate at which these items enter the game world, and insisted that they would not be going away.

4.4.2. Simplified Formulae

The formulae relating to success/fail rates are quite complicated, having several variations and branches, depending on the item trivial (items with trivial of 68 or less use a different formula), the player's skill (a skill of zero does not use mastery), and the player's Mastery level. We know for certain that the trophy is not trivial at skill 300;

therefore, its trivial is over 300 and there is no need to worry about the formula for trivials under 68. Purely by chance, all the collected data happened to be with Mastery 0 or Mastery 3; no data was collected for Mastery 1 or 2. Finally, no data was collected at a player skill under 200. Therefore, only the formulae applicable to this restricted data set will be presented here.

The basic formula for success with Mastery 0 and item trivial greater than 68 is as follows:

```
UncappedRate = (ModifiedSkill - 0.75 * Trivial + 51.5) / 100
```

This formula leads to a number usually but not always between 0 and 1, which is then capped at 5% at the low end and the lower of 95% or the item success cap at the high end. Similarly, the formula for success with Mastery 3 is as follows:

```
                        UncappedRate =
     1-((1-((ModifiedSkill - 0.75 * Trivial + 51.5) / 100))*0.5)
```

Trivial is a constant for the combines in question, since all of them have the same trivial. Substituting *x* for ModifiedSkill (the independent variable) and *y* for UncappedRate (the dependent variable) and rewriting in a more traditional form, the formulae become as follows, where T is the trivial:

```
    Pr(Success | Mastery 0) = y = 0.01x + (.515 - 0.0075 × T)
```

```
    Pr(Success | Mastery 3) = y = 0.005x + (0.7575 - 0.00375 × T)
```

Once the probability is determined, it is then capped at 5% at the low end and the lower of 95% or the item's success cap at the high end.

From this, two things become apparent. First, there is a fixed, linear increase to the chance to succeed as skill increases (specifically, the slope of the equation, or the coefficient of *x*). Second, the trivial can be determined if the *y*-intercept of the function is known. Note that in practical terms, the y-intercept is never seen in game. The lower cap on success usually prevents that from being visible. This is discussed in more detail in the next section.

5. Data Collection

5.1. Methodology for data collection

The first step in conducting the analysis is to collect data. The only real way to collect data for this analysis is to perform combine attempts in the game and record the results. To this end, players were asked to submit their success/fail results when making trophies, along with their raw skill, any modifiers used, and any Mastery abilities they may have.

Accordingly, 1144 attempts at making trophies were performed. The majority were done personally by the author; the remainder were performed by other players who reported their results. When possible, the author personally observed and verified the results. The submitters were asked to present the tradeskill in which they attempted the combine; their unmodified skill at the time; the modifier percentage they used, if any; their mastery level, if any; and how many successes and fails they had with these statistics.

5.2. Risks and Complications

There are a number of potential risks and complications to this analysis.

First, there is always the possibility that somehow, by some horrid streak of bad luck, the collected data consists entirely of extreme or non-representative data. As players of the game often joke, the game's random number generator (which plays a significant role in determining whether players succeed or fail) is sentient, vindictive, and hates players! This risk was mitigated by attempting to collect a large quantity of data points spread over a large range of skill levels.
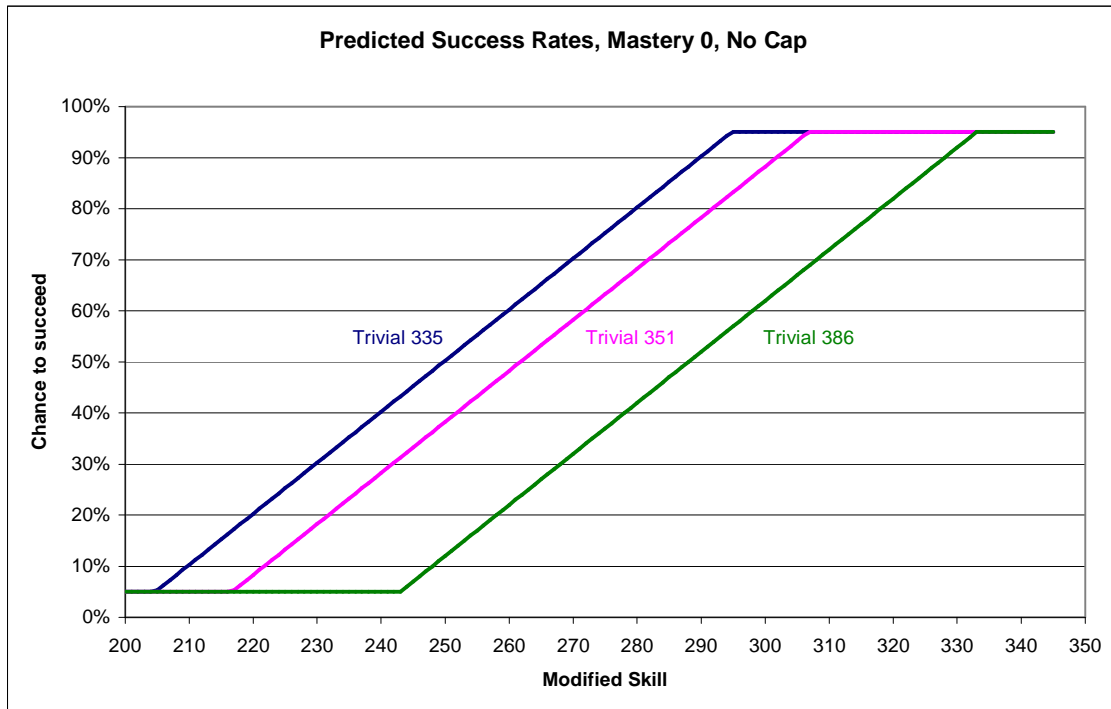
Next, there is a risk that the formulae described above are incorrect in some aspects. The actual formulae used in the game are not known to players. Rather, the formulae reported above were derived by players using a statistical analysis not unlike this one. Although the developers have confirmed the accuracy of the formulae, there is still a chance that the in-game formulae differ in some significant way from the known formulae, or that the in-game formulae were changed at some point after the developers' confirmation.

Although there is a risk of deception by people who submitted their results, I would judge the risk to be negligible. The veracity of the vast majority of the results was confirmed by the author personally by monitoring the people doing the combines. The other results are quite few in comparison. If any of them were falsely reported, the analysis would likely reject them as noise in the data.

The biggest concern, however, is that there has been a change to the trivial of the trophies since the new revisions were introduced. The original analysis to determine the formulae was performed around 2002. At the time, players' raw skill was capped at 250, not 300 as it currently stands. In addition, modified skill was capped at 252. Likewise, the highest known trivial was 335, which corresponded to a difficulty of 250. Again, it was assumed that difficulty was a one-byte unsigned integer. There was no evidence that caps on success rates existed at that time.

Accordingly, it is difficult to determine whether a particular combine with low success rates is due to a high trivial or a low trivial and a success cap. Consider the following three cases. These display graphically the chance to succeed a particular combine at a given modified skill.

The first graph represents the chance to succeed given three different trivials, no mastery, and no item success cap.

Predicted Success Rates, Mastery 0, No Cap

Trivial 335   Trivial 351   Trivial 386

(y-axis: Chance to succeed, 0% to 100%; x-axis: Modified Skill, 200 to 350)

From this graph, it is clear that the slopes of the lines are parallel. If the lower cap were not present, the lines would continue until they reach the *y*-axis. Each would have a different intercept, and as noted above, the intercept is dependent on the trivial.

Next, let us examine the impact of mastery. The graph below shows the same three trivial items, but this time, Mastery 3 is assumed.

