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# 📊 Visual Guide: Why Closing Events Matter & Max Position Tracking

## 🎯 Core Concept Visualization

### The Fundamental Rule

┌─────────────────────────────────────────────────────────────┐  
│ WATCH TIME IS ONLY COUNTED BETWEEN EVENT PAIRS │  
│ │  
│ ✅ VALID PAIRS (Counted): │  
│ • video\_play → video\_pause │  
│ • video\_play → video\_ended │  
│ • video\_resume → video\_pause │  
│ • video\_resume → video\_ended │  
│ │  
│ ❌ INVALID (Not Counted): │  
│ • video\_play → [nothing] │  
│ • video\_resume → [nothing] │  
│ • video\_pause → video\_resume (no watching here) │  
│ • video\_pause → video\_play (new segment) │  
└─────────────────────────────────────────────────────────────┘

## 🎬 Peter’s Journey - Step by Step

### Timeline Visualization

Video Timeline: 0s ────────────────→ 30s ────────→ 300s (end)  
 ├─────────────────────┼─────────────────┤  
 | First Watch | Video Length |  
 | (30 seconds) | (5 minutes) |  
  
  
🎥 Event Sequence:  
  
Time: 10:00:00 10:00:30 10:00:35 10:01:05  
Event: ▶️ PLAY ⏸️ PAUSE ▶️ RESUME ❌ CLOSE  
Position: 0s 30s 20s ~50s  
 │ │ │ │  
 └─────────────────────────────┘ │ │  
 ✅ VALID PAIR │ │  
 Watching: 0s → 30s │ │  
 Counted: 30 seconds │ │  
 └─────────────────────┘  
 ❌ INVALID PAIR  
 Resume → [nothing]  
 Not counted: 0 seconds

### What Actually Happened vs What Gets Counted

┌─────────────────────────────────────────────────────────────────────────┐  
│ REALITY (What Peter Actually Did) │  
├─────────────────────────────────────────────────────────────────────────┤  
│ │  
│ 0s ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━► 30s │  
│ └──────────── Watched 30s ────────┘ │  
│ │  
│ 30s ⟲ (rewind) 20s (instant, no watching) │  
│ │  
│ 20s ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━► 50s │  
│ └──────── Watched 30s more ───────┘ │  
│ │  
│ Total actual watch time: 60 seconds │  
│ Max position reached: 30s (before rewind) │  
│ Final position: ~50s (when browser closed) │  
└─────────────────────────────────────────────────────────────────────────┘  
  
┌─────────────────────────────────────────────────────────────────────────┐  
│ WHAT SCRIPT COUNTS (Based on Event Pairs) │  
├─────────────────────────────────────────────────────────────────────────┤  
│ │  
│ Segment 1: play(0s) → pause(30s) │  
│ 0s ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━► 30s │  
│ └────── ✅ COUNTED: 30s ──────────┘ │  
│ │  
│ [Rewind detected: 30s → 20s, but no watching happened] │  
│ │  
│ Segment 2: resume(20s) → [browser close, no event] │  
│ 20s ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━► ~50s │  
│ └────── ❌ NOT COUNTED: 0s ───────┘ │  
│ (No closing event!) │  
│ │  
│ Total counted watch time: 30 seconds │  
│ Max position tracked: 30s (from pause event) │  
└─────────────────────────────────────────────────────────────────────────┘

## 🔍 Understanding Max Position vs Watch Time

### Important Distinction

┌──────────────────────────────────────────────────────────────────┐  
│ MAX POSITION ≠ WATCH TIME │  
├──────────────────────────────────────────────────────────────────┤  
│ │  
│ maxPosition: Furthest point reached in video │  
│ (from ANY event with currentTime) │  
│ │  
│ totalWatchTime: Only counted from VALID EVENT PAIRS │  
│ (requires both start AND end event) │  
│ │  
└──────────────────────────────────────────────────────────────────┘

