w2.1- Introduction to Quality Tools


w2.1- Introduction to Quality Tools.mp4
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Quality Tools
• Flow Charts and Process Maps
• Checksheets
• Histograms
• Pareto Charts
• Cause and Effect diagrams
• Scatter Diagrams
• Six Sigma measures
• Cost of Quality
Each of these tools has a specific
function in our improvement efforts.
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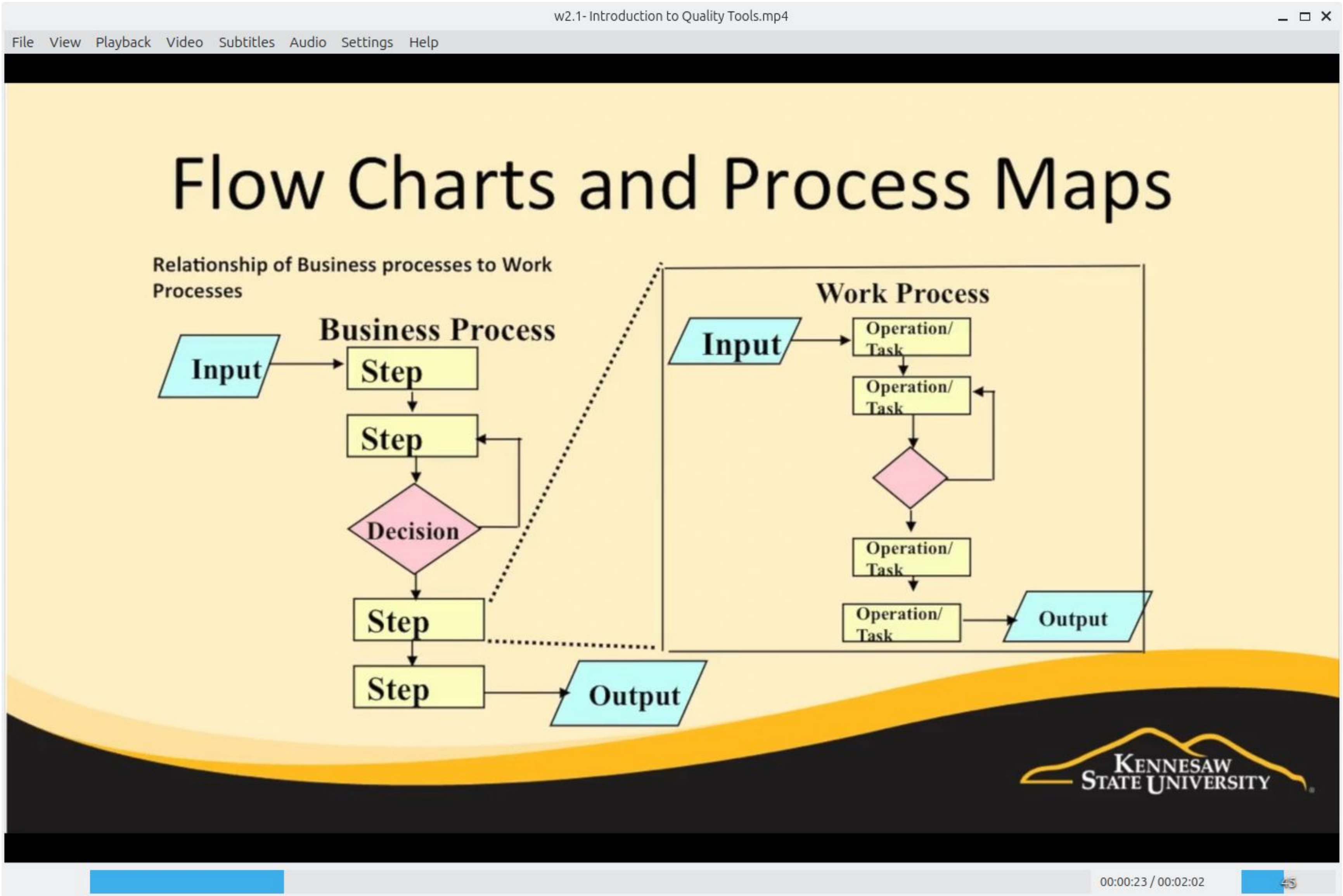
00:00:10 / 00:02:02


w2.1- Introduction to Quality Tools.mp4
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Help
Flow Charts and Process Maps
Relationship of Business processes to Work Processes
Business Process
Input
Step
Step
Decision
Step
Step
Output
Work Process
Input
Operation/ Task
Operation/ Task
Operation/ Task
Operation/ Task
Output
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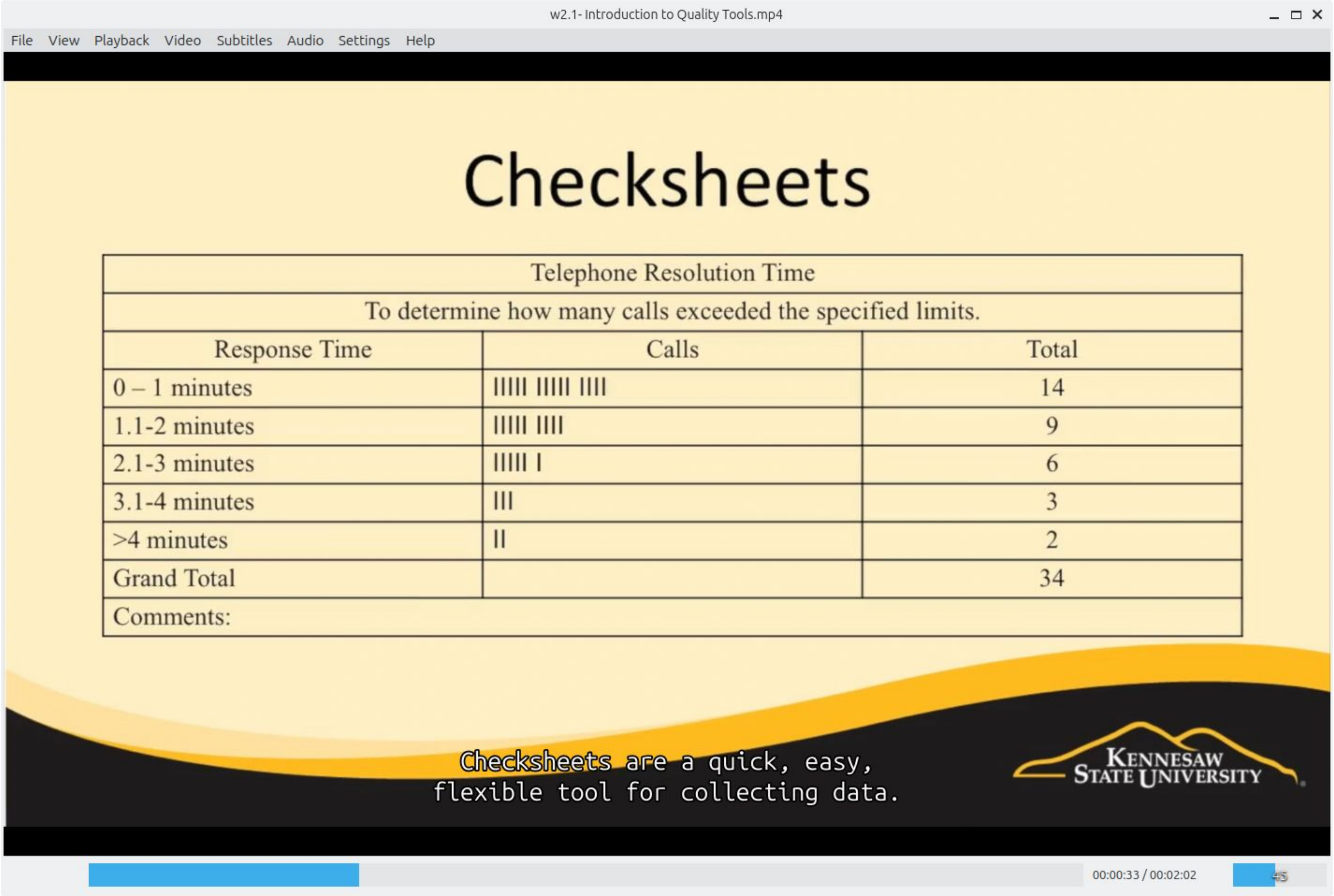
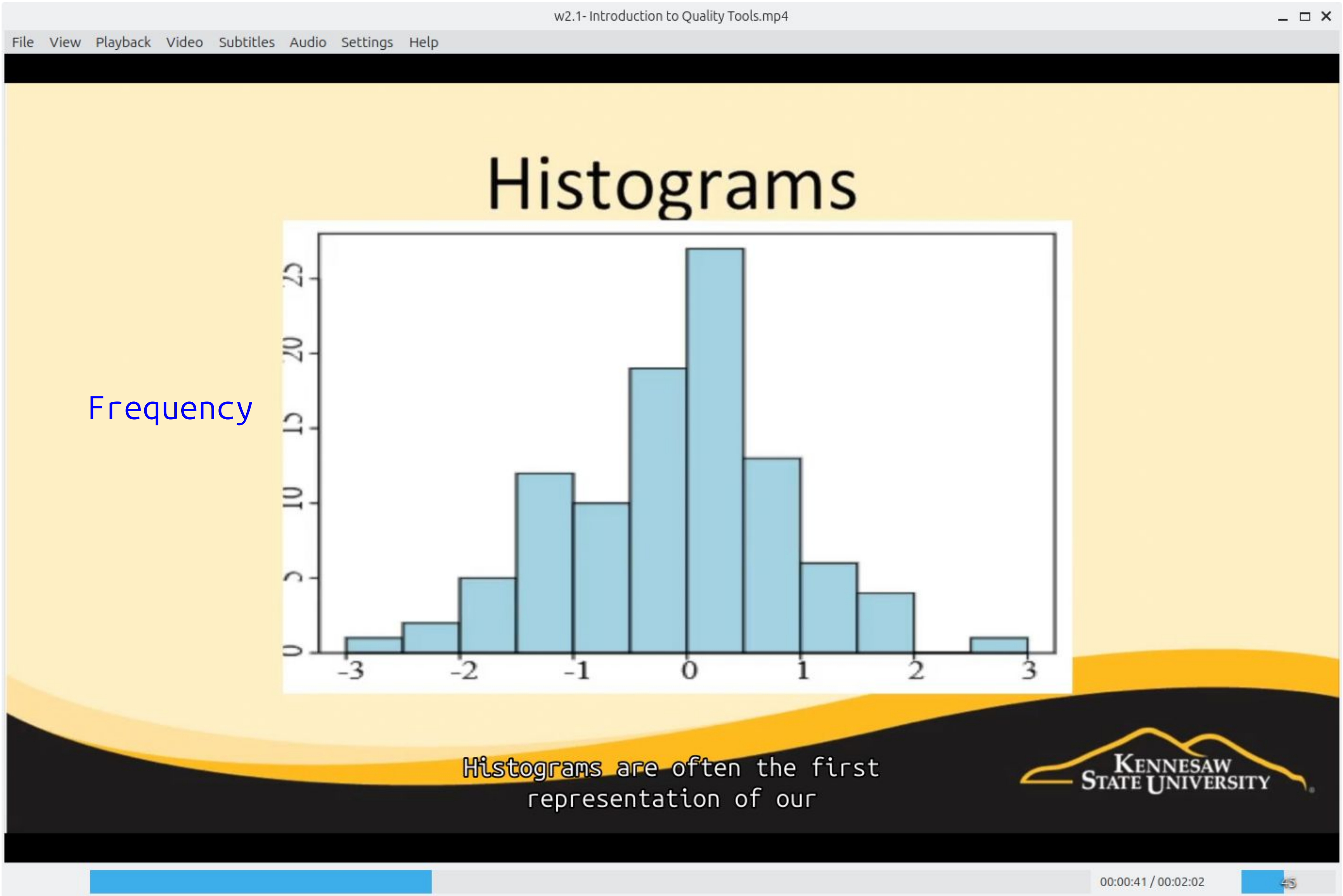


Checksheets

Telephone Resolution Time		
To determine how many calls exceeded the specified limits.		
Response Time	Calls	Total
0 – 1 minutes	IIIII IIIII IIII	14
1.1-2 minutes	IIIII IIII	9
2.1-3 minutes	IIIII I	6
3.1-4 minutes	III	3
>4 minutes	II	2
Grand Total		34
Comments:		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Histograms
Frequency
-3 -2 -1 0 1 2 3
Histograms are often the first
representation of our
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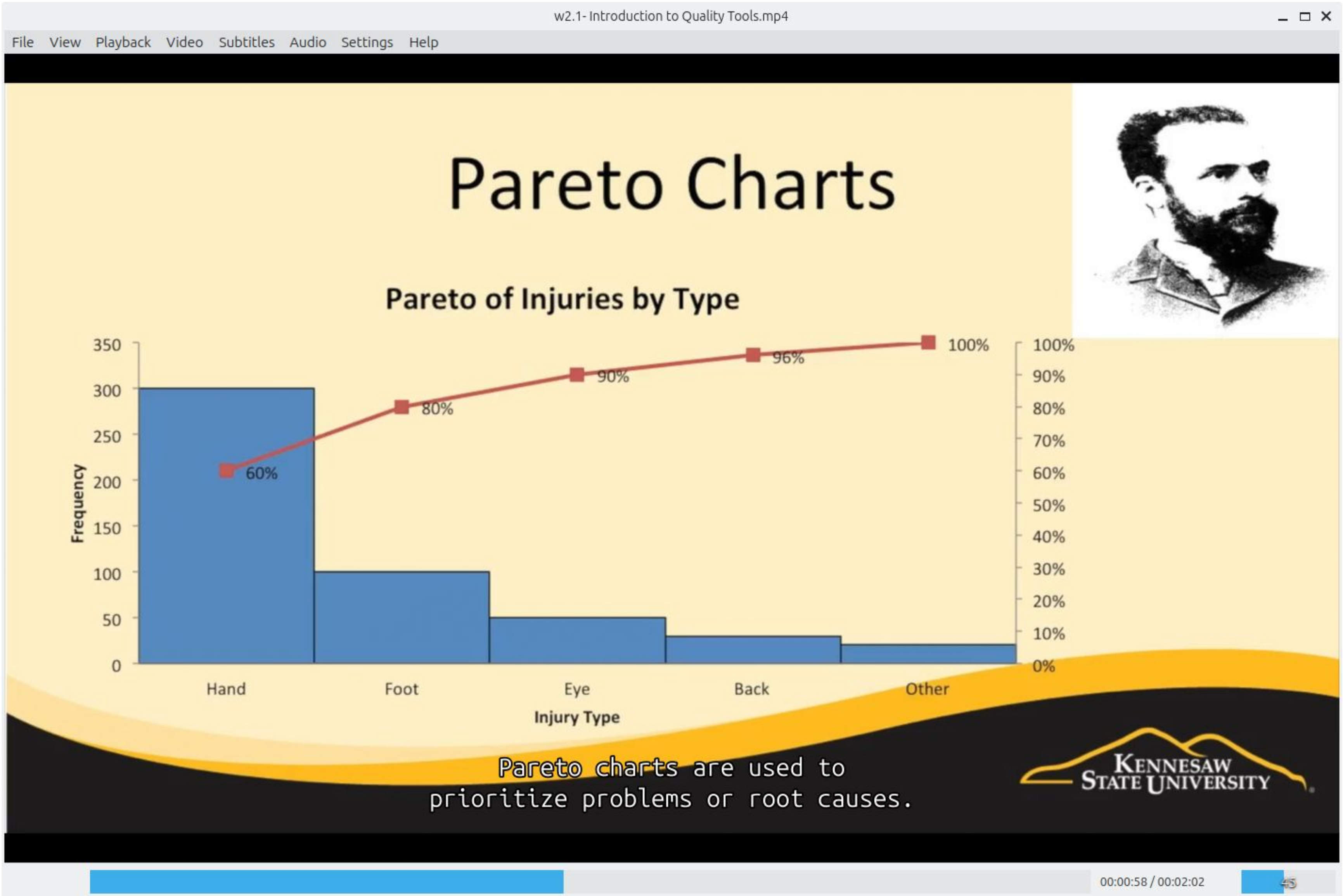
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Pareto Charts
Pareto of Injuries by Type
Frequency
350
300
250
200
150
100
50
0
60%
80%
90%
96%
100%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Hand
Foot
Eye
Back
Other
Injury Type
Pareto charts are used to
prioritize problems or root causes.
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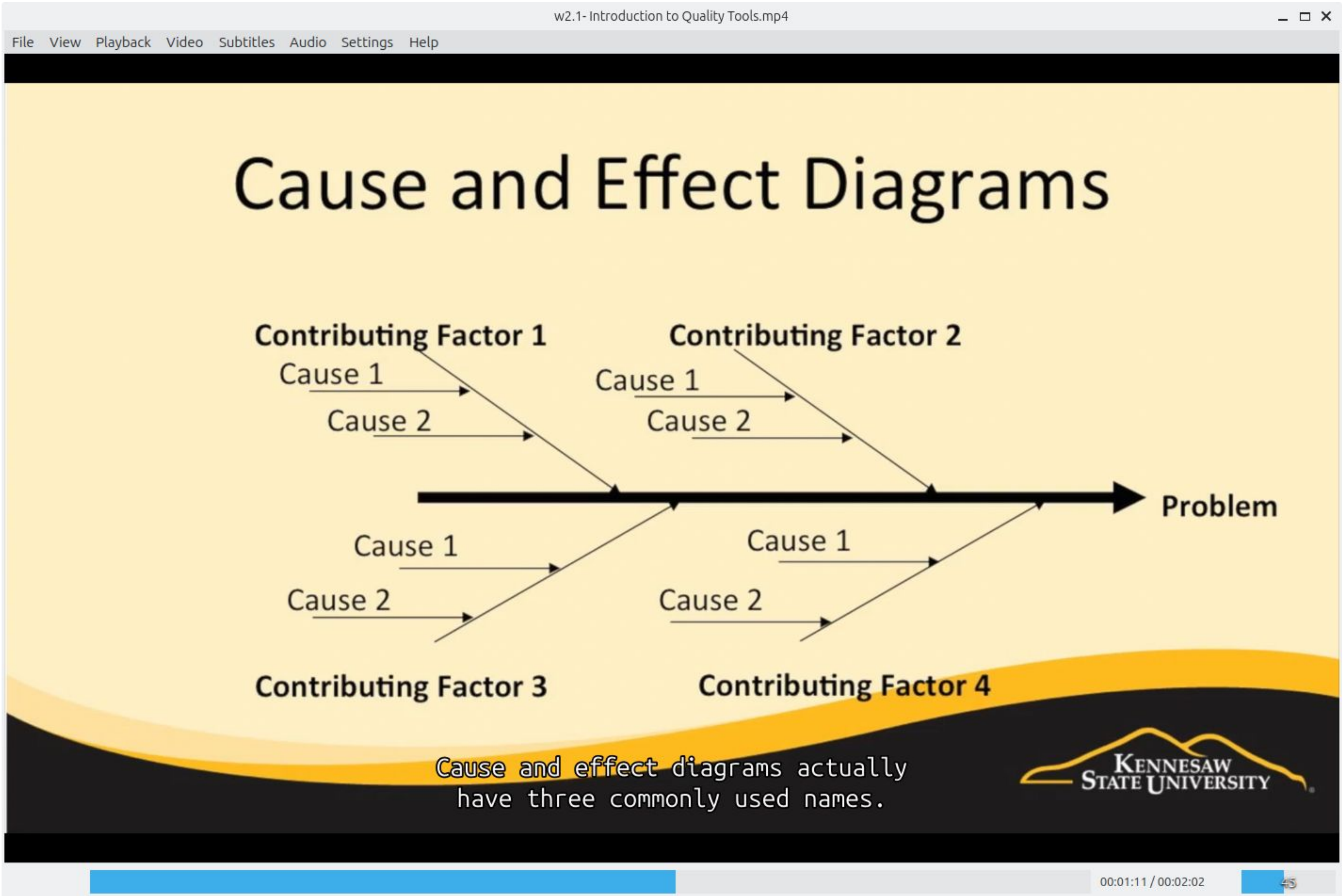
00:00:58 / 00:02:02


w2.1- Introduction to Quality Tools.mp4
File View Playback Video Subtitles Audio Settings Help
Cause and Effect Diagrams
Contributing Factor 1
Cause 1
Cause 2
Contributing Factor 2
Cause 1
Cause 2
Problem
Cause 1
Cause 2
Cause 1
Cause 2
Contributing Factor 3
Contributing Factor 4
Cause and effect diagrams actually
have three commonly used names.
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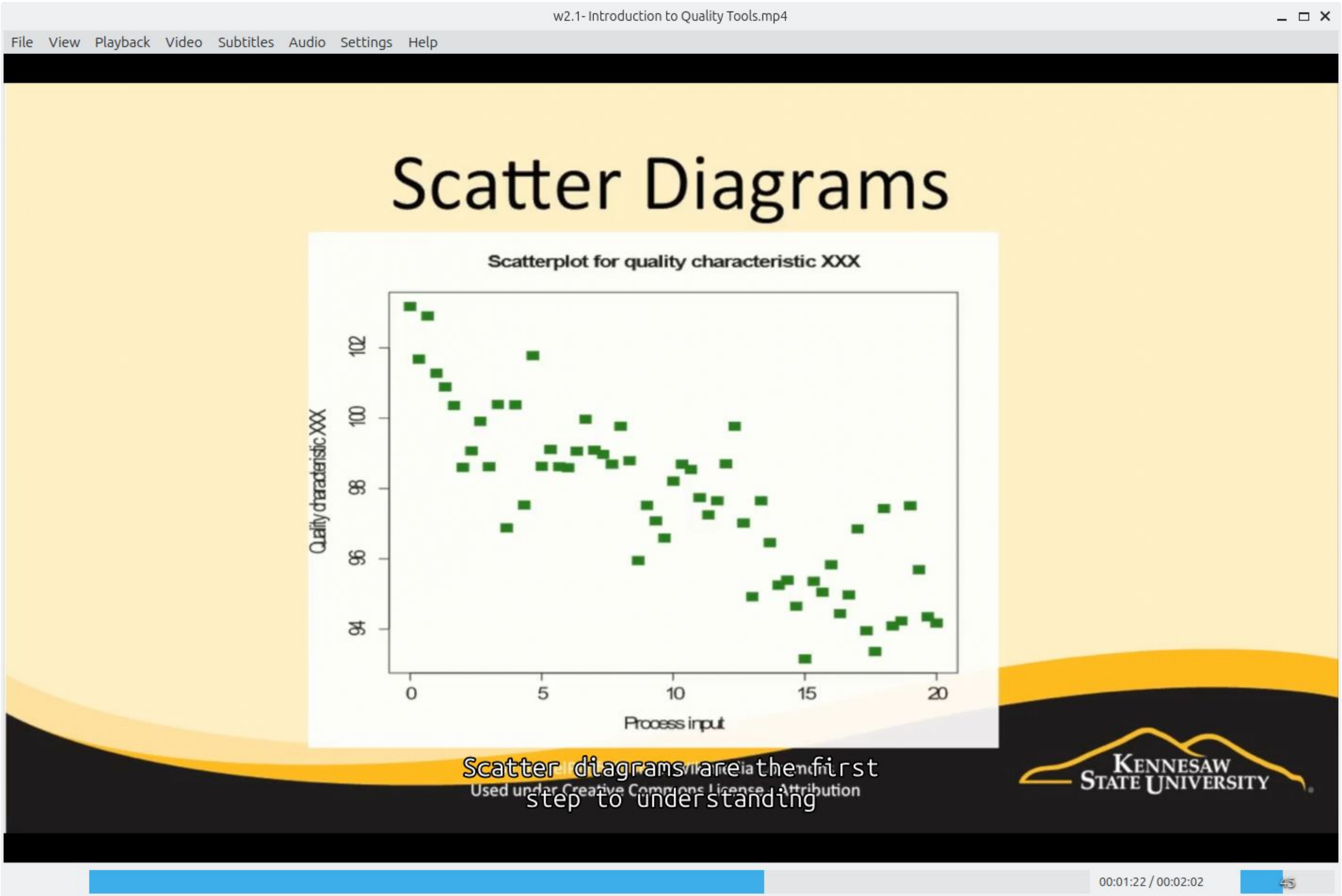
00:01:11 / 00:02:02


w2.1- Introduction to Quality Tools.mp4
File View Playback Video Subtitles Audio Settings Help
Scatter Diagrams
Scatterplot for quality characteristic XXX
Quality characteristic XXX
94
96
98
100
102
0
5
10
15
20
Process input
Scatter diagrams are the first
step to understanding
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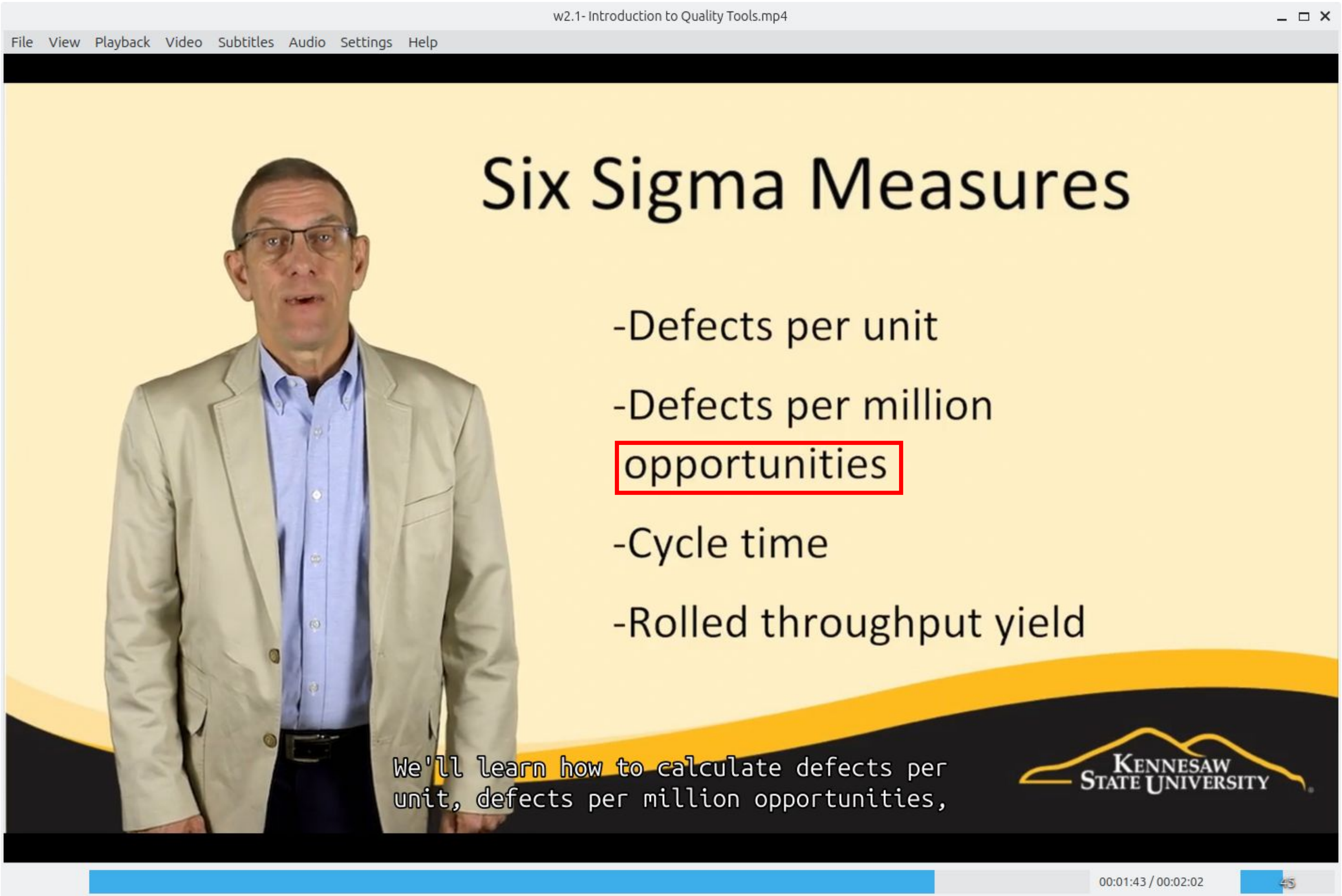
00:01:22 / 00:02:02


w2.1- Introduction to Quality Tools.mp4
File View Playback Video Subtitles Audio Settings Help
Six Sigma Measures
-Defects per unit
-Defects per million
opportunities
-Cycle time
-Rolled throughput yield
We'll learn how to calculate defects per
unit, defects per million opportunities,
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00:01:43 / 00:02:02


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Volume: 35
Quality Costs
Internal Failure
绩效考核
External Failure
Appraisal
Prevention
Finally, we'll examine
the cost of quality, how
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10
00:01:52 / 00:02:02
35

Appraisal Costs (Cost of Good Quality)

Appraisal costs are the expenses incurred to **measure, evaluate, or inspect** products, processes, and services to ensure they **conform to quality standards**. They are proactive costs, designed to detect defects *before* they become a larger problem.

- **Goal:** To determine the degree of conformance to quality requirements.
- **Examples:**
  - **Inspecting** incoming raw materials.
  - **In-process checks** and final product testing.
  - **Audits** of the quality system.
  - Maintaining and **calibrating** measurement and test equipment.
  - Labor costs for **quality assurance (QA)** personnel.

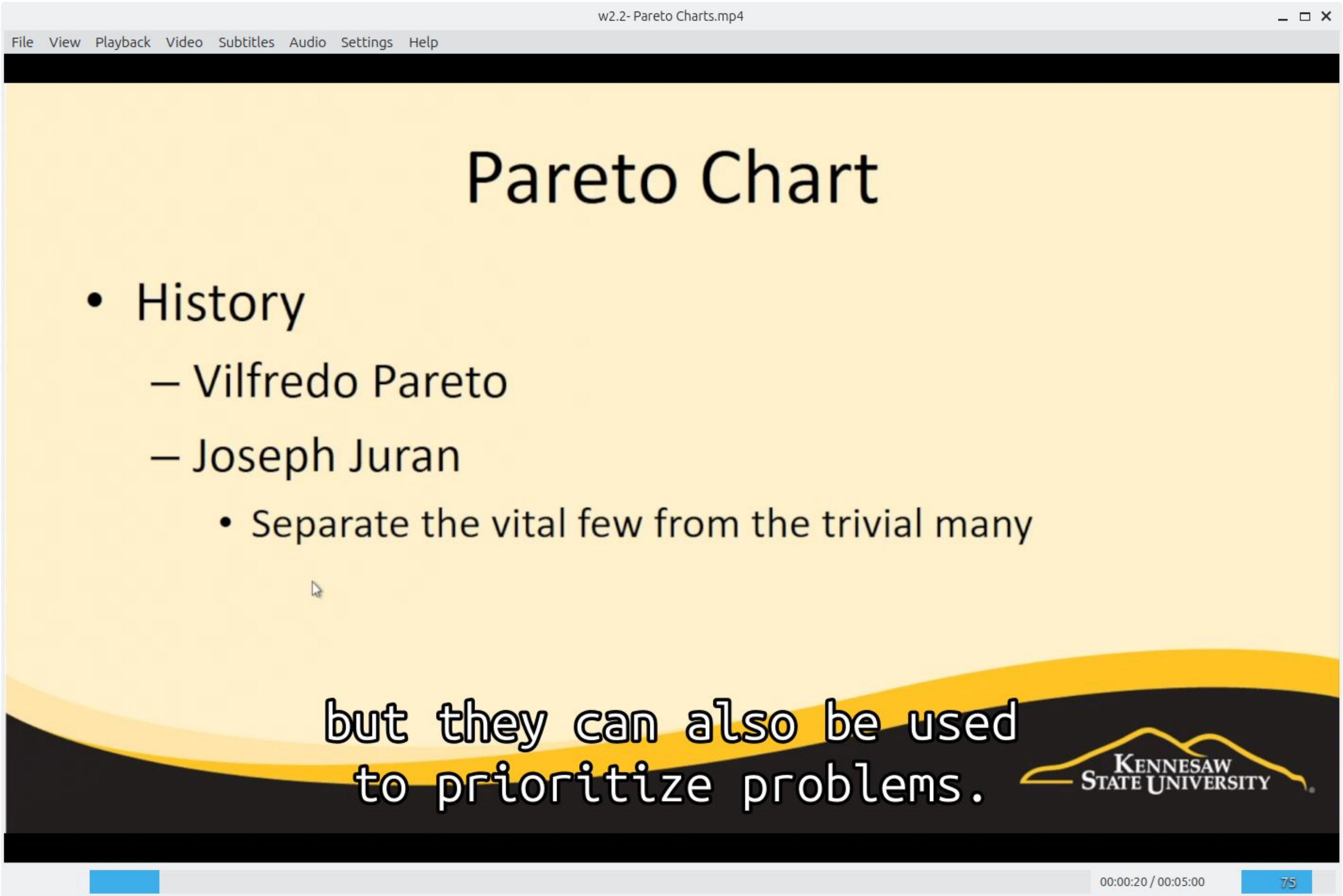
Tool	Primary Purpose	Key Insight
Flow Charts / Process Maps	Understanding processes (often the first step).	Visualize the process to identify areas for improvement.
Checksheets	Quick, easy, and flexible **data collection.**	Used with several other tools to gather raw data.
Histograms	First visual representation of data.	Reveal the **shape, center, and spread** of the data at a glance.
Pareto Charts	**Prioritize problems or root causes.**	Source of the **80/20 rule** (focus efforts where they have the biggest impact).
Cause and Effect Diagrams	**Brainstorm possible root causes** of a problem.	Also known by three other common names (e.g., Fishbone or Ishikawa).
Scatter Diagrams	Understanding the **relationship between two variables.**	Indicate if variables are related, but **cannot infer cause-and-effect.**

Key Six Sigma Measures and Concepts

The module also promises to cover important Lean and Six Sigma measures and concepts:

- **Calculations:** How to calculate metrics like **Defects Per Unit (DPU)**, **Defects Per Million Opportunities (DPMO)**, **Cycle Time**, and **Rolled Throughput Yield (RTY)**.
- **Cost of Quality (COQ)**: Examining how different events contribute to the overall cost and the far-reaching financial effects of poor quality.

w2.2- Pareto Charts


w2.2- Pareto Charts.mp4
File View Playback Video Subtitles Audio Settings Help
Pareto Chart
• History
– Vilfredo Pareto
– Joseph Juran
• Separate the vital few from the trivial many
but they can also be used
to prioritize problems.
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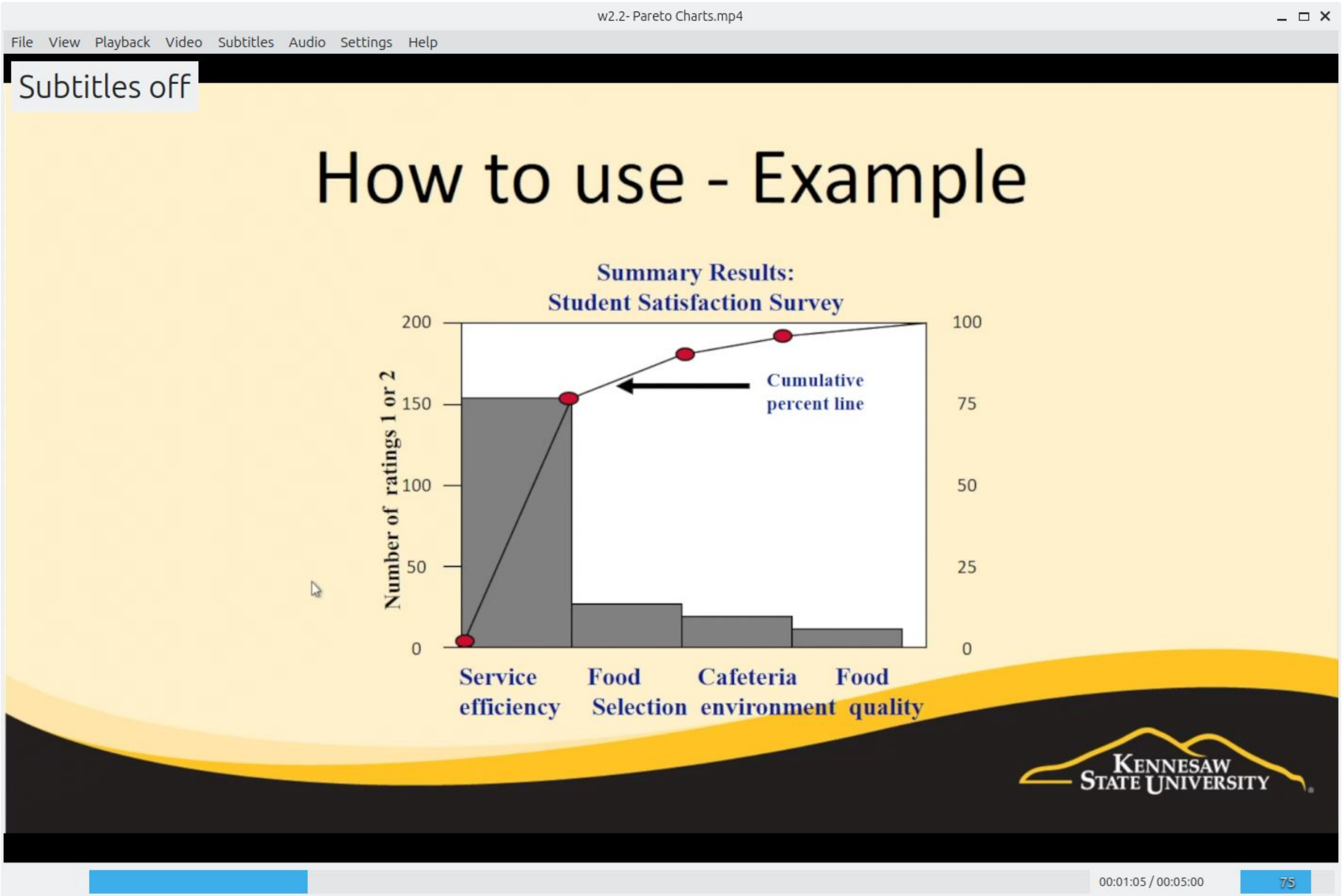
00:00:20 / 00:05:00
75


w2.2- Pareto Charts.mp4
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How to use - Example
Summary Results:
Student Satisfaction Survey
Number of ratings 1 or 2
200
150
100
50
0
100
75
50
25
0
Cumulative percent line
Service efficiency
Food Selection
Cafeteria environment
Food quality
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00:01:05 / 00:05:00
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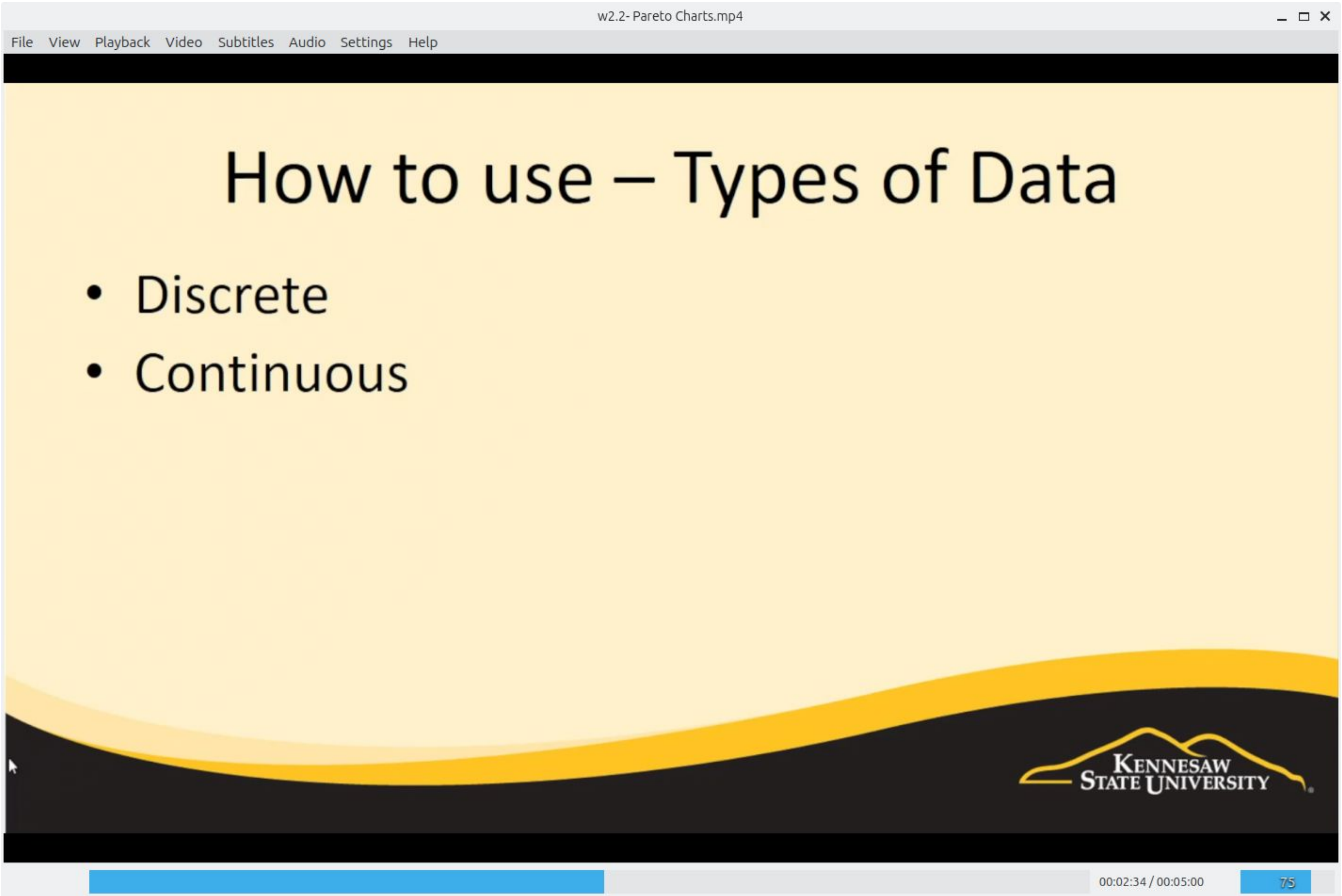
w2.2- Pareto Charts.mp4
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How to use – Types of Data
• Discrete
• Continuous
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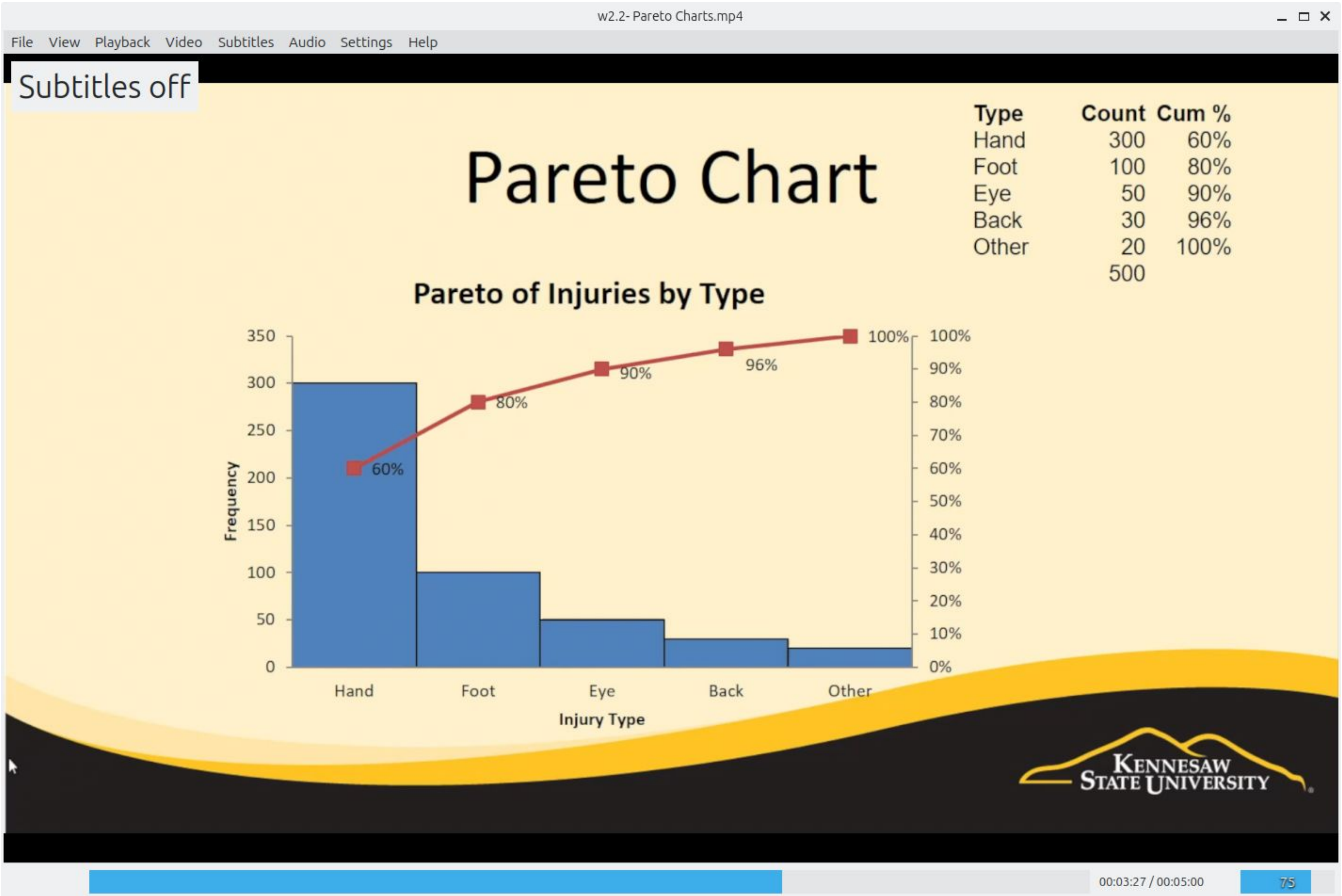
00:02:34 / 00:05:00
75