Predicted Success Rates, Mastery 3, No Cap

Chart: X-axis "Modified Skill" ranging from 200 to 350; Y-axis "Chance to succeed" ranging from 0% to 100%. Three lines labeled Trivial 335, Trivial 351, and Trivial 386.
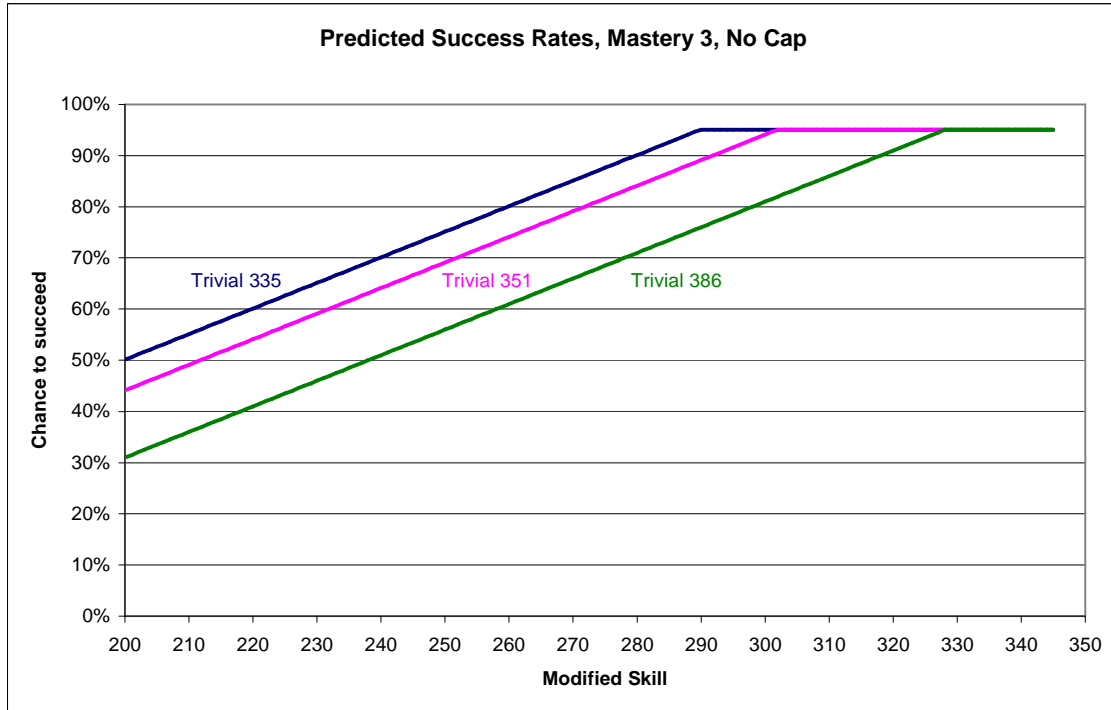
Note here that the slope is again constant across all three trivials, although it is different from the slope in the previous graph. Again, if the graph were extended to the left and the lower cap ignored, the *y*-intercept would allow us to determine the trivial.

The next graph below is a repeat of the first case, but this time a cap of 75% is imposed on the chance to succeed. Notice that it is essentially identical, save that the chance to succeed no longer exceeds 75%.

Predicted Success Rates, Mastery 0, 75% Cap

Chance to succeed vs. Modified Skill

Trivial 335   Trivial 351   Trivial 386
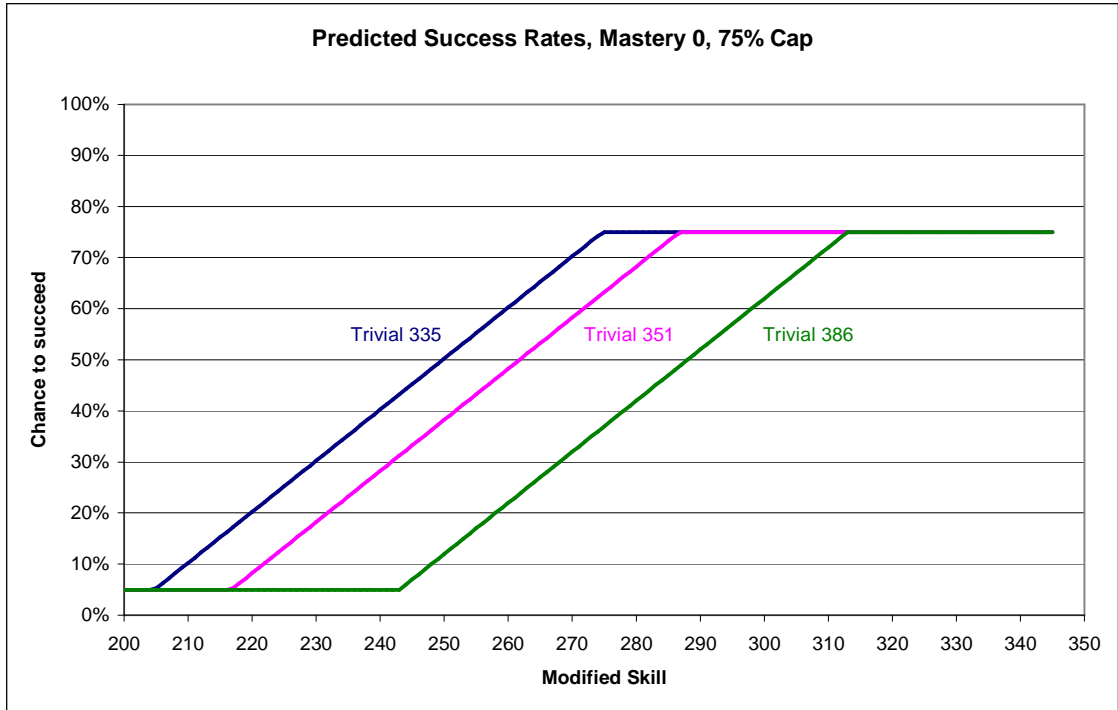
The next graph combines elements of the previous three. It represents an item with trivial 335 and no cap, another with trivial 335 and a 75% cap, and an item with trivial 386. All assume no Mastery, for simplicity.

Predicted Success Rates, Mastery 0, Mixed Caps

Chance to succeed vs. Modified Skill
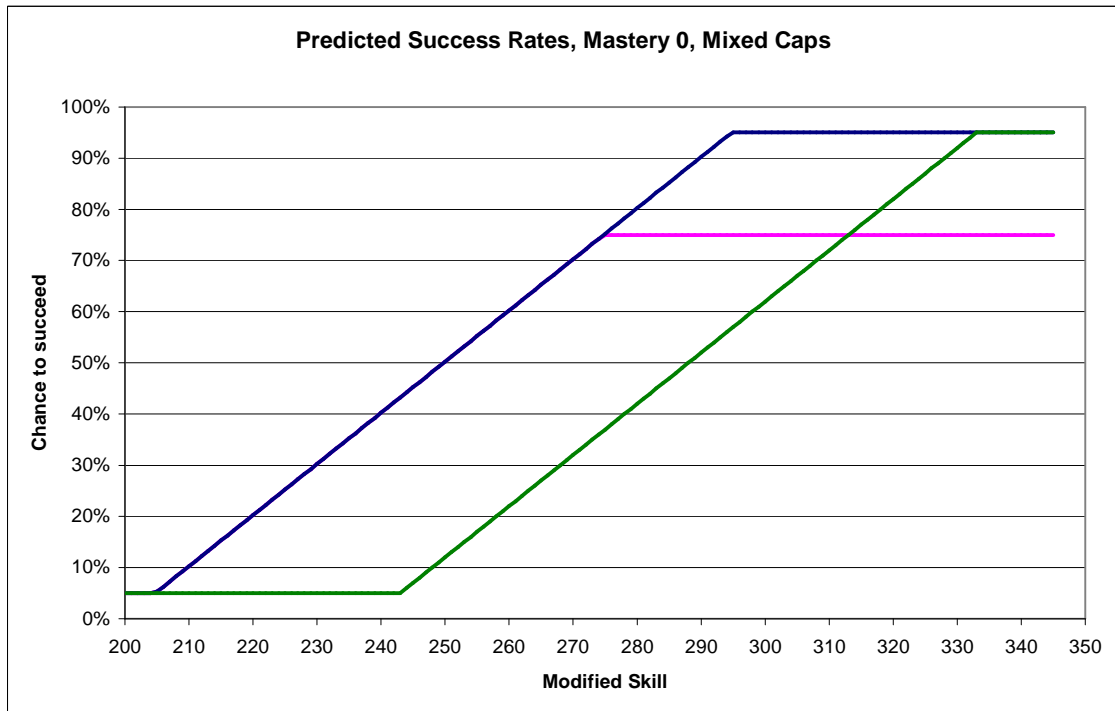
Clearly, if you only gather data on success results from people whose skill is 290 or higher, it would be very difficult to differentiate between an item with a high trivial and

no cap, and an item with a lower trivial and a cap. The best way to differentiate is to observe the success rates at lower level of skill, where the differences are more pronounced.