### Peter’s Example

Events:  
 ▶️ play(0s)  
 ⏸️ pause(30s) ← maxPosition = 30s  
 ▶️ resume(20s)  
 ❌ [close]  
  
┌─────────────────────────────────────────────────────────┐  
│ maxPosition = 30s │  
│ (Highest currentTime value from any event) │  
│ │  
│ totalWatchTime = 30s │  
│ (Only from valid pair: play→pause) │  
│ │  
│ completionPercentage = (30 / 300) \* 100 = 10% │  
│ (Based on maxPosition) │  
│ │  
│ watchPercentage = (30 / 300) \* 100 = 10% │  
│ (Based on totalWatchTime) │  
└─────────────────────────────────────────────────────────┘

## 🎭 Scenario Comparison: The Rewind Question

### Scenario A: Peter’s Actual Journey (Rewind then Close)

┌──────────────────────────────────────────────────────────────────┐  
│ Events: play(0) → pause(30) → resume(20) → [close] │  
└──────────────────────────────────────────────────────────────────┘  
  
Video Position Timeline:  
0s ══════════════════════════► 30s ⟲ 20s ══════════► 50s (close)  
├─────────────────────────────┤ ├──────────────────┤  
│ ✅ Segment 1: 30s counted │ │ ❌ Lost: 30s │  
└─────────────────────────────┘ └──────────────────┘  
  
Max Position Tracking:  
 Event 1 (play): maxPosition = 0s  
 Event 2 (pause): maxPosition = 30s ← Highest!  
 Event 3 (resume): maxPosition = 30s (still 30s, because 20 < 30)  
 [close]: maxPosition = 30s (no event to update)  
  
Result:  
 totalWatchTime: 30s  
 maxPosition: 30s ← Uses highest position (30), not last (20)  
 watchPercentage: 10%  
 completionPercentage: 10%

### Scenario B: No Rewind, Just Forward (then Close)

┌──────────────────────────────────────────────────────────────────┐  
│ Events: play(0) → pause(30) → resume(30) → [close at 60s] │  
└──────────────────────────────────────────────────────────────────┘  
  
Video Position Timeline:  
0s ══════════════════════════► 30s ══════════════════► 60s (close)  
├─────────────────────────────┤ ├──────────────────────┤  
│ ✅ Segment 1: 30s counted │ │ ❌ Lost: 30s │  
└─────────────────────────────┘ └──────────────────────┘  
  
Max Position Tracking:  
 Event 1 (play): maxPosition = 0s  
 Event 2 (pause): maxPosition = 30s  
 Event 3 (resume): maxPosition = 30s (30 ≥ 30, no change)  
 [close]: maxPosition = 30s (no event to update)  
  
Result:  
 totalWatchTime: 30s (Same as Scenario A!)  
 maxPosition: 30s (No event at 60s to update this)  
 watchPercentage: 10%  
 completionPercentage: 10%

## 🚨 Critical Insight: The Closing Event Problem

### Visual Representation

┌────────────────────────────────────────────────────────────────────┐  
│ WITHOUT CLOSING EVENT: │  
├────────────────────────────────────────────────────────────────────┤  
│ │  
│ ▶️ resume(20s) ───→ ❌ [browser close at ~50s] │  
│ │  
│ What we KNOW: │  
│ • User pressed resume at 20s │  
│ • Browser closed (no event) │  
│ │  
│ What we DON'T KNOW: │  
│ • Where did user actually stop watching? │  
│ • Did they watch to 50s? 40s? 21s? │  
│ • Did they pause first then close? │  
│ • Did they immediately close after resume? │  
│ │  
│ Script Decision: CONSERVATIVE APPROACH │  
│ ❌ Don't count this segment at all │  
│ ❌ Don't guess or estimate │  
│ ✅ Only count what we KNOW for certain │  
│ │  
└────────────────────────────────────────────────────────────────────┘  
  