w2.2- Pareto Charts.mp4
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Subtitles off
Pareto Chart
Type Count Cum %
Hand 300 60%
Foot 100 80%
Eye 50 90%
Back 30 96%
Other 20 100%
500
Pareto of Injuries by Type
Frequency
350
300
250
200
150
100
50
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
60%
80%
90%
96%
100%
Hand
Foot
Eye
Back
Other
Injury Type
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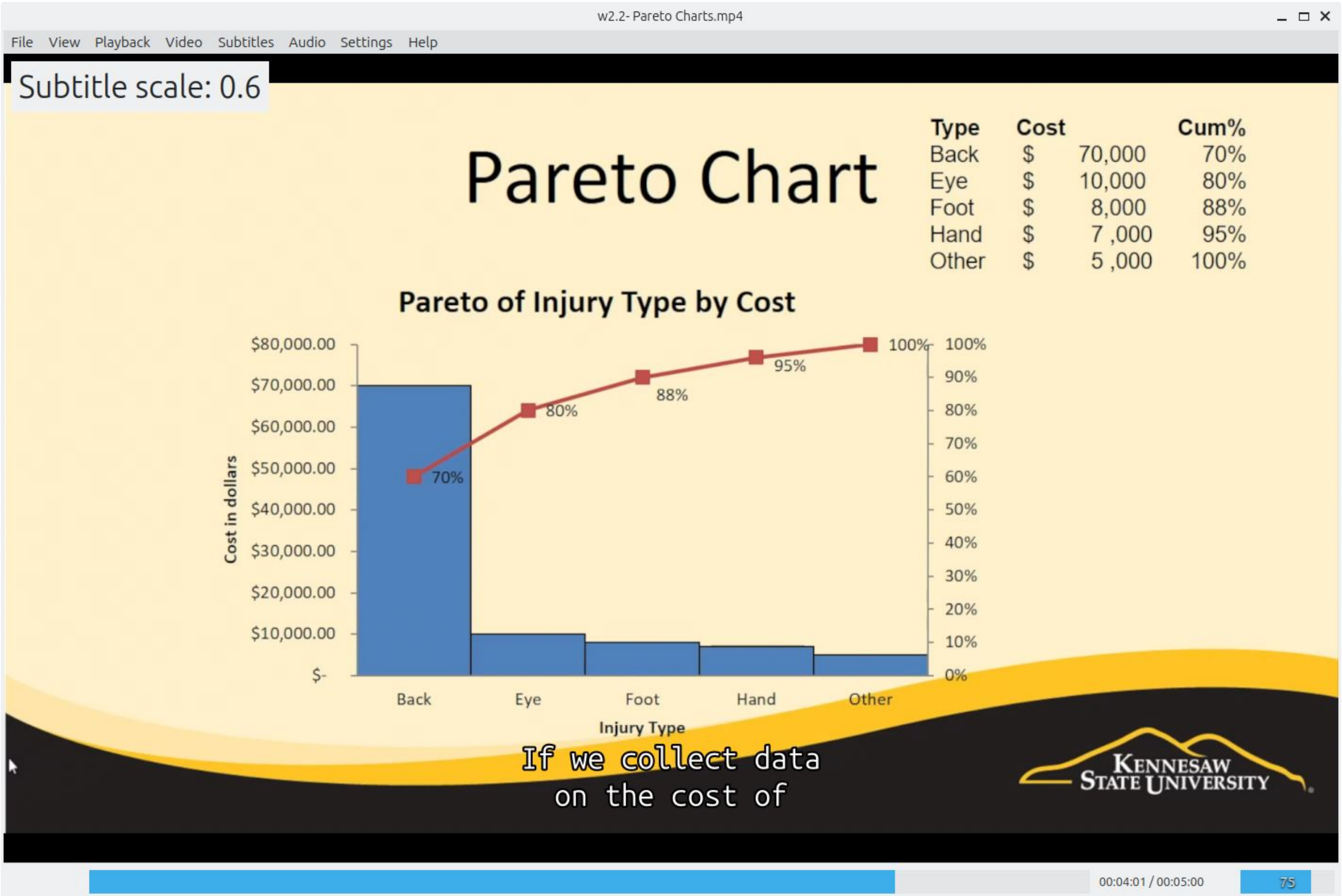
00:03:27 / 00:05:00
75


w2.2- Pareto Charts.mp4
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Subtitle scale: 0.6
Pareto Chart
Type Cost Cum%
Back $ 70,000 70%
Eye $ 10,000 80%
Foot $ 8,000 88%
Hand $ 7 ,000 95%
Other $ 5 ,000 100%
Pareto of Injury Type by Cost
Cost in dollars
$80,000.00
$70,000.00
$60,000.00
$50,000.00
$40,000.00
$30,000.00
$20,000.00
$10,000.00
$-
70%
80%
88%
95%
100%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Back
Eye
Foot
Hand
Other
Injury Type
If we collect data
on the cost of
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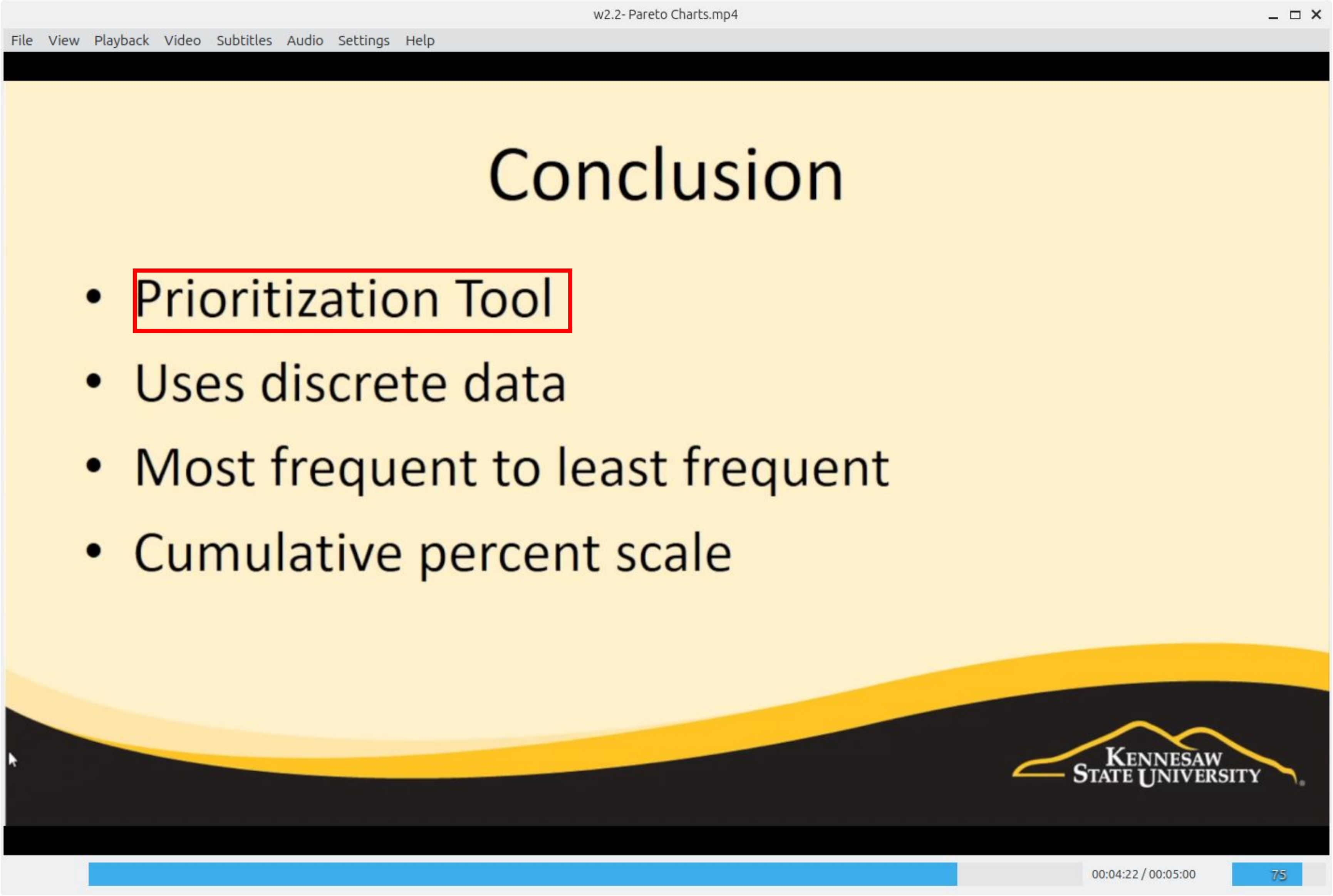
00:04:01 / 00:05:00
75


w2.2- Pareto Charts.mp4
File View Playback Video Subtitles Audio Settings Help
Conclusion
• Prioritization Tool
• Uses discrete data
• Most frequent to least frequent
• Cumulative percent scale
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00:04:22 / 00:05:00
75

📊 Pareto Charts: Prioritizing Efforts

Pareto Charts are a powerful tool used in quality improvement to **prioritize problems or root causes** by visually separating the most significant factors from the rest. They help answer the question: "If you can't fix everything, what should you fix first?"

Origin and the 80/20 Rule

- **Vilfredo Pareto (19th Century):** The chart and concept were developed by the Italian economist who formulated the **80/20 Rule**.
  - **General Idea:** The rule suggests that **20%** of the factors account for **80%** of the result (e.g., 20% of customers account for 80% of business).
- **Joseph Juran's Quality Adaptation:** Quality guru Joseph Juran adapted this concept, stating that **80% of the defects come from 20% of the causes**. Juran named this the **"vital few"** (the 20% that matter) versus the **"trivial many"** (the remaining 80%).

Structure of a Pareto Chart

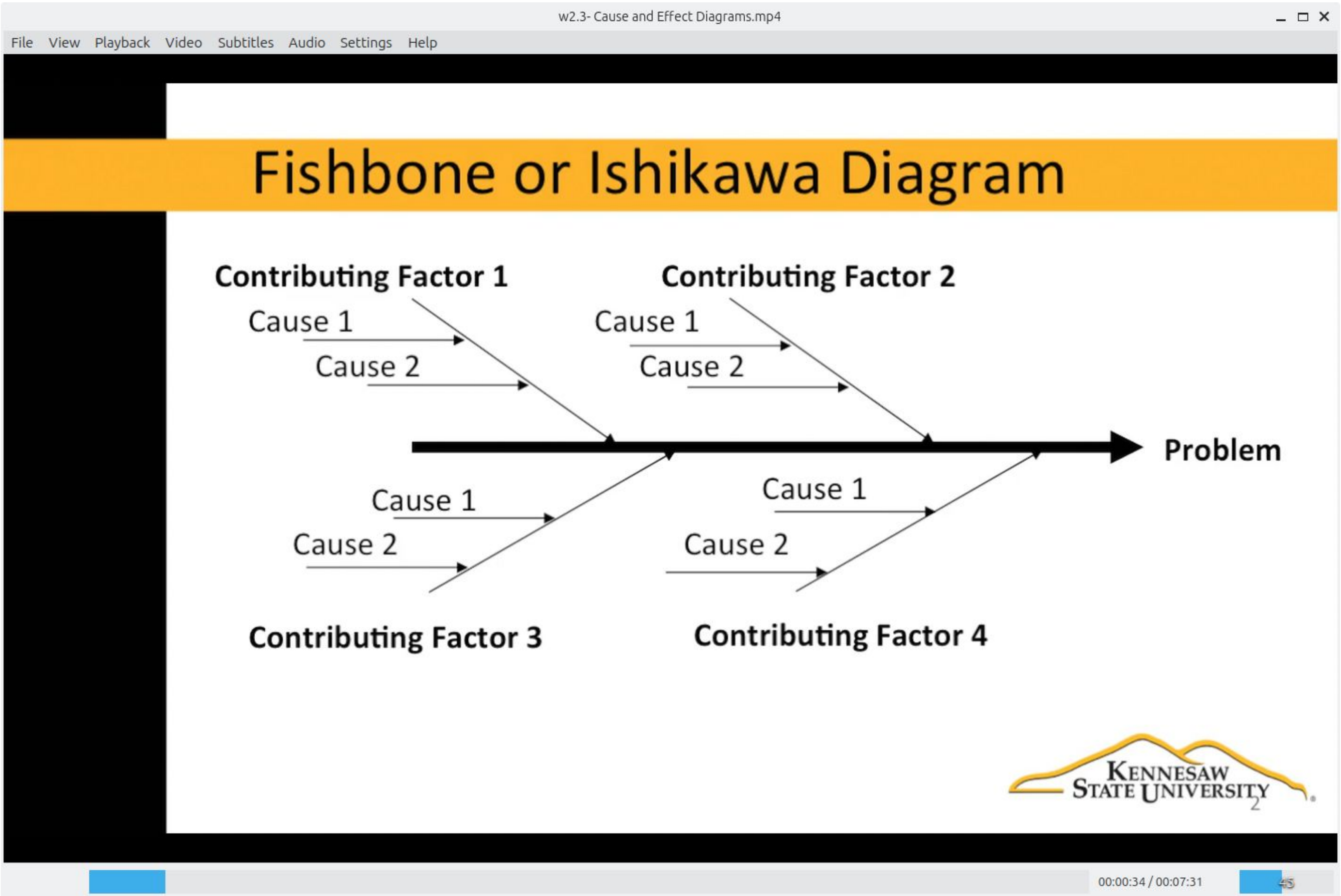
A Pareto chart is a combination chart that presents data in two ways:

1. **Bars (Frequency/Count):**
    - The bars represent the **frequency or count** of each category (e.g., poor ratings, injury types).
    - They are always arranged from **most frequent to least frequent**, with the **tallest bar on the left**.
    - The corresponding scale for the bar height is on the **left side** of the chart.
2. **Line (Cumulative Percentage):**
    - The line shows the **cumulative percent** of the total, tracked from left to right.
    - The corresponding scale for the cumulative percentage is on the **right side** of the chart.

Data and Focus

- **Data Type:** Pareto diagrams use **discrete data** (counts or frequencies). Continuous data can be converted into discrete groups (like for a histogram) before counting.
- **Interpretation:** By using the 80/20 Rule, the **first two or three bars** usually account for about 80% of the problem. Focusing improvement efforts on these few categories yields the **maximum effect**.
- **Critical Consideration:** It is crucial to **think carefully about what is being measured**. For example:
  - Measuring injuries by **type of occurrence** might prioritize hand injuries.
  - Measuring injuries by **cost** might prioritize back injuries (due to lost time). The chart's priority will change depending on the data collected.

w2.3- Cause and Effect Diagrams


w2.3- Cause and Effect Diagrams.mp4
File View Playback Video Subtitles Audio Settings Help
Fishbone or Ishikawa Diagram
Contributing Factor 1
Cause 1
Cause 2
Contributing Factor 2
Cause 1
Cause 2
Problem
Cause 1
Cause 2
Contributing Factor 3
Cause 1
Cause 2
Contributing Factor 4
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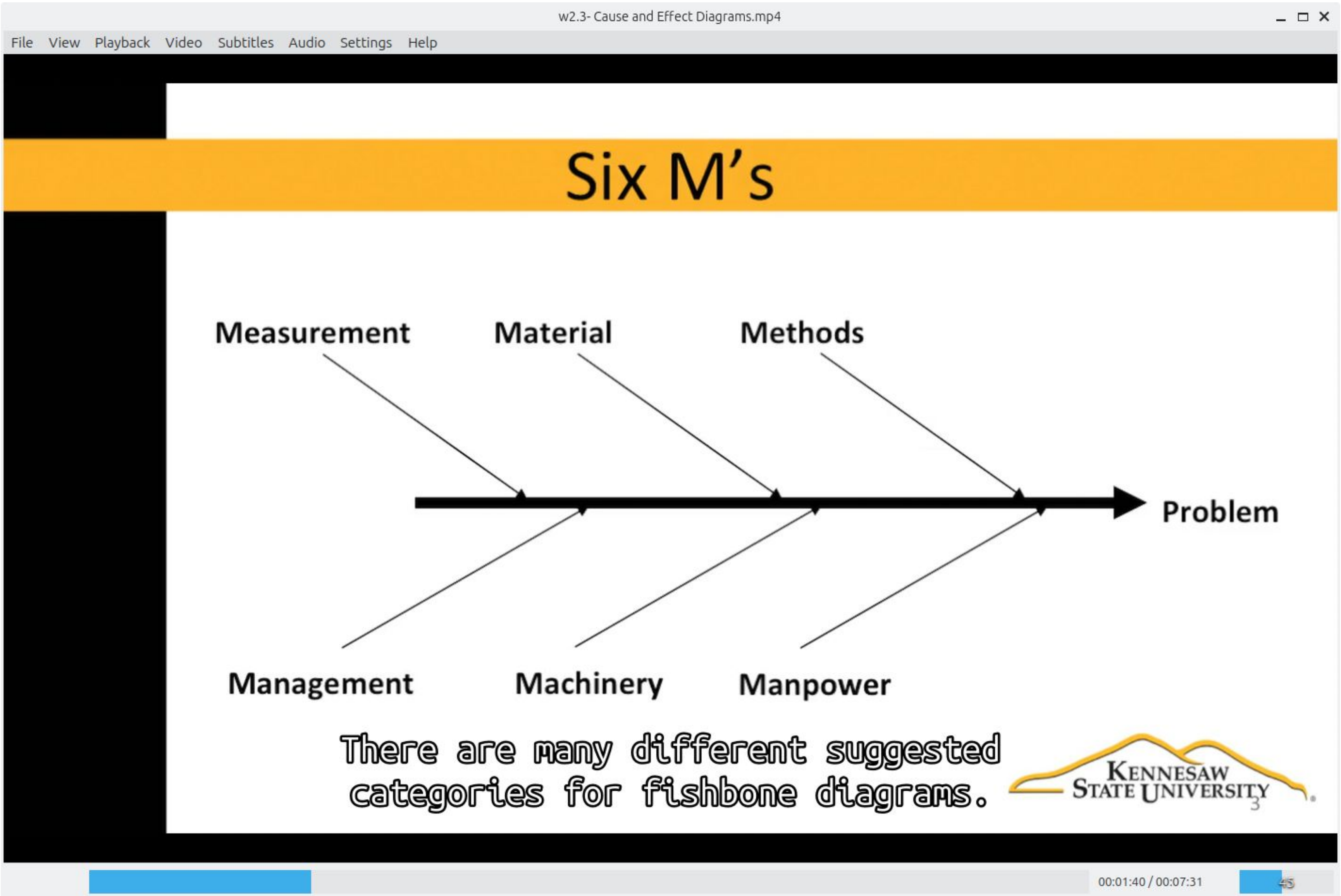
00:00:34 / 00:07:31


w2.3- Cause and Effect Diagrams.mp4
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Six M's
Measurement
Material
Methods
Problem
Management
Machinery
Manpower
There are many different suggested
categories for fishbone diagrams.
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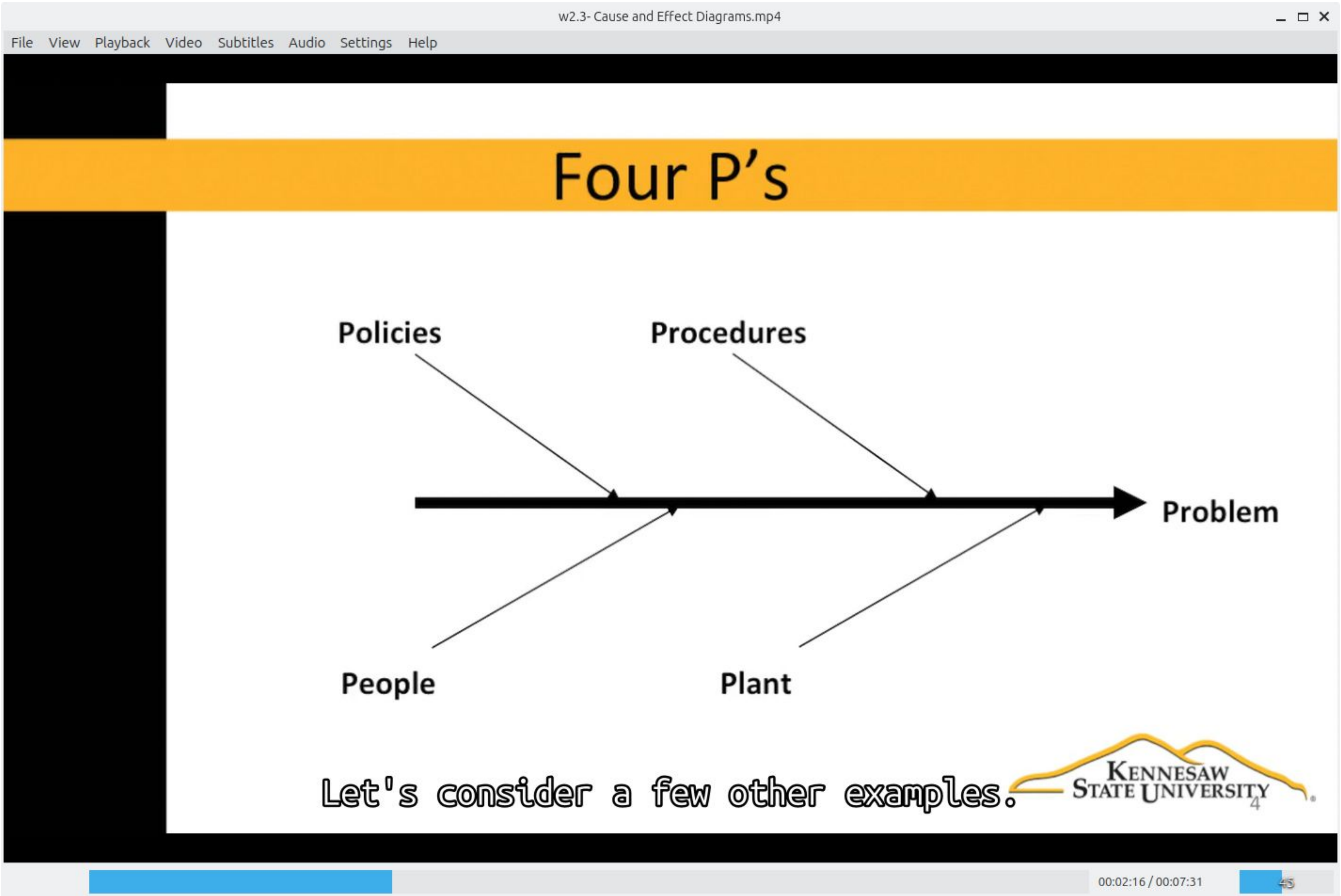
00:01:40 / 00:07:31


w2.3- Cause and Effect Diagrams.mp4
File View Playback Video Subtitles Audio Settings Help
Four P's
Policies
Procedures
Problem
People
Plant
Let's consider a few other examples.
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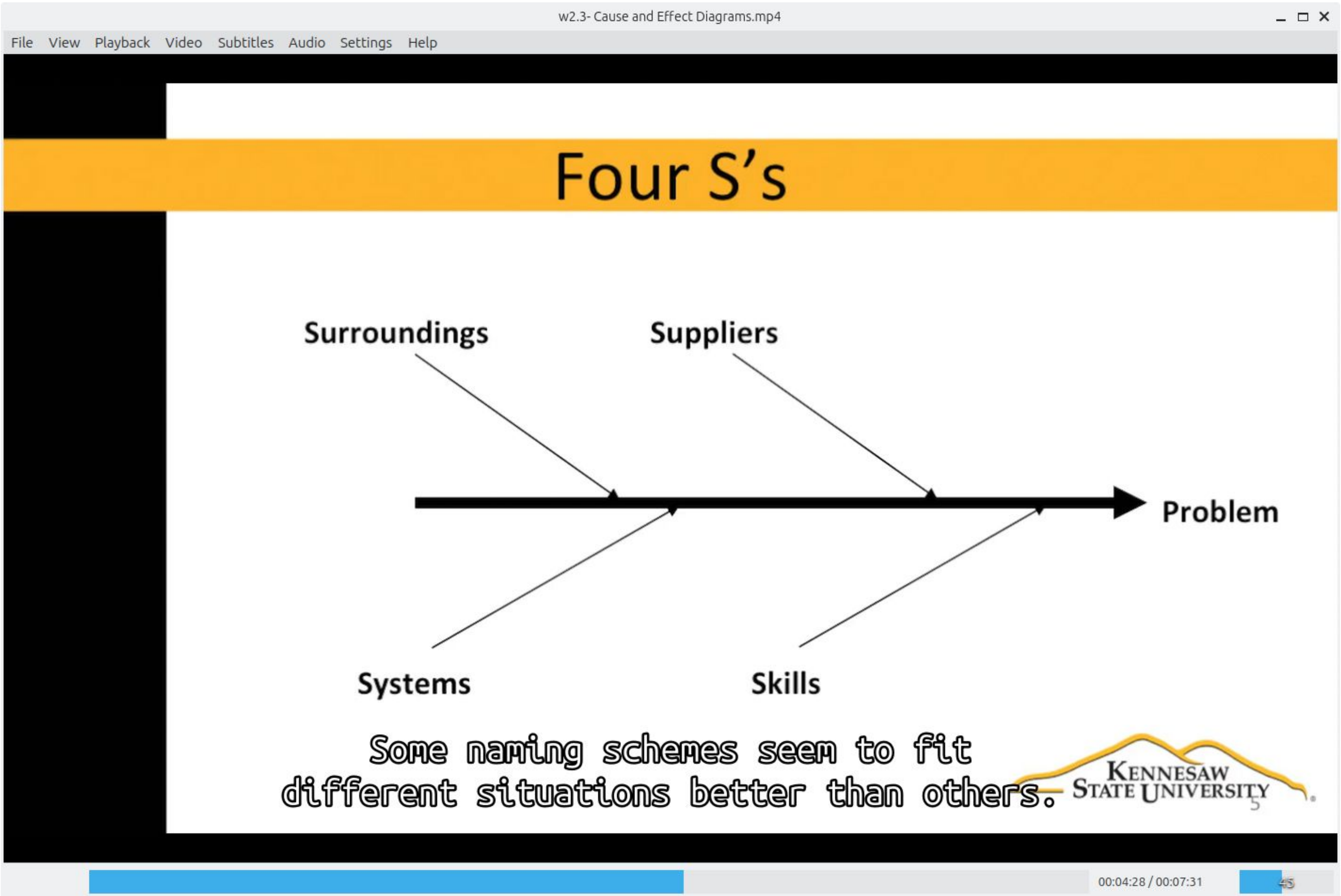
4
00:02:16 / 00:07:31


w2.3- Cause and Effect Diagrams.mp4
File View Playback Video Subtitles Audio Settings Help
Four S's
Surroundings
Suppliers
Problem
Systems
Skills
Some naming schemes seem to fit
different situations better than others.
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00:04:28 / 00:07:31

w2.3- Cause and Effect Diagrams.mp4

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How to

- Structured Brainstorm
  - Draw Fishbone, with the problem at the head
  - Identify categories
  - Use post-it notes
  - Transfer to more permanent form.

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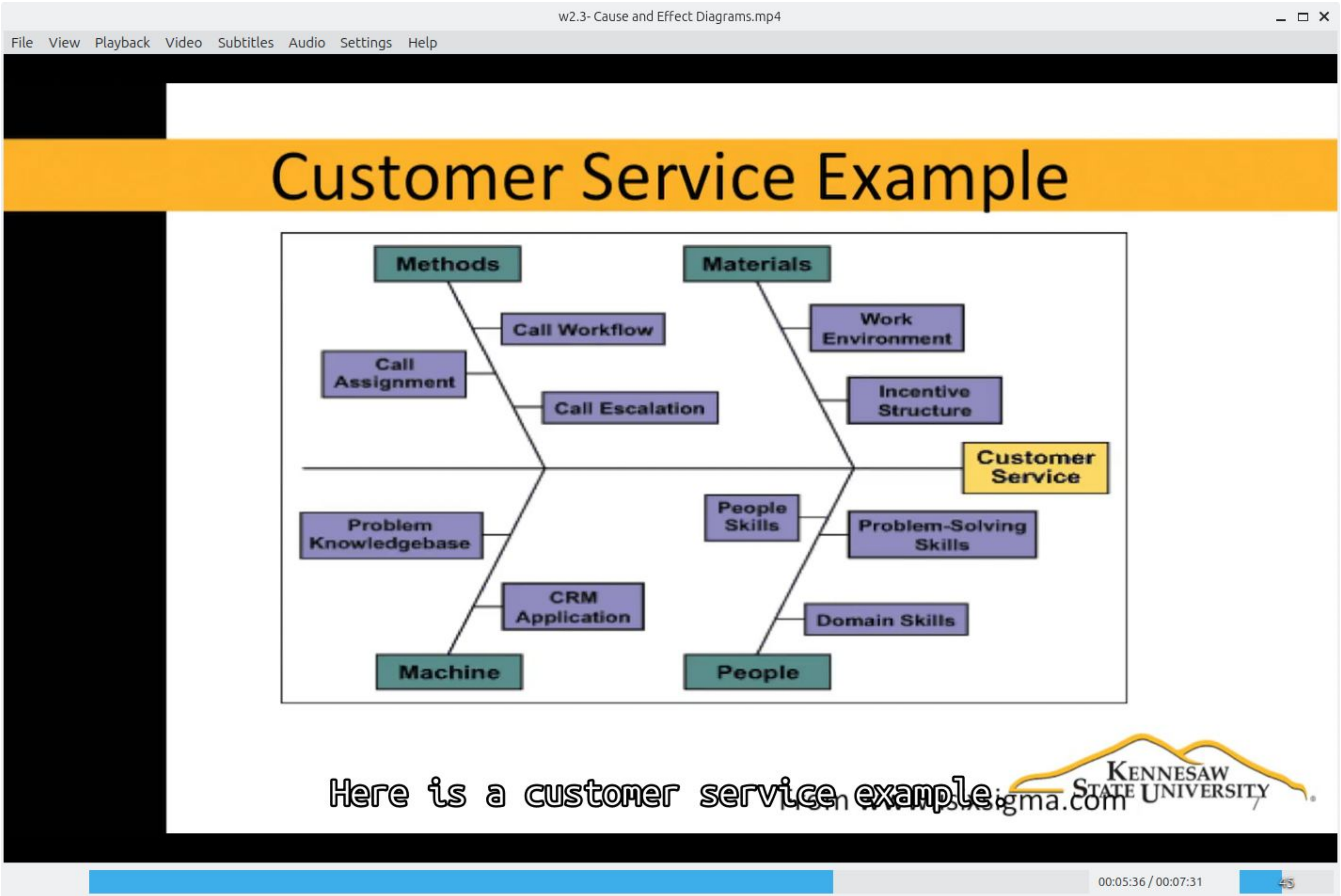
w2.3- Cause and Effect Diagrams.mp4
File View Playback Video Subtitles Audio Settings Help
Customer Service Example
Methods
Materials
Call Workflow
Work Environment
Call Assignment
Call Escalation
Incentive Structure
Customer Service
People Skills
Problem Knowledgebase
Problem-Solving Skills
CRM Application
Domain Skills
Machine
People
from www.isixsigma.com
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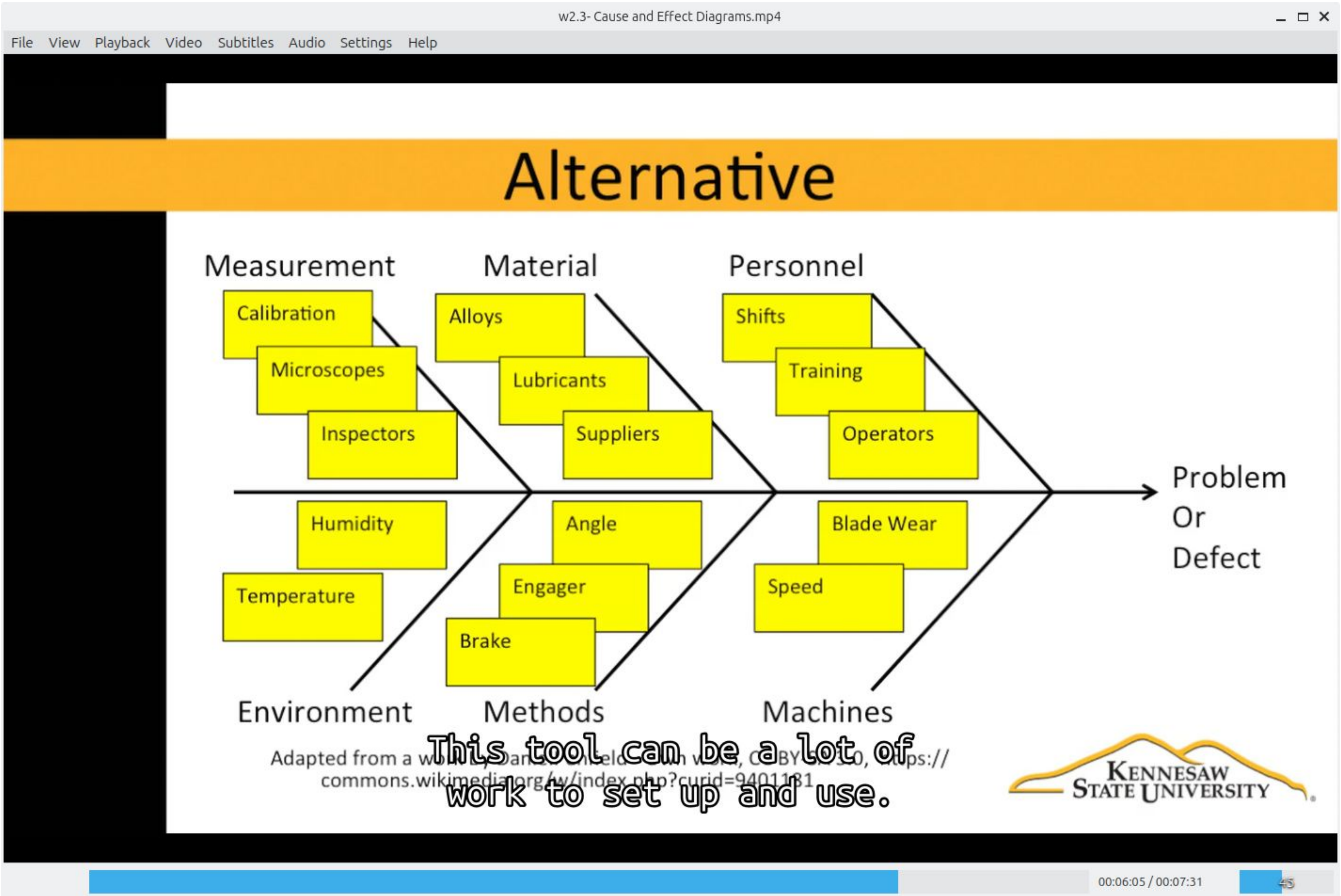
Here is a customer service example.
00:05:36 / 00:07:31


w2.3- Cause and Effect Diagrams.mp4
File View Playback Video Subtitles Audio Settings Help
Alternative
Measurement
Material
Personnel
Calibration
Microscopes
Inspectors
Alloys
Lubricants
Suppliers
Shifts
Training
Operators
Problem
Or
Defect
Humidity
Temperature
Angle
Engager
Brake
Blade Wear
Speed
Environment
Methods
Machines
This tool can be a lot of
work to set up and use.
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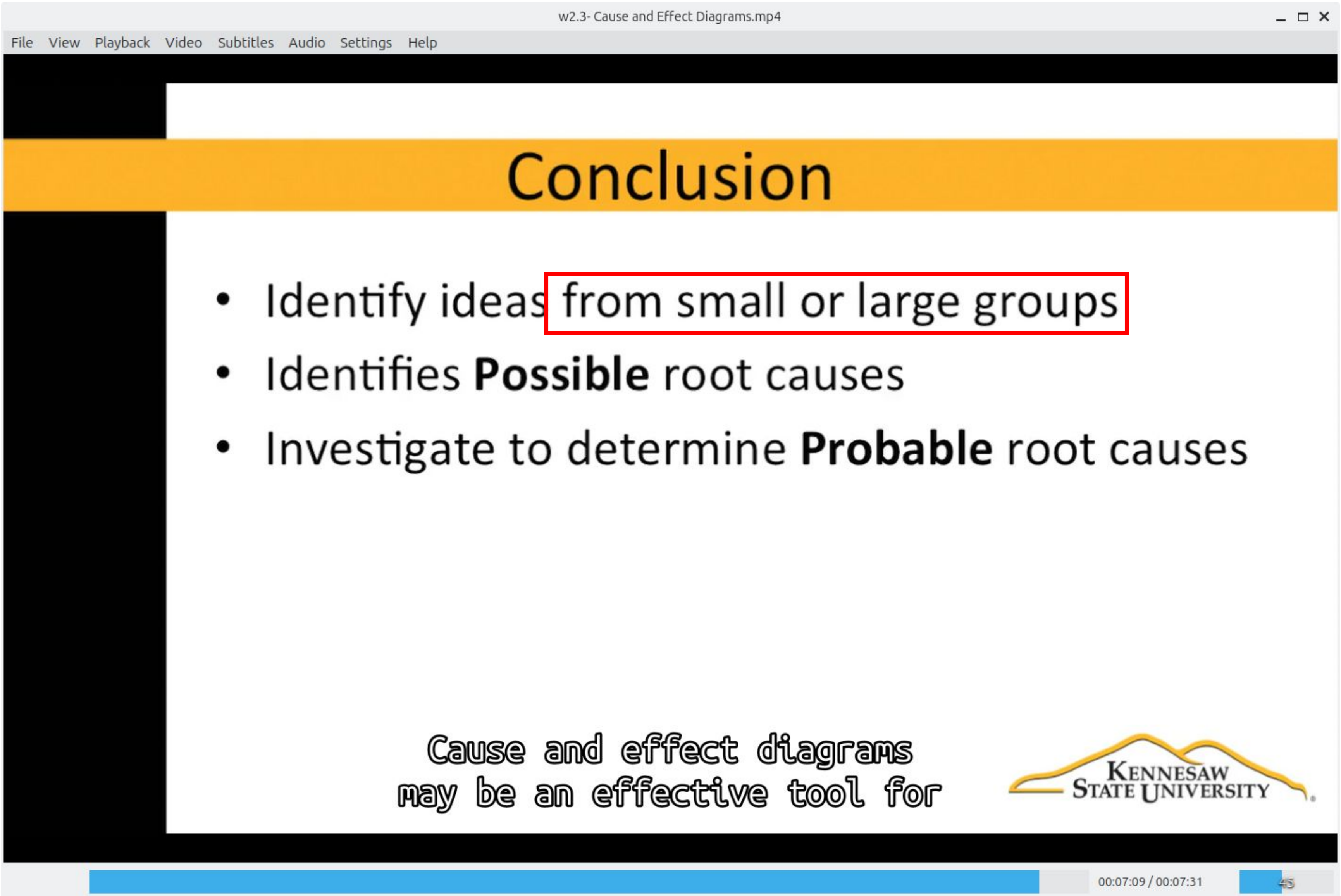
00:06:05 / 00:07:31


w2.3- Cause and Effect Diagrams.mp4
File View Playback Video Subtitles Audio Settings Help
Conclusion
• Identify ideas from small or large groups
• Identifies Possible root causes
• Investigate to determine Probable root causes
Cause and effect diagrams
may be an effective tool for
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00:07:09 / 00:07:31

🐟 Cause and Effect Diagrams (Fishbone / Ishikawa)

The **Cause and Effect Diagram**, created by **Kaoru Ishikawa** in the 1960s, is a structured **brainstorming tool** used to identify and display all **possible root causes** of a problem.

Names and Purpose

- **Three Common Names:**
  1. **Cause and Effect Diagram** (Ishikawa's original name)
  2. **Ishikawa Diagram** (in his honor)
  3. **Fishbone Diagram** (due to its appearance)
- **Purpose:** To gather ideas from as many people as possible, explore all potential causes, and display them in a structured way. **It generates a large quantity of *possible* causes, but does not definitively identify the *root* cause; further investigation is required.**

Structure and Categories

The diagram looks like the skeleton of a fish:

- **Fish Head:** Contains the **problem statement** (or effect) being analyzed.
- **Major Bones:** Represent the **major factors** or categories that contribute to the problem. The categories are used to spur different areas of thought.
    - **Common Categories:** The 6 'M's (e.g., Manpower, Machines, Materials, Methods, Measurement, Mother Nature/Environment) or 4 'P's (e.g., Policies, Procedures, People, Plant/Facilities).
    - **Flexibility:** Users should **not be constrained** by standard schemes and can create their own categories that best fit the department or application (usually four to six major bones).
- **Minor Bones:** Represent the **more elementary causal factors** that fall under each major category.

Application Examples

The transcript provides examples of common categories for service problems:

- **Policies:** Can cause issues if they are obsolete, poorly understood, or have unintended consequences.
- **Procedures:** Often a source of waste (e.g., long signature lists, redundant forms) that frustrate customers.
- **People:** Represent the greatest opportunity for delight or disappointment. Employees must have the **knowledge, skills, and authority** to provide service.
- **Plant/Facilities:** Can cause problems due to lack of facilities, lack of access, or outdated equipment.

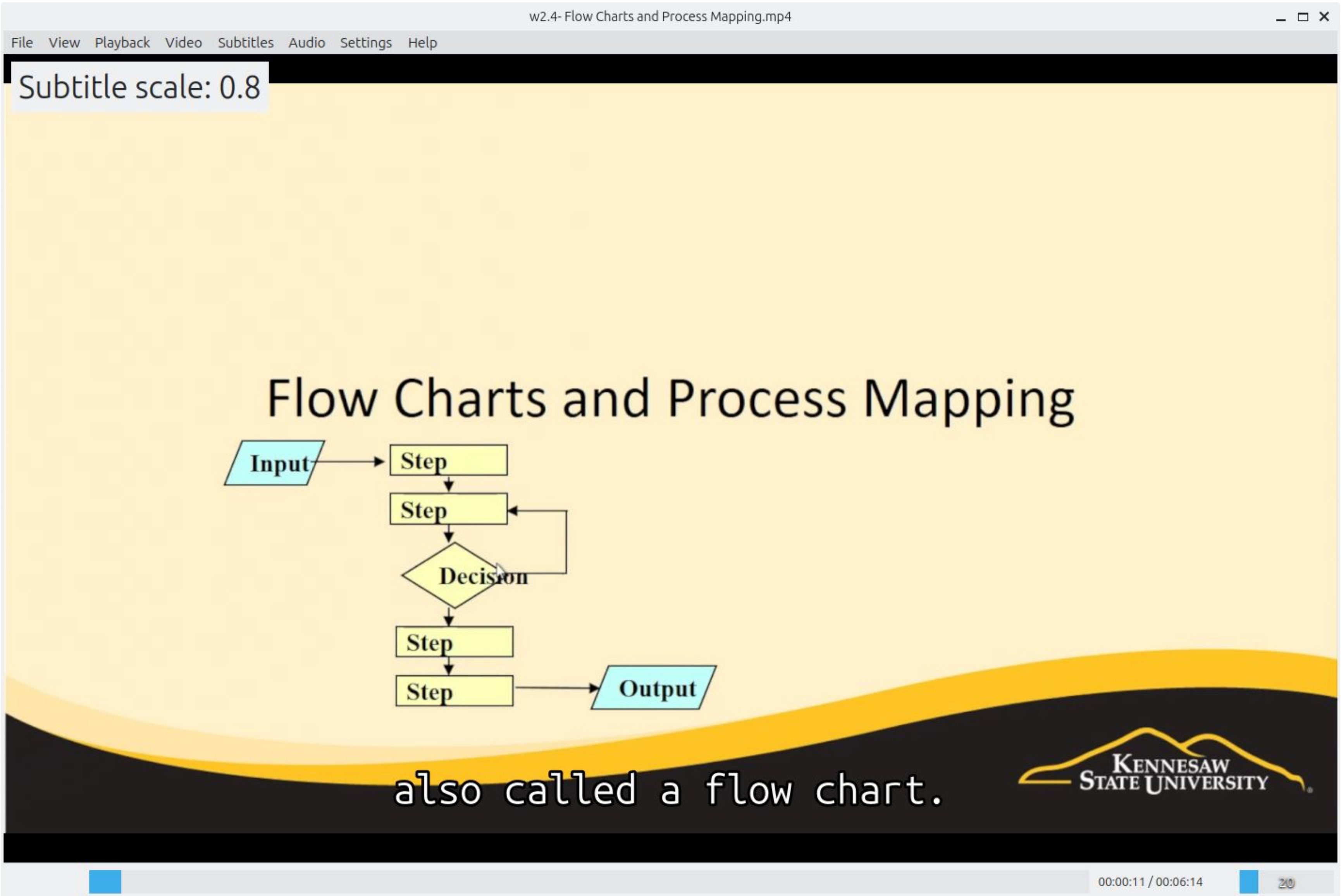
How to Use the Diagram

1. **Draw the Structure:** Draw the fishbone structure with the **precise problem statement at the head**.
2. **Add Categories:** Draw the major bones and label the categories. Do not "agonize" over the categories; their goal is just to spur different ideas.
3. **Brainstorm:** Use the team to brainstorm ideas. A common method is to use **post-it notes** and stick the ideas next to the appropriate bone. Do not allow debates over which bone an idea fits; either pick one or write the idea twice.
4. **Preserve:** Take a picture to preserve the work.