Another consideration is that although we rely on the *y*-intercept, it is never found directly in the game. Consider the following graph, which shows the capped (green) and uncapped (red) chance to succeed from skill zero to 345. The chart assumes trivial 335, mastery 0, and no item cap.

Capped vs. Uncapped Success Rates
Trivial 335, no cap, no Mastery
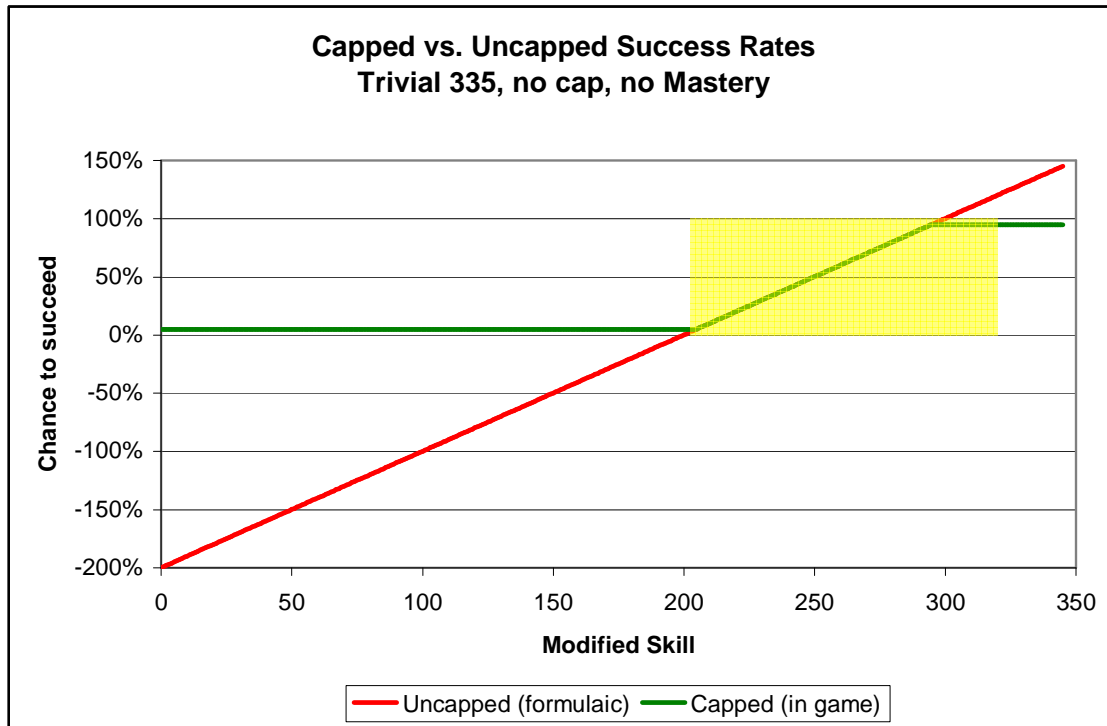
Notice that the green line, which represents the actual success rates in the game, is capped at 5% and 95% at either end. Therefore, it is not possible to get meaningful data at modified skills under 200 or so. This is unfortunate, as any data obtained at those skills would help to stabilize the regression estimate.

Also on the chart above, notice the region highlighted in yellow. This is the region in which all the collected data lies. Therefore, there is a large risk that by extrapolating to the *y*-intercept, the margin of error becomes so large as to lose the value of the estimate.

5.3. Data Cleaning and Summarization

The raw data that was collected is presented in Appendix 2. As previously noted, 1144 individual attempts were recorded.

The raw success/fail results that were collected were converted to success ratios, or proportions. For each modified skill level, the ratio was calculated as follows:

$$P_{skill} = \frac{\#\ Successes}{Total\ attempts}$$

Skill levels at which less than five individual success/fail results were collected were discarded; less than five results at a skill level would give a proportion that was too coarse to be useful.

This resulted in 29 useful proportions at Mastery 0 and seven useful proportions at Mastery 3. For each proportion, a margin of error was calculated as follows:

$$\sigma_{\hat{p}} = SE_{\hat{p}} = \sqrt{\frac{pq}{n}}$$

$$ME = 2 \cdot \sigma_{\hat{p}}$$

These data were collated and sorted, then graphed for a visual analysis, as follows. Note that the graphs have an upper cap on the *x*-axis of 320, since no data was collected for modified skills over 315. The error bars on all the graphs represent a two-sigma margin of error.

The first graph presents the data collected with Mastery 0.

Success Ratio, Mastery 0, Clean Data
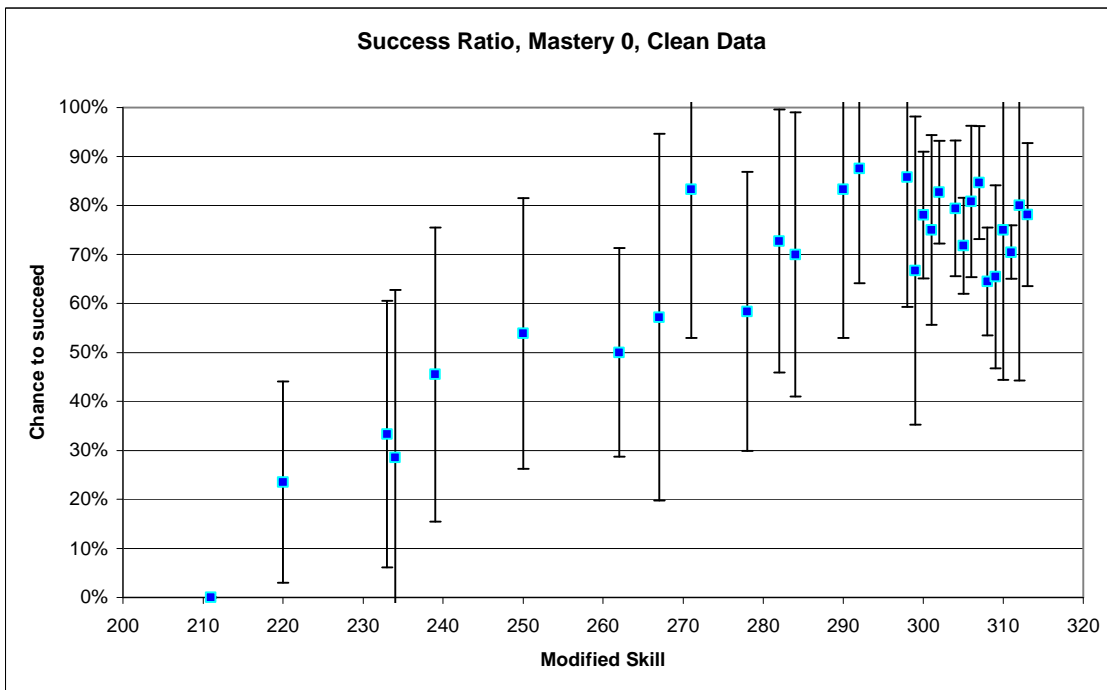
The next graph presents the collected data with Mastery 3.