┌────────────────────────────────────────────────────────────────────┐  
│ WITH CLOSING EVENT: │  
├────────────────────────────────────────────────────────────────────┤  
│ │  
│ ▶️ resume(20s) ───→ ⏸️ pause(50s) ───→ ❌ [close] │  
│ │  
│ What we KNOW: │  
│ • User pressed resume at 20s │  
│ • User pressed pause at 50s │  
│ • User watched from 20s to 50s │  
│ │  
│ Script Decision: │  
│ ✅ Count this segment: 50 - 20 = 30 seconds │  
│ ✅ Update maxPosition to 50s │  
│ ✅ We KNOW this is accurate │  
│ │  
└────────────────────────────────────────────────────────────────────┘

## 📊 The Max Position Question - Detailed Example

### Why Max Position Uses 30s (Not 20s After Rewind)

Event Sequence with Max Position Tracking:  
  
Event 1: ▶️ play(0s)  
┌────────────────────────────────────┐  
│ currentTime: 0s │  
│ maxPosition: 0s │  
└────────────────────────────────────┘  
  
Event 2: ⏸️ pause(30s)  
┌────────────────────────────────────┐  
│ currentTime: 30s │  
│ maxPosition: MAX(0s, 30s) = 30s ✅ │  
└────────────────────────────────────┘  
  
Event 3: ▶️ resume(20s) [User rewound!]  
┌────────────────────────────────────┐  
│ currentTime: 20s │  
│ maxPosition: MAX(30s, 20s) = 30s │ ← Still 30s!  
└────────────────────────────────────┘  
  
[Browser closes - no event]  
┌────────────────────────────────────┐  
│ Final maxPosition: 30s │  
│ (No new event to update it) │  
└────────────────────────────────────┘  
  
The Code:  
maxPosition = \_max("currentTime") // Takes the highest value

## 🎨 Complete Example Matrix

Let me show you ALL the scenarios side-by-side:

┌──────────┬─────────────────────────────┬─────────┬─────────┬───────────┐  
│ Scenario │ Event Sequence │ Watch │ Max Pos │ Counted % │  
│ │ │ Time │ │ │  
├──────────┼─────────────────────────────┼─────────┼─────────┼───────────┤  
│ 1 │ play(0) → pause(30) │ 30s ✅ │ 30s │ 10% │  
│ │ │ │ │ │  
├──────────┼─────────────────────────────┼─────────┼─────────┼───────────┤  
│ 2 │ play(0) → pause(30) │ 30s ✅ │ 30s │ 10% │  
│ │ → resume(30) → [close] │ 0s ❌ │ │ │  
│ │ │ = 30s │ │ │  
├──────────┼─────────────────────────────┼─────────┼─────────┼───────────┤  
│ 3 │ play(0) → pause(30) │ 30s ✅ │ 30s │ 10% │  
│ │ → resume(20) → [close] │ 0s ❌ │ │ │  
│ │ [Your scenario] │ = 30s │ │ │  
├──────────┼─────────────────────────────┼─────────┼─────────┼───────────┤  
│ 4 │ play(0) → pause(30) │ 30s ✅ │ 50s │ 20% │  
│ │ → resume(20) → pause(50) │ 30s ✅ │ │ │  
│ │ │ = 60s │ │ │  
├──────────┼─────────────────────────────┼─────────┼─────────┼───────────┤  
│ 5 │ play(0) → [close at 30s] │ 0s ❌ │ 0s │ 0% │  
│ │ │ │ │ │  
├──────────┼─────────────────────────────┼─────────┼─────────┼───────────┤  
│ 6 │ play(0) → pause(30) │ 30s ✅ │ 80s │ 27% │  
│ │ → resume(30) → pause(80) │ 50s ✅ │ │ │  
│ │ │ = 80s │ │ │  
└──────────┴─────────────────────────────┴─────────┴─────────┴───────────┘  
  
Key:  
✅ = Segment counted (has closing event)  
❌ = Segment NOT counted (missing closing event)