Alternative Use for Large Groups

For complex problems or when seeking input from a **large number of people**, a large diagram (e.g., on a 4x8 foot board) can be placed in a high-traffic area. Anyone can contribute via post-it notes. This requires **active management** (organizing notes and removing non-serious suggestions) by the team.

w2.4- Flow Charts and Process Mapping


w2.4- Flow Charts and Process Mapping.mp4
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Subtitle scale: 0.8
Flow Charts and Process Mapping
Input
Step
Step
Decision
Step
Step
Output
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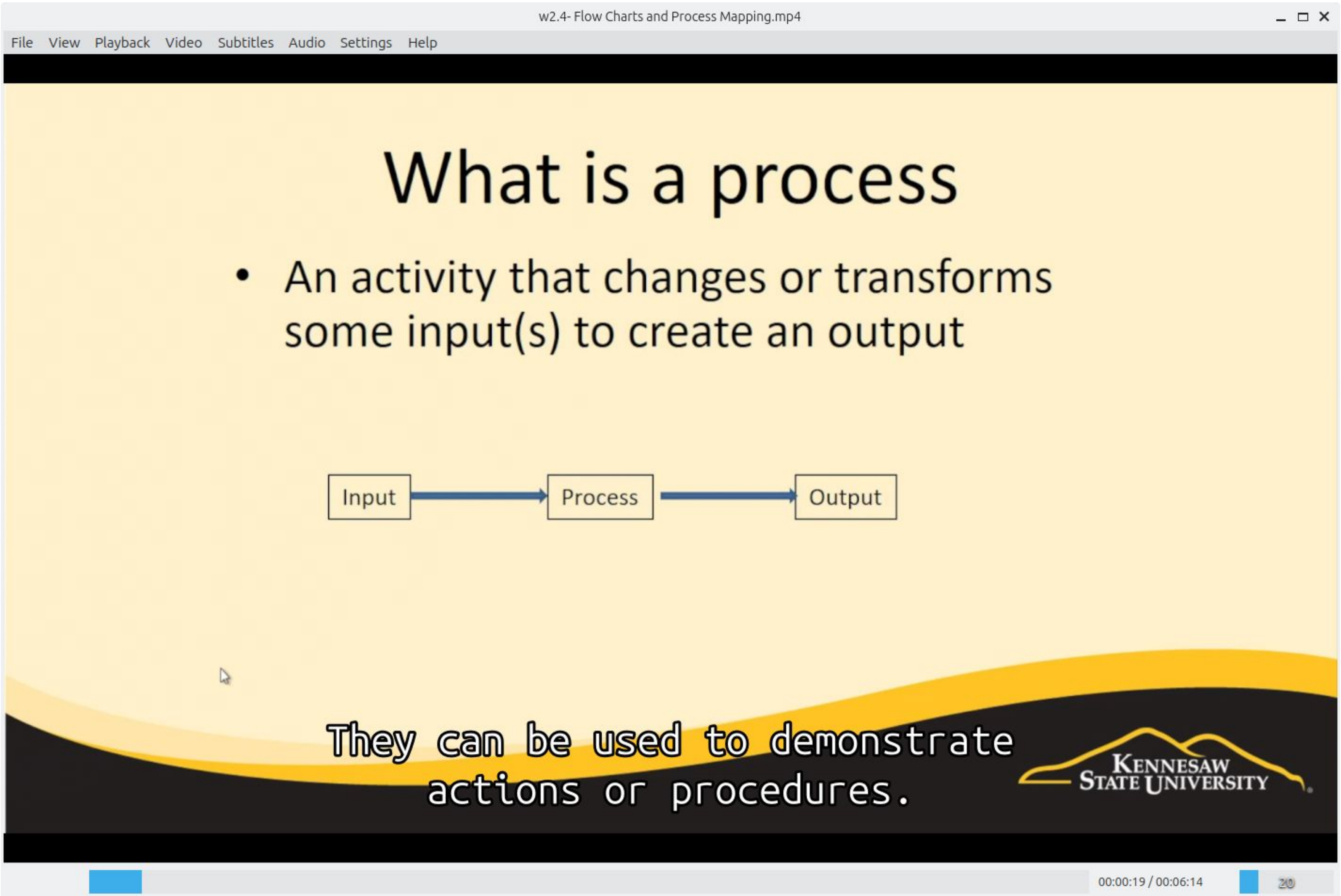
also called a flow chart.
00:00:11 / 00:06:14


w2.4- Flow Charts and Process Mapping.mp4
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What is a process
• An activity that changes or transforms some input(s) to create an output
Input
Process
Output
They can be used to demonstrate actions or procedures.
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00:00:19 / 00:06:14


w2.4- Flow Charts and Process Mapping.mp4
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Tools for Mapping Processes
Process Maps – a picture of the sequence of steps in a process, represented by symbols
(used to plan projects, describe processes…)
Five Types
• Basic – outlines major steps in a process
• Detailed – used to improve a process
• Top Down – Major steps, nest level of sub steps
• Deployment – detailed process with people
• Opportunity – highlights opportunities for improvement
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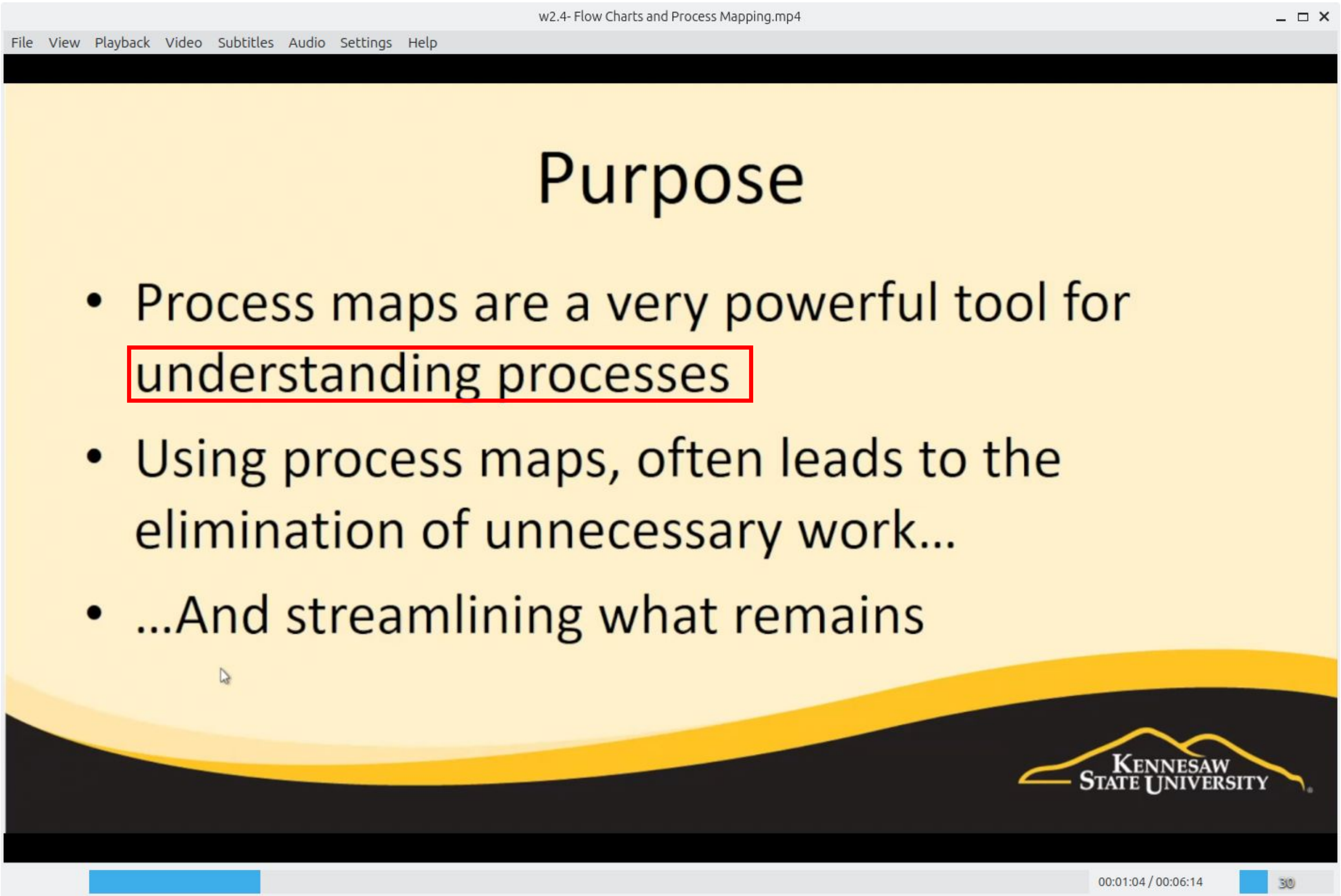
00:00:44 / 00:06:14
30


w2.4- Flow Charts and Process Mapping.mp4
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Purpose
• Process maps are a very powerful tool for understanding processes
• Using process maps, often leads to the elimination of unnecessary work…
• …And streamlining what remains
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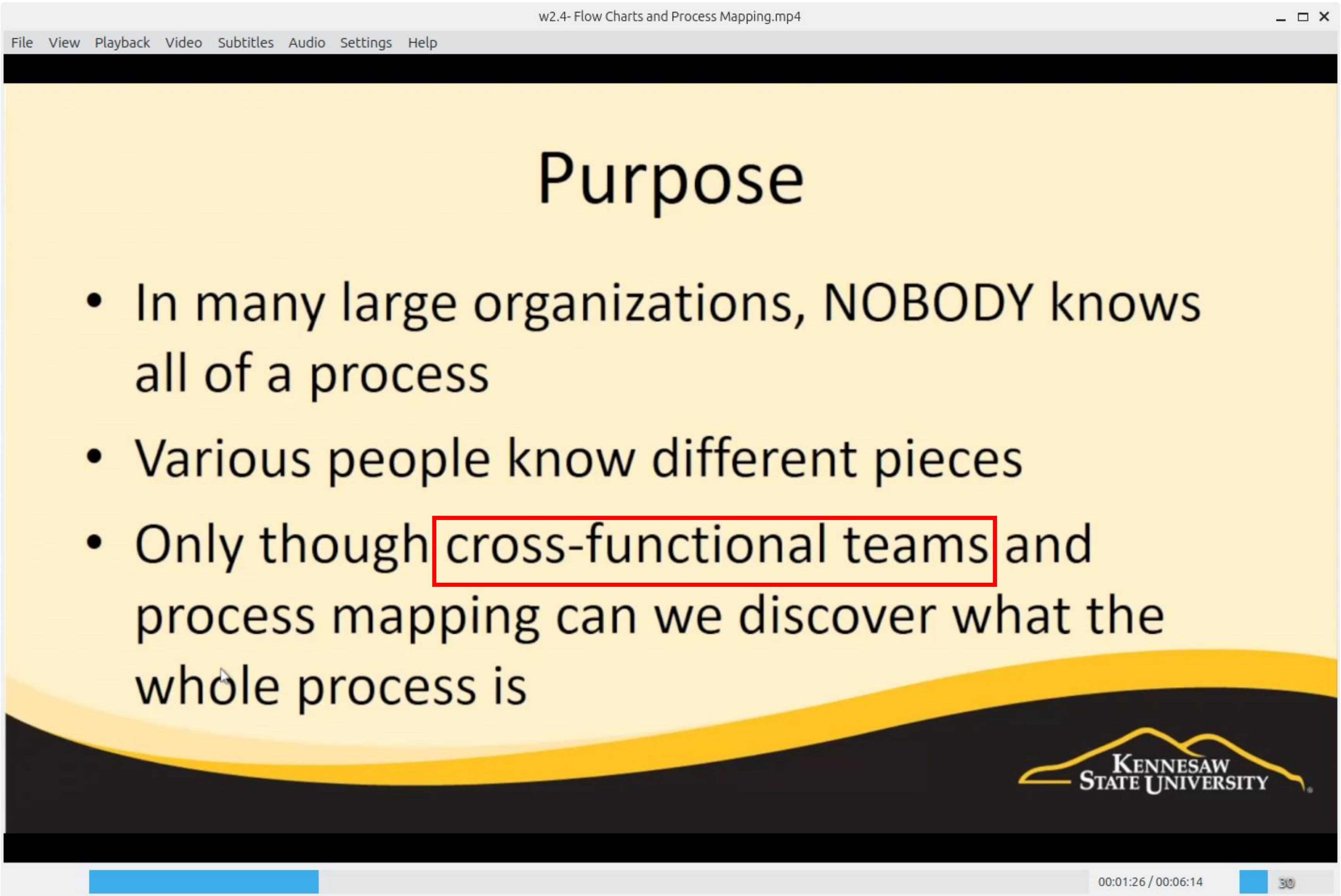
00:01:04 / 00:06:14


w2.4- Flow Charts and Process Mapping.mp4
File View Playback Video Subtitles Audio Settings Help
Purpose
• In many large organizations, NOBODY knows all of a process
• Various people know different pieces
• Only though cross-functional teams and process mapping can we discover what the whole process is
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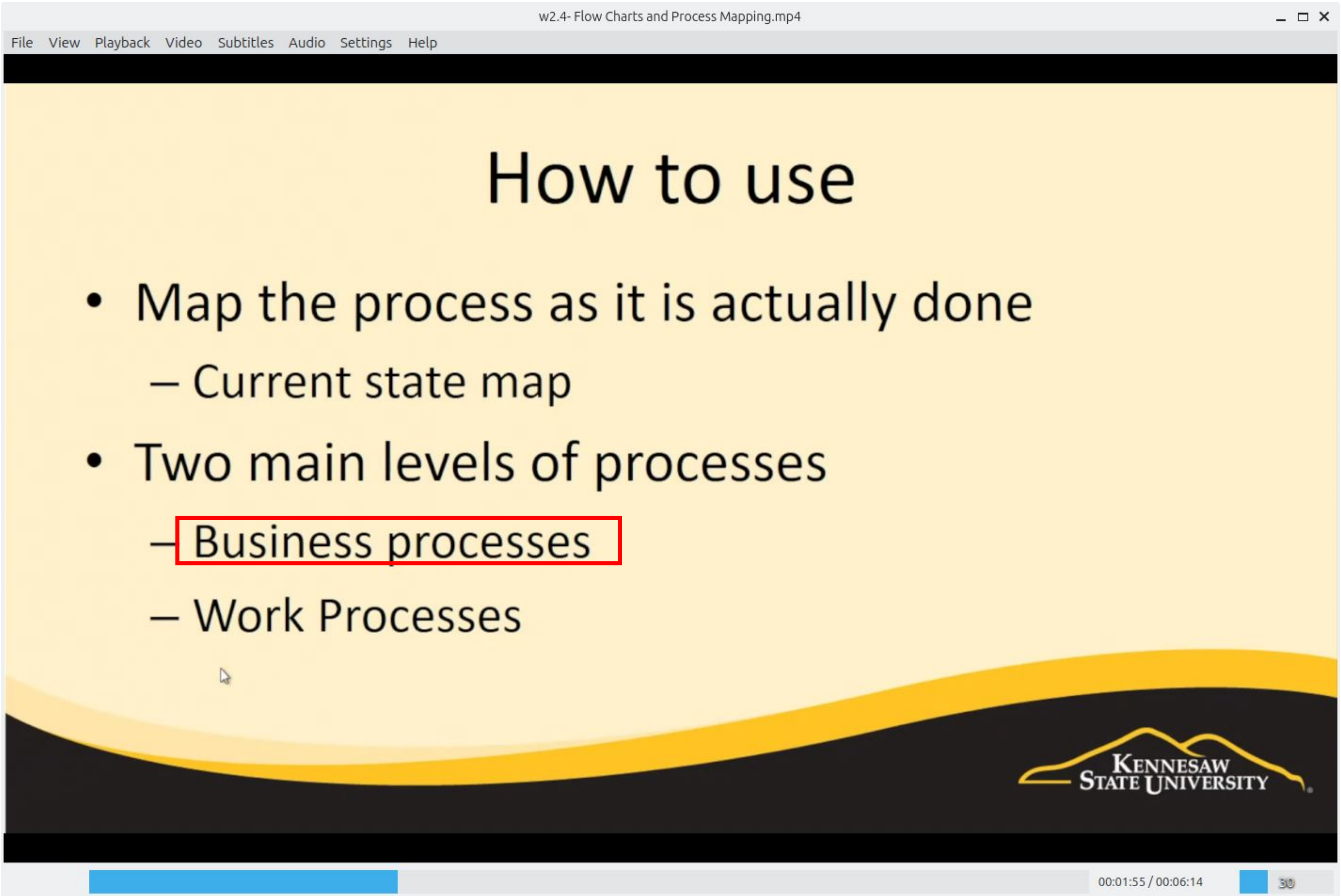
00:01:26 / 00:06:14


w2.4- Flow Charts and Process Mapping.mp4
File View Playback Video Subtitles Audio Settings Help
How to use
• Map the process as it is actually done
– Current state map
• Two main levels of processes
– Business processes
– Work Processes
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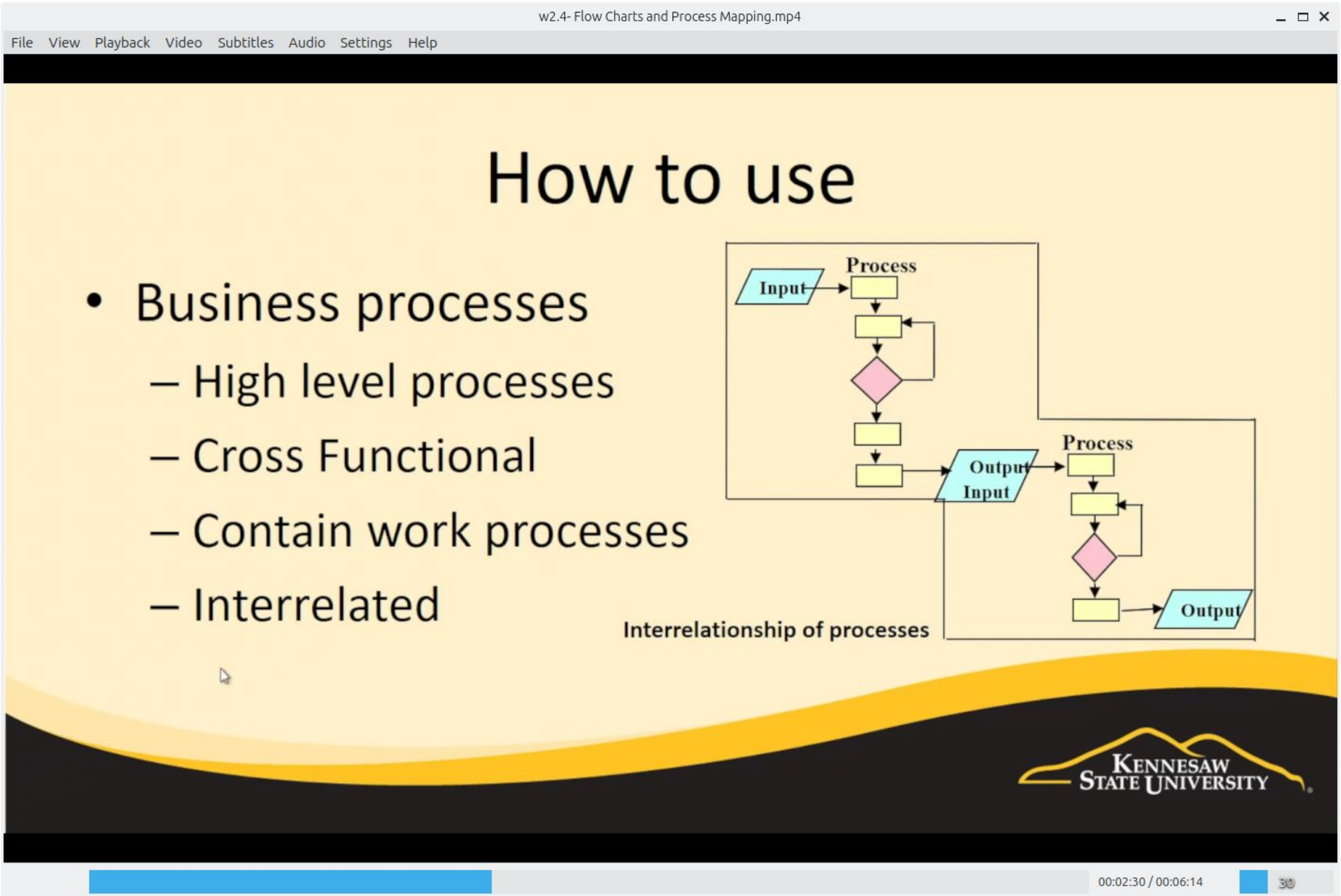
00:01:55 / 00:06:14


w2.4- Flow Charts and Process Mapping.mp4
File View Playback Video Subtitles Audio Settings Help
How to use
• Business processes
– High level processes
– Cross Functional
– Contain work processes
– Interrelated
Input
Process
Output
Input
Process
Output
Interrelationship of processes
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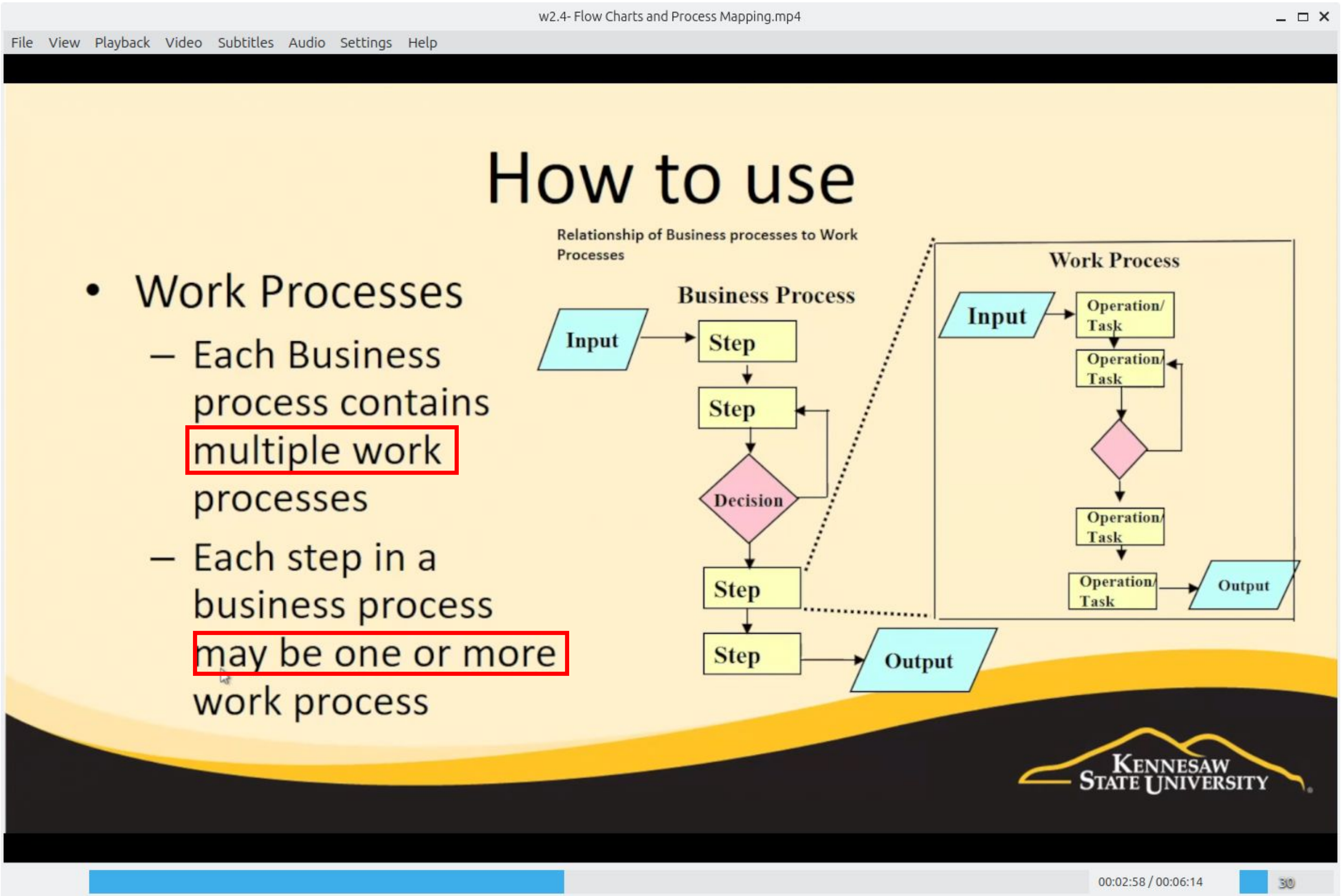
w2.4- Flow Charts and Process Mapping.mp4
File View Playback Video Subtitles Audio Settings Help
How to use
Work Processes
Each Business process contains multiple work processes
Each step in a business process may be one or more work process
Relationship of Business processes to Work Processes
Business Process
Input
Step
Step
Decision
Step
Step
Output
Work Process
Input
Operation/ Task
Operation/ Task
Operation/ Task
Operation/ Task
Output
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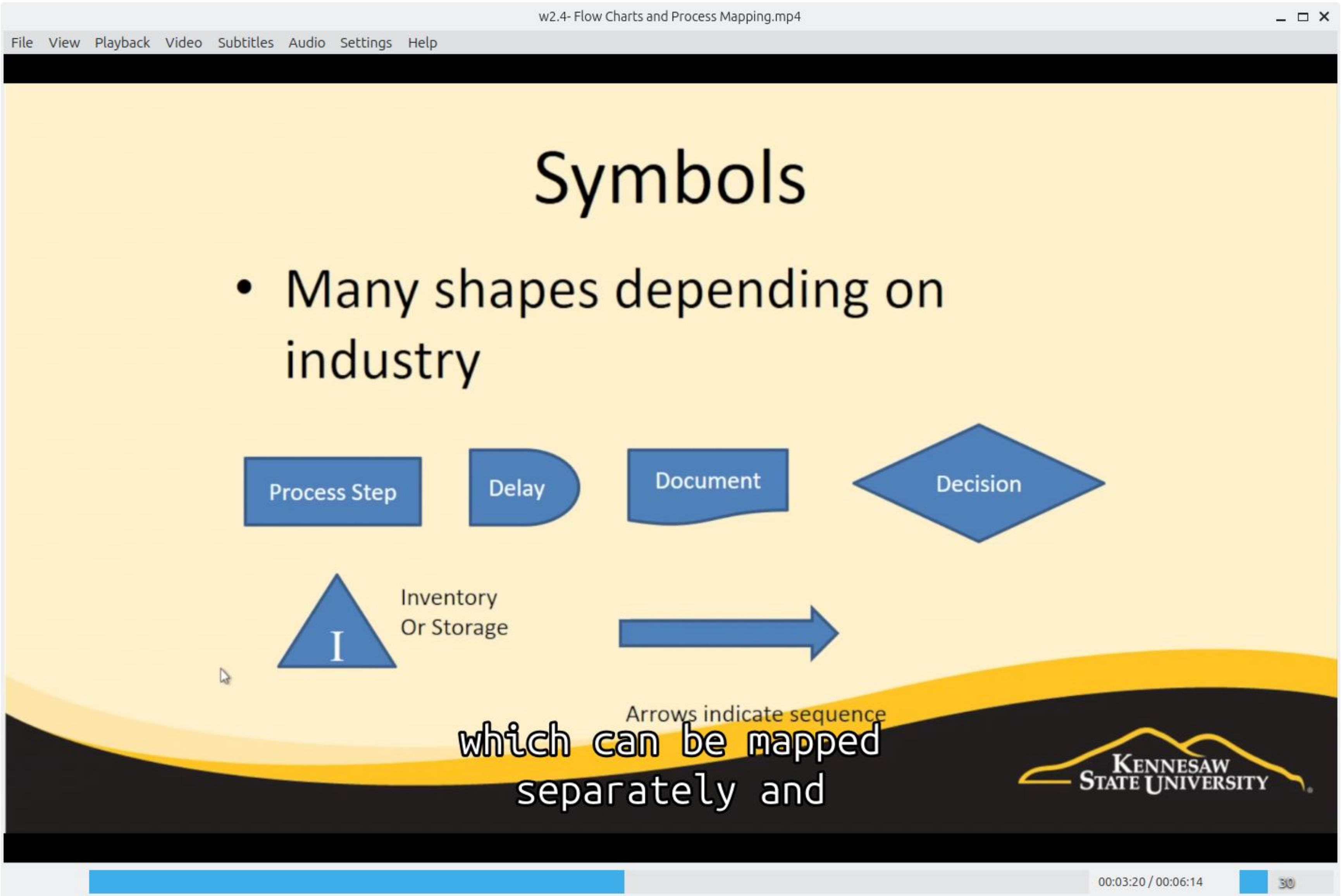
00:02:58 / 00:06:14


w2.4- Flow Charts and Process Mapping.mp4
File View Playback Video Subtitles Audio Settings Help
Symbols
• Many shapes depending on industry
Process Step
Delay
Document
Decision
I
Inventory
Or Storage
Arrows indicate sequence
which can be mapped
separately and
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00:03:20 / 00:06:14
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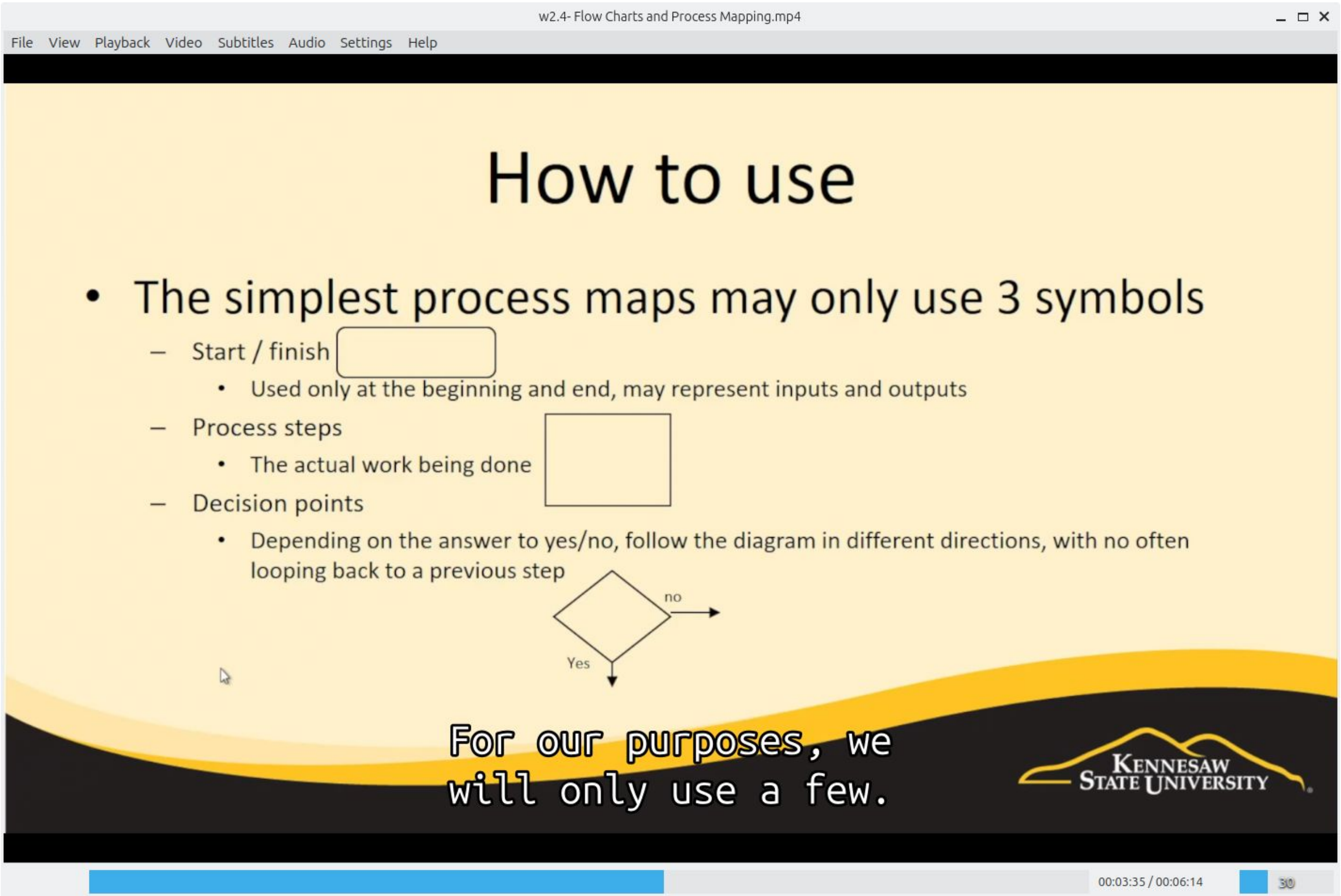
w2.4- Flow Charts and Process Mapping.mp4
File View Playback Video Subtitles Audio Settings Help
How to use
• The simplest process maps may only use 3 symbols
– Start / finish
• Used only at the beginning and end, may represent inputs and outputs
– Process steps
• The actual work being done
– Decision points
• Depending on the answer to yes/no, follow the diagram in different directions, with no often looping back to a previous step
no
Yes
For our purposes, we
will only use a few.
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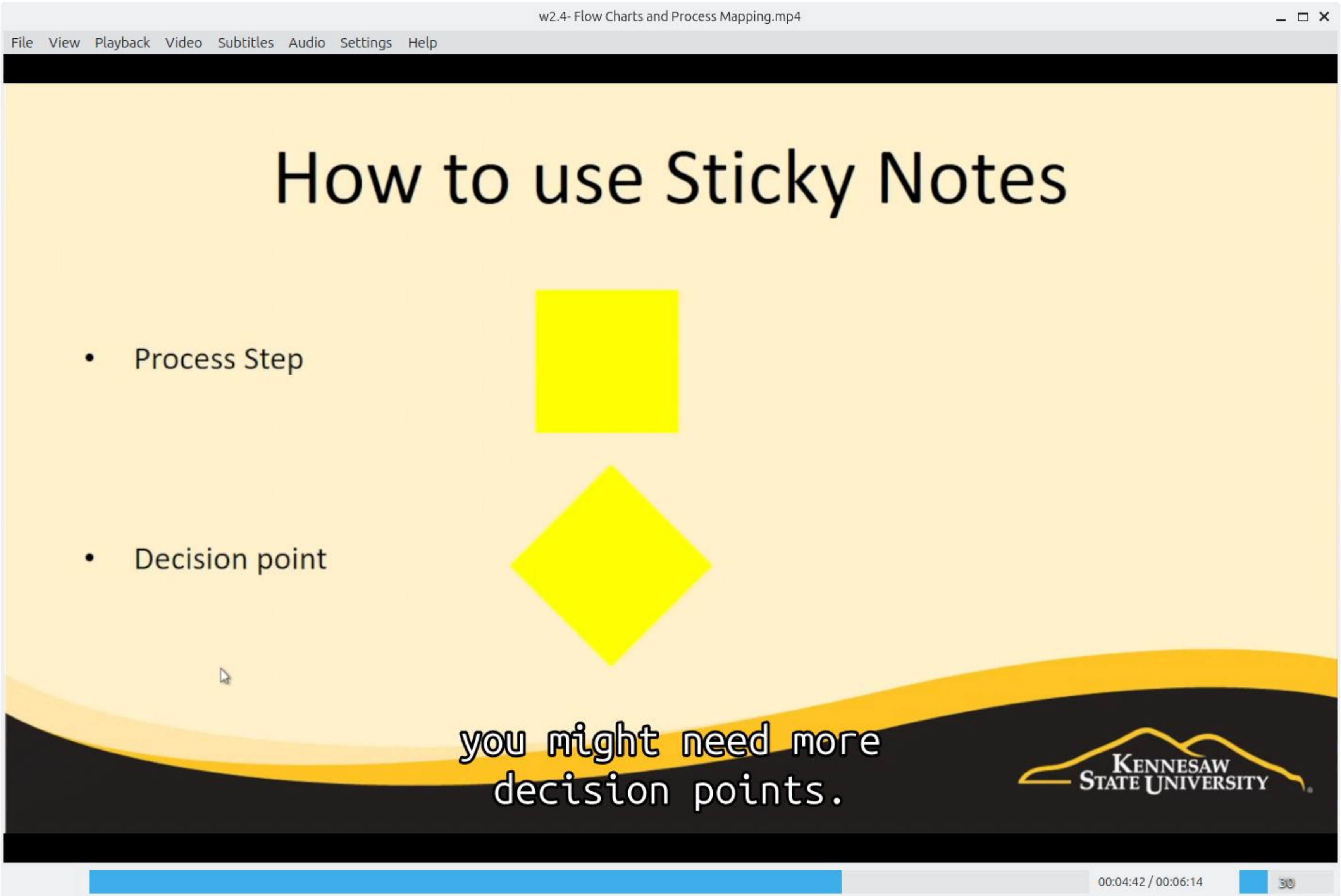
w2.4- Flow Charts and Process Mapping.mp4
File View Playback Video Subtitles Audio Settings Help
How to use Sticky Notes
• Process Step
• Decision point
you might need more
decision points.
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00:04:42 / 00:06:14
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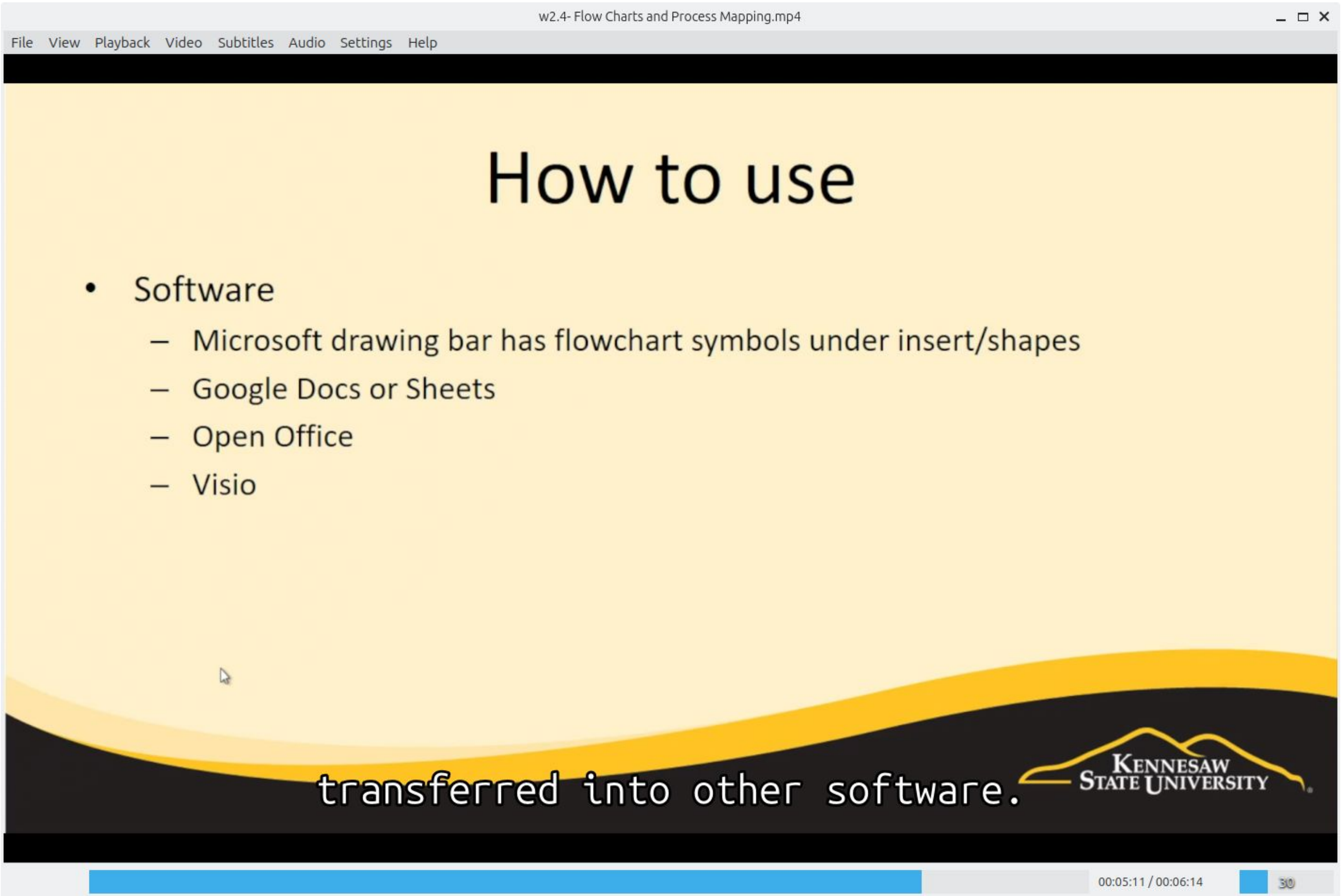
w2.4- Flow Charts and Process Mapping.mp4
File View Playback Video Subtitles Audio Settings Help
How to use
• Software
– Microsoft drawing bar has flowchart symbols under insert/shapes
– Google Docs or Sheets
– Open Office
– Visio
transferred into other software.
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00:05:11 / 00:06:14
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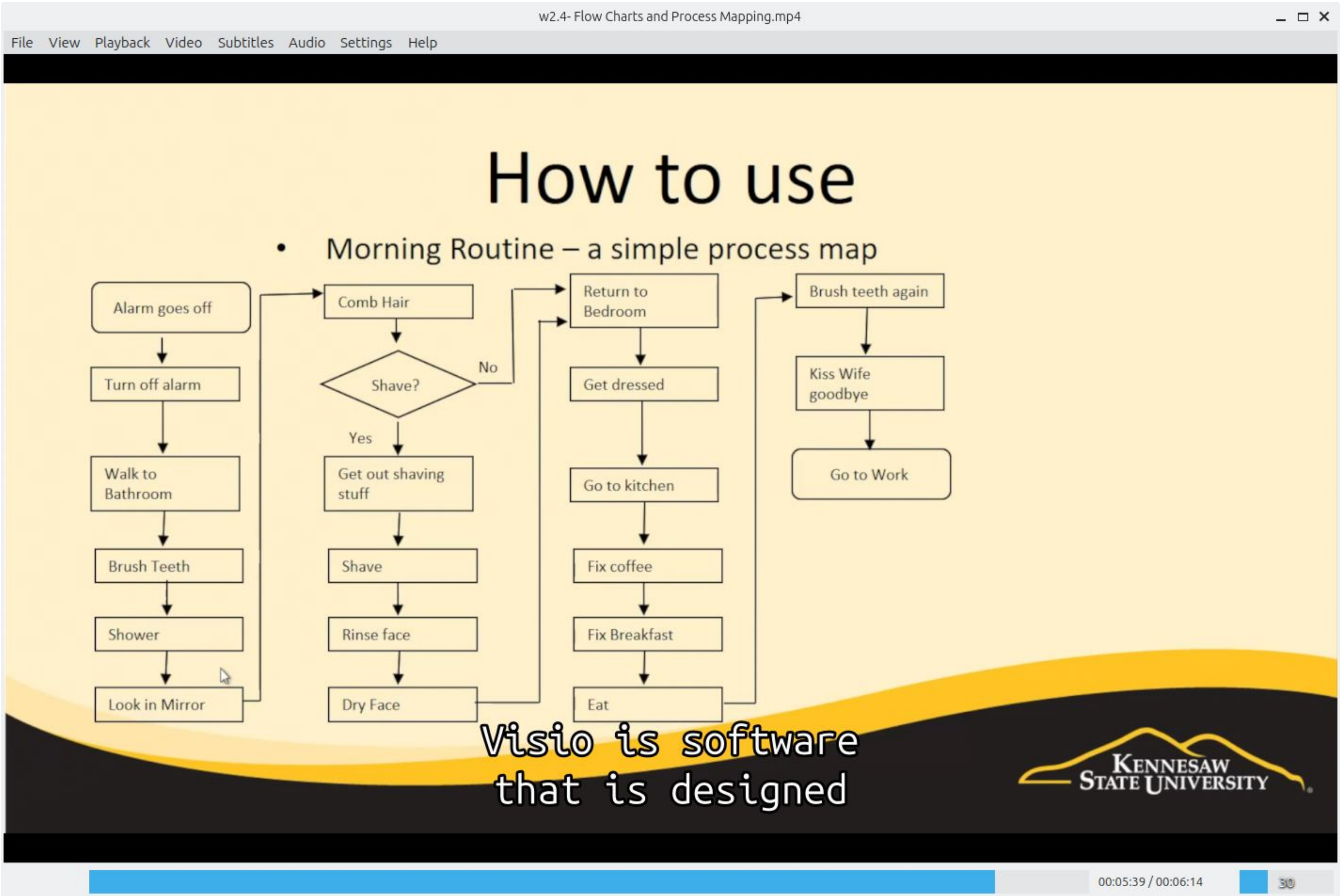
w2.4- Flow Charts and Process Mapping.mp4
File View Playback Video Subtitles Audio Settings Help
How to use
• Morning Routine – a simple process map
Alarm goes off
Turn off alarm
Walk to Bathroom
Brush Teeth
Shower
Look in Mirror
Comb Hair
Shave?
No
Yes
Get out shaving stuff
Shave
Rinse face
Dry Face
Return to Bedroom
Get dressed
Go to kitchen
Fix coffee
Fix Breakfast
Eat
Brush teeth again
Kiss Wife goodbye
Go to Work
Visio is software
that is designed
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00:05:39 / 00:06:14
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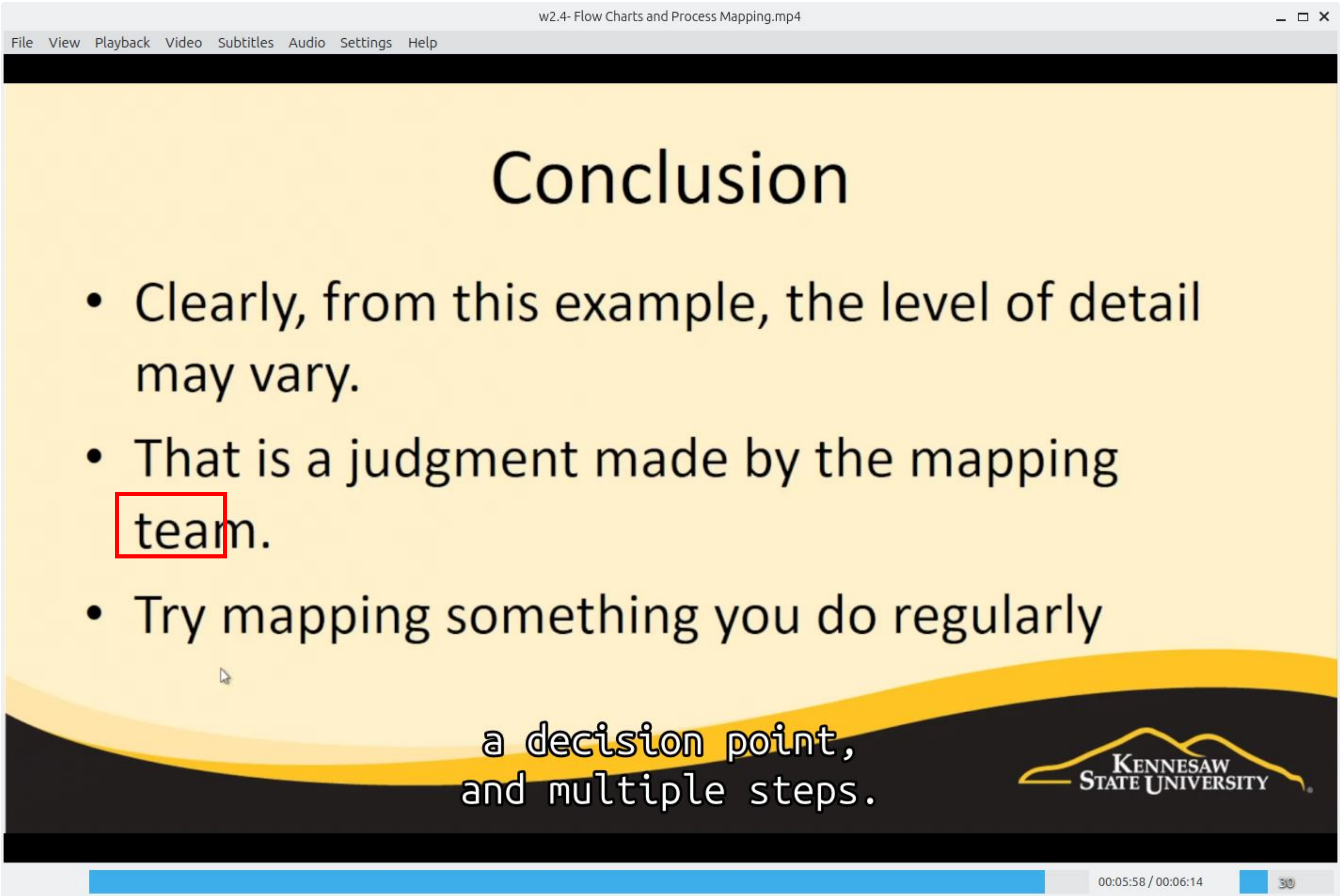
w2.4- Flow Charts and Process Mapping.mp4
File View Playback Video Subtitles Audio Settings Help
Conclusion
• Clearly, from this example, the level of detail may vary.
• That is a judgment made by the mapping team.
• Try mapping something you do regularly
a decision point,
and multiple steps.
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🗺️ Flow Charts and Process Mapping

Process maps, also called **flow charts**, are fundamental tools in process improvement. They are often the **starting point** for any improvement effort as they provide a visual, schematic representation of actions or procedures.