Success Ratio, Mastery 3, Clean Data

Chance to succeed (y-axis): 0% to 100%

Modified Skill (x-axis): 200 to 320
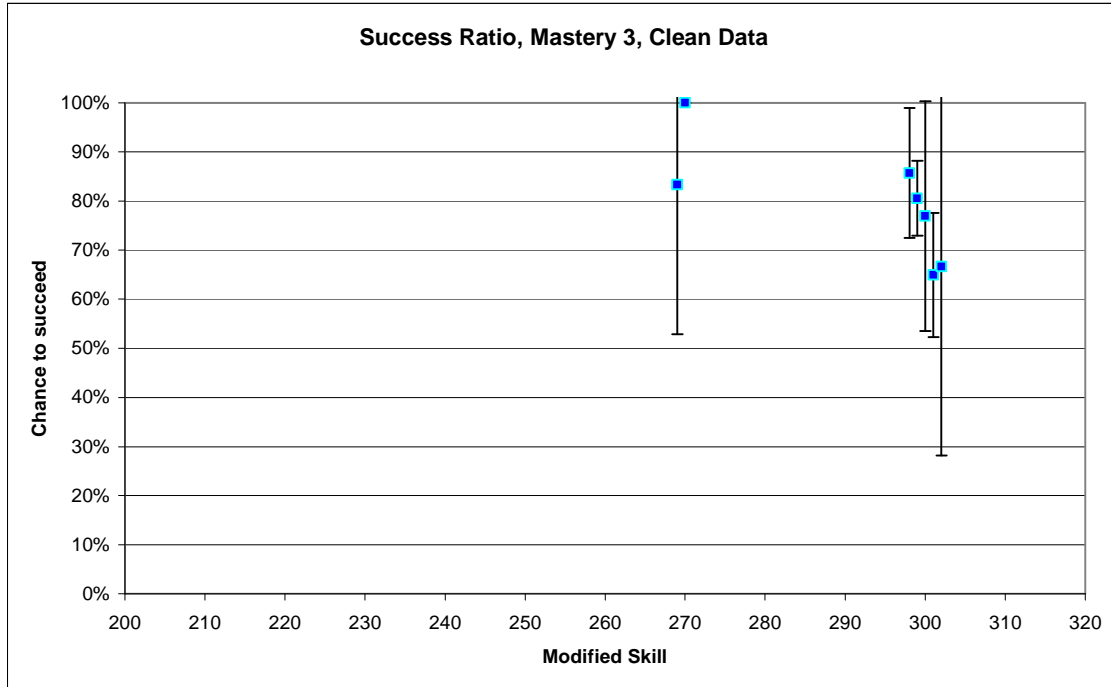
6. Analysis

From the above graph of data with Mastery 0, it would appear that there is a roughly linear increase in the chance to succeed until somewhere in the vicinity of modified skill 270-285. From skill about 280-315, it is clear that there is some sort of cap on the success rates, as none of the data points exceed 90%.

For purposes of comparison, here is the first graph repeated, with the predicted chance to succeed if the trivial were 335 and the success cap were 75%.

The second graph above (depicting data with Mastery 3) is less enlightening, but again, it is notable that the majority of the data points are under 90%. This again strongly argues for a cap.

Accordingly, this analysis will proceed in two parts. First, we will attempt to determine the success cap. Second, we will attempt to determine the *y*-intercept, from which we can calculate the trivial.

From the graphs, it is not immediately obvious where the break between the linear increase and the horizontal cap effect would be. Therefore, all data points up to a skill of 285 will be used to determine the trivial, and all data points from skill 280 and up will be used to determine the cap. This slight overlap should help assure that all the relevant data points are included without corrupting the calculations.

6.1. Determining the Success Cap

Since the success cap overrides the formulaic chance to succeed, even if the person has a mastery ability, we can safely combine the data from Mastery 0 and Mastery 3 in the

relevant range (skill 280 and up). A regression analysis was then performed on the data. This created the following data set. (For clarity, figures may be restricted to three decimal places or three significant figures, as appropriate.)

Mastery 0 and 3 Combined						
Modified Skill	**Observed Successes**	**Observed Fails**	**Observed Total**	**Observed Success Ratio**	**Predicted Success Ratio**
282	8	3	11	72.727%	78.592%
284	7	3	10	70.000%	78.388%
290	5	1	6	83.333%	77.778%
292	7	1	8	87.500%	77.575%
298	30	5	35	85.714%	76.965%
299	93	24	117	79.487%	76.863%
300	42	12	54	77.778%	76.762%
301	52	25	77	67.532%	76.660%
302	47	11	58	81.034%	76.558%
304	27	7	34	79.412%	76.355%
305	61	24	85	71.765%	76.253%
306	21	5	26	80.769%	76.151%
307	33	6	39	84.615%	76.050%
308	49	27	76	64.474%	75.948%
309	17	9	26	65.385%	75.846%
310	6	2	8	75.000%	75.745%
311	198	83	281	70.463%	75.643%
312	4	1	5	80.000%	75.541%
313	25	7	32	78.125%	75.440%
Total	**732**	**256**	**988**		

We are in the odd position of desiring a *low* R^2 value, and ideally both R^2 and the slope would be zero. In other words, there should be no correlation whatsoever between the modified skill and the success rate. The margin of error was calculated using two sigma.

```
                    H₀: Slope = 0

                    Hₐ: Slope ≠ 0

                      α = 0.05

    y-intercept = 1.072638545 ± 1.096265423, p-value = 0.0670

        Range of y-intercept: -0.023626877 to 2.168903968

Slope (x coefficient) = -0.001016744 ± 0.003631608, p-value = 0.583

          Range of slope: -0.004648352 to 0.002614864

            ŷ = -0.001016744 x + 1.072638545

                  R² = 0.018109218
```

Note the huge p-value on the slope. It is safe to say that we fail to reject the null hypothesis. Accordingly, the slope is essentially zero, confirming the existence of a cap on the chance to succeed. The implication of this is that skill is not relevant, and we can reduce all the skill levels to a single calculation, as follows. Note that this is mathematically identical to taking a weighed average of the observed success rates, since the observed success ratio is simply the observed successes divided by total attempts; multiplying by the total attempts would just reverse the calculation.

Mastery 0 and 3 Combined				
	Successes	**Fails**	**Total**	**Success Ratio**
Total Attempts	732	256	988	74.089%

```
Average success ratio: 74.0891%

Standard error: 1.394%

Margin of error (two sigma): 2.788%

Estimated cap: 74.0891% ± 2.788%

Range: 71.301% to 76.877%
```
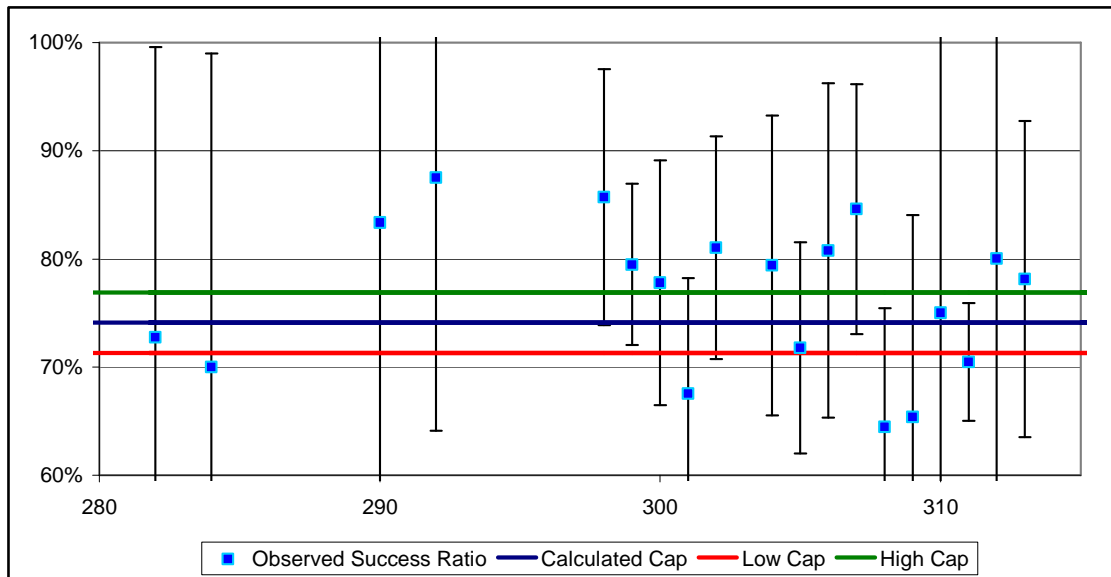
The following graph helps illustrate this conclusion. Note that both axis scales have been changed to show the data more clearly.