## 🔬 Deep Dive: Why Scenario 3 and 4 Differ

### Scenario 3: Rewind + Browser Close (Your Question)

┌─────────────────────────────────────────────────────────────────┐  
│ play(0) → pause(30) → resume(20) → [close] │  
└─────────────────────────────────────────────────────────────────┘  
  
Step-by-step:  
  
1️⃣ Segment: play(0) → pause(30)  
 ✅ Valid pair  
 Watch time: 30 - 0 = 30s  
 Running total: 30s  
  
2️⃣ Segment: resume(20) → [nothing]  
 ❌ Invalid (no closing event)  
 Watch time: Cannot calculate  
 Running total: 30s (unchanged)  
  
Final Metrics:  
 totalWatchTime: 30s  
 maxPosition: 30s ← MAX(0, 30, 20) = 30  
 watchPercentage: 10%  
 completionPercentage: 10%

### Scenario 4: Rewind + Pause Before Close

┌─────────────────────────────────────────────────────────────────┐  
│ play(0) → pause(30) → resume(20) → pause(50) │  
└─────────────────────────────────────────────────────────────────┘  
  
Step-by-step:  
  
1️⃣ Segment: play(0) → pause(30)  
 ✅ Valid pair  
 Watch time: 30 - 0 = 30s  
 Running total: 30s  
  
2️⃣ Segment: resume(20) → pause(50)  
 ✅ Valid pair (has closing event!)  
 Watch time: 50 - 20 = 30s  
 Running total: 60s  
  
Final Metrics:  
 totalWatchTime: 60s  
 maxPosition: 50s ← MAX(0, 30, 20, 50) = 50  
 watchPercentage: 20%  
 completionPercentage: 16.7%  
  
The ONLY difference: One ⏸️ pause event at the end!

## 💡 The Golden Rule Visualized

╔══════════════════════════════════════════════════════════════════╗  
║ THE GOLDEN RULE ║  
╠══════════════════════════════════════════════════════════════════╣  
║ ║  
║ To count watch time, you need TWO events: ║  
║ ║  
║ ┌──────────┐ ┌──────────┐ ║  
║ │ START │ ───→ │ END │ ║  
║ │ EVENT │ │ EVENT │ ║  
║ └──────────┘ └──────────┘ ║  
║ play/resume pause/ended ║  
║ ║  
║ Without BOTH events, we cannot know how much time passed! ║  
║ ║  
║ ┌──────────┐ ┌──────────┐ ║  
║ │ START │ ───→ │ ? │ ← NO CLOSING EVENT ║  
║ │ EVENT │ │ │ ║  
║ └──────────┘ └──────────┘ ║  
║ play/resume [nothing] ║  
║ ║  
║ Result: ❌ Cannot count this segment ║  
║ ❌ Watch time = 0 ║  
║ ✅ maxPosition still updated from previous events ║  
║ ║  
╚══════════════════════════════════════════════════════════════════╝

## 🎯 Why Max Position Matters

### Use Cases for Max Position

┌─────────────────────────────────────────────────────────────────┐  
│ maxPosition tells you: │  
│ • How far into the video did the user get? │  
│ • What's the furthest point they reached? │  
│ • Did they skip to the end? (maxPosition ≈ videoDuration) │  
│ • Where did they drop off? │  
│ │  
│ totalWatchTime tells you: │  
│ • How much time did they actually spend watching? │  
│ • How engaged were they? │  
│ • Can calculate: minutes watched, watch percentage │  
│ │  
│ Both metrics are important but measure different things! │  
└─────────────────────────────────────────────────────────────────┘

### Example Where They Differ

User skips around a lot:  
  
play(0) → pause(10) ✅ 10s watched, maxPos = 10s  
resume(50) → pause(60) ✅ 10s watched, maxPos = 60s  
resume(100) → pause(110) ✅ 10s watched, maxPos = 110s  
  
Results:  
 totalWatchTime: 30s (10 + 10 + 10)  
 maxPosition: 110s (furthest point reached)  
   
 watchPercentage: 10% (30 / 300)  
 completionPercentage: 36.7% (110 / 300)  
   
User explored 36.7% of the video but only watched 10% of it!