What is a Process?

A process is an activity, typically a sequence of steps, that receives an **input** and converts it into an **output**. This applies to manufacturing (raw material into a product), service delivery, or acting on information.

Purpose and Importance

The primary purpose of mapping a process is to **gain a complete understanding** of the process so it can be improved.

- **Documentation:** Maps are useful for **training, certification,** and eliminating lengthy written procedures.
- **Team-Based Effort:** For high-level processes that cross functional boundaries, often **no single person knows the whole process**. Mapping requires a team that includes the people who **actually use the process daily**.
- **Current State:** It is crucial to map the process **as it is actually performed** (the **current state map**), not the way it was designed or how management *thinks* it is done.

Levels of Processes

Processes exist at multiple levels:

1. **Business Processes:** **High-level processes** (e.g., accounting, customer service) that often cut across different functional departments. They contain multiple work processes.
2. **Work Processes:** The more detailed steps contained within a business process (e.g., billing within accounting). Mapping these separately provides much more detail.

Key Symbols (Simplified)

While there are many different shapes, a basic process map can be created using just three core symbols:

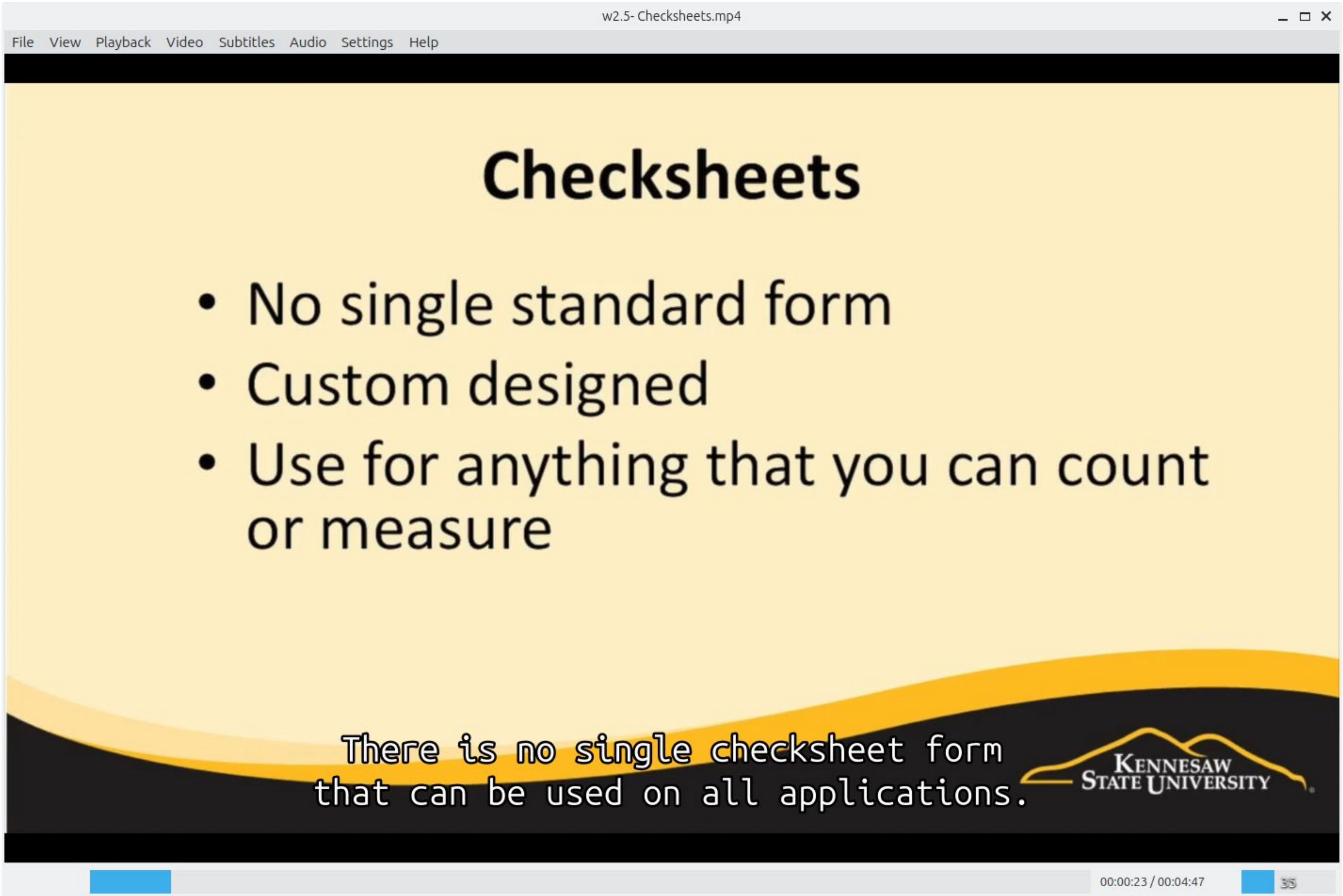
Symbol (Shape)	Name	Purpose
Oval / Rounded Rectangle	**Start/End**	Marks the beginning and end of the process.
Square / Rectangle	**Process Step**	Represents an action or step in the process.
Diamond	**Decision Point**	Represents a point where a decision is made, which can only have **two possible outcomes** (e.g., Yes/No, Pass/Fail).

Mapping Techniques

- **Group Mapping:** A simple technique is to use **sticky notes.** Steps can be written on standard notes, which can be easily rearranged. A sticky note turned 45 degrees can serve as a decision point.
- **Digital Tools:** Maps can be transferred into software like **Microsoft Word/Excel, Google Docs/Sheets,** or dedicated programs like **Visio** for a permanent and professional version.

The biggest challenge for a mapping team is determining and consistently using the **appropriate level of detail**.

w2.5- Checksheets


w2.5- Checksheets.mp4
File View Playback Video Subtitles Audio Settings Help
Checksheets
• No single standard form
• Custom designed
• Use for anything that you can count or measure
There is no single checksheet form
that can be used on all applications.
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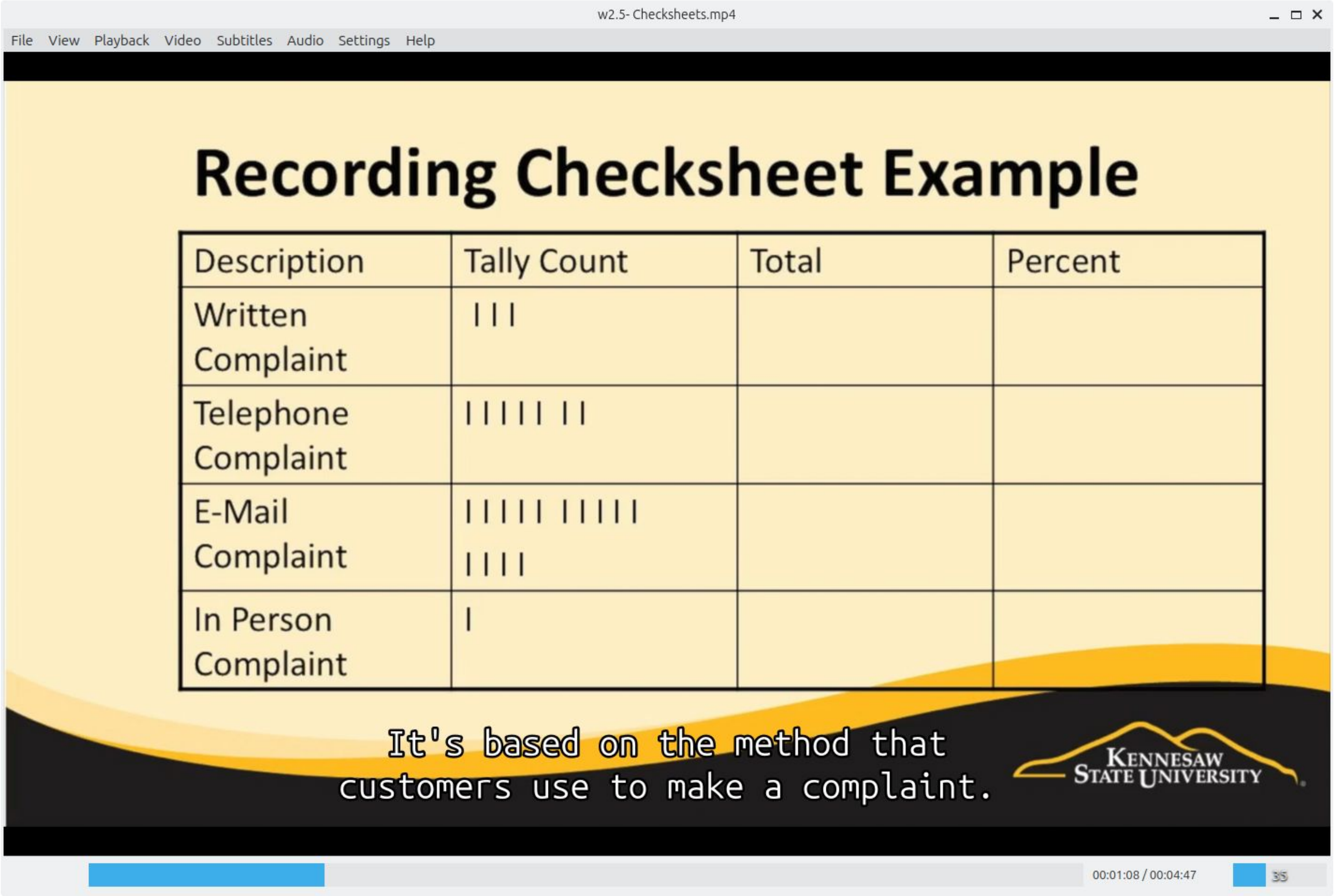
w2.5- Checksheets.mp4
File View Playback Video Subtitles Audio Settings Help
Recording Checksheet Example

Description	Tally Count	Total	Percent
Written Complaint	I I I		
Telephone Complaint	I I I I I I I		
E-Mail Complaint	I I I I I I I I I I I I I I		
In Person Complaint	I		

It's based on the method that
customers use to make a complaint.
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00:01:08 / 00:04:47
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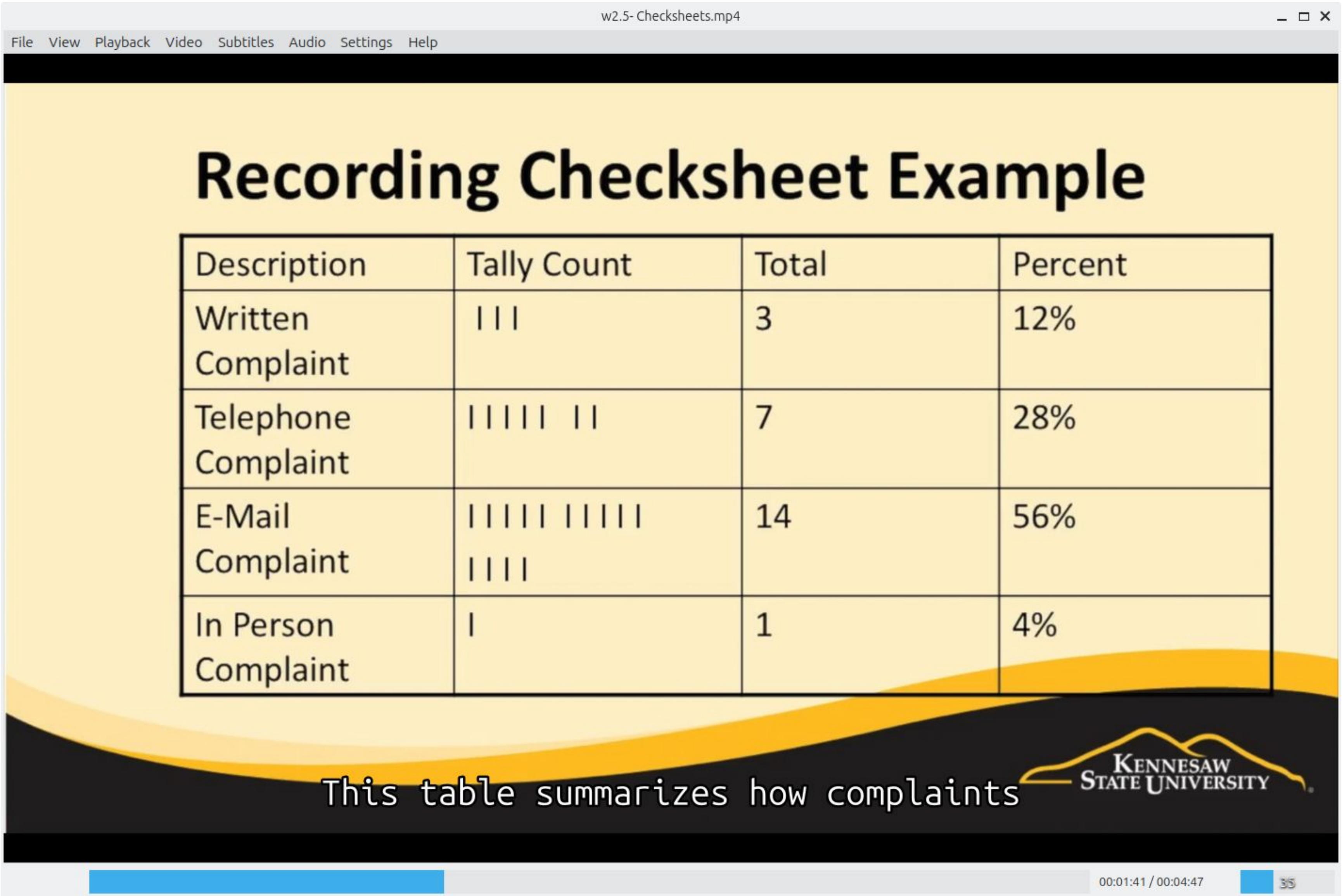
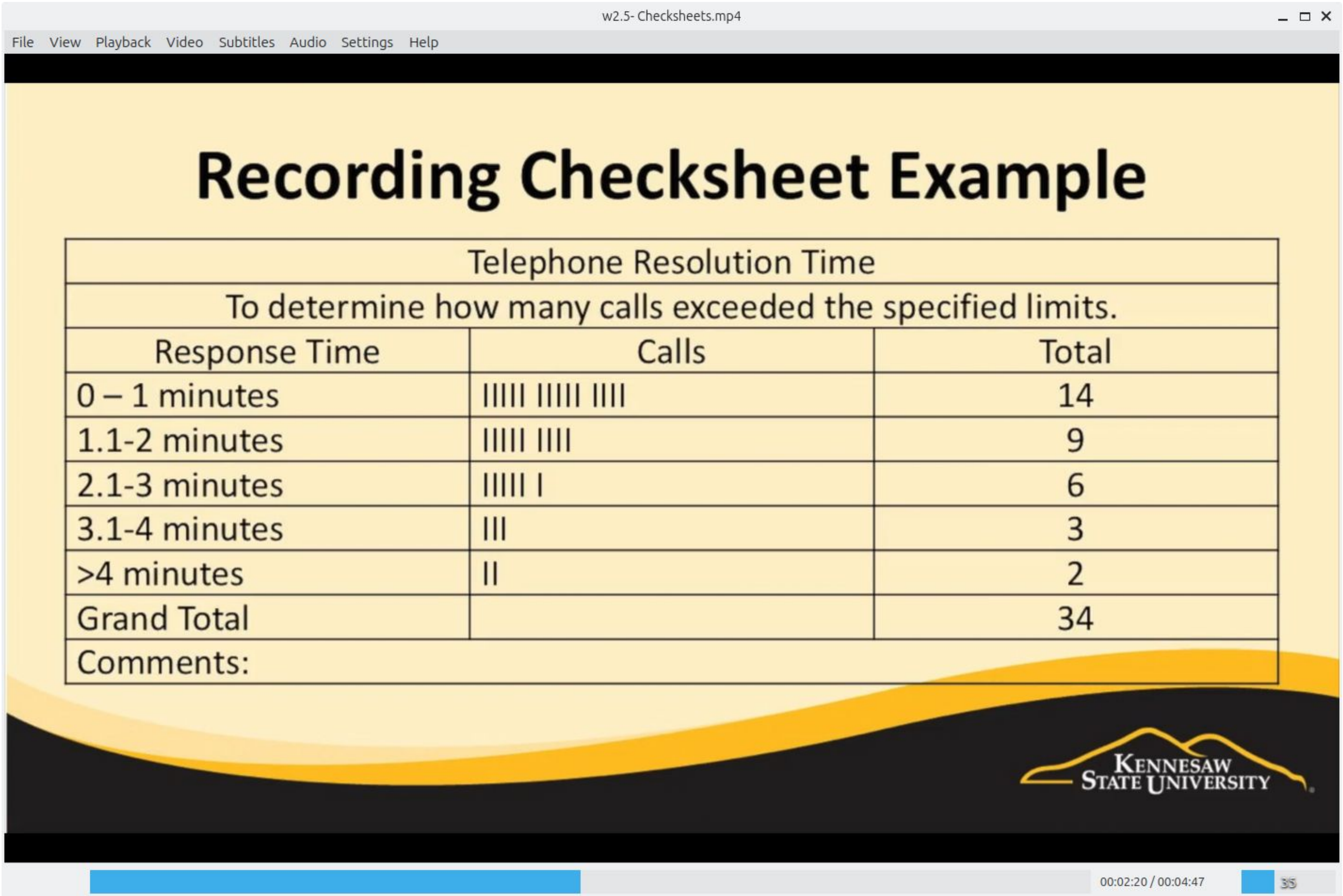


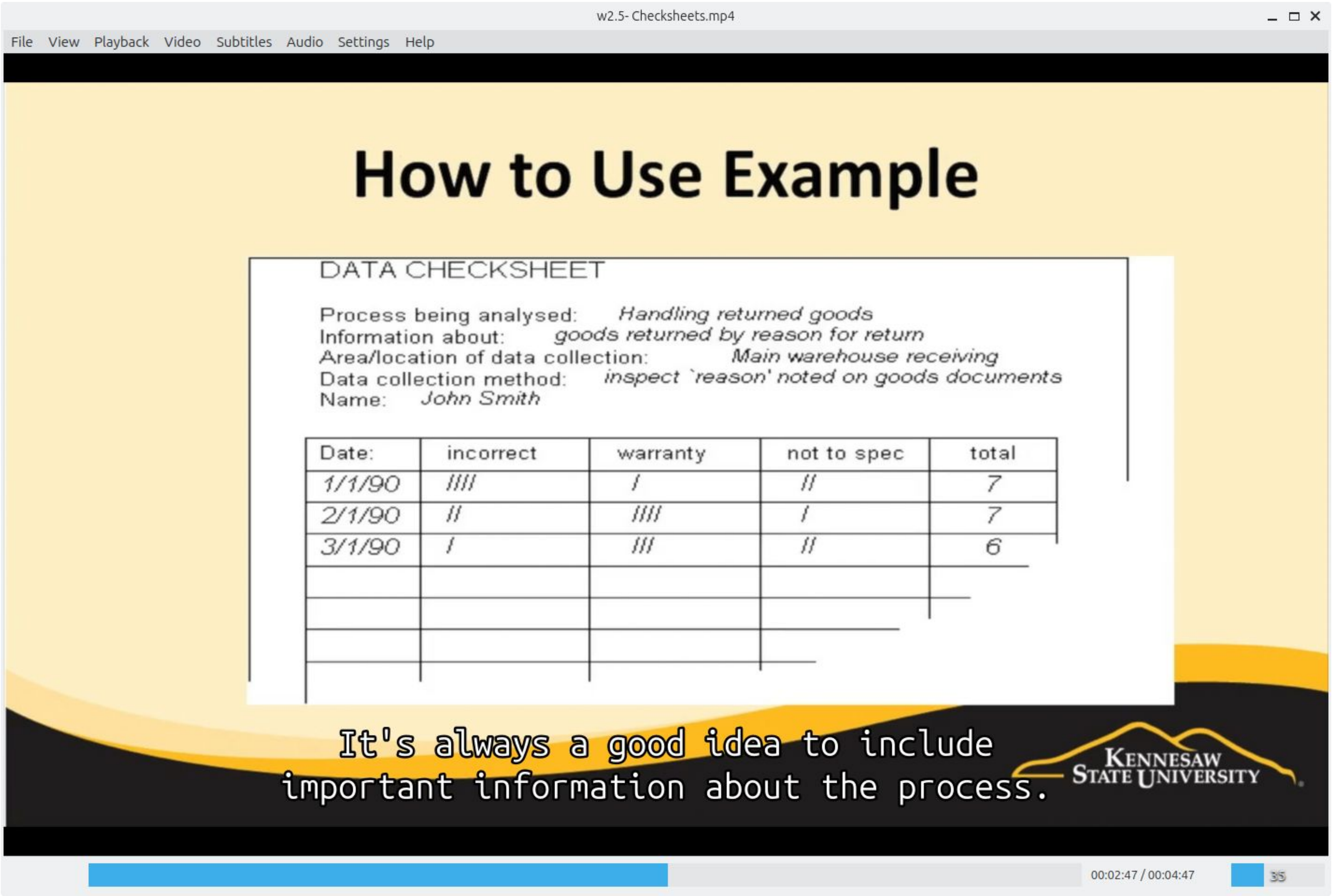
Recording Checksheet Example

Description	Tally Count	Total	Percent
Written Complaint	III	3	12%
Telephone Complaint	IIIII II	7	28%
E-Mail Complaint	IIIII IIIII IIII	14	56%
In Person Complaint	I	1	4%



Recording Checksheet Example

Telephone Resolution Time		
To determine how many calls exceeded the specified limits.		
Response Time	Calls	Total
0 – 1 minutes	IIIII IIIII IIII	14
1.1-2 minutes	IIIII IIII	9
2.1-3 minutes	IIIII I	6
3.1-4 minutes	III	3
>4 minutes	II	2
Grand Total		34
Comments:		

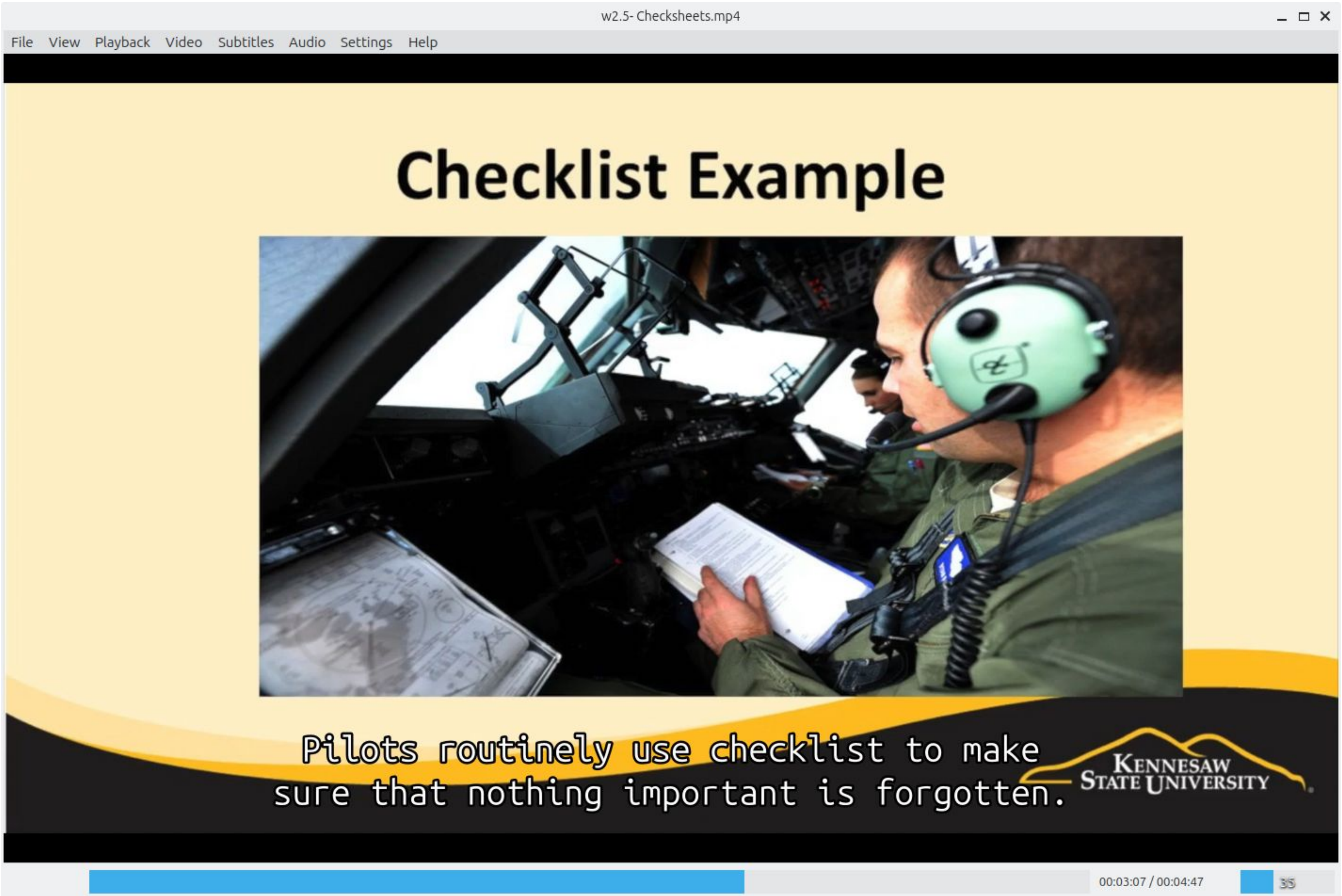


How to Use Example

DATA CHECKSHEET

Process being analysed: *Handling returned goods*
Information about: *goods returned by reason for return*
Area/location of data collection: *Main warehouse receiving*
Data collection method: *inspect `reason' noted on goods documents*
Name: *John Smith*

Date:	incorrect	warranty	not to spec	total
1/1/90	////	/	//	7
2/1/90	//	////	/	7
3/1/90	/	///	//	6


w2.5- Checksheets.mp4
File View Playback Video Subtitles Audio Settings Help
Checklist Example
Pilots routinely use checklist to make
sure that nothing important is forgotten.
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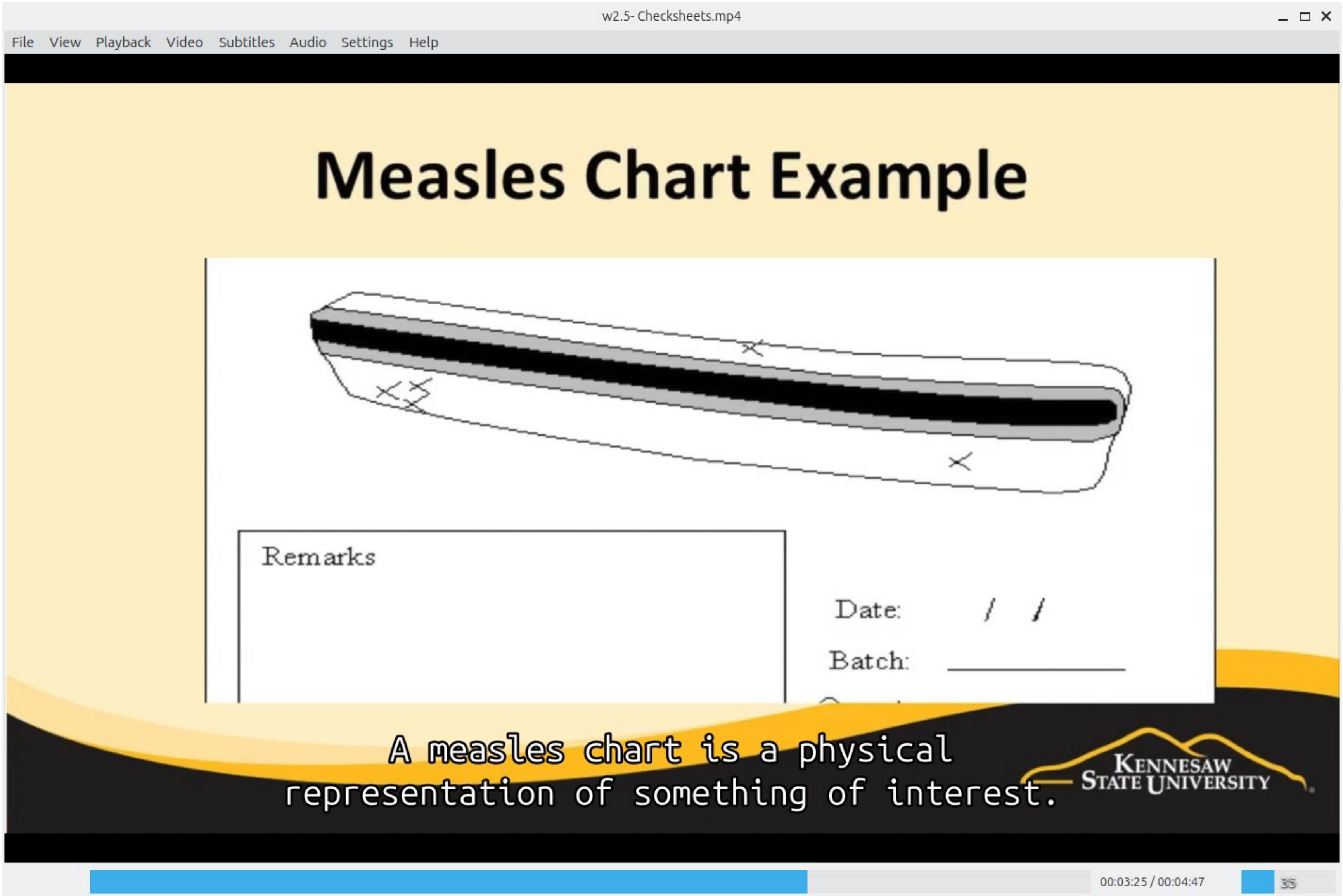
w2.5- Checksheets.mp4
File View Playback Video Subtitles Audio Settings Help
Measles Chart Example
Remarks
Date: / /
Batch:
A measles chart is a physical
representation of something of interest.
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00:03:25 / 00:04:47

w2.5- Checksheets.mp4

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Measles Chart Example

Line	Mon	Tues	Wed	Thur	Fri
Line 1	1 3 3 2	2 3 1	1 1 2	3 3 2	3 3 3 2
Line 2	1	2 1	2	2	1
KEY: 1 = paint defect, 2 = bent part, 3 = other					

It's also possible with the measles chart record more than one type of defect.

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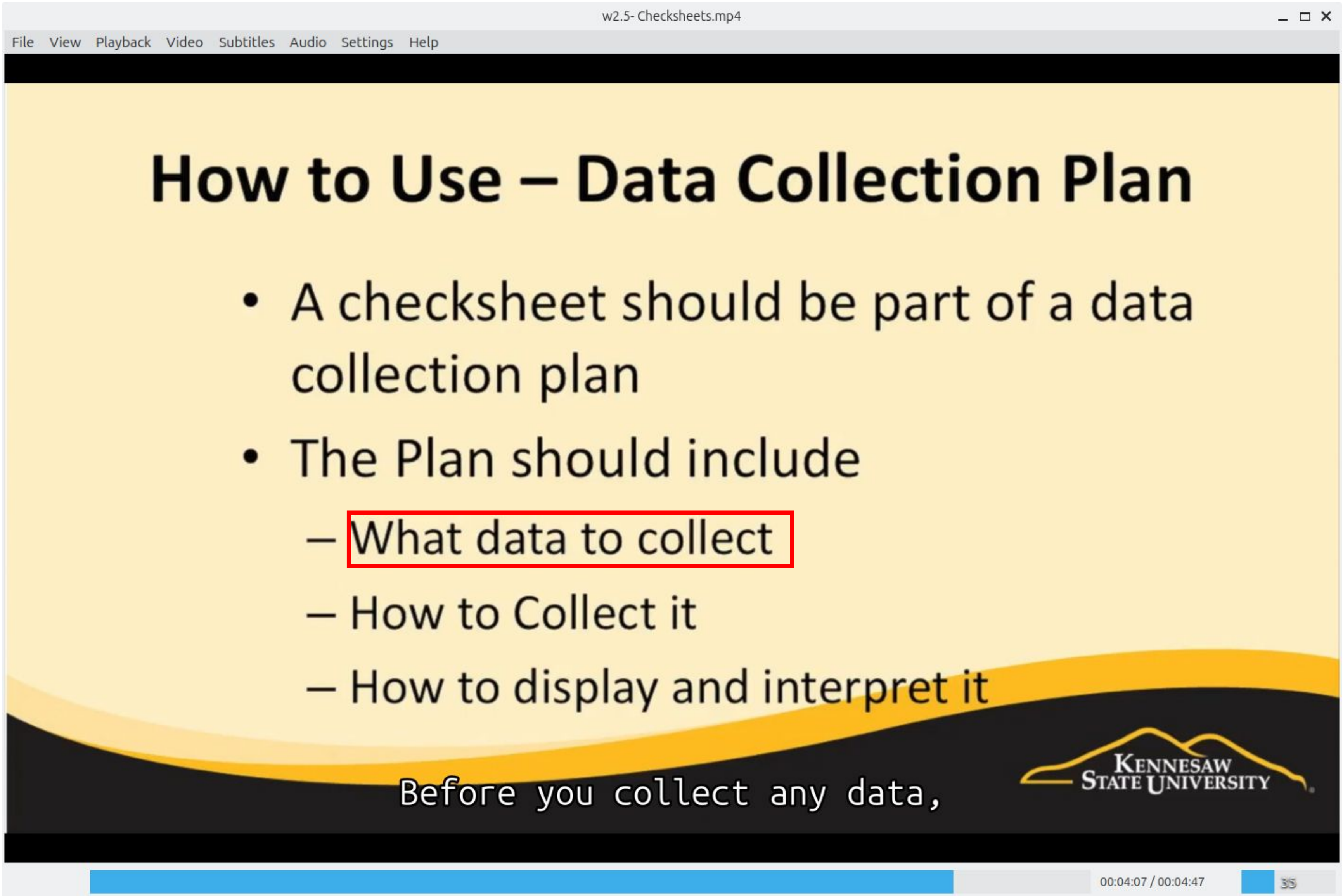
w2.5- Checksheets.mp4
File View Playback Video Subtitles Audio Settings Help
How to Use – Data Collection Plan
• A checksheet should be part of a data collection plan
• The Plan should include
– What data to collect
– How to Collect it
– How to display and interpret it
Before you collect any data,
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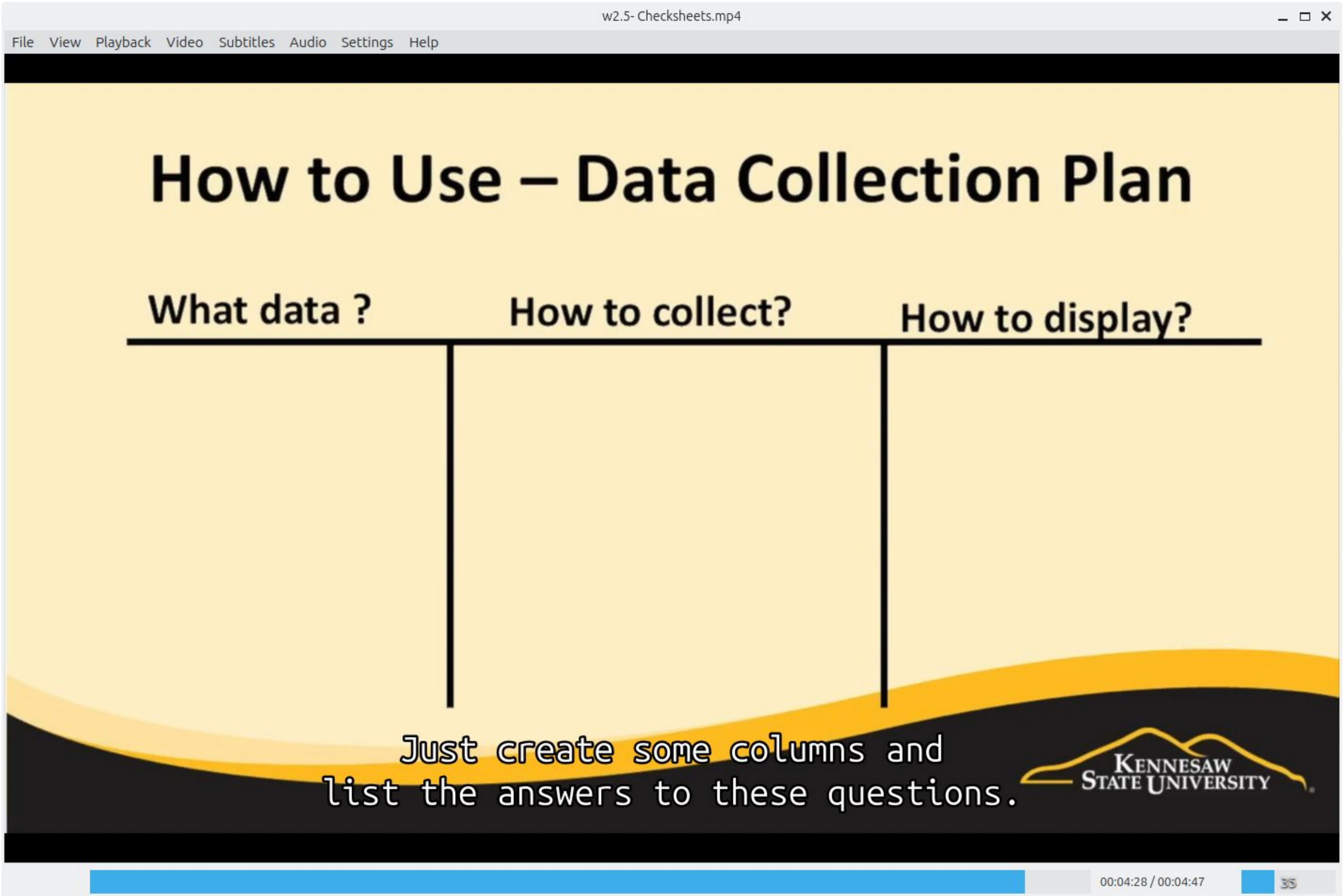
00:04:07 / 00:04:47


w2.5- Checksheets.mp4
File View Playback Video Subtitles Audio Settings Help
How to Use – Data Collection Plan
What data ?
How to collect?
How to display?
Just create some columns and
list the answers to these questions.
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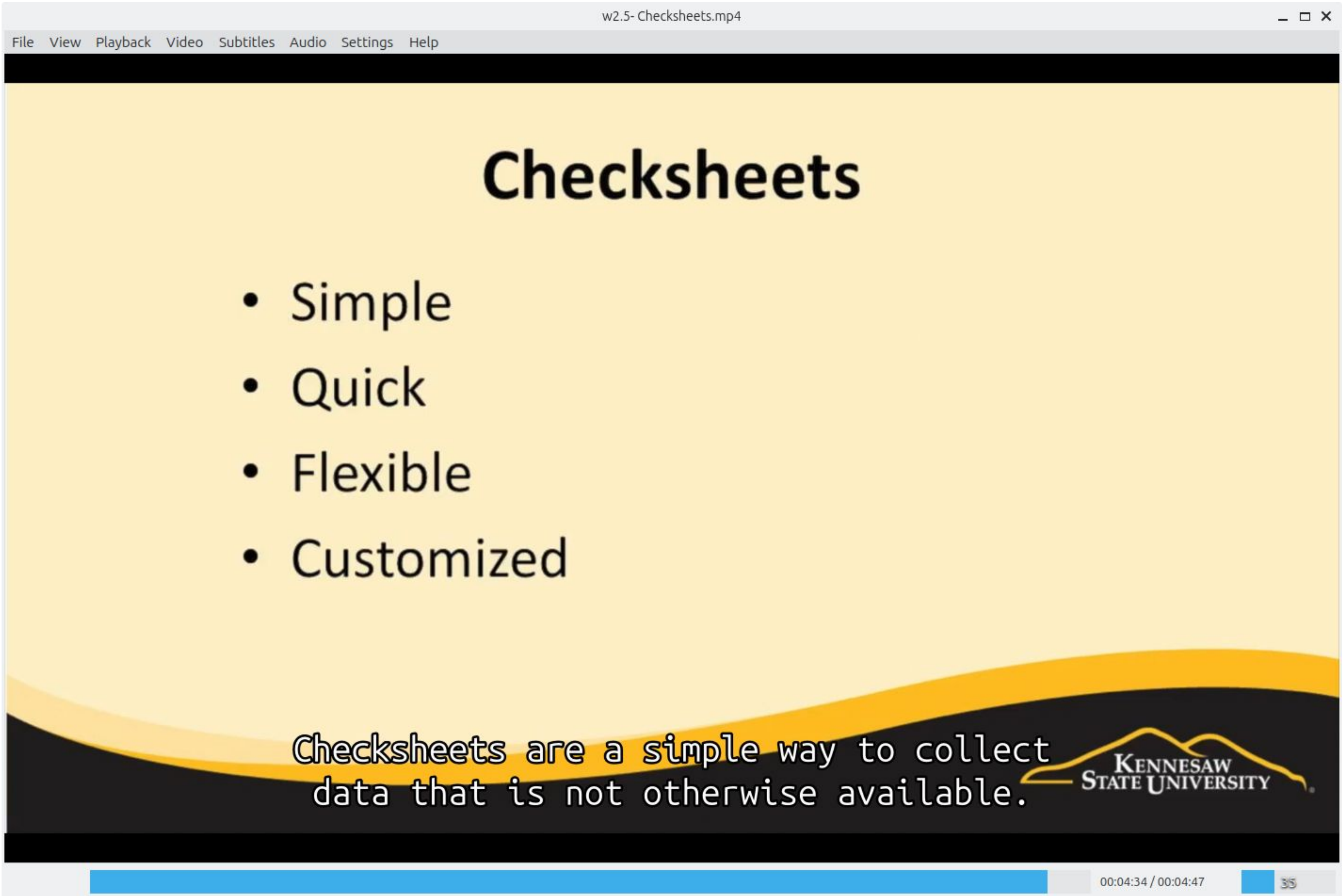
00:04:28 / 00:04:47


w2.5- Checksheets.mp4
File View Playback Video Subtitles Audio Settings Help
Checksheets
• Simple
• Quick
• Flexible
• Customized
Checksheets are a simple way to collect
data that is not otherwise available.
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00:04:34 / 00:04:47

📝 Checksheets: A Simple Data Collection Tool

Checksheets are **simple, quick, flexible, and usually temporary** tools used to collect initial data when starting a process improvement project. They are customizable and can be used to count or measure various events like **defects, complaints, or phone calls**.