Human nature being what it is, the developers of EverQuest probably chose a round number for the cap. Therefore, I would conclude that the cap is 75%.

6.2. Determining the Trivial

Unlike the cap analysis, the data for the trivial cannot be combined; the slopes for Mastery 0 and Mastery 3 are different. Therefore, each should be analyzed separately. Note that graphs in this section have an upper limit on the *x*-axis of 300.

6.2.1. Mastery 0 Data

The results of the linear regression are as follows:

Mastery 0					
Modified Skill	Observed Successes	Observed Fails	Observed Total	Observed Success Ratio	Predicted Success Ratio
211	0	10	10	0.000%	11.915%
220	4	13	17	23.529%	19.730%
233	4	8	12	33.333%	31.018%
234	2	5	7	28.571%	31.886%
239	5	6	11	45.455%	36.228%
250	7	6	13	53.846%	45.779%
262	11	11	22	50.000%	56.199%
267	4	3	7	57.143%	60.541%
271	5	1	6	83.333%	64.014%
278	7	5	12	58.333%	70.093%
282	8	3	11	72.727%	73.566%
284	7	3	10	70.000%	75.303%
Total	**64**	**74**	**138**		

Again, the regression was done using two sigma for the margin of error.

```
     y-intercept = -1.71302842 ± 0.29305540, p-value < 0.0002

       Range of y-intercept: -2.29913923 to -1.12691762

Slope (x coefficient) = 0.00868329 ± 0.00115508, p-value < 0.0002

         Range of slope: 0.00637313 to 0.01099345

            ŷ = 0.00868329 x - 1.71302842

               R² = 0.849652289
```

Graphically, the data is as follows. The regression line is in black.

Trivial analysis
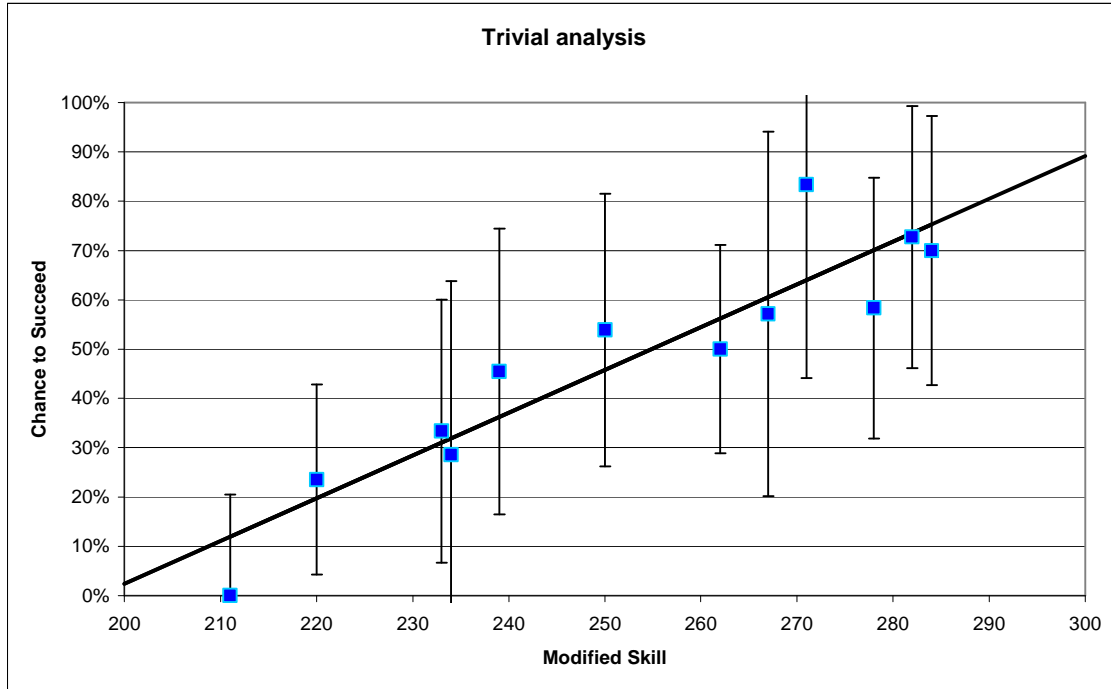
It is interesting to note that there is a significant difference between the observed slope and the known slope from the actual formula. The observed slope is approximately 0.00868 (to three significant figures), whereas the formulaic slope is exactly 0.01. This is just barely within the margin of error, but it still represents a difference of approximately 13% from the known slope. While this may appear minor, it can lead to a huge distortion in the calculated trivial. The following graph overlays the previous one with the predicted success rate of a combine with trivial 335, mastery 0, and a 75% success cap (in green).

Trivial analysis with predicted rate
Trivial 335, 75% cap
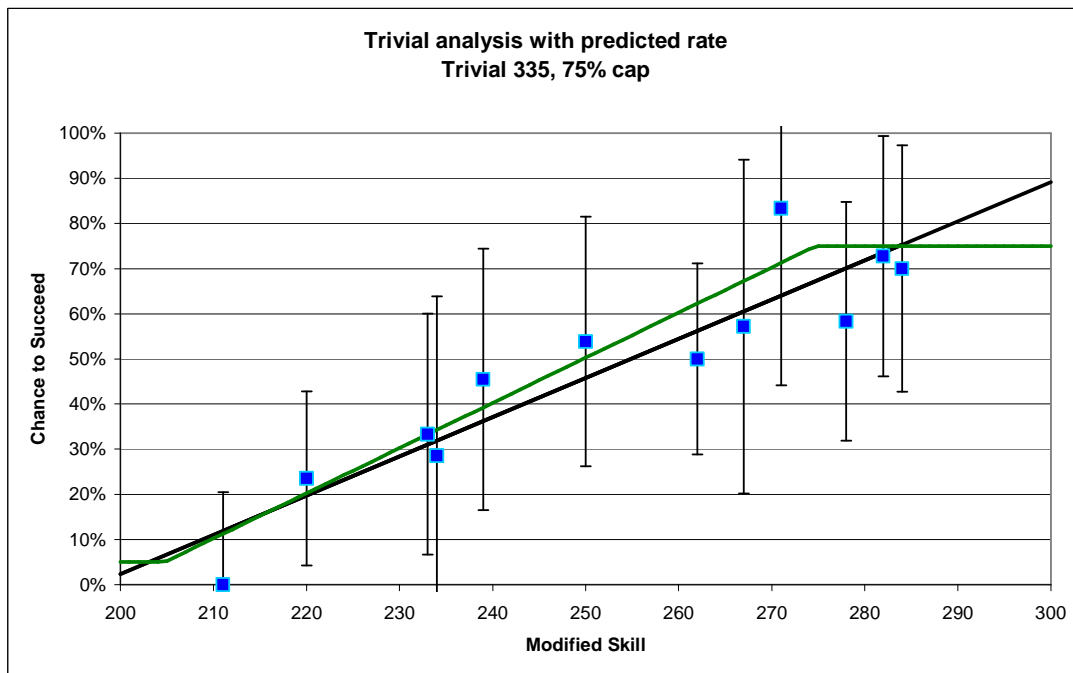
The visual disparity is striking, but the full impact can be seen if the upper and lower caps are ignored, and both the regression line and the predicted success line are extended to the zero-point on the *x*-axis. The observed data are not included for clarity's sake, but they all exist within the yellow region (which is also approximately the region represented in the previous graph).