## 📱 Real-World Analogy

Think of it like a fitness tracker:

┌──────────────────────────────────────────────────────────────┐  
│ MAX POSITION = Furthest distance from home │  
│ (Where did you go?) │  
│ │  
│ WATCH TIME = Actual time spent walking │  
│ (How long were you active?) │  
│ │  
│ You might walk to a location 5km away (maxPosition = 5km) │  
│ But if you run there, you only spent 20 minutes active │  
│ (totalWatchTime = 20 min) │  
│ │  
│ Or you might walk around your neighborhood for 1 hour │  
│ (totalWatchTime = 60 min) │  
│ But only get 1km from home │  
│ (maxPosition = 1km) │  
│ │  
│ Both metrics tell you something different! │  
└──────────────────────────────────────────────────────────────┘

## 🎬 Final Visual Summary

╔══════════════════════════════════════════════════════════════════╗  
║ PETER'S VIDEO SESSION - COMPLETE BREAKDOWN ║  
╠══════════════════════════════════════════════════════════════════╣  
║ ║  
║ Video Timeline: 0s ─────────────→ 300s (5 minutes) ║  
║ ║  
║ ┌────────────────────────────────────────────────────────────┐ ║  
║ │ 10:00:00 │ ▶️ PLAY at 0s │ ║  
║ │ │ ↓ (watching...) │ ║  
║ │ │ 0s ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━► 30s │ ║  
║ │ │ │ ║  
║ │ 10:00:30 │ ⏸️ PAUSE at 30s │ ║  
║ │ │ ✅ COUNTED: 30 seconds │ ║  
║ │ │ maxPosition = 30s │ ║  
║ │ │ │ ║  
║ │ 10:00:35 │ ▶️ RESUME at 20s (rewound 10s) │ ║  
║ │ │ ↓ (watching...) │ ║  
║ │ │ 20s ━━━━━━━━━━━━━━━━━━━━━━━━━━━━► ~50s │ ║  
║ │ │ │ ║  
║ │ 10:01:05 │ ❌ BROWSER CLOSE (no event sent) │ ║  
║ │ │ ❌ NOT COUNTED: 0 seconds │ ║  
║ │ │ maxPosition = 30s (unchanged - no event) │ ║  
║ └────────────────────────────────────────────────────────────┘ ║  
║ ║  
║ FINAL METRICS: ║  
║ totalWatchTime: 30s ║  
║ maxPositionReached: 30s ← Uses highest, not last! ║  
║ watchPercentage: 10% ║  
║ completionPercentage: 10% ║  
║ totalBackwardSkips: 1 ║  
║ engagementScore: 3.5 ║  
║ engagementTier: Minimal ║  
║ ║  
╚══════════════════════════════════════════════════════════════════╝

## 🔑 Key Takeaways

1. **Closing Event Requirement**
   * ✅ Watch time only counted with BOTH start and end events
   * ❌ Missing closing event = segment not counted
   * This is CONSERVATIVE but ACCURATE
2. **Max Position Tracking**
   * Always tracks the HIGHEST position reached
   * Unaffected by rewinds (uses MAX, not LAST)
   * Updated from ANY event with currentTime
   * Used for completionPercentage
3. **Peter’s Scenario Answer**
   * Actual watch: 60 seconds (30 + 30)
   * Counted watch: 30 seconds (only first segment)
   * Max position: 30 seconds (highest reached before rewind)
   * Missing: 30 seconds after resume (no closing event)
4. **To Fix This**
   * Add heartbeat events (every 30s)
   * Add beforeunload handler
   * Or accept conservative estimates

Does this visualization help clarify the concept? 🎯