Three Main Types of Checksheets

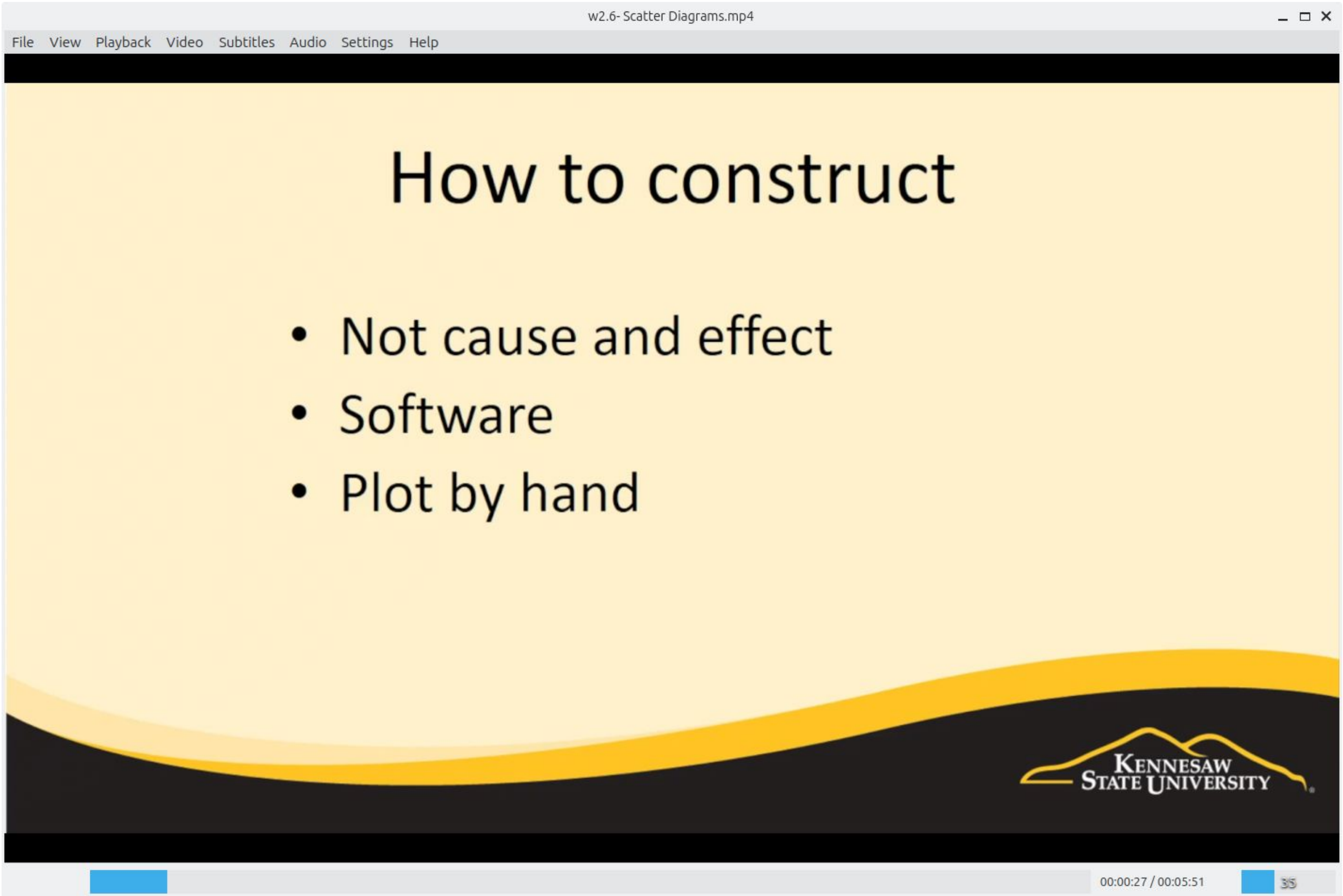
Type	Purpose	Example
1. Recording Checksheets	Used to record counts or measurement data for analysis.	Tallying the number of customer complaints received via letter, phone, or email.
2. Checklists	A list of written reminders to ensure important steps in a complex or delicate procedure are not forgotten.	A pilot's pre-flight checklist, a hotel housekeeping list, or a medical procedure checklist.
3. Measles Charts	Used to identify the **physical location** of defects or other issues on an object.	A drawing of a product (e.g., a car bumper) where marks are placed exactly where defects occur to track patterns.

Key Design and Use Principles

- **Customization:** There is no single universal checksheet form; the design **must be customized** to the specific data being evaluated.
- **Data Separation:** Data can be separated by shift, production line, or other factors to allow for detailed analysis.
- **Process Information:** It is always a good practice to include important contextual information at the top of the sheet, such as the **location, area, shift, and involved personnel**.
- **Data Plan:** Before collecting any data, even with a simple checksheet, a **plan** should be created. The plan should define **which data to collect, how it will be collected, who will collect it, and what will be done with the data.**

For improvement projects where the necessary initial data is not available, a checksheet is an excellent place to start.

w2.6- Scatter Diagrams


w2.6- Scatter Diagrams.mp4
File View Playback Video Subtitles Audio Settings Help
How to construct
• Not cause and effect
• Software
• Plot by hand
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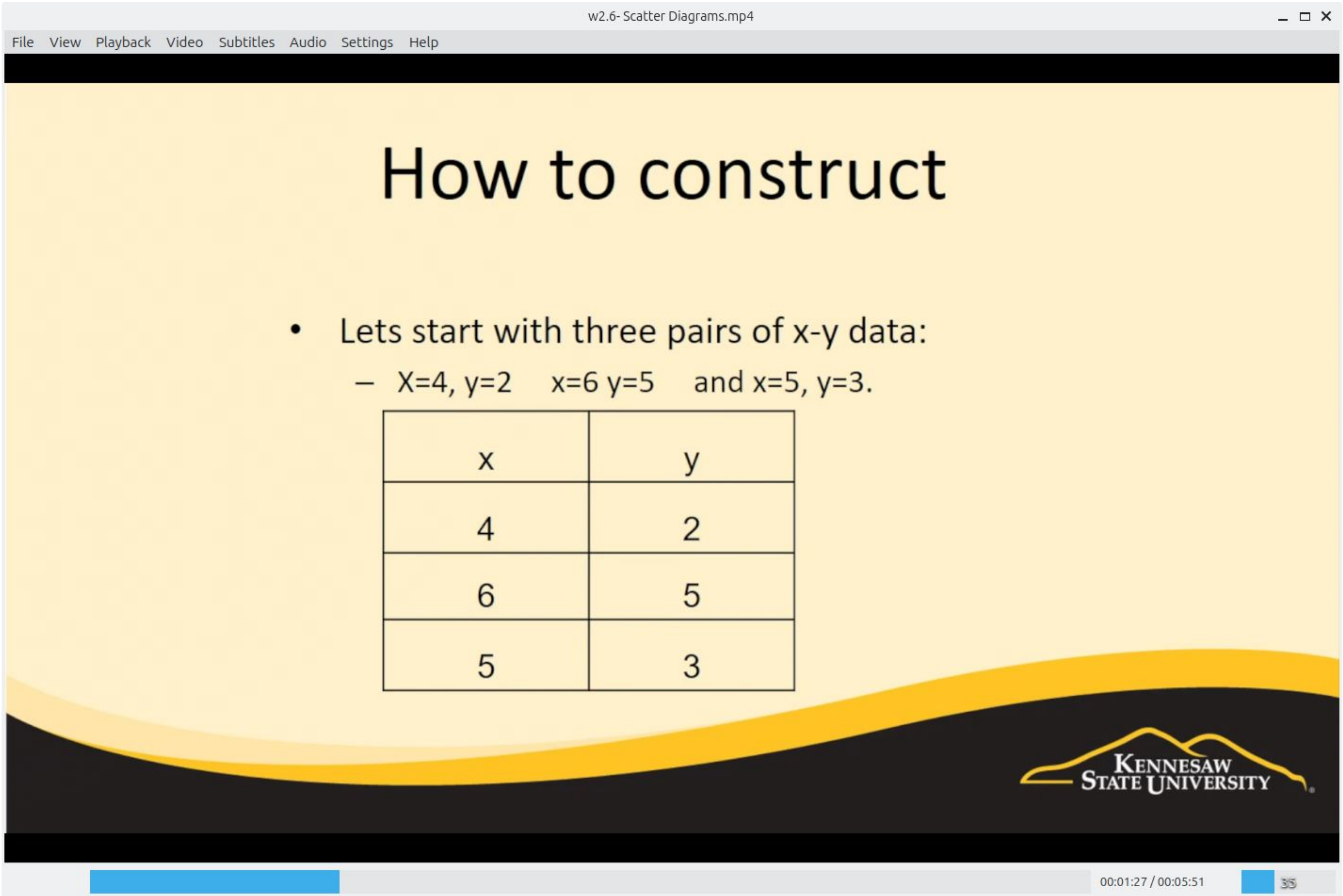
00:00:27 / 00:05:51


w2.6- Scatter Diagrams.mp4
File View Playback Video Subtitles Audio Settings Help
How to construct
• Lets start with three pairs of x-y data:
– X=4, y=2 x=6 y=5 and x=5, y=3.
x y
4 2
6 5
5 3
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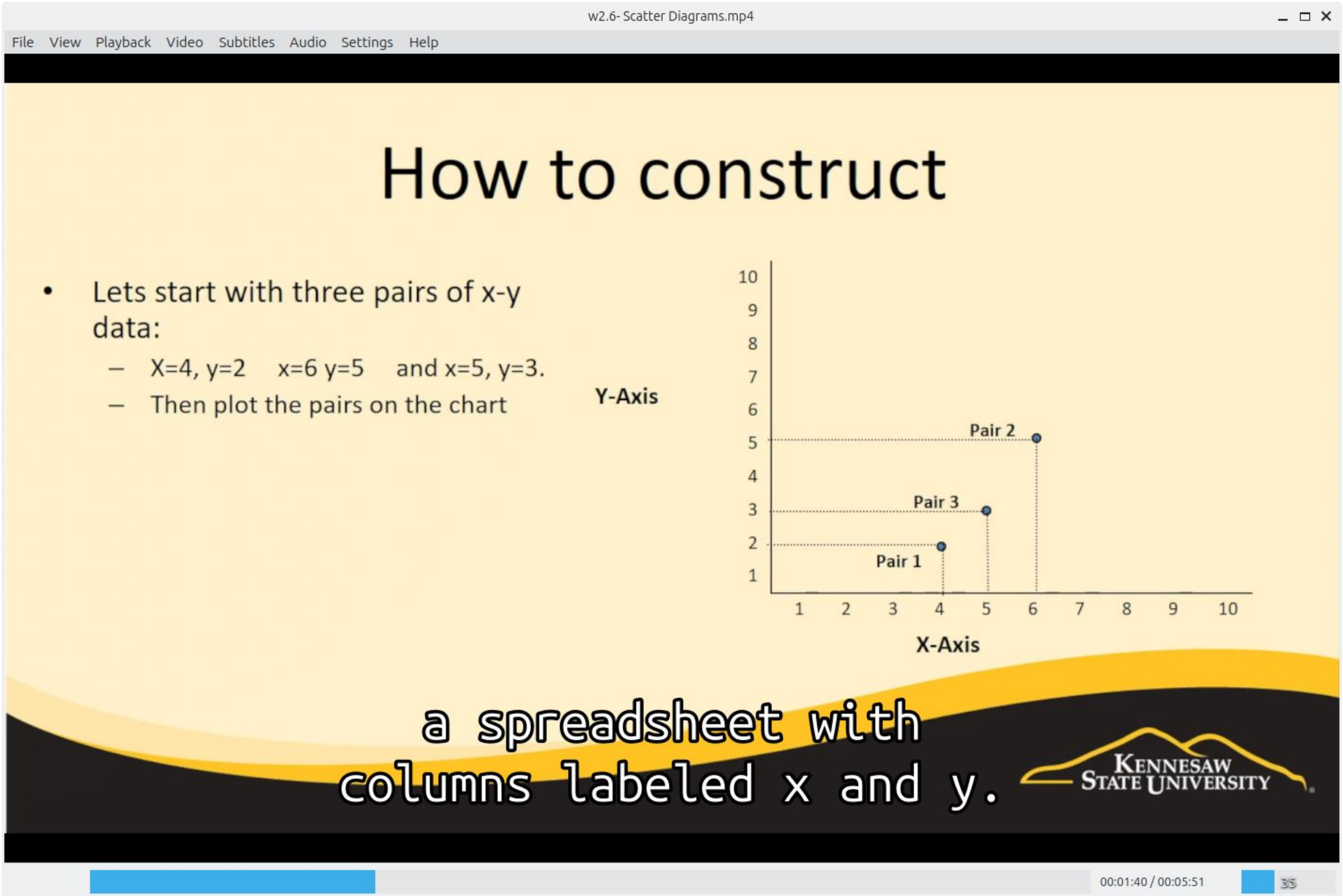
w2.6- Scatter Diagrams.mp4
File View Playback Video Subtitles Audio Settings Help
How to construct
Lets start with three pairs of x-y data:
– X=4, y=2 x=6 y=5 and x=5, y=3.
– Then plot the pairs on the chart
Y-Axis
10
9
8
7
6
5
4
3
2
1
Pair 2
Pair 3
Pair 1
1 2 3 4 5 6 7 8 9 10
X-Axis
a spreadsheet with
columns labeled x and y.
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00:01:40 / 00:05:51
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w2.6- Scatter Diagrams.mp4
File View Playback Video Subtitles Audio Settings Help
Things to look for:
Strong Positive
Weak Positive
No Relationship
Strong Negative
Weak Negative
would probably have
at least 30 pairs.
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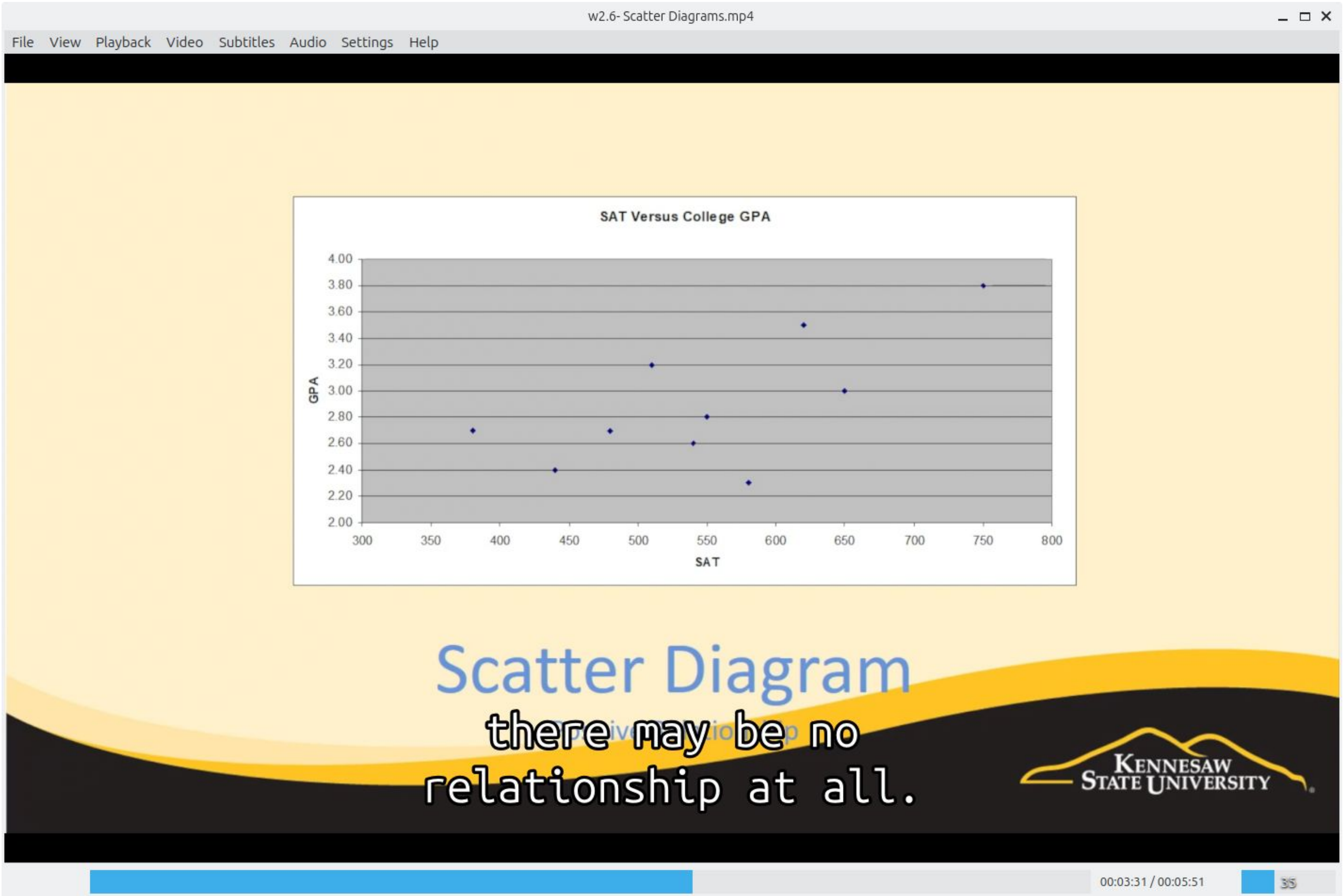
00:02:29 / 00:05:51


w2.6- Scatter Diagrams.mp4
File View Playback Video Subtitles Audio Settings Help
SAT Versus College GPA
GPA
4.00
3.80
3.60
3.40
3.20
3.00
2.80
2.60
2.40
2.20
2.00
300 350 400 450 500 550 600 650 700 750 800
SAT
Scatter Diagram
there may be no
relationship at all.
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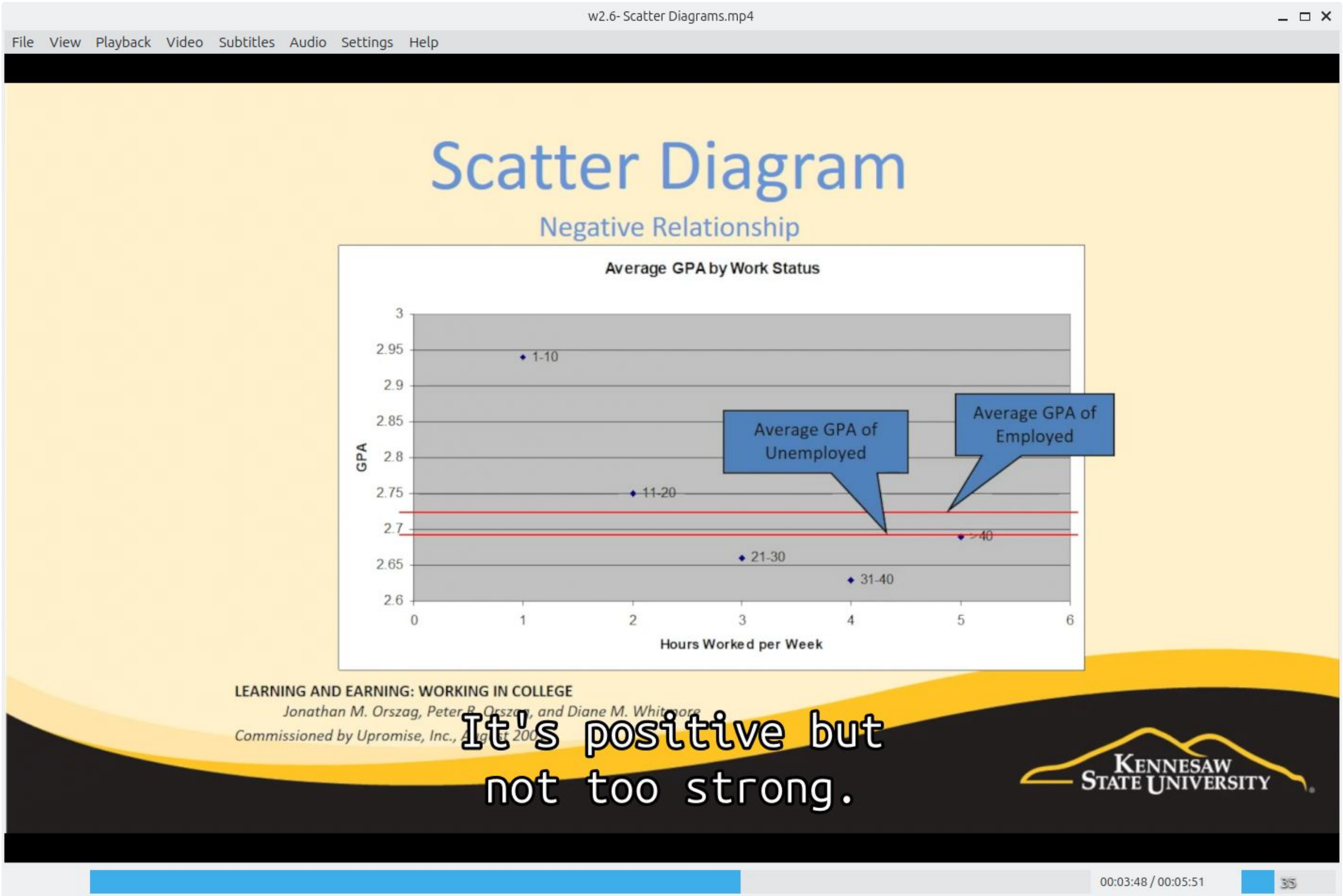
00:03:31 / 00:05:51


w2.6- Scatter Diagrams.mp4
File View Playback Video Subtitles Audio Settings Help
Scatter Diagram
Negative Relationship
Average GPA by Work Status
GPA
Hours Worked per Week
1-10
11-20
21-30
31-40
>40
Average GPA of Unemployed
Average GPA of Employed
LEARNING AND EARNING: WORKING IN COLLEGE
Jonathan M. Orszag, Peter R. Orszag, and Diane M. Whitmore
Commissioned by Upromise, Inc.,
It's positive but
not too strong.
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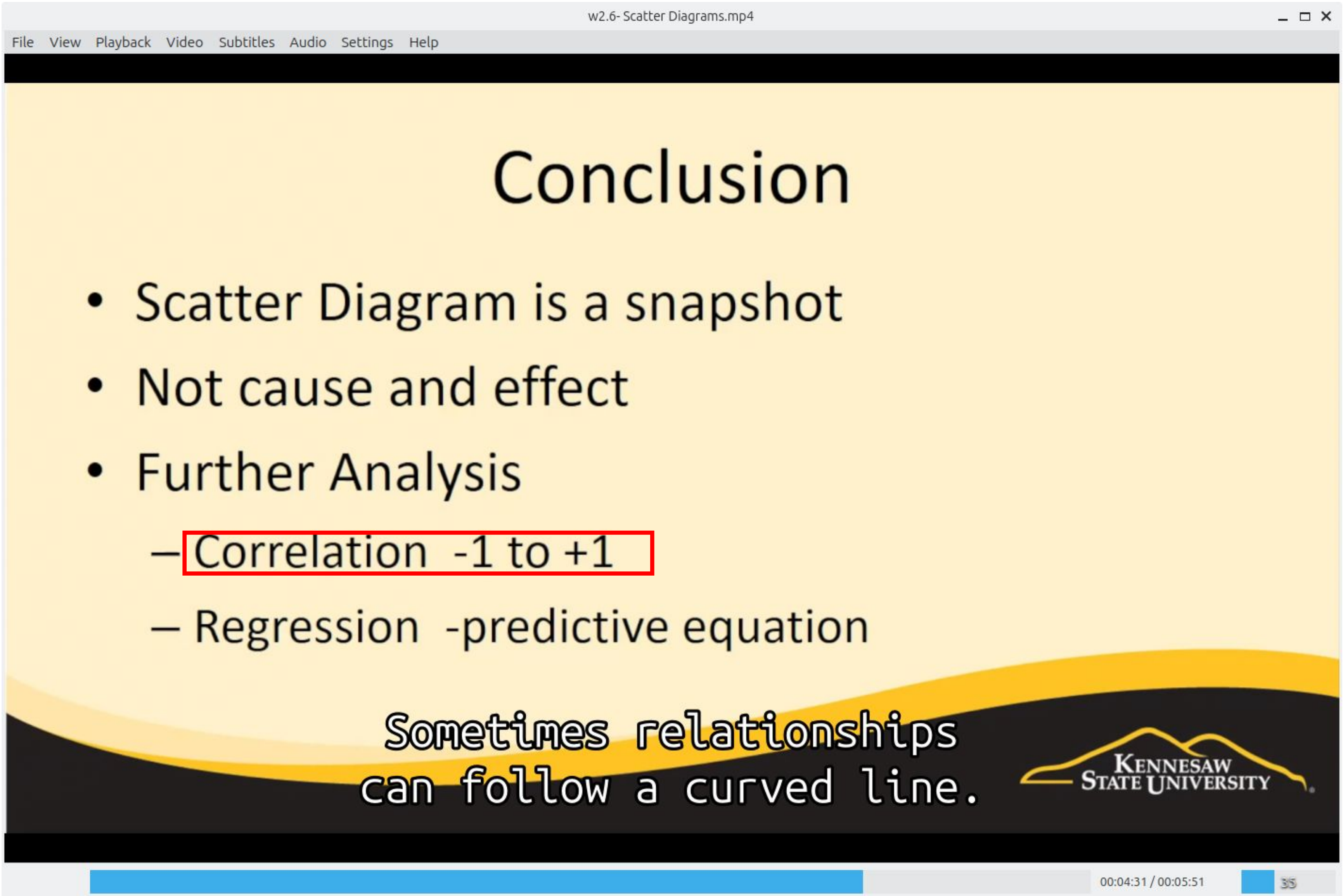
00:03:48 / 00:05:51


w2.6- Scatter Diagrams.mp4
File View Playback Video Subtitles Audio Settings Help
Conclusion
• Scatter Diagram is a snapshot
• Not cause and effect
• Further Analysis
– Correlation -1 to +1
– Regression -predictive equation
Sometimes relationships
can follow a curved line.
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00:04:31 / 00:05:51

📈 Scatter Diagrams

Scatter Diagrams (or **Scatter Plots**) are visual tools used to investigate the **possible relationship** (or correlation) between two variables that relate to the same event. They are a valuable first step in exploring potential root causes.

Structure and Construction

- **Purpose:** To visually represent relationships that can later be confirmed using correlation and regression analysis.
- **Axes:**
  - **X-axis (Horizontal):** Represents the **independent variable** (the potential cause).
  - **Y-axis (Vertical):** Represents the **dependent variable** (the effect or the variable you are trying to fix).
- **Plotting:** Each event or occurrence is represented by an **x-y pair** (two pieces of data) plotted as a single point on the chart. A useful scatter plot typically requires at least 30 pairs of data.

Interpreting Relationships

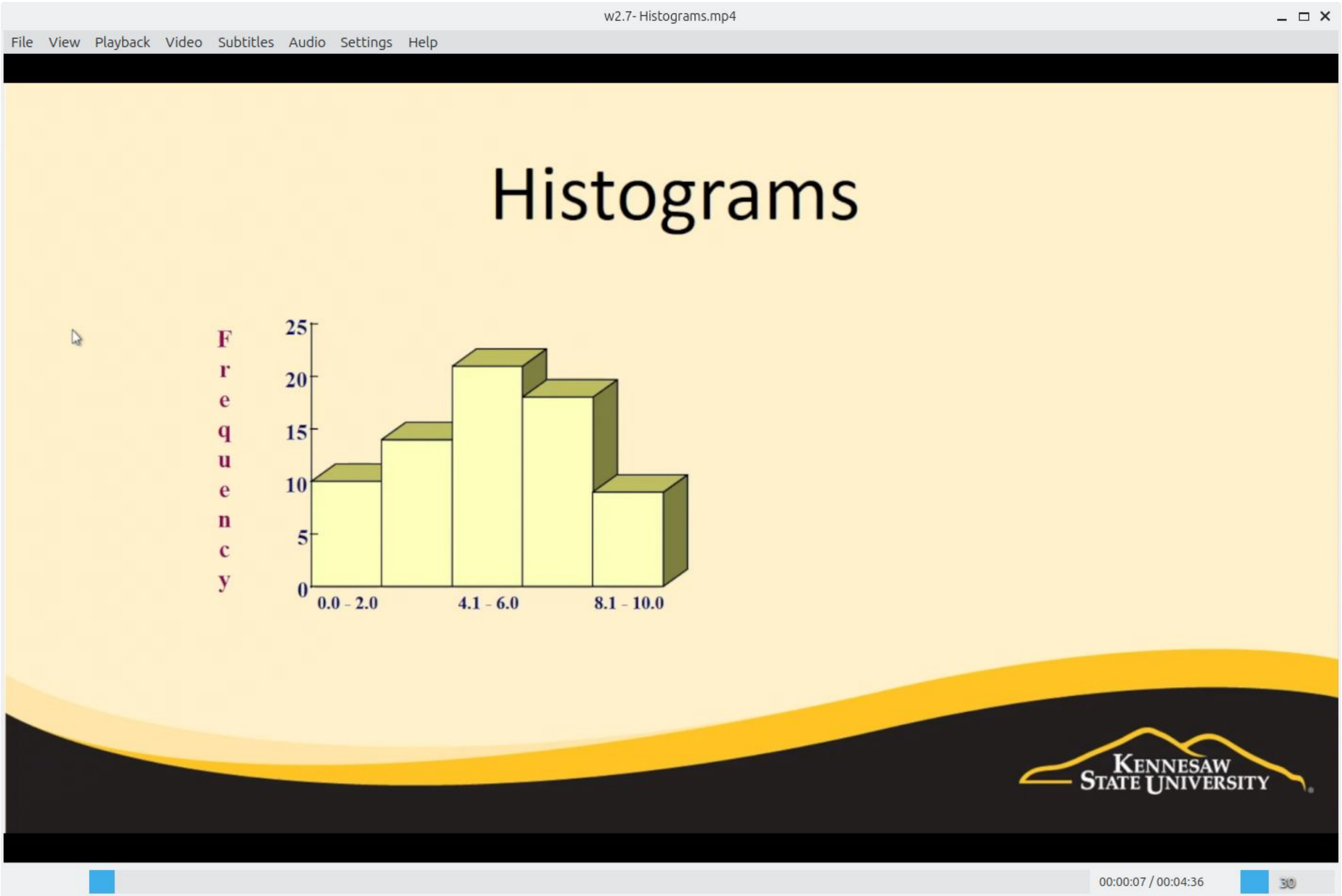
The way the data points cluster indicates the type and strength of the relationship:

Pattern	Correlation Type	Interpretation	Strength
Lower-Left to Upper-Right	**Positive**	As the **X** variable increases, the **Y** variable also increases.	The closer the points cluster around the line of best fit, the **stronger** the relationship.
Upper-Left to Lower-Right	**Negative**	As the **X** variable increases, the **Y** variable decreases.	The more scattered the points, the **weaker** the relationship.
No Particular Direction	**None** (Zero Correlation)	There is no significant relationship between the two variables.	N/A

Correlation vs. Causation

- **Correlation:** Tells you the **direction** and **strength** of a relationship between two variables. The value ranges between $\boxed{-1 \text{ (perfect negative) and } +1 \text{ (perfect positive)}}$, with $\mathbf{0}$ meaning no relationship.
- **Causation:** A scatter diagram **does not specifically indicate cause-and-effect**. It shows that two variables move together, but you cannot tell $\boxed{\text{if } X \text{ causes } Y, Y \text{ causes } X}$, or if a $\boxed{\text{third factor causes changes in both}}$. Further statistical analysis (like regression) is needed to infer causation.

w2.7- Histograms


w2.7- Histograms.mp4
File View Playback Video Subtitles Audio Settings Help
Histograms
Frequency
25
20
15
10
5
0
0.0 - 2.0
4.1 - 6.0
8.1 - 10.0
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00:00:07 / 00:04:36
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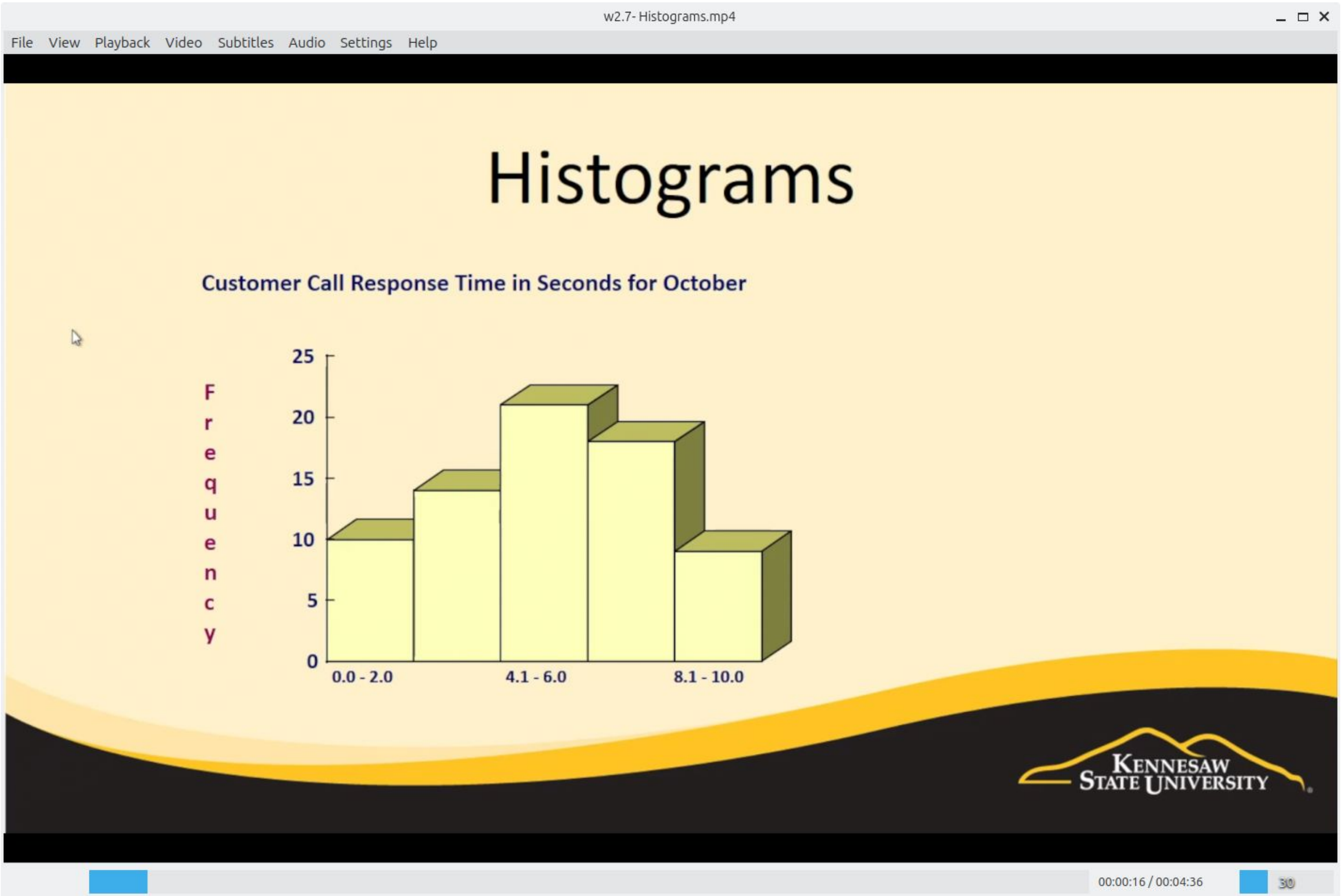
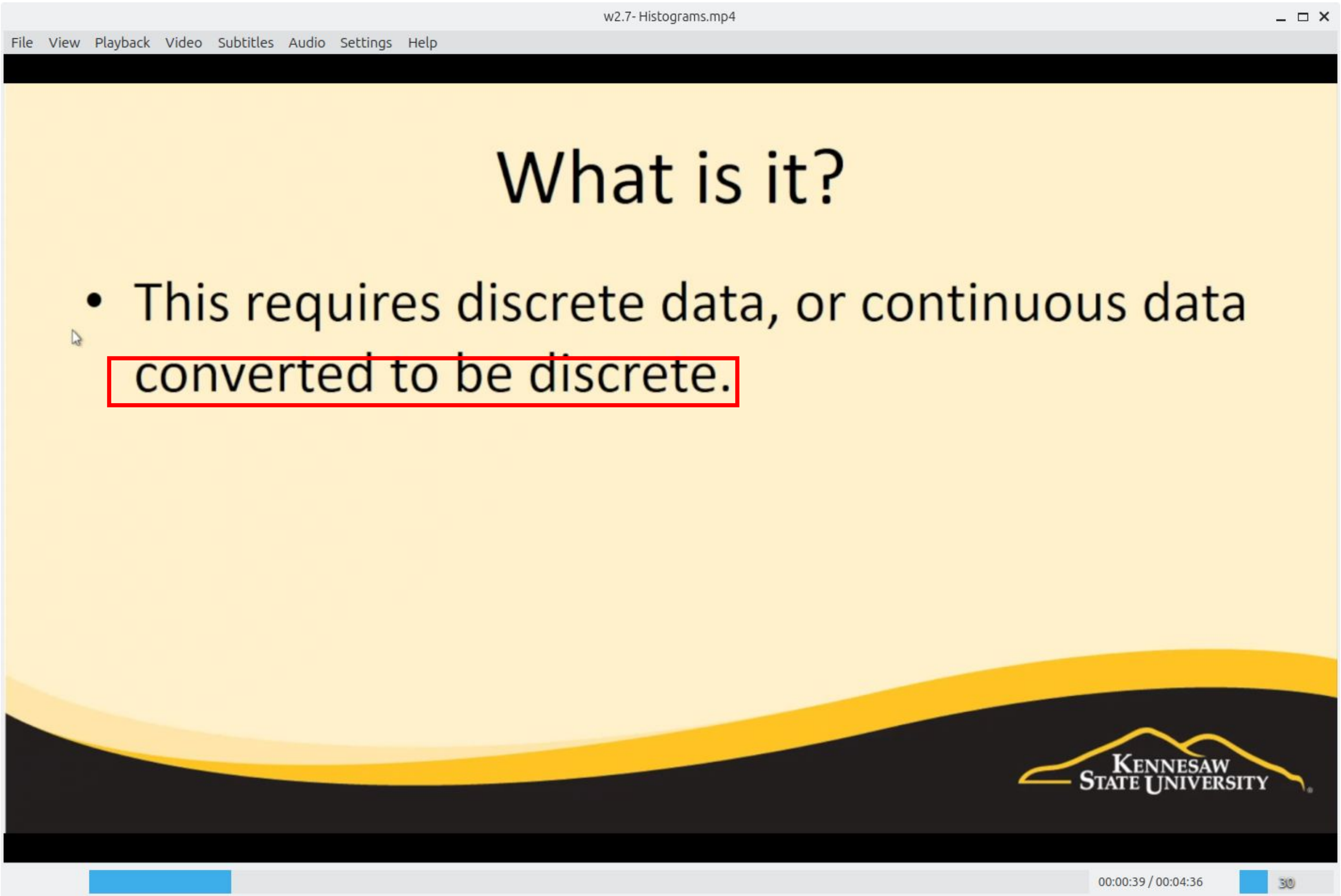

w2.7- Histograms.mp4
File View Playback Video Subtitles Audio Settings Help
Histograms
Customer Call Response Time in Seconds for October
Frequency
25
20
15
10
5
0
0.0 - 2.0
4.1 - 6.0
8.1 - 10.0
Kennesaw State University
00:00:16 / 00:04:36


w2.7- Histograms.mp4
File View Playback Video Subtitles Audio Settings Help
What is it?
• This requires discrete data, or continuous data converted to be discrete.
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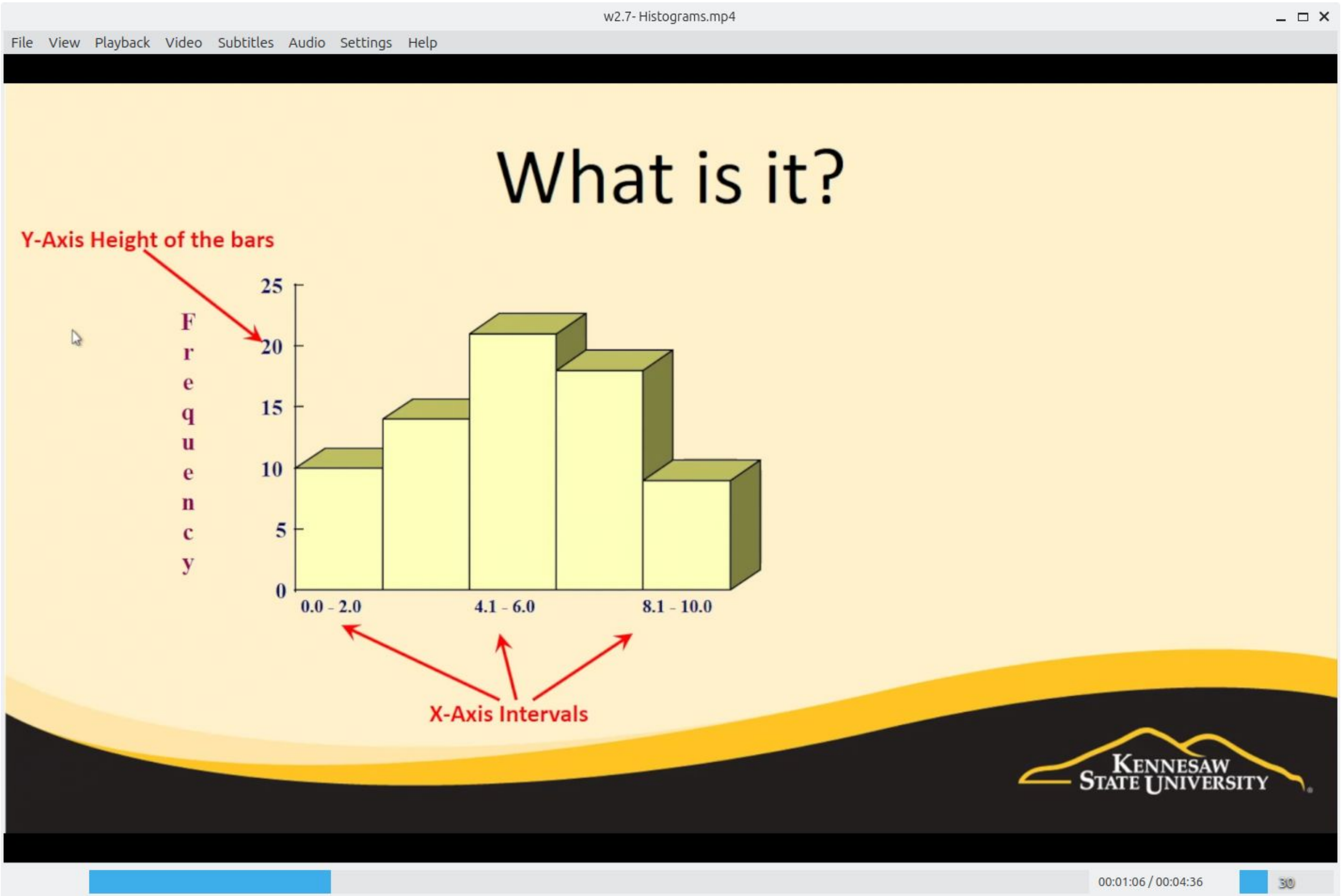
00:00:39 / 00:04:36


w2.7- Histograms.mp4
File View Playback Video Subtitles Audio Settings Help
What is it?
Y-Axis Height of the bars
Frequency
25
20
15
10
5
0
0.0 - 2.0
4.1 - 6.0
8.1 - 10.0
X-Axis Intervals
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00:01:06 / 00:04:36

w2.7- Histograms.mp4

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Grouping data

- How many groups?
  - 5 – 20 depending on the data $\sqrt{n}$
  - Number of groups =
- How wide
  - Subtract the lowest value from the highest value
  - Divide by the number of groups
  - Round up
  - Equal size