Comparison of Regression Line and Predicted Success Line
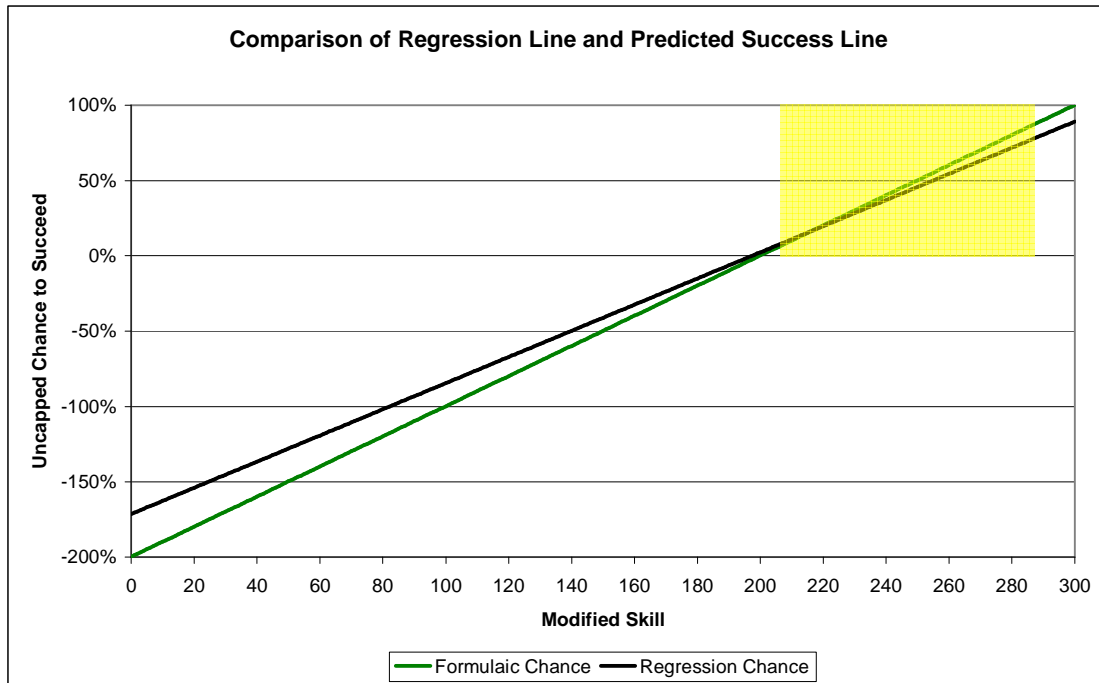
The difference at the zero skill point is considerable. The regression line predicts approximately -171%, while the formulaic line predicts approximately -200%.

As explained earlier, the trivial can be determined by solving backwards from the y-intercept, as follows:

```
Pr(Success | Mastery 0) = y = 0.01x + (.515 – 0.0075 × T)

     Point value: –1.71302842 = .515 – 0.0075 × T_point

               T_point = 297.070 = 297

   Maximum value: –2.29913923 = .515 – 0.0075 × T_max

               T_max = 375.218 = 375

   Minimum value: –1.12691762 = .515 – 0.0075 × T_min

               T_min = 218.922 = 219

         Trivial range = 219 - 375
```

Clearly, this answer is not useful. For example, it is known for certain that the trivial is over 300; yet the analysis permits trivials in the range of 219-300. The disparity in slopes between the regression formula and the known formula is generating such a massive range when the lines are extrapolated to the *y*-intercept that little useful information regarding the trivial can be derived.

6.2.2. Mastery 3 Data

Insufficient data was collected to perform an analysis for Mastery 3 combines. By observing the graph of the data presented earlier, it is immediately obvious that a meaningful linear relationship cannot be derived.

6.2.3. Alternate Analysis

To avoid the problem observed when analyzing the Mastery 0 data, a manual regression of sorts was run. Trivials must be whole integer values, and the range is finite. In addition, the slope of the equation is already known from the in-game formula. All that is needed is the intercept, which in turn is based on the trivial.

Therefore, the predicted chance to succeed for each modified skill was calculated for all trivials in the range of 300-404 (that being the highest confirmed trivial in the game). An advantage of this system is that it also allowed for the inclusion of the Mastery 3 data with modified skills in the appropriate range. The observed success rate at the corresponding skill/mastery level was then subtracted, and the difference was squared. The squared differences for each potential trivial were then added up. The lowest observed difference was at a trivial of 340.

Seeking further confirmation, a weighed sum of the squared differences was taken. Each squared difference was multiplied by the number of success/fail results it represented, added up for that trivial, then divided by the total number of success/fail results observed. The lowest difference in this case appeared at a trivial of 342.

Both these results are within the range of possible trivials determined by the linear regression analysis performed previously. Furthermore, they are more useful predictors of the trivial because they are based on the known formula, rather than a calculated estimate.

6.2.4. Additional Considerations

As previously stated, the trophies were originally invented when the highest possible difficulty was 255, which would correspond to a trivial of 342. At that time, the item with the highest known trivial (335) had a difficulty of 250. It is possible that the developers chose to match the difficulty of those items, and it is also possible that they chose to make the trophies the hardest-to-make items in the game at that time.

We must also consider that the only known trivial for a trophy is 335. This trophy is made using poison-making, which is not one of the tradeskills studied in this analysis. There is reason to believe that poison-making is handled differently from the other tradeskills. Up until very recently, players could increase their skill in poison making by using "training points" at their guild master. This essentially allowed those players to

increase their skill without any meaningful effort and with minimal cost. The general tradeskills studied here all required players to raise their skill by actually making items that are not trivial to them, which entailed a much greater cost in platinum pieces (money) and time. Since the trophies are intended to be a reward for achieving high skill, it is possible that the poison-making trophy is handled differently than the trophies for the general tradeskills.

Lacking any additional information, I would conclude that the statistical analysis is correct and that the trivial is in the range of 340-342, or approximately 341.

6.3. Conclusions

The statistical analysis indicates that the most likely trivial for the trophies is 341 ± 1 point, with a success cap of $74.0891\% \pm 2.788\%$. As a working approximation, the trivial is most likely 342 with a success cap of 75%.

6.4. Further Research

The primary problem with this analysis is a paucity of data at low skill levels (200-250). This created the surprisingly broad range for the trivial when performing the linear analysis. There were too few data points to establish a good regression line, which resulted in a broad range for possible trivial values. Future research would do well to collect more data in this range.

Although the analysis did not test the slope in the trivial analysis against the known slope, it is interesting to note that the p-value of the linear regression slope is significant. This means that we would have had to reject a null hypothesis that the slope is 0.01. However, we know for a fact that the slope *must* be 0.01 from the in-game formula. Again, this problem would likely be resolved with additional data points at the lower range.

Although the cap analysis proceeded smoothly, additional data points in the cap range would also help to narrow it down further.

7. Appendices

7.1. Appendix 1: Raw Data

Mastery 0				
Modified Skill	**Successes**	**Fails**	**Total**	**Success Ratio**
210	0	3	3	0.0%
211	0	10	10	0.0%
212	0	2	2	0.0%
220	4	13	17	23.5%
233	4	8	12	33.3%
234	2	5	7	28.6%
238	3	1	4	75.0%
239	5	6	11	45.5%
250	7	6	13	53.8%
251	1	0	1	100.0%
252	1	0	1	100.0%
262	11	11	22	50.0%
267	4	3	7	57.1%
271	5	1	6	83.3%
272	1	0	1	100.0%
277	3	0	3	100.0%
278	7	5	12	58.3%
282	8	3	11	72.7%
284	7	3	10	70.0%
290	5	1	6	83.3%
291	3	0	3	100.0%
292	7	1	8	87.5%
298	6	1	7	85.7%
299	6	3	9	66.7%
300	32	9	41	78.0%
301	15	5	20	75.0%
302	43	9	52	82.7%
303	2	1	3	66.7%
304	27	7	34	79.4%
305	61	24	85	71.8%
306	21	5	26	80.8%
307	33	6	39	84.6%
308	49	27	76	64.5%
309	17	9	26	65.4%
310	6	2	8	75.0%
311	198	83	281	70.5%
312	4	1	5	80.0%
313	25	7	32	78.1%
315	1	0	1	100.0%
Total	**634**	**281**	**915**	

Mastery 3				
Modified Skill	Successes	Fails	Total	Success Ratio
269	5	1	6	83.3%
270	6	0	6	100.0%
271	4	0	4	100.0%
288	1	0	1	100.0%
298	24	4	28	85.7%
299	87	21	108	80.6%
300	10	3	13	76.9%
301	37	20	57	64.9%
302	4	2	6	66.7%
Total	178	51	229	

7.2. Appendix 2: Sample Implementation of the Success/Fail Formulae

This is a code sample written in Visual Basic for Applications. It is designed to be used as a custom formula in Microsoft Excel. It is included here to help the programmatically oriented understand how the chance to succeed or fail is calculated.

```
Function SuccessRate
  (
  Trivial As Integer,
  RawSkill As Integer,
  Optional Modifier As Integer = 0,
  Optional Mastery As Integer = 0,
  Optional SuccessCap As Double = 1,
  ) As Double

'This function calculates the average (predicted) chance of success
'for a given tradeskill combine.

'Note: This code is significantly NOT optimized. It's written
'to promote readability. There are a ton of optimizations that
'could be done to speed it up.

'Expected Inputs:
'----------------
'Trivial: Integer greater than or equal to zero

'RawSkill: Integer in the range of 0 to 300

'Modifier: Integer greater than or equal to zero. 5 indicates 5%,
'etc. This is optional; you may choose to not include it. The
'default value is no modifier. However, you must include it if you
'use mastery or a success cap.

'Mastery: Integer from 0 to 3, inclusive. 0 = no mastery, 1 =
'Crafting Mastery 1, etc. This is optional; you may choose to not
'include it. However, you must include it if you include a success
```

```
'cap. If you include this value, you must also provide a modifier
'value. The default value is no mastery.

'SuccessCap: Floating point value from 0 to 1, inclusive. This is
'the maximum chance to succeed at this item and overrides the
'formulaic cap. The default value is 100%, or no cap. This value
'is optional, but if you include it, you must include both Modifier
'and Mastery.

'Output:
'--------
'The predicted average success rate for a given combine, as a
'Double between 0 and 1, inclusive. Multiply by 100 to get the
'percentage as a number between 0 and 100.

'If invalid arguments are supplied, the function returns -1.


'Error Checking
If Trivial < 0
 Or RawSkill < 0
 Or RawSkill > 300
 Or Modifier < 0
 Or Mastery < 0
 Or Mastery > 3
 Or SuccessCap < 0
 Or SuccessCap > 1
Then
 SuccessRate = -1
 Exit Function
End If

'Combines with trivial 15 or less always succeed
If Trivial <= 15 Then
 SuccessRate = 1
 Exit Function
End If


'The skill modified by a geerlok or similar
Dim ModifiedSkill As Double

'The base chance of success, before caps are applied
Dim PrecapRate As Double

'The maximum chance to succeed a combine -- this is calculated
Dim UpperCap As Double

'The minimum chance to succeed is fixed
Const LowerCap = 0.05


'Calculate modified skill to account for geerloks or similar
ModifiedSkill = Int(RawSkill * (Modifier / 100 + 1))

'Calculate the chance of success before the upper and lower
```

```vb
'caps are applied
If Trivial < 68 Then
 PrecapRate = (ModifiedSkill - Trivial + 66) / 100
Else
 PrecapRate = (ModifiedSkill - 0.75 * Trivial + 51.5) / 100
End If

'Apply mastery if appropriate
If RawSkill <> 0 Then

 Select Case Mastery
  Case 1
   'Mastery 1 reduces the chance to fail by 10%
   PrecapRate = PrecapRate + ((1 - PrecapRate) * 0.1)
  Case 2
   'Mastery 2 reduces the chance to fail by 25%
   PrecapRate = PrecapRate + ((1 - PrecapRate) * 0.25)
  Case 3
   'Mastery 3 reduces the chance to fail by 50%
   PrecapRate = PrecapRate + ((1 - PrecapRate) * 0.5)
 End Select

End If

'Calculate the upper cap for the chance of success
If RawSkill >= Trivial + 40 Then
 'Apply check for very trivial combines; it can reduce
 'the chance to fail slightly
 UpperCap = 0.95 + (Int((RawSkill - Trivial) / 40)) / 100

 'Chance to succeed can never exceed 100%, so check to make sure
 'we never get above that
 If UpperCap > 1 Then UpperCap = 1
Else
 UpperCap = 0.95
End If

'Apply the item cap
If SuccessCap < UpperCap Then
 UpperCap = SuccessCap
End If

'Apply upper and lower caps, and return the appropriate result
If PrecapRate > UpperCap Then
 SuccessRate = UpperCap
ElseIf PrecapRate < LowerCap Then
 SuccessRate = LowerCap
Else
 SuccessRate = PrecapRate
End If

End Function
```

7.3. Appendix 3: Demonstration of an EverQuest Tradeskill Combine

This section is intended as a visual guide for those who have never played EverQuest or similar games. It is a demonstration of a simple combine to create a piece of armor called "Banded Mail." Our crafter first enters the smithy and purchases the needed supplies from the vendor. In the background, you can see the forge where the crafter will work.

Finding the necessary components for a tradeskill combine is not always easy. Some items are sold by vendors in unlimited quantities, while others have to be found by adventuring or defeating enemies. Our adventurer's banded mail is made entirely with store-bought items, so there is no problem with acquiring the components.

Once our crafter has purchased the components, she approaches the forge. Clicking on the forge opens the tradeskill container interface (to the right) and the character's inventory window (on the left). From the inventory window, the smith can view her statistics, equipped items such as weapons and armor, and bags.

Next, our crafter opens her bags to find the necessary items. One of each item needed is placed inside the forge. (A Leatherfoot Haversack is one type of bag available in the game.)

Once all the items are placed inside the container, the smith presses the Combine button. The game then determines whether the combine succeeded or failed. In this case, it succeeded. The components are "used up," and the resulting piece of armor appears on the smith's cursor.

Our smith is now the proud owner of a new suit of Banded Mail!