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00:01:23 / 00:04:36

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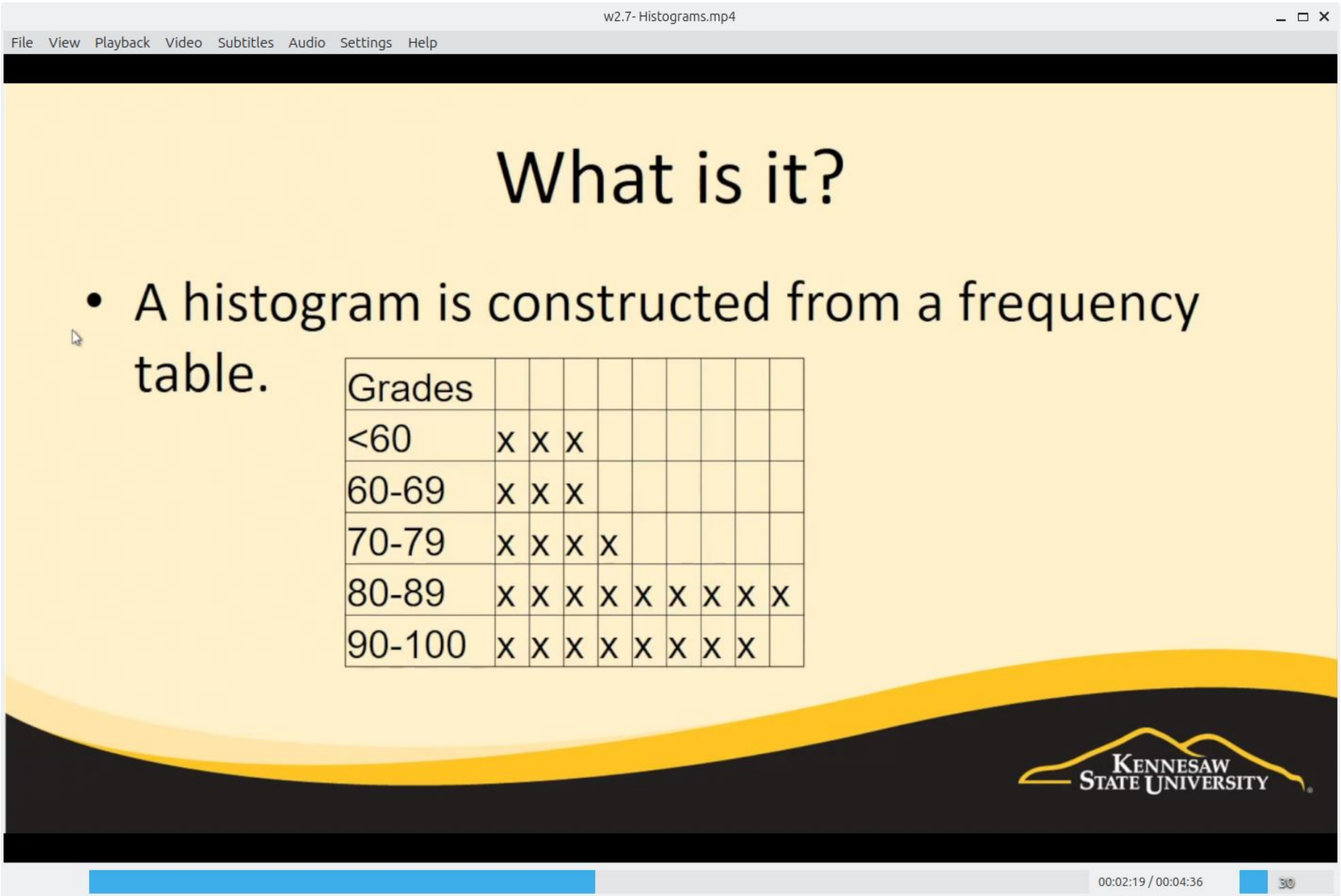
w2.7- Histograms.mp4
File View Playback Video Subtitles Audio Settings Help
What is it?
• A histogram is constructed from a frequency table.
Grades
<60 x x x
60-69 x x x
70-79 x x x x
80-89 x x x x x x x x x
90-100 x x x x x x x x
Kennesaw State University
00:02:19 / 00:04:36
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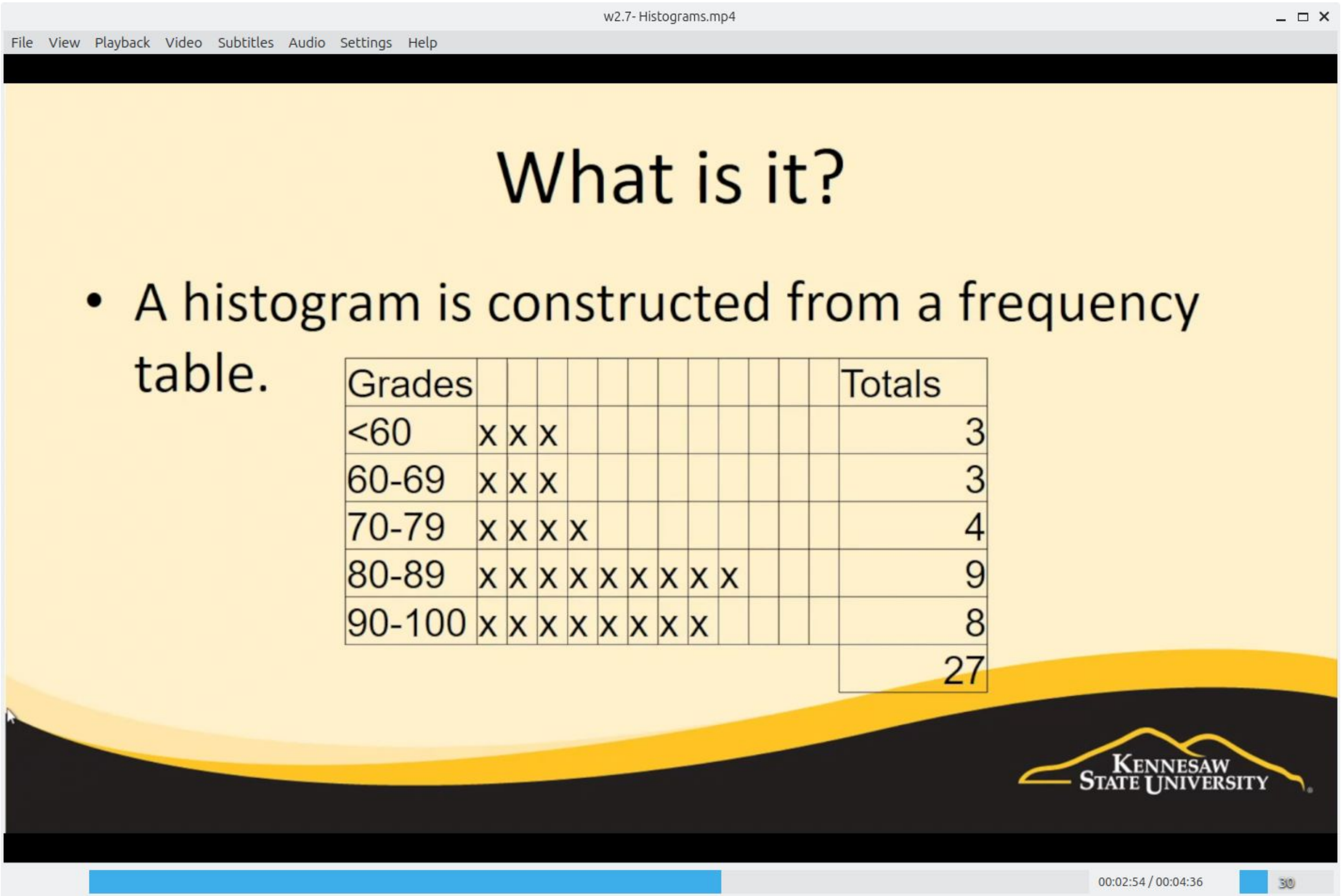
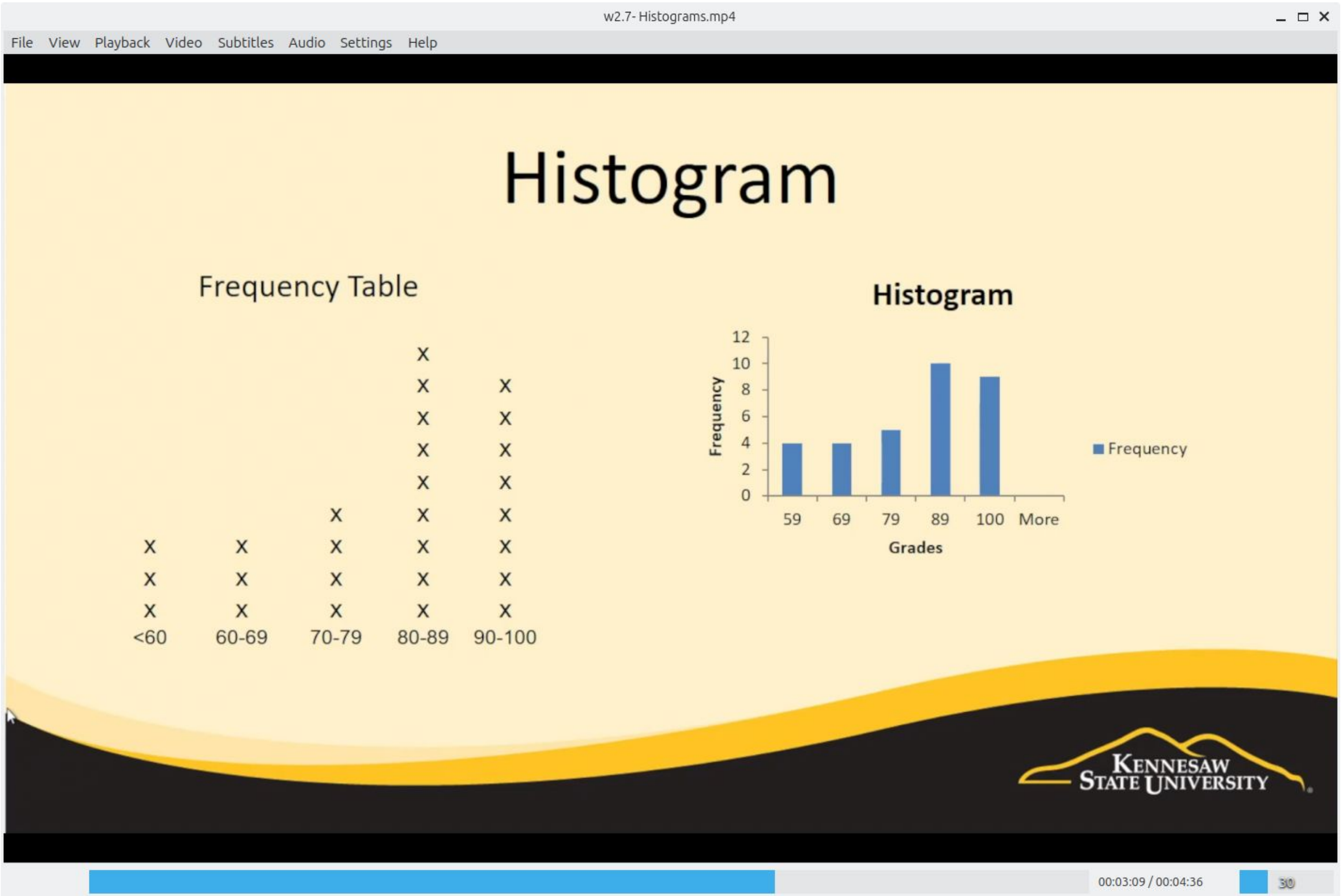
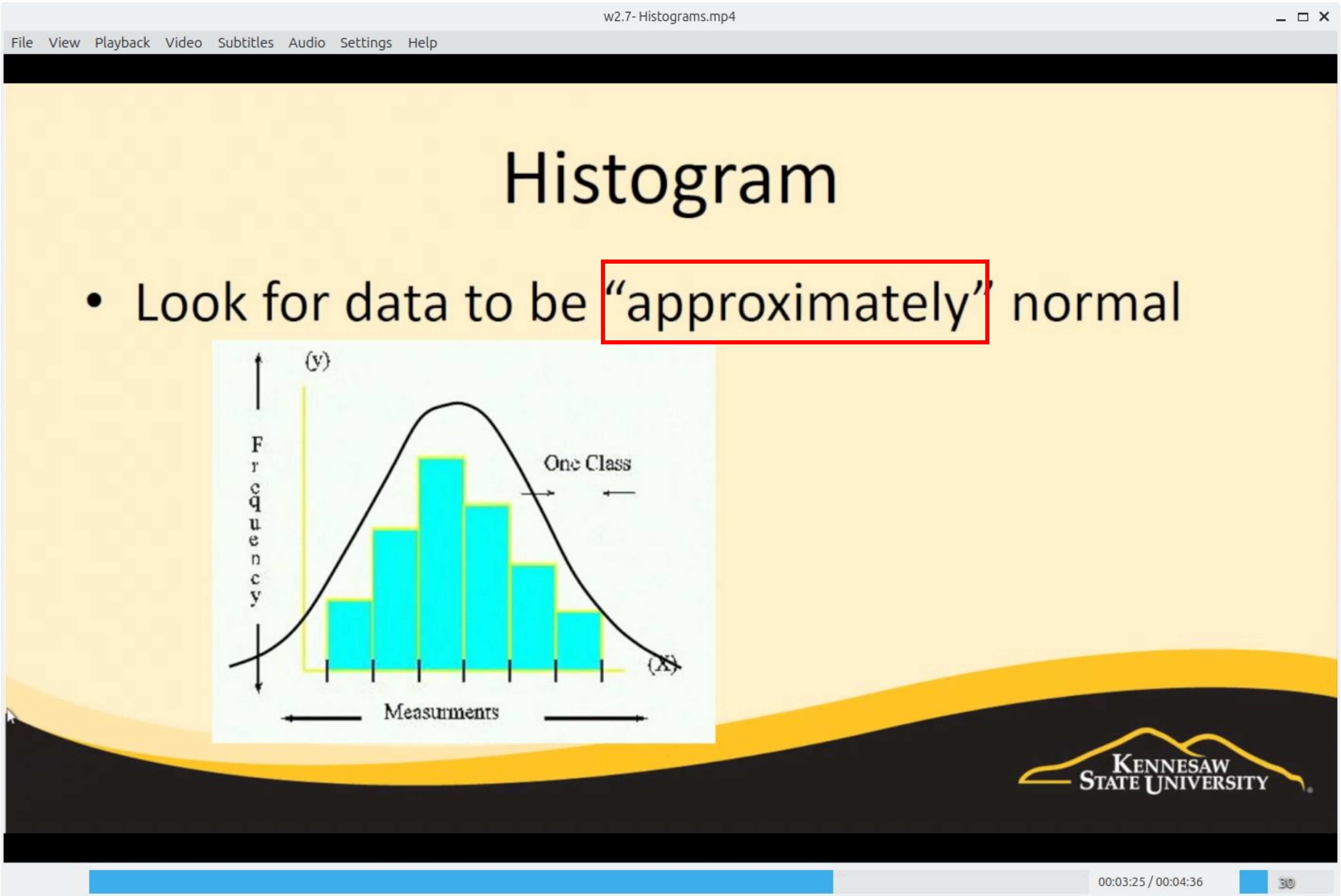
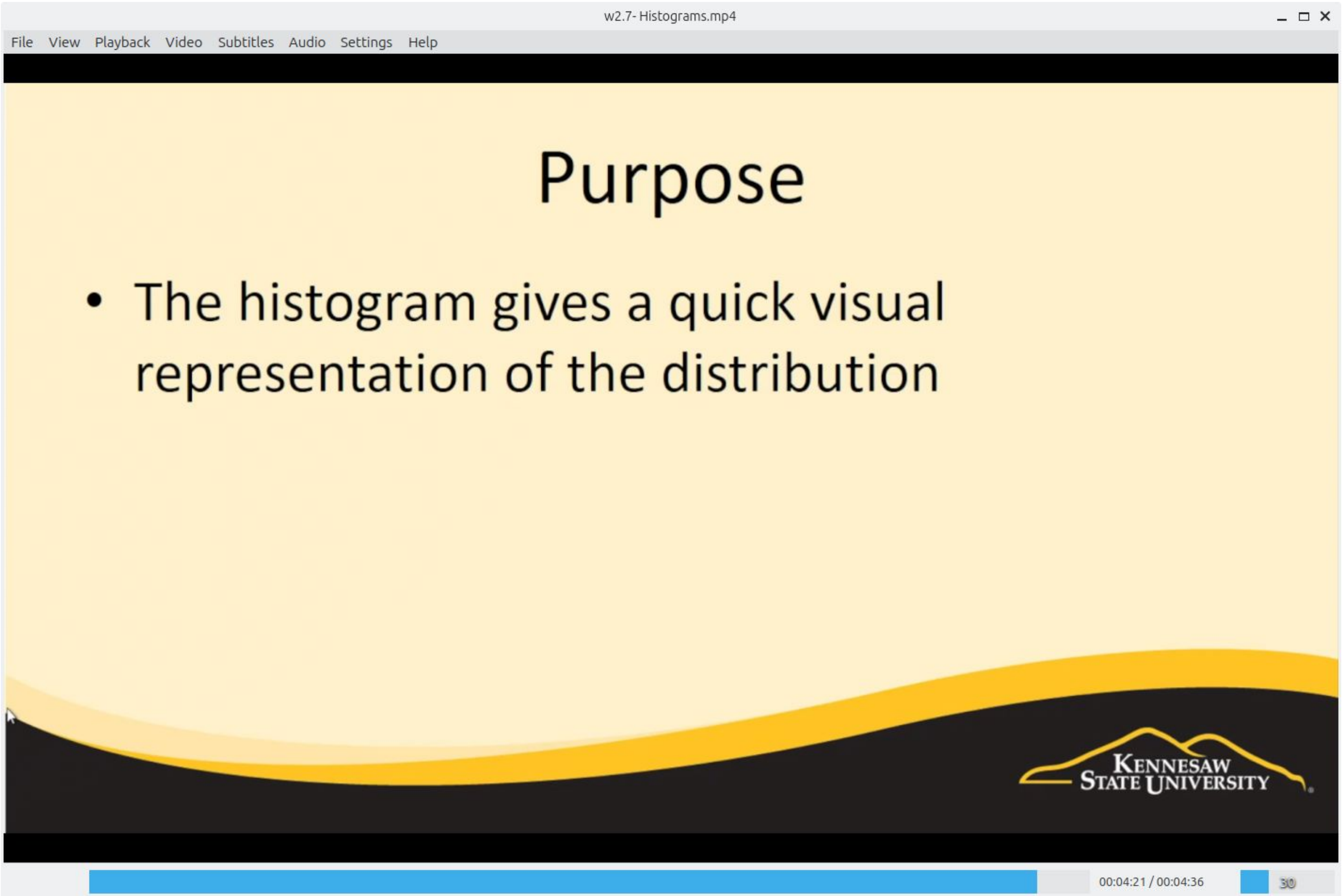

w2.7- Histograms.mp4
File View Playback Video Subtitles Audio Settings Help
What is it?
• A histogram is constructed from a frequency table.
Grades Totals
<60 x x x 3
60-69 x x x 3
70-79 x x x x 4
80-89 x x x x x x x x x 9
90-100 x x x x x x x x 8
27
Kennesaw State University
00:02:54 / 00:04:36
30


w2.7- Histograms.mp4
File View Playback Video Subtitles Audio Settings Help
Histogram
Frequency Table
X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X
<60 60-69 70-79 80-89 90-100
Histogram
Frequency
0 2 4 6 8 10 12
59 69 79 89 100 More
Grades
Frequency
KENNESAW STATE UNIVERSITY
00:03:09 / 00:04:36
30


w2.7- Histograms.mp4
File View Playback Video Subtitles Audio Settings Help
Histogram
• Look for data to be "approximately" normal
(y)
Frequency
One Class
(X)
Measurments
KENNESAW STATE UNIVERSITY
00:03:25 / 00:04:36
30


w2.7- Histograms.mp4
File View Playback Video Subtitles Audio Settings Help
Purpose
• The histogram gives a quick visual representation of the distribution
KENNESAW STATE UNIVERSITY
00:04:21 / 00:04:36

📊 Histograms: Understanding Data Distribution

A **histogram** is a special type of bar graph that serves as a **graphic representation (a picture) of a frequency distribution**. It is a fundamental tool used to understand the characteristics of your data, such as its shape, center, and spread.

Structure of a Histogram

- **Vertical Axis (Y-axis):** Represents the **frequency** or count—how many times something happened.
- **Horizontal Axis (X-axis):** Represents the **intervals or groups** of the measured data.
- **Bars:** The **height** of each rectangle located above an interval shows the frequency (or number of scores) that fell into that group.

Creating a Histogram from Data

To construct a histogram, data must be converted into **discrete groups** or **intervals** so that frequencies can be counted.

1. Handling Data Types

- **Discrete Data (Simple Counts):** If the data consists of simple counts (e.g., number of complaints by type), the categories are already defined for the X-axis.
- **Continuous Data (Measurements):** If the data involves measurements (e.g., exam scores from 0 to 100), it must be grouped into intervals to make it discrete.

2. Grouping Continuous Data

When grouping measurement data, you must determine the appropriate number and size of the groups:

- **Number of Groups (k):** The number of groups should be approximately equal to the **square root of n**, where n is the total number of data points.
- **Group Width (w):** Calculate the range of the data, then divide it by the number of groups.

$$w = \frac{\text{Largest Value} - \text{Smallest Value}}{k}$$

  - If the result is a fraction, **round up**.
  - All groups should ideally be the same size and must have **no overlap** (each value must fall into one and only one group).

3. Tallying and Plotting

Using the defined groups (often done on a checksheet):

- Create a tally mark for every data point that falls into an interval.
- Sum the tallies to get the total frequency for each group.
- Plot the frequencies as the height of the bars above the corresponding intervals on the X-axis.

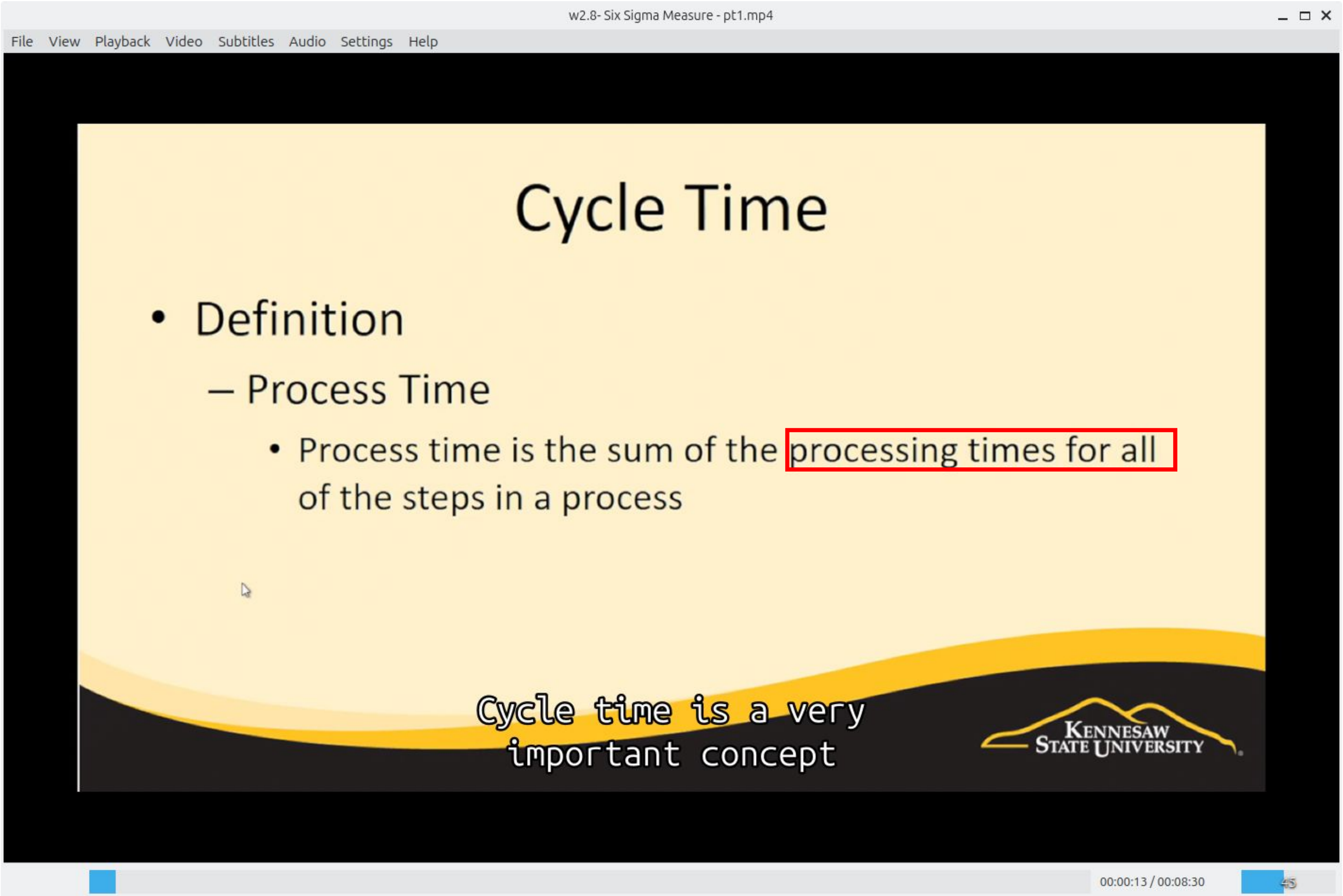
Interpreting a Histogram

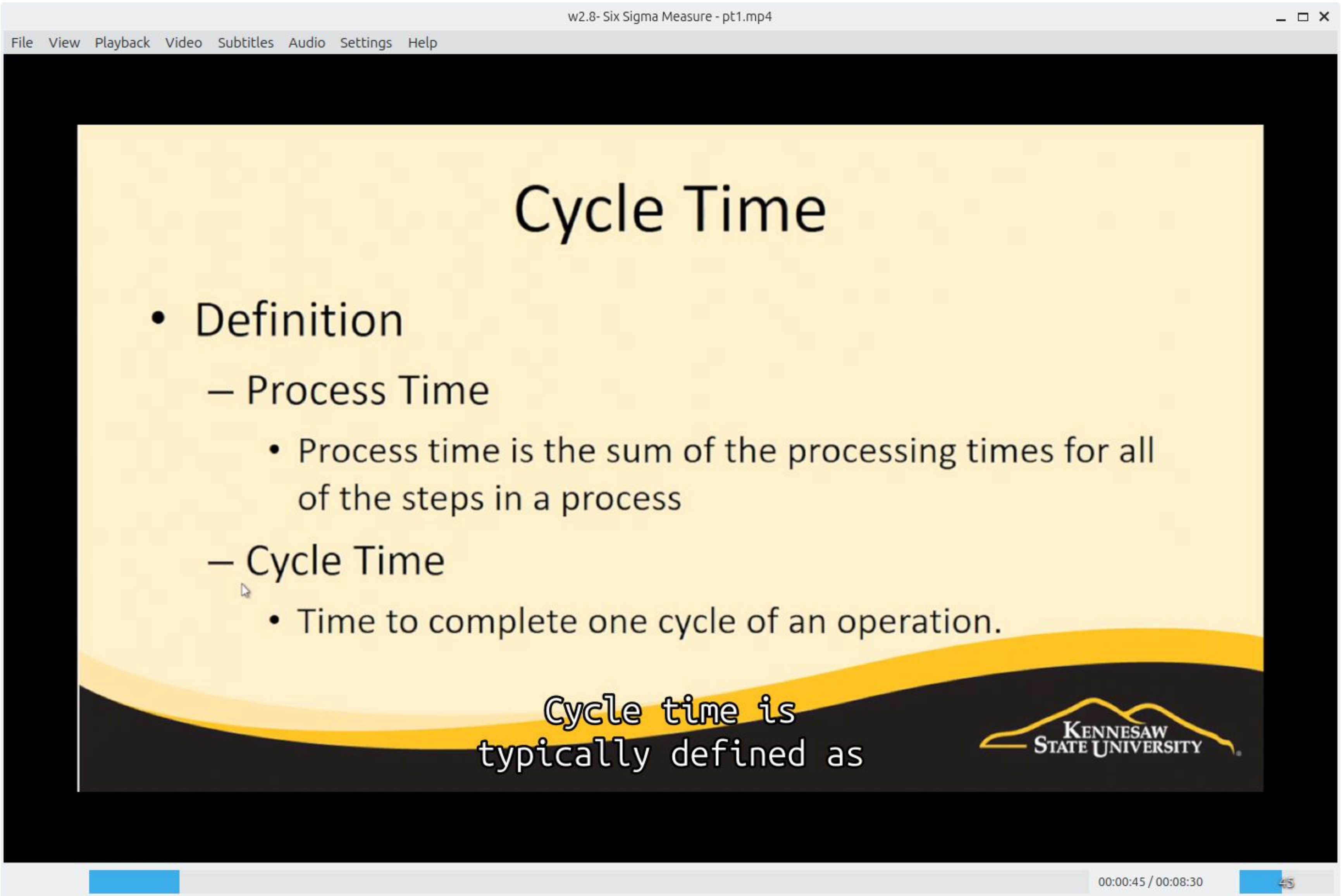
A histogram helps you visually answer key questions about your data, which can guide further analysis:

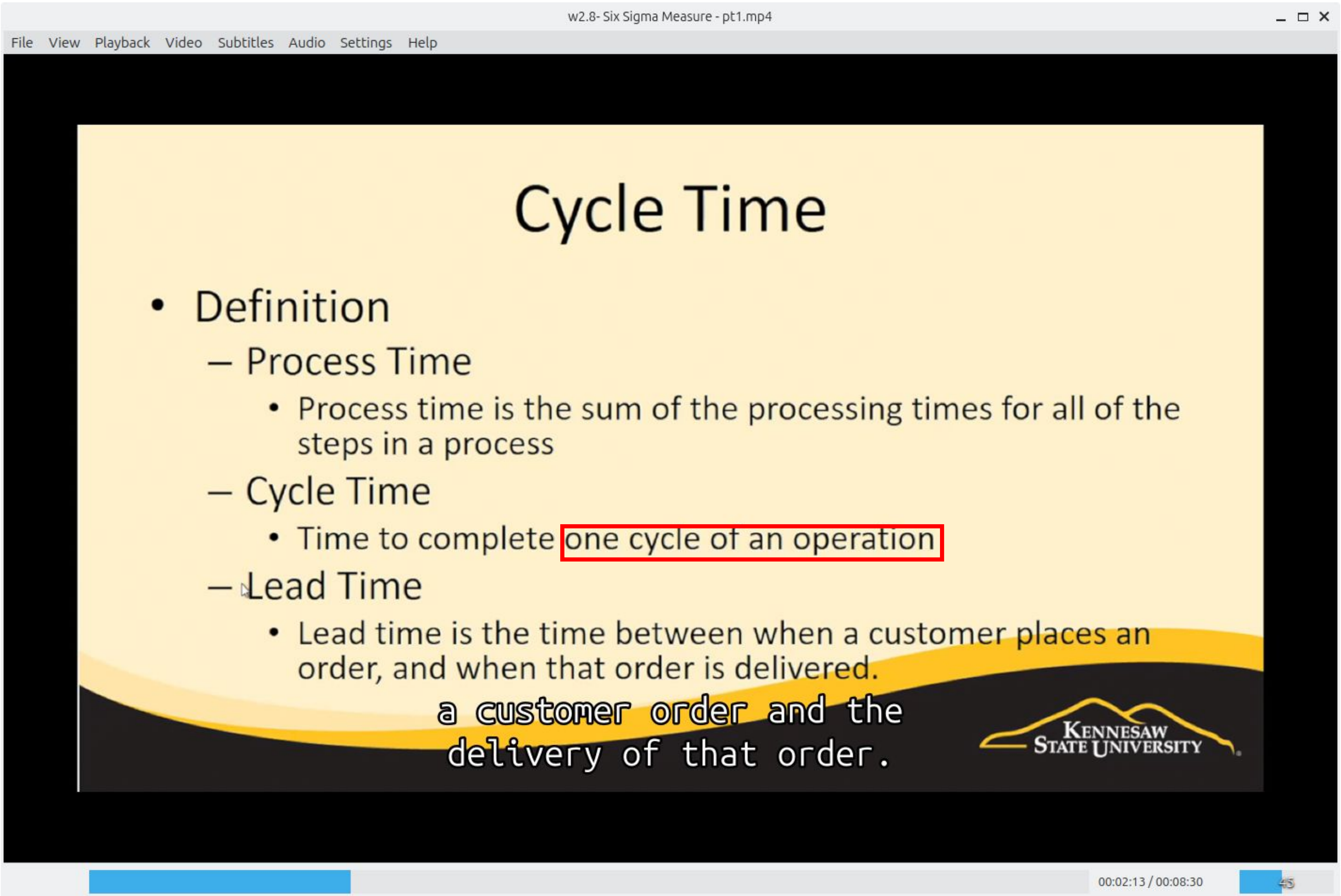
- **Normality (The Bell Curve):** Does the data follow a **normal distribution**? You are looking for a rough fit—is the distribution generally **higher near the middle** and smaller as it moves left or right? (Small samples may not look perfectly normal.)
- **Center:** Where is the **approximate center** of the data? (This relates to measures like the mean or median.)
- **Spread (Range):** What is the spread of the data? This is the difference between the lowest and highest values.
- **Outliers:** Are there any **unusual values** (outliers) that fall far outside the main cluster of data?

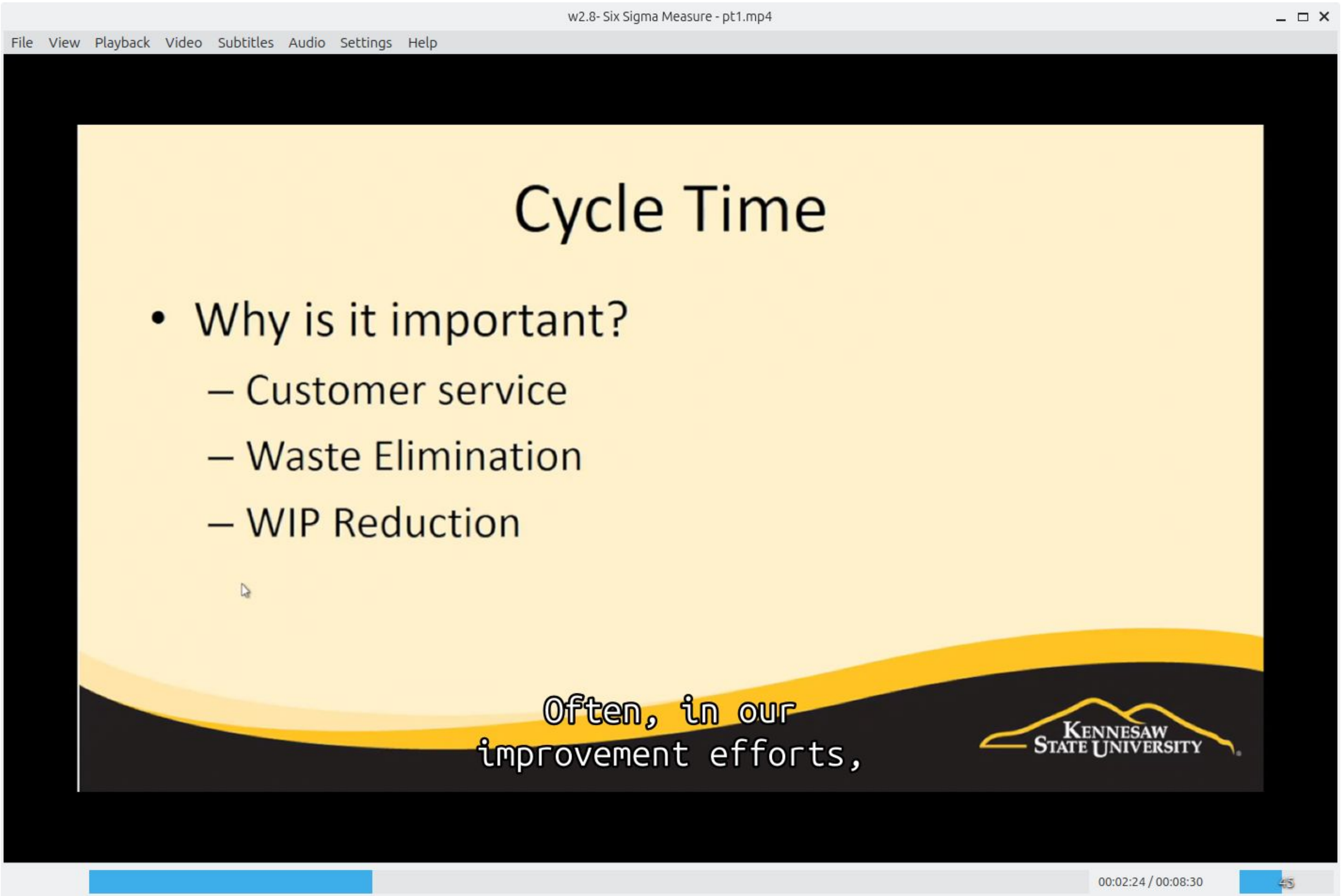
The answers to these questions help determine what type of statistical analysis is appropriate for the data.