The smith also receives a text message confirming the success. Notice in particular the last two lines in blue text. The first line indicates that this combine is trivial – our smith can no longer increase her skill by making Banded Mail. The second line indicates a successful combine.
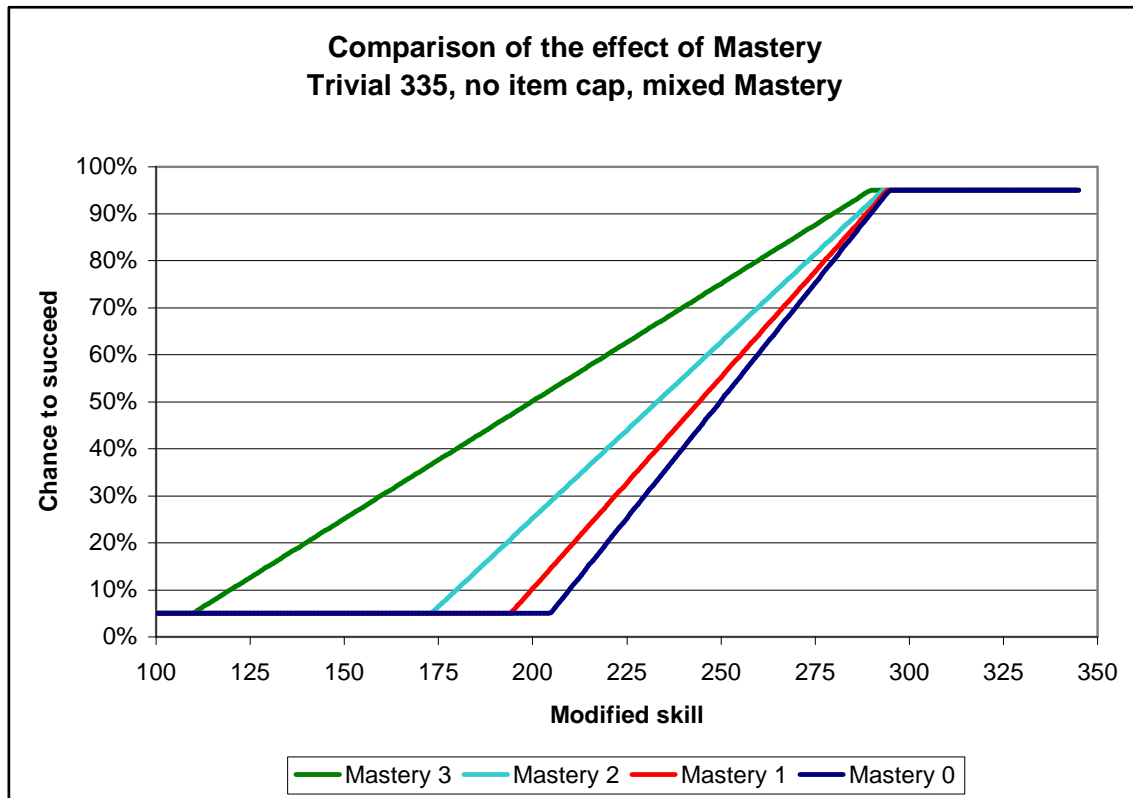
```
                          Main Chat
Sectional Mold.'
You give 1 platinum 2 gold 5 silver 9 copper to Kaleras Darkanvil.
Wegal Darkanvil regards you indifferently -- what would you like your tombston
Wegal Darkanvil says 'Greetings, Ragbit. You look like you could use a Small
Mold.'
Taking a screenshot...
Requesting favorite recipes...
Taking a screenshot...
Taking a screenshot...
Taking a screenshot...
You can no longer advance your skill from making this item.
You have fashioned the items together to create something new!
Taking a screenshot...
```

For future combine attempts, our smith can use the so-called "new" interface (implemented around February 2004) that allows her to see the exact trivial of the item she is making. The Banded Mail she just made has a trivial of 115. Notice that her modified skill is displayed in the upper right hand corner.

```
                      Tradeskill Window            ? x
Min. Trivial:      0            Blacksmithing (240)
Max. Trivial:      500
Partial Name:    banded                    Forge
   Search Recipes                    Experiment

Known Matching Recipes:

Recipe Name          Trivial
Banded Belt            95
Banded Boots           95
Banded Bracer          95
Banded Cloak          102
Banded Gauntlets      102
Banded Gorget          92
Banded Helm           106
Banded Leggings       108
Banded Mail           115
Banded Mantle          95
Banded Mask            90
Banded Sleeves        102
Large Banded Belt      95
Large Banded Boots     95
Large Banded Bracer    95
Large Banded Cloak    102

Favorite Recipes:                  Combine
  Add   Remove   Show           Auto-Inventory

                    Open with Ctrl-R-click   Close
```
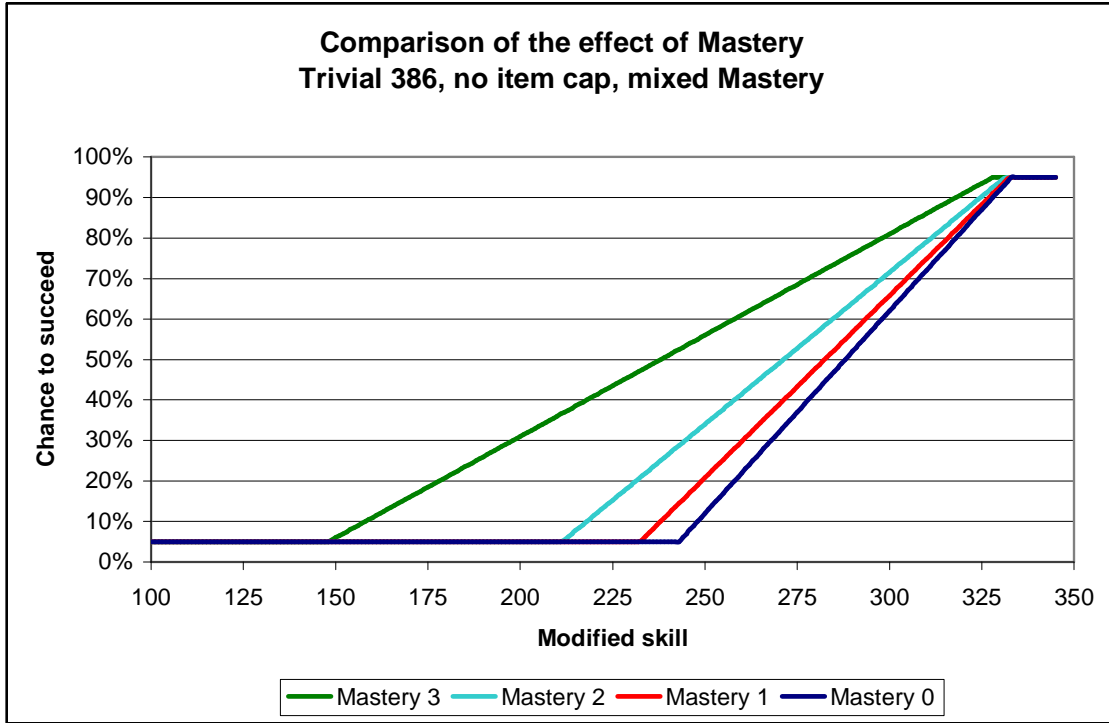
7.4.   Appendix 4: Effect of Masteries and Success Caps

As a final note, it is interesting to compare the potential success rates for a combine done with and without mastery. This allows us to see at what point mastery becomes useful, and at what point it ceases to provide a benefit to the tradeskiller.

Consider the following graph, which depicts an item with trivial 335, no item success cap, and all three mastery levels.

In contrast, this next graph uses a trivial of 386.

**Comparison of the effect of Mastery
Trivial 386, no item cap, mixed Mastery**

Chance to succeed (y-axis): 0% to 100%
Modified skill (x-axis): 100 to 350

Legend: Mastery 3, Mastery 2, Mastery 1, Mastery 0

Finally, this last chart is an item with trivial 386 and a 62% item cap.

**Comparison of the effect of Mastery
Trivial 386, 62% item cap, mixed Mastery**

Chance to succeed (y-axis): 0% to 100%
Modified skill (x-axis): 100 to 350

Legend: Mastery 3, Mastery 2, Mastery 1, Mastery 0