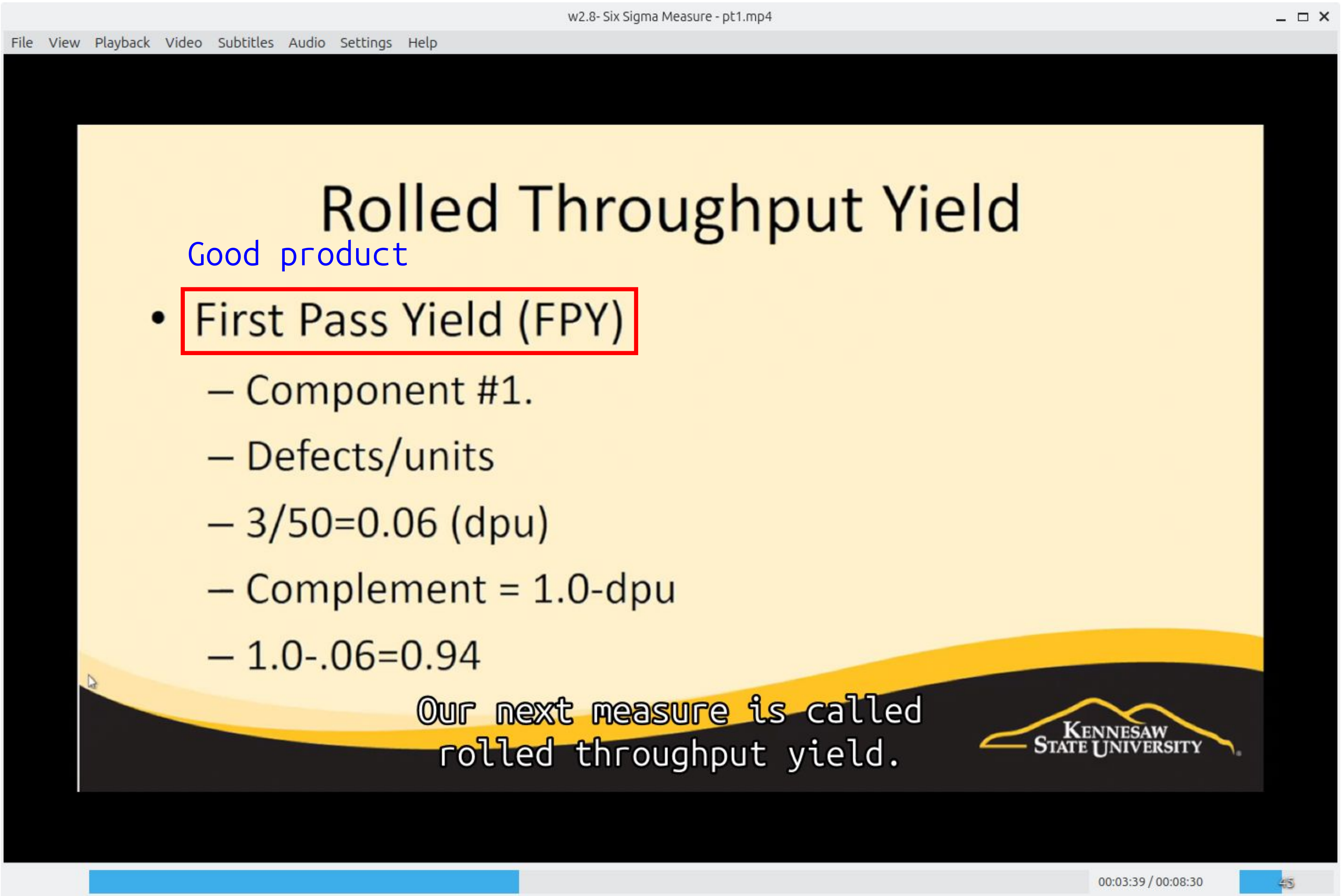
w2.8- Six Sigma Measure - pt1


w2.8- Six Sigma Measure - pt1.mp4
File View Playback Video Subtitles Audio Settings Help
Cycle Time
• Definition
– Process Time
• Process time is the sum of the processing times for all of the steps in a process
Cycle time is a very important concept
KENNESAW STATE UNIVERSITY
00:00:13 / 00:08:30


w2.8- Six Sigma Measure - pt1.mp4
File View Playback Video Subtitles Audio Settings Help
Cycle Time
• Definition
– Process Time
• Process time is the sum of the processing times for all of the steps in a process
– Cycle Time
• Time to complete one cycle of an operation.
Cycle time is
typically defined as
KENNESAW STATE UNIVERSITY
00:00:45 / 00:08:30


w2.8- Six Sigma Measure - pt1.mp4
File View Playback Video Subtitles Audio Settings Help
Cycle Time
• Definition
– Process Time
• Process time is the sum of the processing times for all of the steps in a process
– Cycle Time
• Time to complete one cycle of an operation
– Lead Time
• Lead time is the time between when a customer places an order, and when that order is delivered.
a customer order and the
delivery of that order.
KENNESAW STATE UNIVERSITY
00:02:13 / 00:08:30


w2.8- Six Sigma Measure - pt1.mp4
File View Playback Video Subtitles Audio Settings Help
Cycle Time
• Why is it important?
– Customer service
– Waste Elimination
– WIP Reduction
Often, in our
improvement efforts,
KENNESAW
STATE UNIVERSITY
00:02:24 / 00:08:30


w2.8- Six Sigma Measure - pt1.mp4
File View Playback Video Subtitles Audio Settings Help
Rolled Throughput Yield
Good product
• First Pass Yield (FPY)
– Component #1.
– Defects/units
– 3/50=0.06 (dpu)
– Complement = 1.0-dpu
– 1.0-.06=0.94
Our next measure is called
rolled throughput yield.
KENNESAW STATE UNIVERSITY
00:03:39 / 00:08:30

First Pass Yield (FPY), also known as **Throughput Yield (TPY)**, is a key quality and efficiency metric, typically used in **manufacturing and production.**

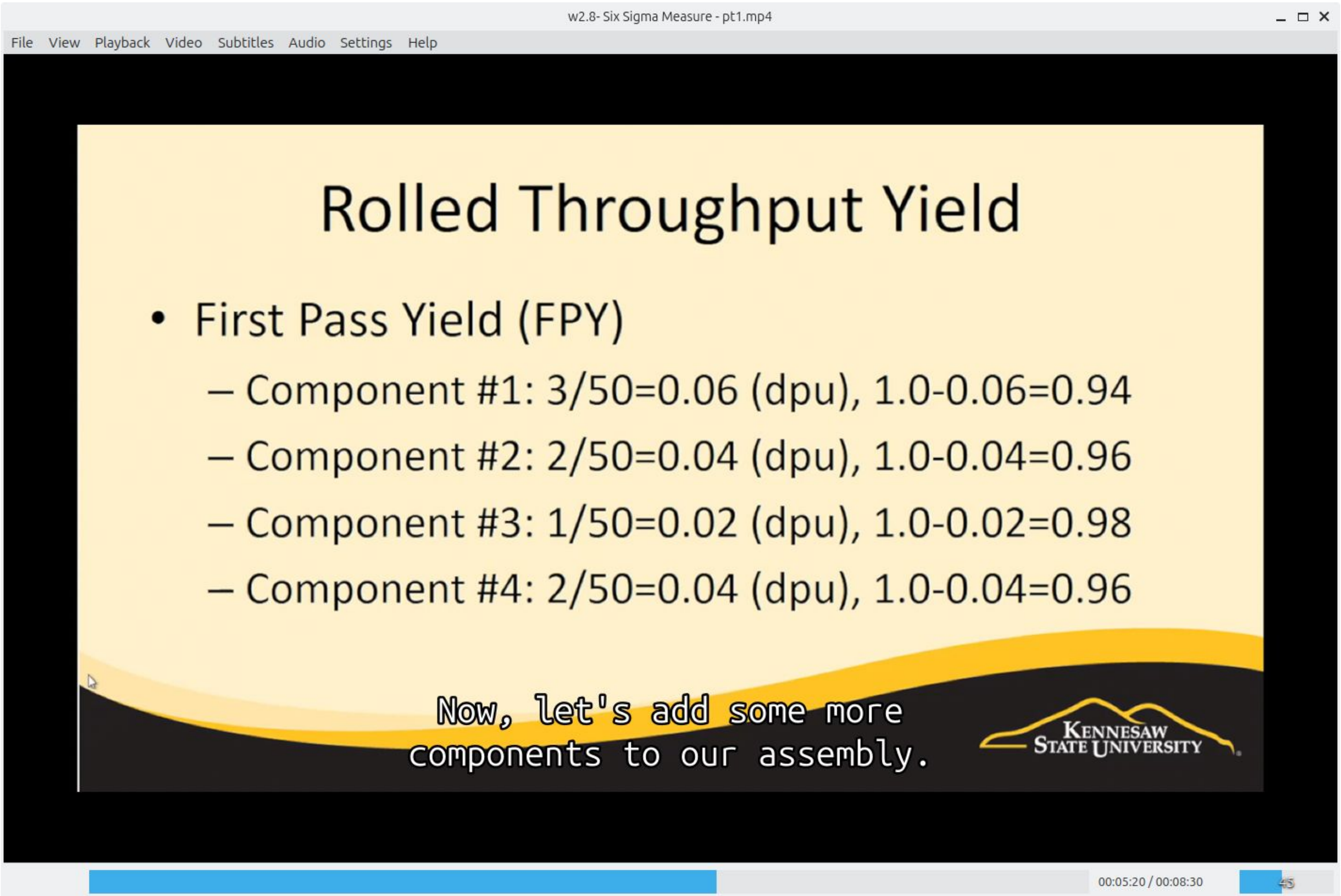
It measures the percentage of units that move through an entire process and meet quality standards **the first time**, without requiring any rework, repair, or being scrapped. Essentially, FPY answers the question: "How many units were made correctly on the first try?"

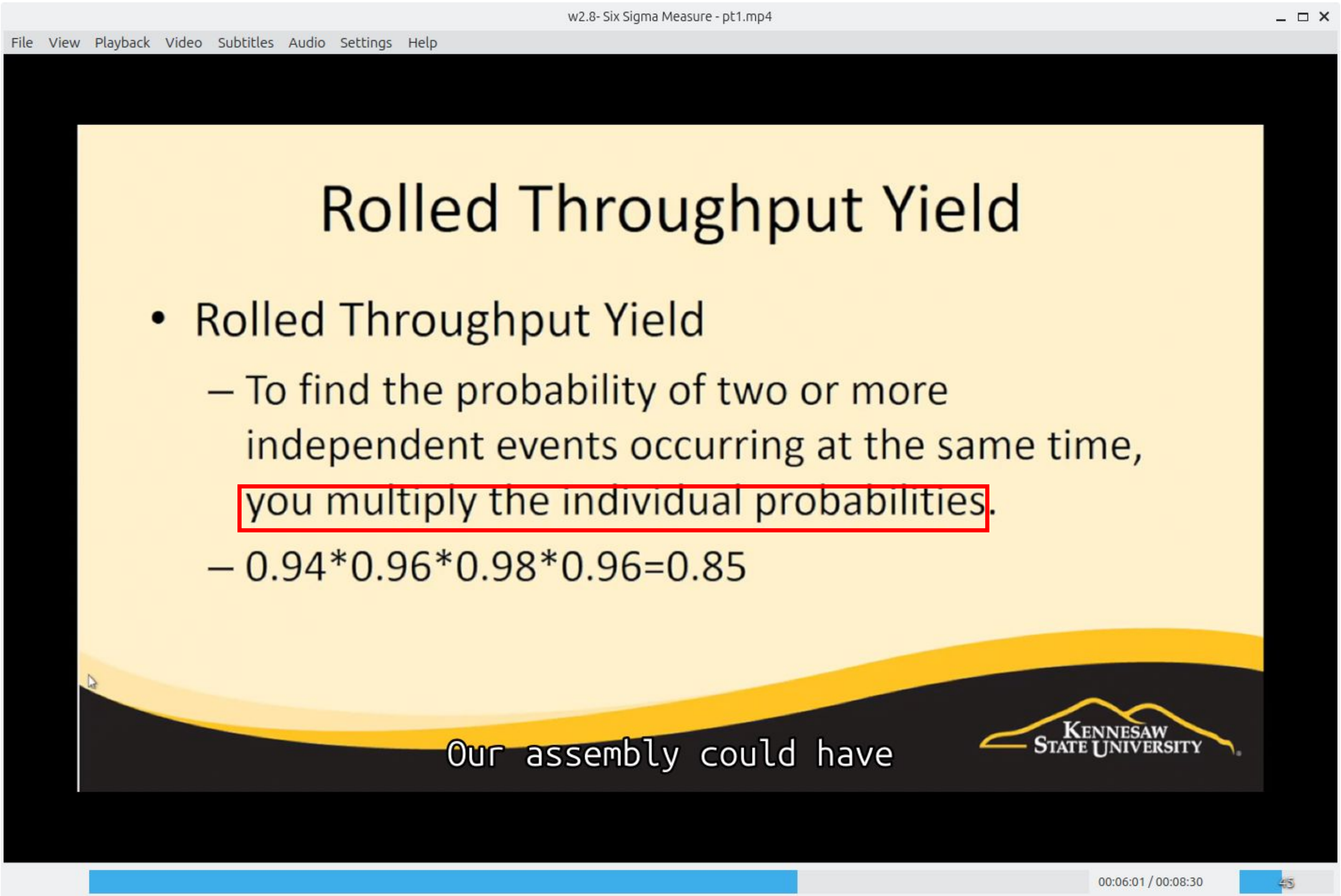
🎯 Formula

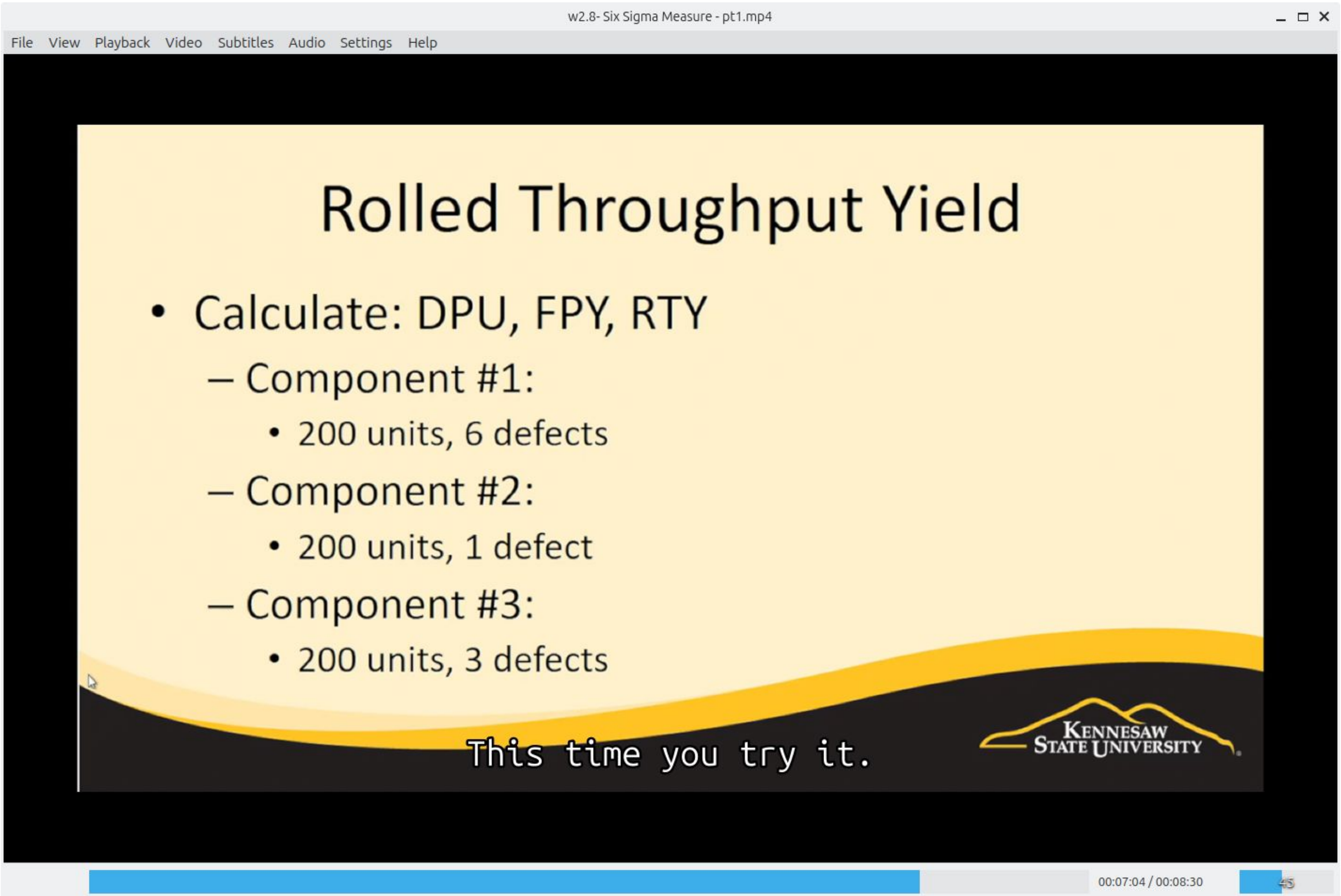
The basic formula for calculating First Pass Yield for a single process step is:

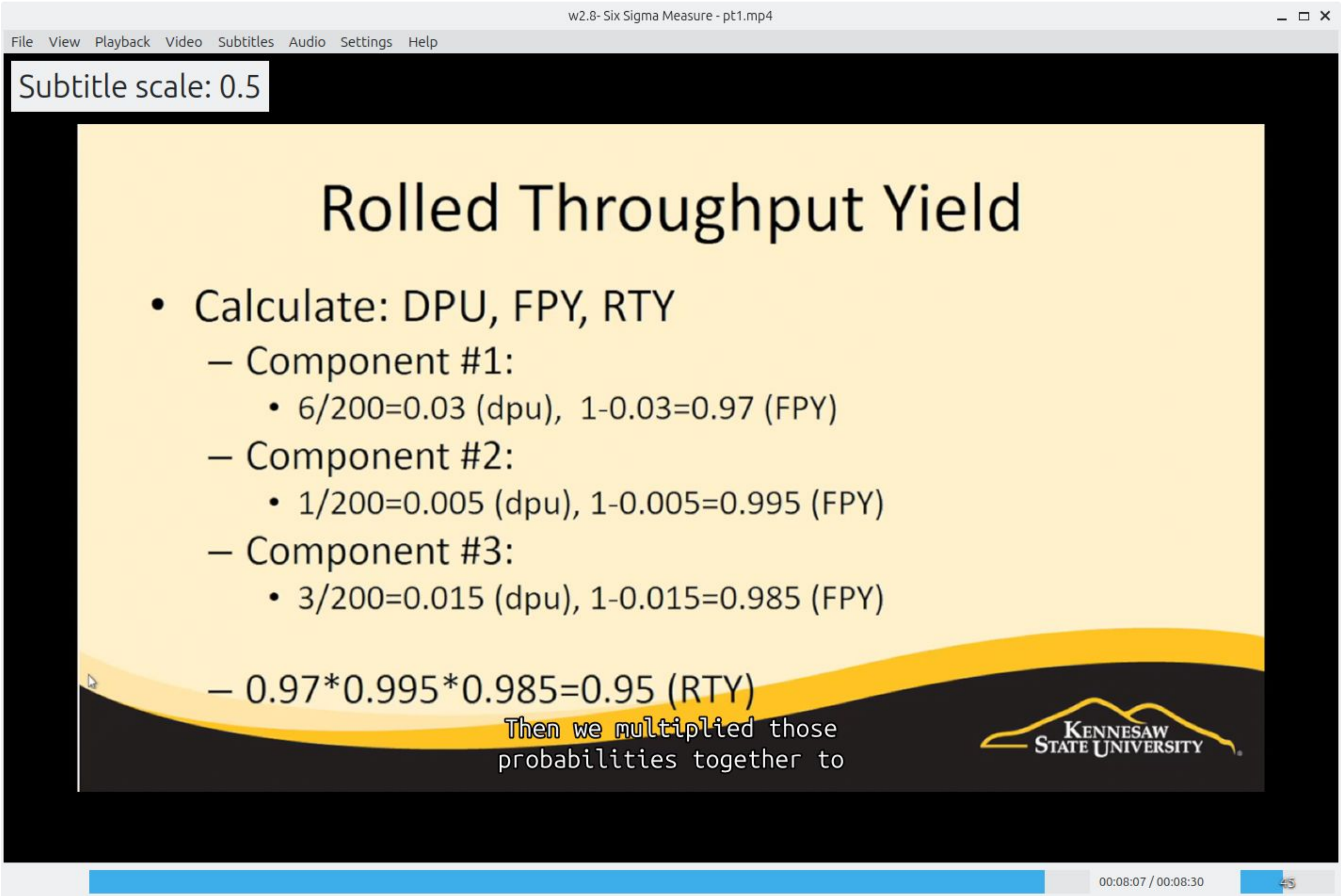
$$\text{FPY} = \frac{\text{Number of Good Units Produced (with no rework)}}{\text{Total Number of Units Entering the Process}}$$

- The numerator, **Good Units Produced (with no rework)**, means the final units that meet all quality specifications immediately after the process. Any units that needed repair or were scrapped are subtracted from the total completed units.
- The result is often expressed as a percentage.


w2.8- Six Sigma Measure - pt1.mp4
File View Playback Video Subtitles Audio Settings Help
Rolled Throughput Yield
• First Pass Yield (FPY)
– Component #1: 3/50=0.06 (dpu), 1.0-0.06=0.94
– Component #2: 2/50=0.04 (dpu), 1.0-0.04=0.96
– Component #3: 1/50=0.02 (dpu), 1.0-0.02=0.98
– Component #4: 2/50=0.04 (dpu), 1.0-0.04=0.96
Now, let's add some more
components to our assembly.
KENNESAW STATE UNIVERSITY
00:05:20 / 00:08:30


w2.8- Six Sigma Measure - pt1.mp4
File View Playback Video Subtitles Audio Settings Help
Rolled Throughput Yield
• Rolled Throughput Yield
– To find the probability of two or more independent events occurring at the same time, you multiply the individual probabilities.
– 0.94*0.96*0.98*0.96=0.85
Our assembly could have
Kennesaw State University
00:06:01 / 00:08:30


w2.8- Six Sigma Measure - pt1.mp4
File View Playback Video Subtitles Audio Settings Help
Rolled Throughput Yield
• Calculate: DPU, FPY, RTY
– Component #1:
• 200 units, 6 defects
– Component #2:
• 200 units, 1 defect
– Component #3:
• 200 units, 3 defects
This time you try it.
KENNESAW STATE UNIVERSITY
00:07:04 / 00:08:30


w2.8- Six Sigma Measure - pt1.mp4
File View Playback Video Subtitles Audio Settings Help
Subtitle scale: 0.5
Rolled Throughput Yield
• Calculate: DPU, FPY, RTY
– Component #1:
• 6/200=0.03 (dpu), 1-0.03=0.97 (FPY)
– Component #2:
• 1/200=0.005 (dpu), 1-0.005=0.995 (FPY)
– Component #3:
• 3/200=0.015 (dpu), 1-0.015=0.985 (FPY)
– 0.97*0.995*0.985=0.95 (RTY)
Then we multiplied those
probabilities together to
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00:08:07 / 00:08:30

Rolled Throughput Yield (RTY) is a crucial metric in **Lean Six Sigma** that measures the true, overall efficiency and quality of a **multi-step process** or a complete production line.

It represents the **probability** that a unit or product will pass through **all** the sequential steps in a process **without any defects, scrap, or rework** required at any stage.

📐 RTY Calculation and Formula

RTY is calculated by **multiplying the First Pass Yield (FPY)** or the individual yield of every single step in the process chain.

$$\mathrm{RTY} = \mathrm{FPY}_1 \times \mathrm{FPY}_2 \times \mathrm{FPY}_3 \times \cdots \times \mathrm{FPY}_n$$

- **RTY:** Rolled Throughput Yield (the overall process yield).
- **FPYn:** First Pass Yield (the percentage of good units produced without rework) for each individual step (*n*).

📏 Six Sigma Measures: Cycle Time and Rolled Throughput Yield

This presentation introduces two critical measures used in Lean and Six Sigma: **Cycle Time** (focused on speed) and **Rolled Throughput Yield** (focused on quality across multiple steps).

1. Cycle Time vs. Related Measures

The concept of Cycle Time is often confused with Process Time and Lead Time:

- **Process Time (Time of actual work):** The time required to **actually perform** all the steps in a process. It **excludes** waiting, transportation, or delay time.
- **Cycle Time (Time from start to end):** The total time required for an individual unit or product to travel from the **beginning to the end of the entire process**. This **includes all waiting time, delays, and transportation**.
  - It is not unusual for Cycle Time to be 10 to 20 times greater than Process Time.
  - Cycle Time is heavily influenced by **batch sizes** and **Work In Process (WIP)** inventory.
- **Lead Time:** The time between a **customer order** and the **delivery of that order**. It includes Cycle Time but also any delays *before* the work even begins.

Value of Reducing Cycle Time

Reducing Cycle Time is a key goal that leads to better customer service. This is achieved by analyzing the current state process map and implementing improvements that **remove waste** (such as waiting time) and **reduce batch sizes**.

---

2. Rolled Throughput Yield (RTY)

Rolled Throughput Yield (RTY) is a measure of quality that accounts for multiple steps or components in a process.

- **Definition:** RTY is the **probability that a process with more than one step or component will produce an entirely error or defect-free unit** upon final completion.
- **Concept:** The more steps or components in an assembly, the more opportunities there are for failure, dramatically lowering the final yield.

Calculation Steps

Calculating RTY requires two preceding steps:

1. **Calculate Defects Per Unit (DPU):**

$$\text{DPU} = \frac{\text{Number of Defects}}{\text{Number of Units}}$$

2. **Calculate First Pass Yield (FPY) for Each Step/Component:**

   - FPY is the complement of DPU. It is the probability that a single step or component will be defect-free.

$$\text{FPY} = 1 - \text{DPU}$$

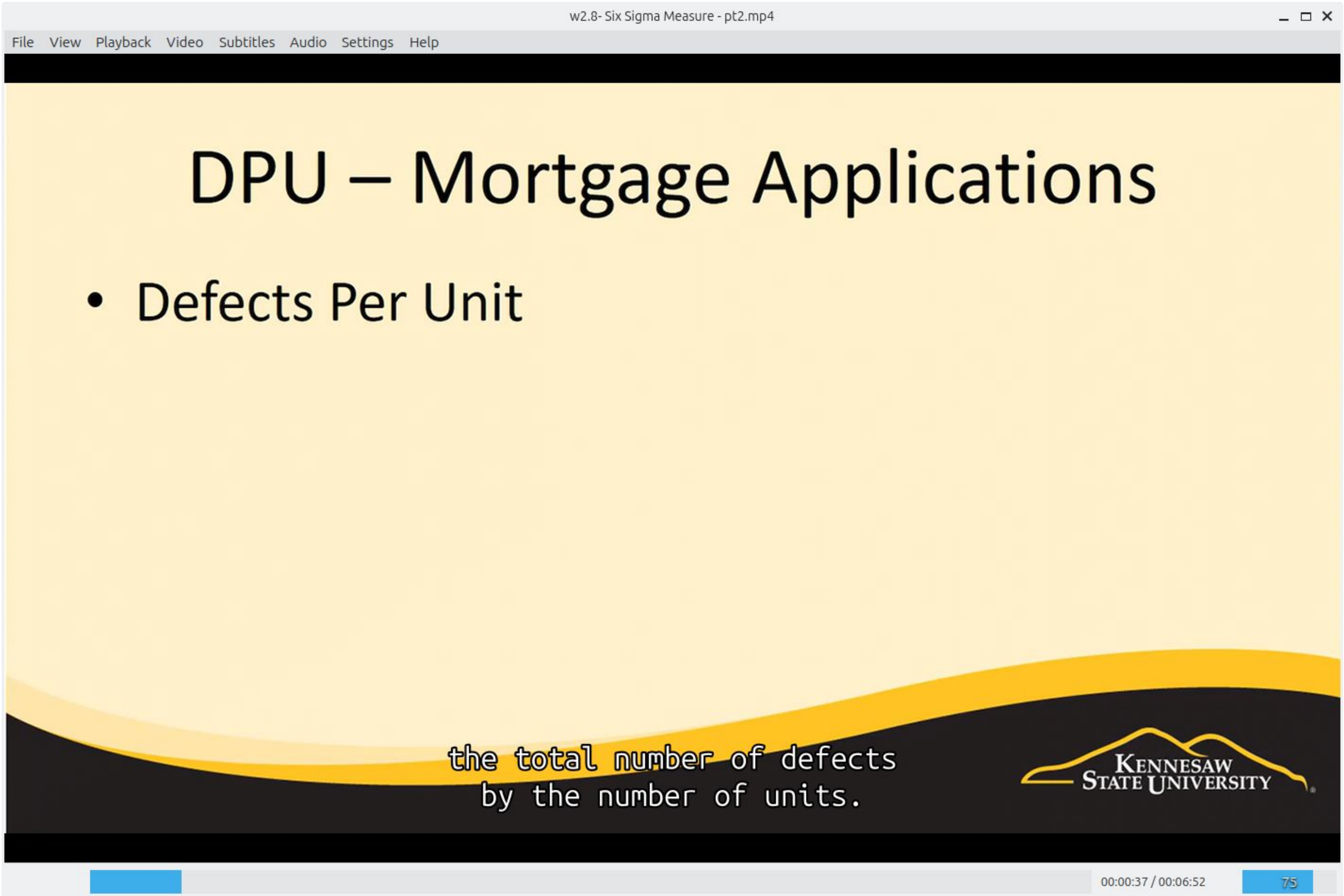
   - (Example: If $\text{DPU} = 0.06$, then $\text{FPY} = 1 - 0.06 = 0.94$, or 94% good quality.)

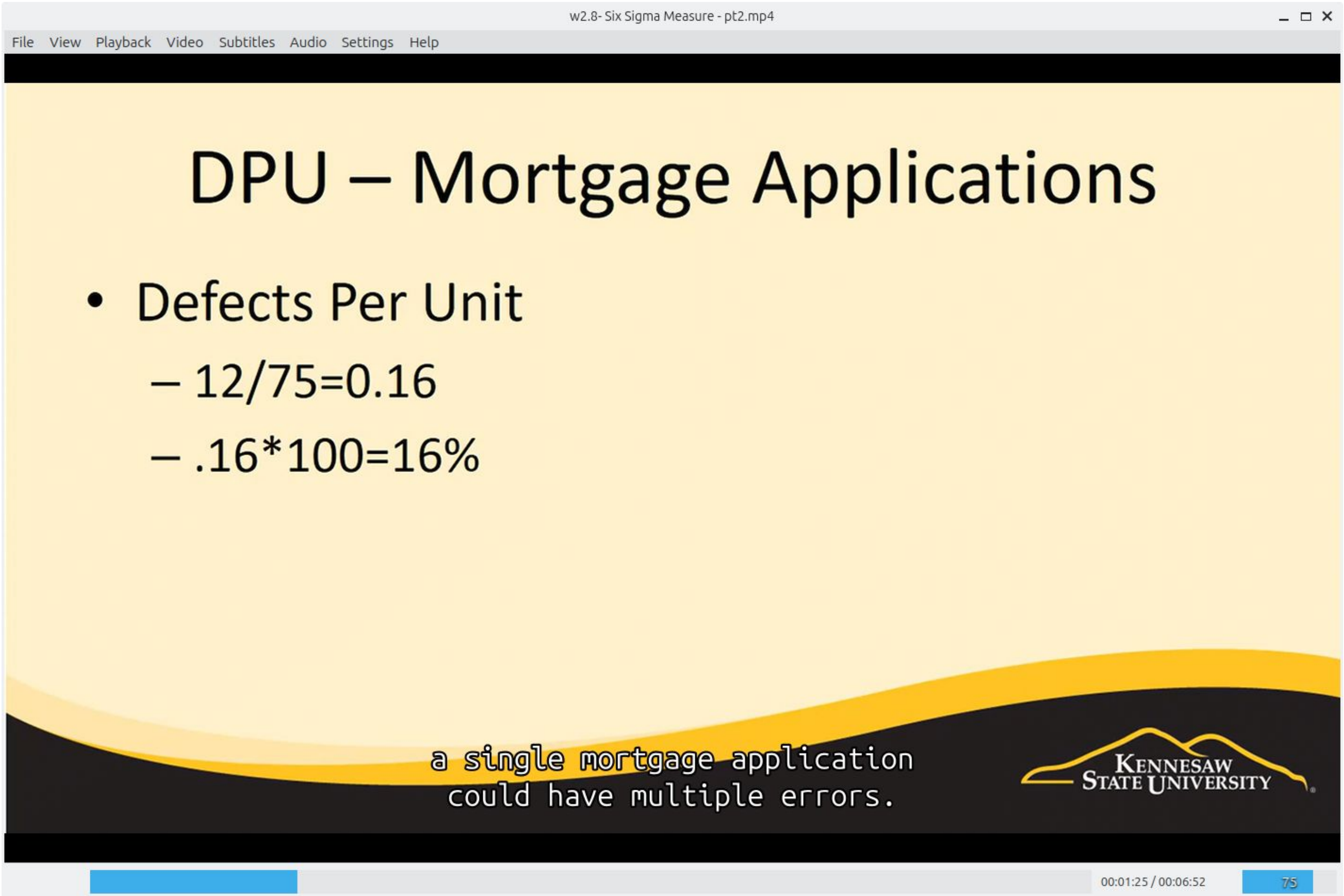
3. **Calculate Rolled Throughput Yield (RTY):**
    - Using the multiplication rule of probability, RTY is the product of the FPY for every step/component in the process.

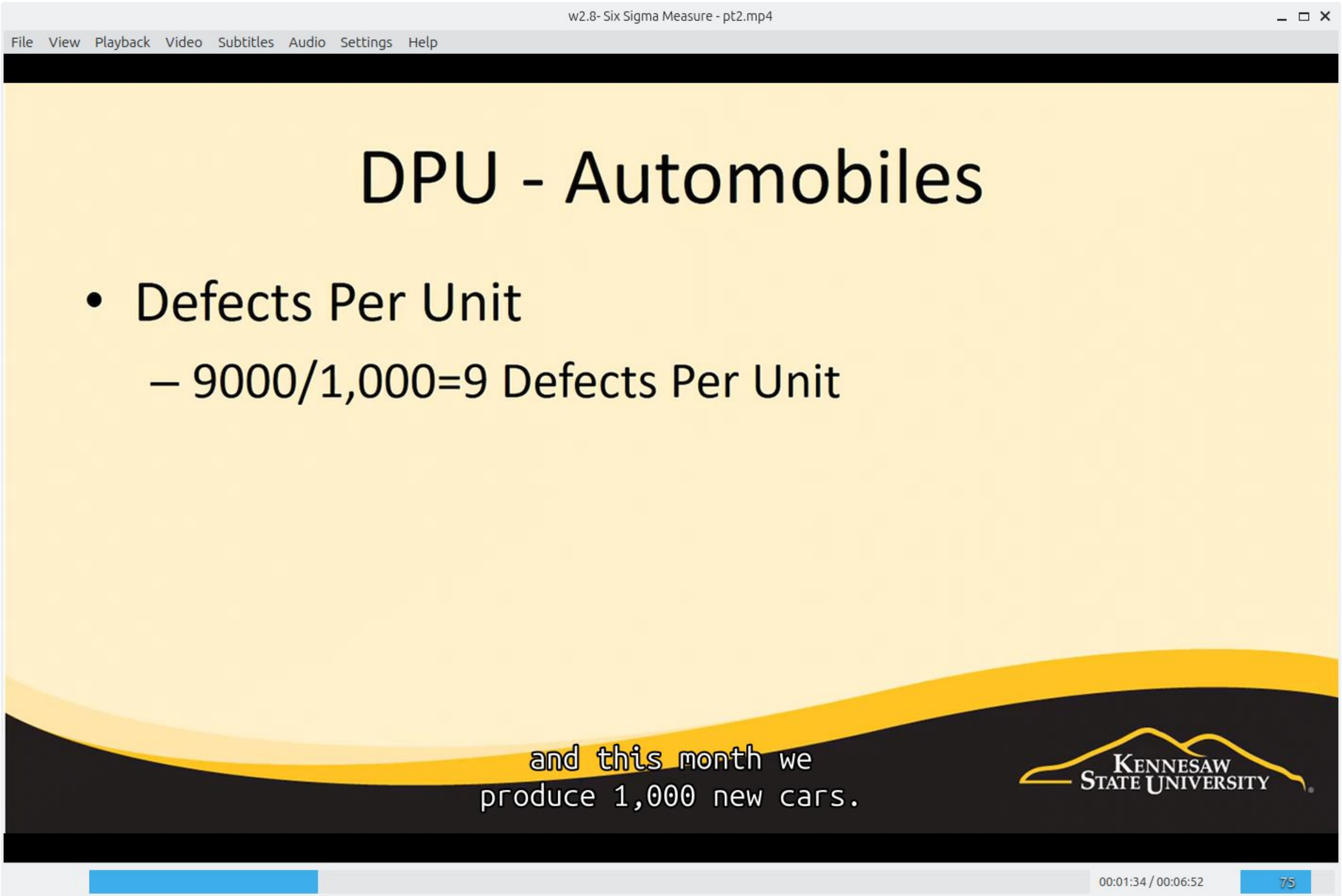
$$\mathrm{RTY} = \mathrm{FPY}_1 \times \mathrm{FPY}_2 \times \mathrm{FPY}_3 \times \ldots \times \mathrm{FPY}_n$$

    - (Example: For an assembly with four components with FPYs of 0.94, 0.96, 0.98, and 0.96, the $\mathrm{RTY} \approx 0.85$. This means there is only an 85% probability that the final assembly will be defect-free.)

w2.8- Six Sigma Measure - pt2


w2.8- Six Sigma Measure - pt2.mp4
File View Playback Video Subtitles Audio Settings Help
DPU – Mortgage Applications
• Defects Per Unit
the total number of defects
by the number of units.
KENNESAW STATE UNIVERSITY
00:00:37 / 00:06:52
75


w2.8- Six Sigma Measure - pt2.mp4
File View Playback Video Subtitles Audio Settings Help
DPU – Mortgage Applications
• Defects Per Unit
– 12/75=0.16
– .16*100=16%
a single mortgage application
could have multiple errors.
KENNESAW STATE UNIVERSITY
00:01:25 / 00:06:52
75


w2.8- Six Sigma Measure - pt2.mp4
File View Playback Video Subtitles Audio Settings Help
DPU - Automobiles
• Defects Per Unit
– 9000/1,000=9 Defects Per Unit
and this month we
produce 1,000 new cars.
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00:01:34 / 00:06:52
75


w2.8- Six Sigma Measure - pt2.mp4
File View Playback Video Subtitles Audio Settings Help
DPMO - Mortgages
• Defects Per Million Opportunities
– 30*75=2250 opportunities.
Let's go back to
mortgages for a second.
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00:02:08 / 00:06:52
75

w2.8- Six Sigma Measure - pt2.mp4

File View Playback Video Subtitles Audio Settings Help

DPMO - Mortgages

- Defects Per Million Opportunities
  - 30*75=2,250 opportunities.
- Formula for DPMO
  - (Defects/Opportunities)*1,000,000
  - (12/2,250)*1,000,000
  - (0.005333)*1,000,000=5,333.333DPMO
- Shortcut
  - (DPU/Opportunities per unit)*1,000,000
  - (0.16/30)*1,000,000
  - 0.005333*1,000,000 = 5,333.333DPMO

As you can see, this will
give you the same result.

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00:04:19 / 00:06:52 75


w2.8- Six Sigma Measure - pt2.mp4
File View Playback Video Subtitles Audio Settings Help
DPMO - Automobiles
• Defects Per Million Opportunities
– 500 opportunities per vehicle
– 1,000 vehicles
– 500*1,000-500,000
vehicle or 9,000 defects
across 1,000 vehicles.
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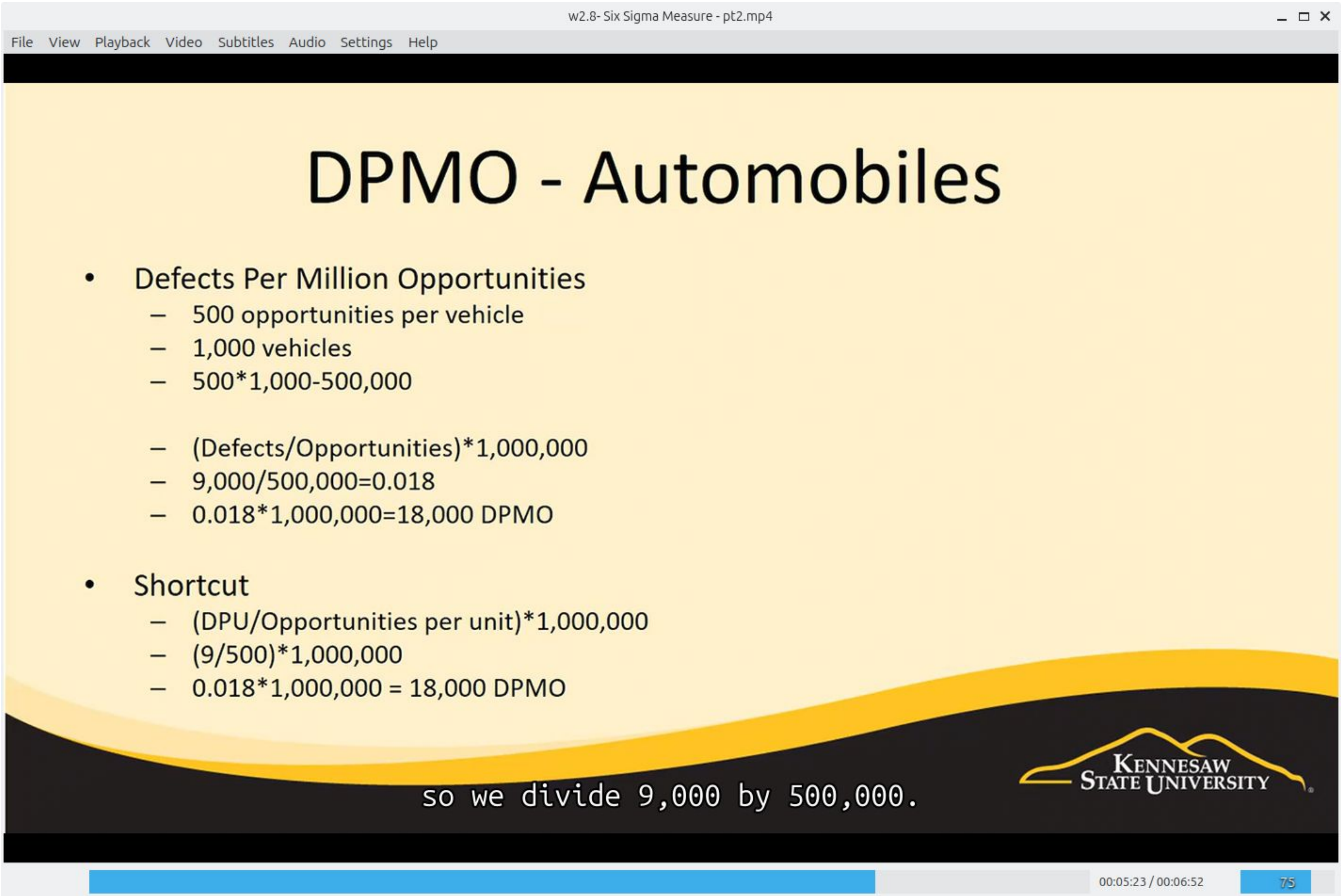
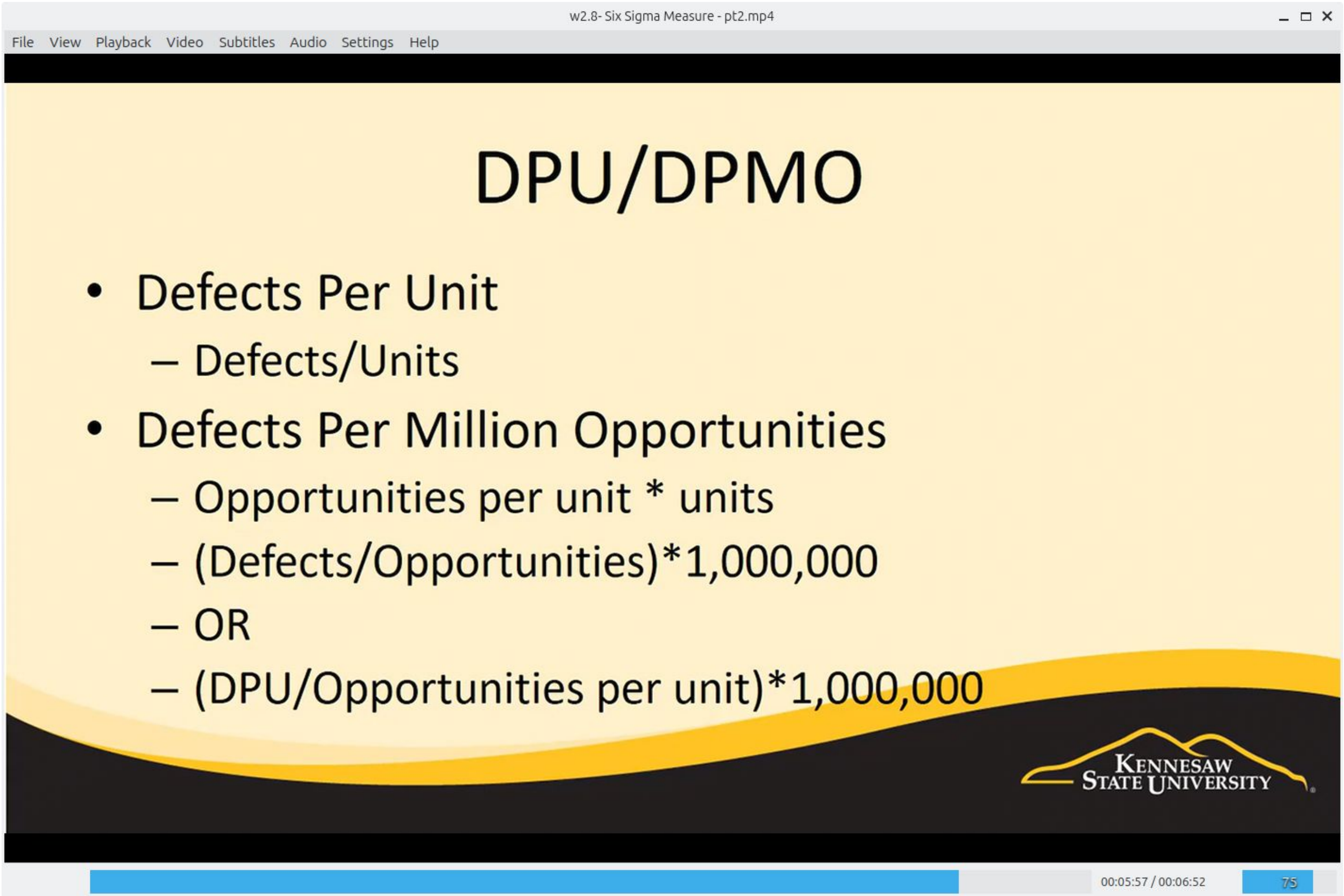
00:04:37 / 00:06:52
75


w2.8- Six Sigma Measure - pt2.mp4
File View Playback Video Subtitles Audio Settings Help
DPMO - Automobiles
• Defects Per Million Opportunities
– 500 opportunities per vehicle
– 1,000 vehicles
– 500*1,000-500,000
– (Defects/Opportunities)*1,000,000
– 9,000/500,000=0.018
– 0.018*1,000,000=18,000 DPMO
• Shortcut
– (DPU/Opportunities per unit)*1,000,000
– (9/500)*1,000,000
– 0.018*1,000,000 = 18,000 DPMO
KENNESAW STATE UNIVERSITY
so we divide 9,000 by 500,000.
00:05:23 / 00:06:52
75


w2.8- Six Sigma Measure - pt2.mp4
File View Playback Video Subtitles Audio Settings Help
DPU/DPMO
• Defects Per Unit
– Defects/Units
• Defects Per Million Opportunities
– Opportunities per unit * units
– (Defects/Opportunities)*1,000,000
– OR
– (DPU/Opportunities per unit)*1,000,000
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00:05:57 / 00:06:52
75

📐 Six Sigma Measures: DPU and DPMO

This presentation covers two fundamental measures used to quantify quality and defects, moving from a simple average to a standardized measure for comparison.

1. Defects Per Unit (DPU)

Defects Per Unit (DPU) is a simple ratio that expresses the average number of defects found per item or unit produced.

Calculation

$$\text{DPU} = \frac{\text{Total Number of Defects Found}}{\text{Total Number of Units Produced (Sample Size)}}$$

Interpretation

- A DPU greater than 1 means, on average, each unit has multiple defects.

- **Example 1 (Mortgage Applications):** 75 applications processed, 12 defects found.

$$\text{DPU} = \frac{12 \text{ defects}}{75 \text{ applications}} = 0.16$$

  Interpretation: 0.16 defects per unit, meaning $\mathbf{16\%}$ of the applications had at least one error (though some units may have more).

- **Example 2 (Automobiles):** $1,000$ cars produced, $9,000$ defects found.

$$\text{DPU} = \frac{9,000 \text{ defects}}{1,000 \text{ cars}} = 9.0$$

  Interpretation: $\mathbf{9}$ defects per unit, on average.

2. Defects Per Million Opportunities (DPMO)

Defects Per Million Opportunities (DPMO) is a common Six Sigma measure that normalizes the defect rate, allowing comparison across processes of varying complexity.

Defining Opportunities

An **opportunity** is defined as every possible place a defect or error could occur in a product or service.

- **Total Opportunities** $= \boxed{\text{Opportunities per Unit}} \times \text{Total Number of Units}$

Calculation (Method 1: Using Total Values)

$$\text{DPMO} = \frac{\text{Total Number of Defects}}{\text{Total Number of Opportunities}} \times 1,000,000$$

- **Example (Mortgage Applications):** 12 defects, 75 applications, 30 fields/opportunities per application.
  - Total Opportunities: $30 \times 75 = 2,250$
  - $$\text{DPMO} = \frac{12}{2,250} \times 1,000,000 = \mathbf{5,333}$$
  - Interpretation: There are $5,333$ errors for every million opportunities.

Calculation (Method 2: Using DPU - Shortcut)

$$\text{DPMO} = \frac{\text{DPU}}{\text{Opportunities per Unit}} \times 1,000,000$$

- **Example (Automobiles):** $\text{DPU} = 9$, $\text{Opportunities per Vehicle} = 500$.
- $$\text{DPMO} = \frac{9}{500} \times 1,000,000 = \mathbf{18,000}$$

DPMO provides a standardized perspective for expressing quality, with a Six Sigma level defined as only 3.4 DPMO.

The phrase **"Defects Per Million Opportunities" (DPMO)** is a key metric used in **Quality Management** and is fundamental to the **Six Sigma methodology**.

It provides a standardized way to measure the performance and quality of any process—whether it's manufacturing a product, handling a customer service request, or processing a loan application—by quantifying the rate of errors.

💡 What is DPMO?

DPMO is the number of defects (or errors) that are expected to occur for every one million chances (opportunities) for an error to occur.

- **Defect:** An error, flaw, or non-conformance to a standard or customer requirement (e.g., a scratch on a car, a typo in an invoice, a button missing on a shirt).
- **Opportunity:** Any step in a process where a defect *could* potentially occur. A single product or unit often has multiple opportunities for a defect.

The metric is powerful because it allows you to compare the quality performance of completely different processes, even if they have varying levels of complexity. A lower DPMO indicates better process performance and higher quality.

The formula is:

$$\text{DPMO} = \frac{\text{Total Defects}(D)}{\text{Total Units}(U) \times \text{Opportunities per Unit}(O)} \times 1,000,000$$

Example Calculation

1. **Process:** Manufacturing a simple ballpoint pen.
2. **Units (U):** 1,000 pens are produced.
3. **Opportunities per Unit (O):** You define 5 possible points of failure for a pen (e.g., the ink cartridge, the ballpoint tip, the cap fit, the barrel print, the pocket clip).
   - *Total Opportunities:* $1,000 \times 5 = 5,000$
4. **Defects (D):** During inspection, you find 15 defects in total across all 1,000 pens (e.g., 8 bad caps, 5 misprinted barrels, 2 broken clips).

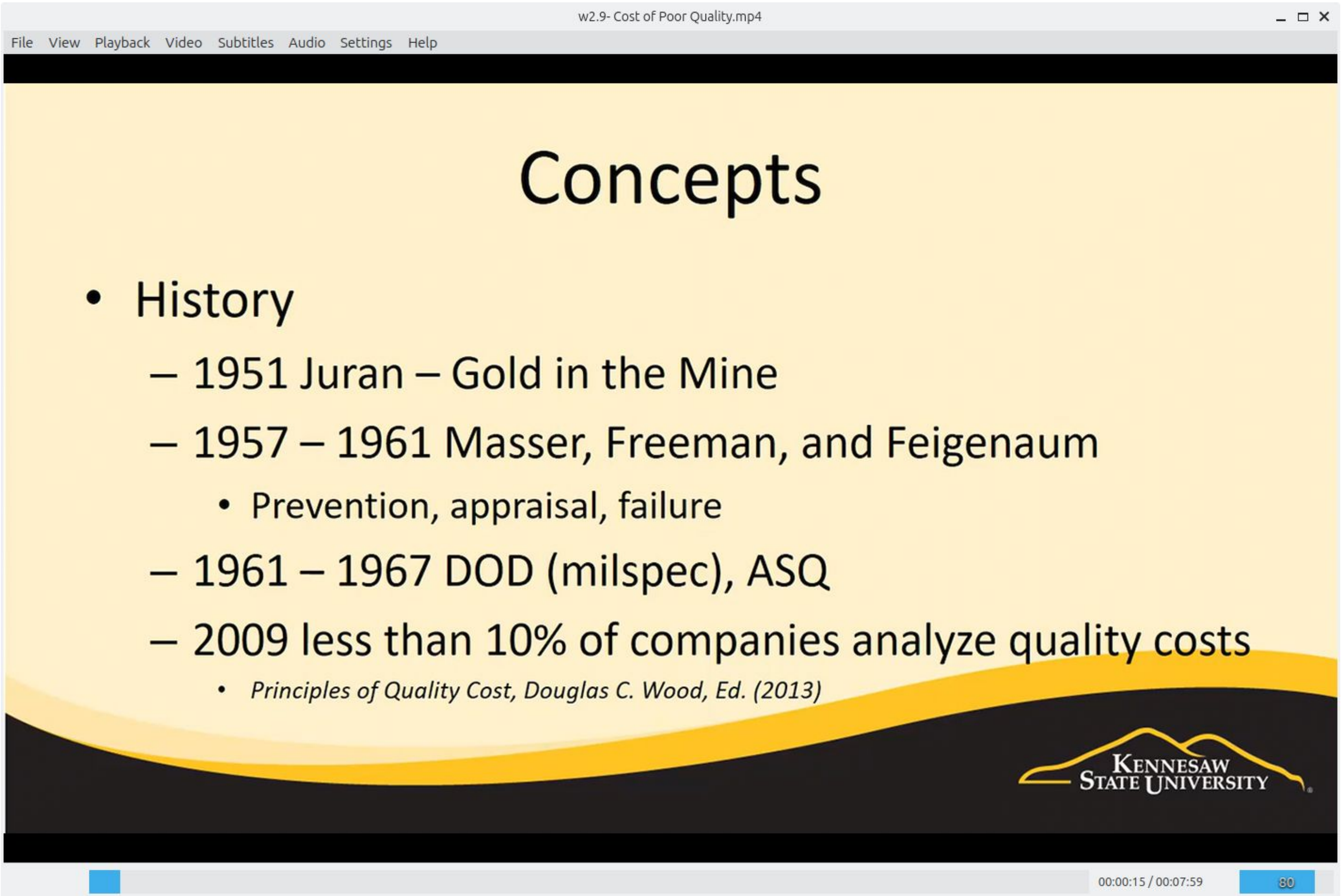
$$\text{DPMO} = \frac{15}{1,000 \times 5} \times 1,000,000 = \frac{15}{5,000} \times 1,000,000 = 0.003 \times 1,000,000 = 3,00$$

The DPMO is **3,000**. This means that if you continued this process, you would expect 3,000 defects for every one million opportunities for a defect to occur.

⭐ Relation to Six Sigma

The entire Six Sigma quality goal is defined by DPMO. A process operating at a **Six Sigma level** has a DPMO of only **3.4 defects per million opportunities**. This is widely regarded as near-perfect quality.

w2.9- Cost of Poor Quality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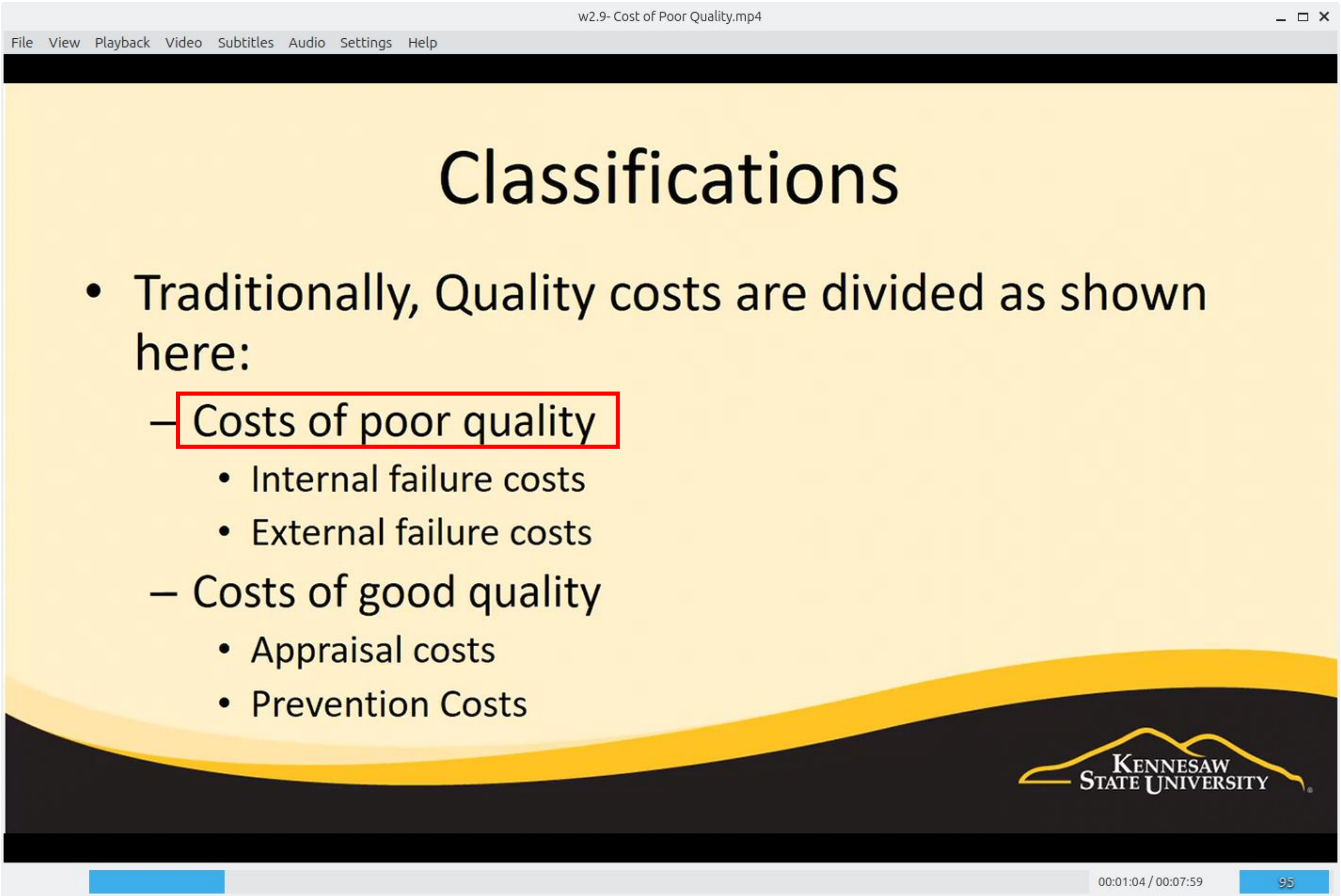
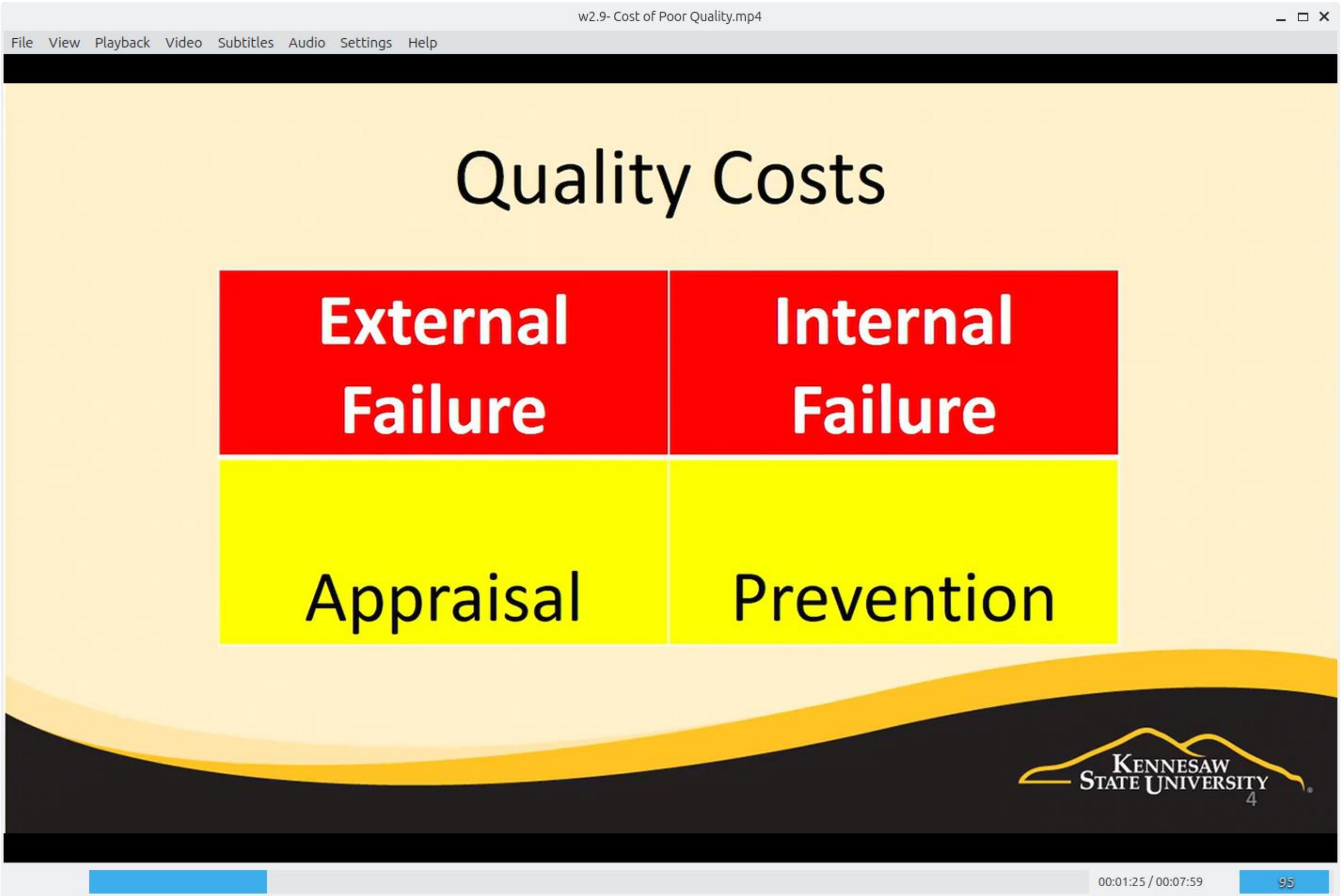
File View Playback Video Subtitles Audio Settings Help
Concepts
• History
– 1951 Juran – Gold in the Mine
– 1957 – 1961 Masser, Freeman, and Feigenaum
• Prevention, appraisal, failure
– 1961 – 1967 DOD (milspec), ASQ
– 2009 less than 10% of companies analyze quality costs
• Principles of Quality Cost, Douglas C. Wood, Ed. (2013)
Kennesaw State University
00:00:15 / 00:07:59
80


w2.9- Cost of Poor Quality.mp4
File View Playback Video Subtitles Audio Settings Help
Classifications
• Traditionally, Quality costs are divided as shown here:
– Costs of poor quality
• Internal failure costs
• External failure costs
– Costs of good quality
• Appraisal costs
• Prevention Costs
KENNESAW STATE UNIVERSITY
00:01:04 / 00:07:59
95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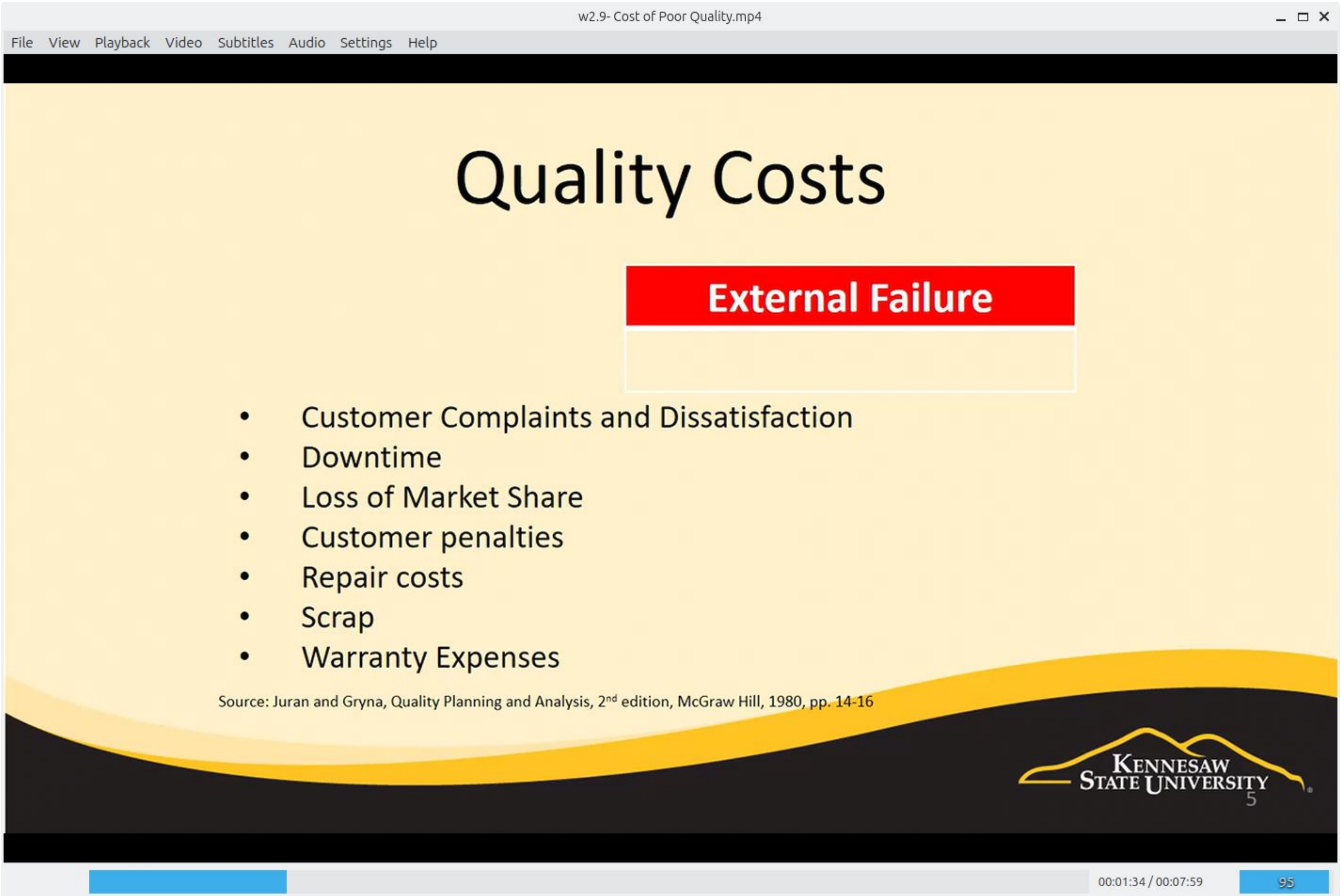
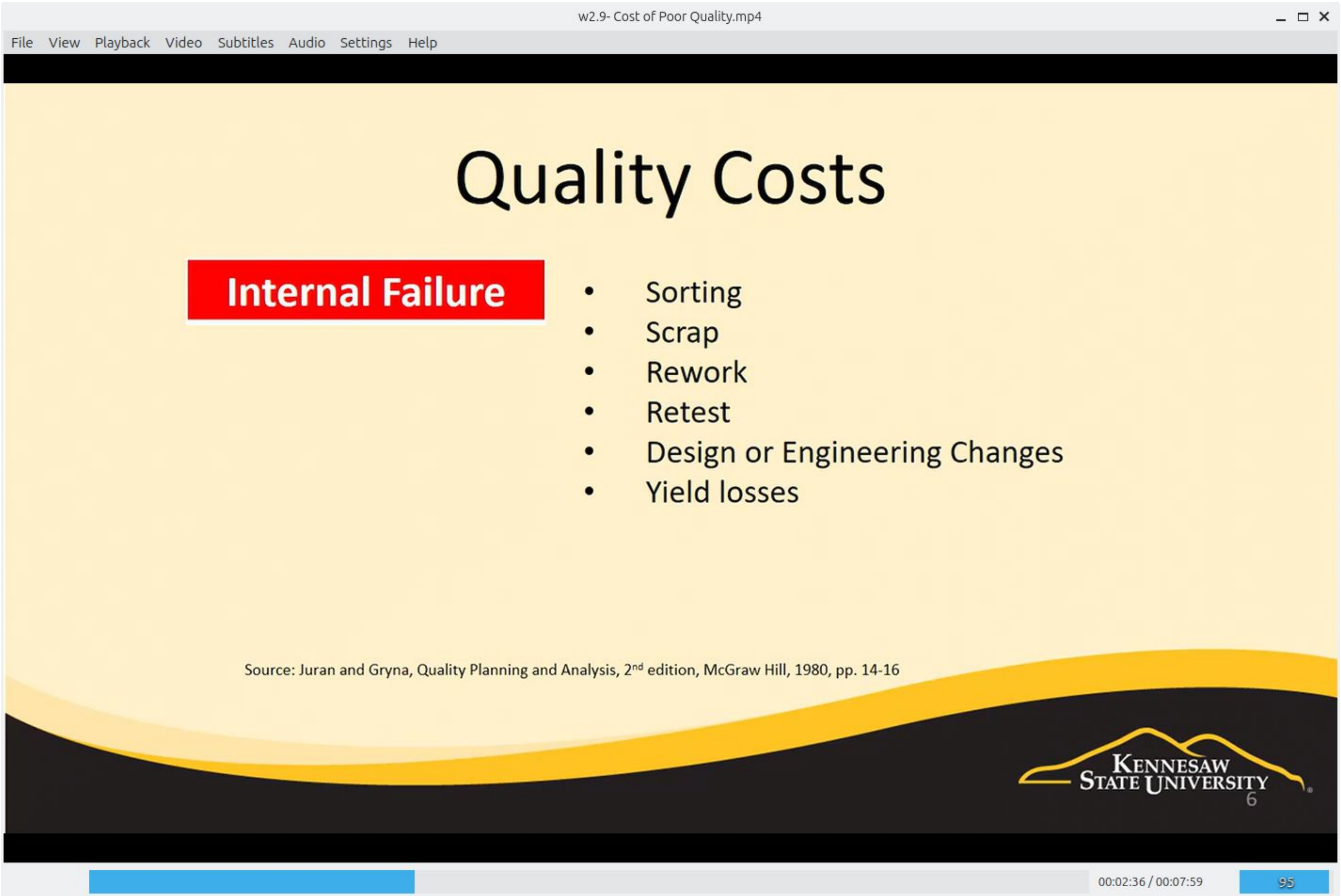
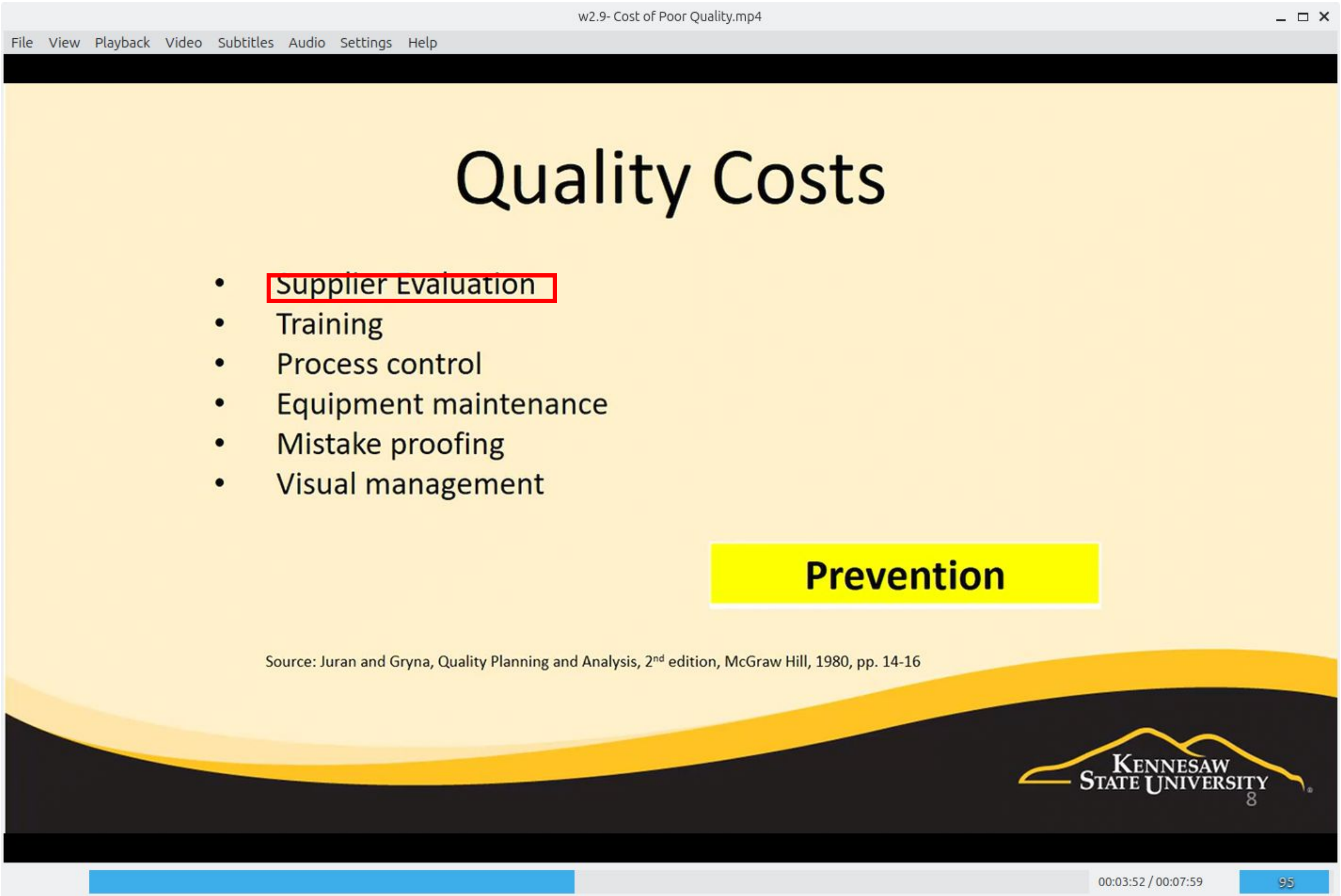
Quality Costs
External Failure
Internal Failure
Appraisal
Prevention
Kennesaw State University
4
00:01:25 / 00:07:59
95


w2.9- Cost of Poor Quality.mp4
File View Playback Video Subtitles Audio Settings Help
Quality Costs
External Failure
• Customer Complaints and Dissatisfaction
• Downtime
• Loss of Market Share
• Customer penalties
• Repair costs
• Scrap
• Warranty Expenses
Source: Juran and Gryna, Quality Planning and Analysis, 2nd edition, McGraw Hill, 1980, pp. 14-16
Kennesaw State University
5
00:01:34 / 00:07:59
95


w2.9- Cost of Poor Quality.mp4
File View Playback Video Subtitles Audio Settings Help
Quality Costs
Internal Failure
Sorting
Scrap
Rework
Retest
Design or Engineering Changes
Yield losses
Source: Juran and Gryna, Quality Planning and Analysis, 2nd edition, McGraw Hill, 1980, pp. 14-16
KENNESAW STATE UNIVERSITY
6
00:02:36 / 00:07:59
95


w2.9- Cost of Poor Quality.mp4
File View Playback Video Subtitles Audio Settings Help
Quality Costs
• Equipment calibration
• Receiving inspection
• Inspection and test
• Materials consumed
Appraisal
Source: Juran and Gryna, Quality Planning and Analysis, 2nd edition, McGraw Hill, 1980, pp. 14-16
KENNESAW STATE UNIVERSITY
7
00:03:07 / 00:07:59
95


w2.9- Cost of Poor Quality.mp4
File View Playback Video Subtitles Audio Settings Help
Quality Costs
• Supplier Evaluation
• Training
• Process control
• Equipment maintenance
• Mistake proofing
• Visual management
Prevention
Source: Juran and Gryna, Quality Planning and Analysis, 2nd edition, McGraw Hill, 1980, pp. 14-16
KENNESAW STATE UNIVERSITY
8
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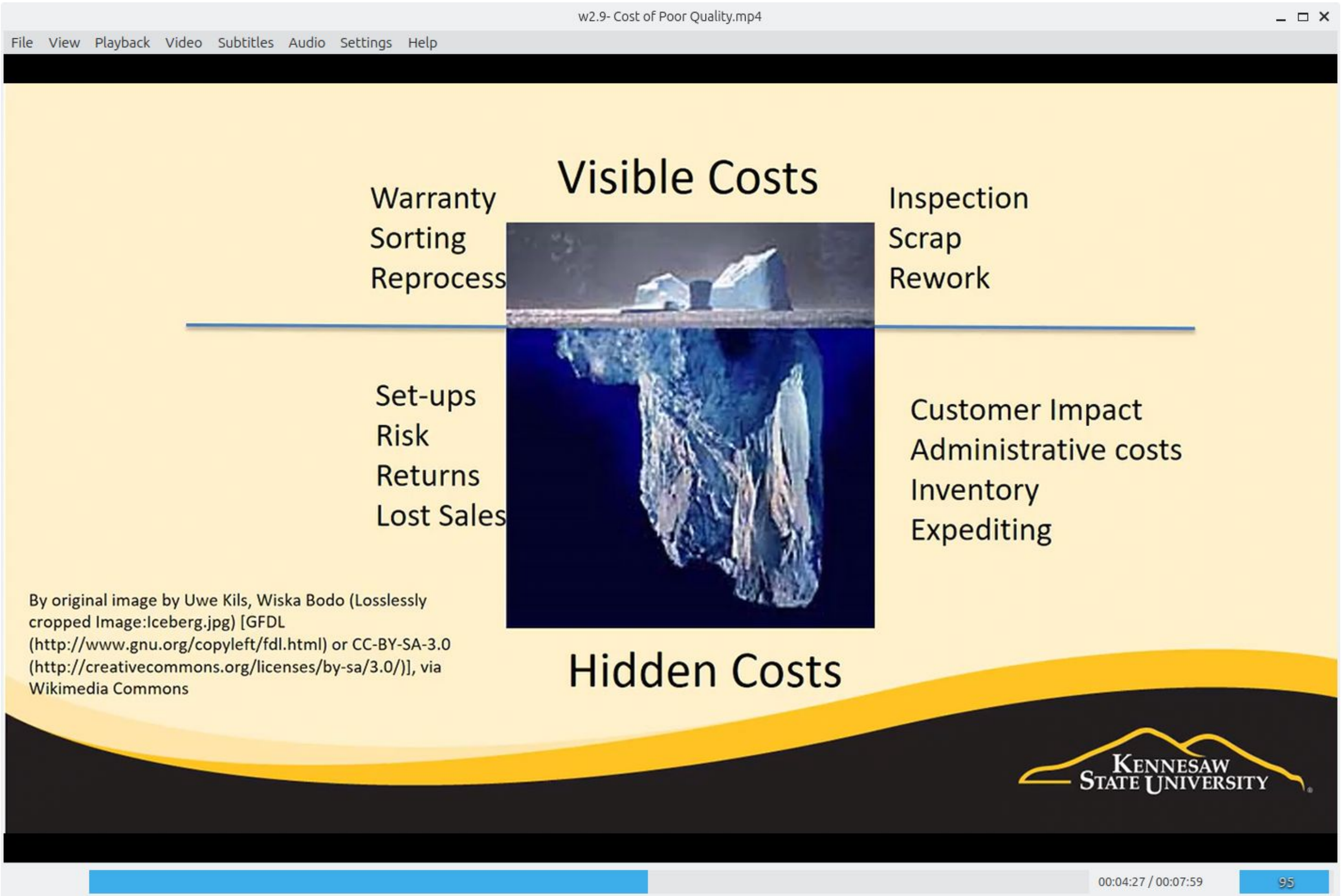
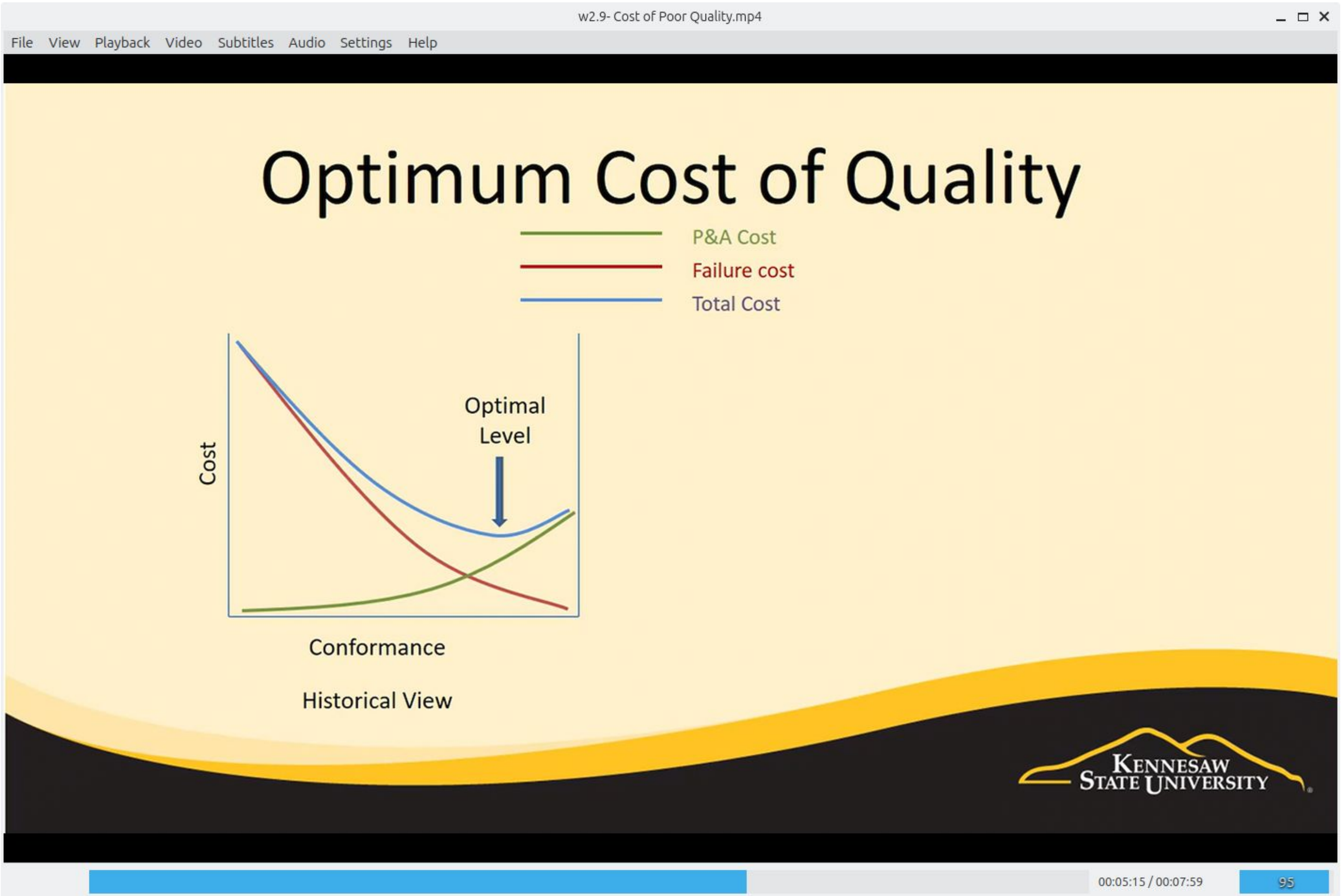
95


w2.9- Cost of Poor Quality.mp4
File View Playback Video Subtitles Audio Settings Help
Visible Costs
Warranty
Sorting
Reprocess
Inspection
Scrap
Rework
Set-ups
Risk
Returns
Lost Sales
Customer Impact
Administrative costs
Inventory
Expediting
By original image by Uwe Kils, Wiska Bodo (Losslessly cropped Image:Iceberg.jpg) [GFDL (http://www.gnu.org/copyleft/fdl.html) or CC-BY-SA-3.0 (http://creativecommons.org/licenses/by-sa/3.0/)], via Wikimedia Commons
Hidden Costs
Kennesaw State University
00:04:27 / 00:07:59
95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File View Playback Video Subtitles Audio Settings Help
Optimum Cost of Quality
P&A Cost
Failure cost
Total Cost
Optimal
Level
Cost
Conformance
Historical View
Kennesaw State University
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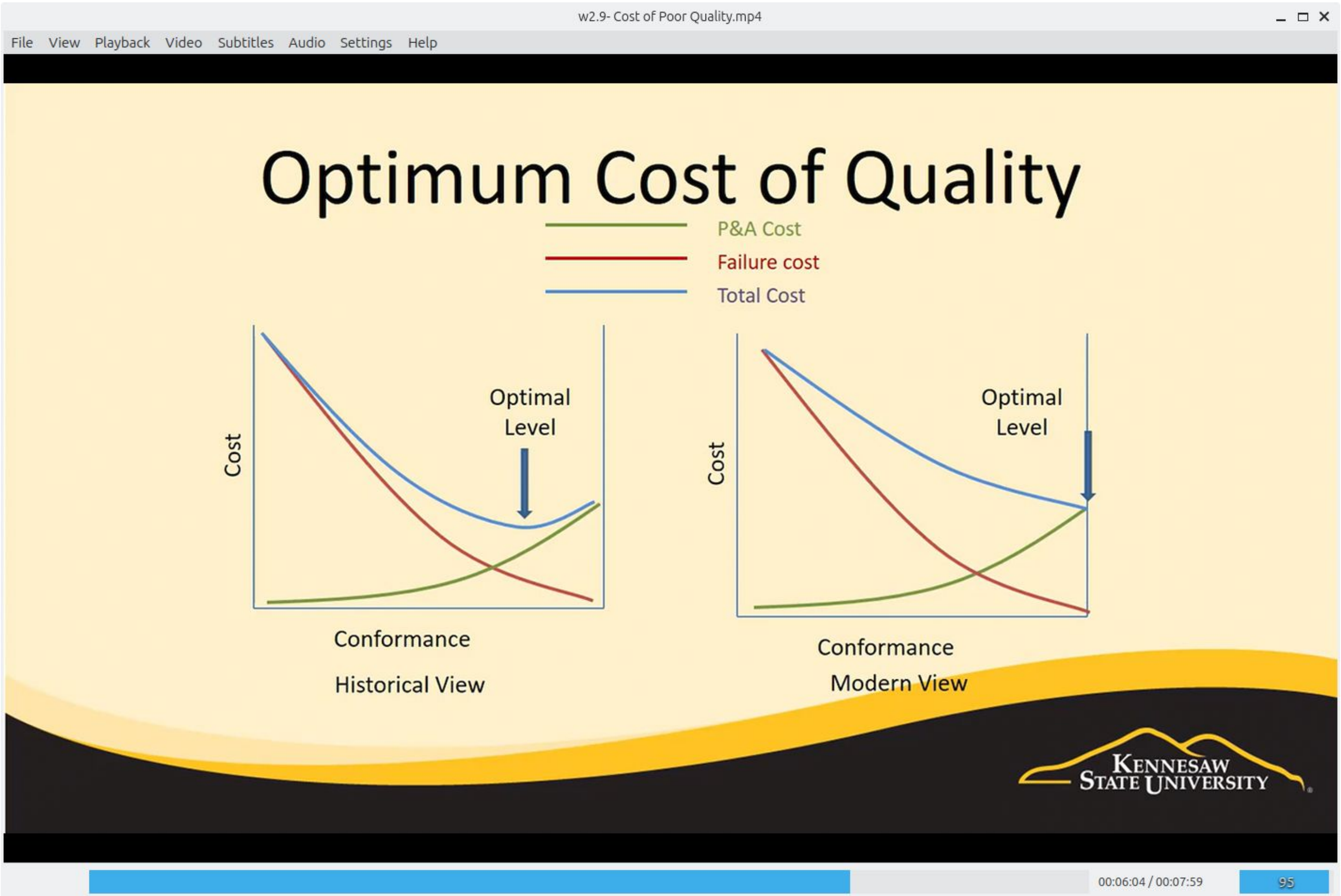
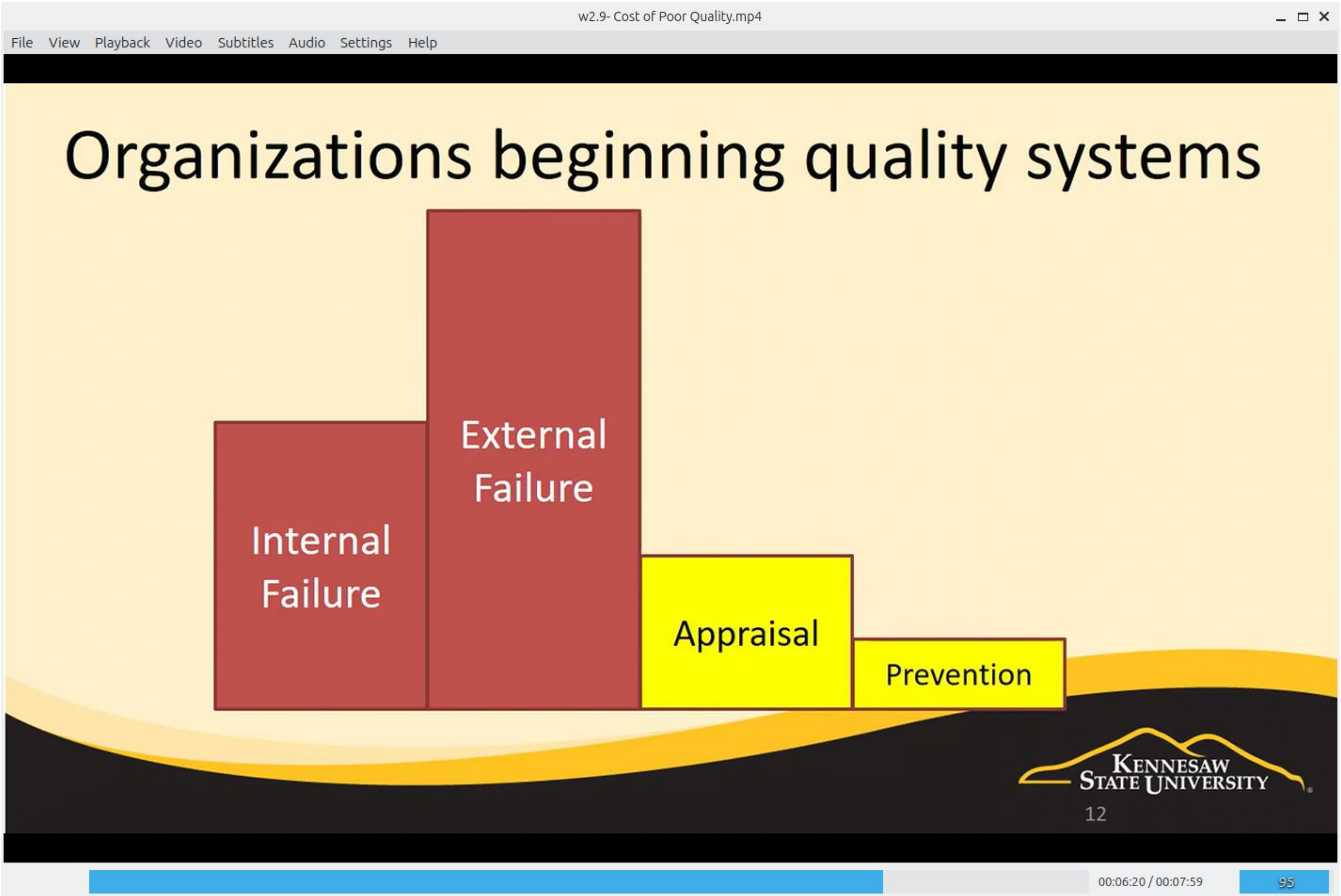
95


w2.9- Cost of Poor Quality.mp4
File View Playback Video Subtitles Audio Settings Help
Optimum Cost of Quality
P&A Cost
Failure cost
Total Cost
Cost
Optimal Level
Conformance
Historical View
Cost
Optimal Level
Conformance
Modern View
KENNESAW STATE UNIVERSITY
00:06:04 / 00:07:59
95


w2.9- Cost of Poor Quality.mp4
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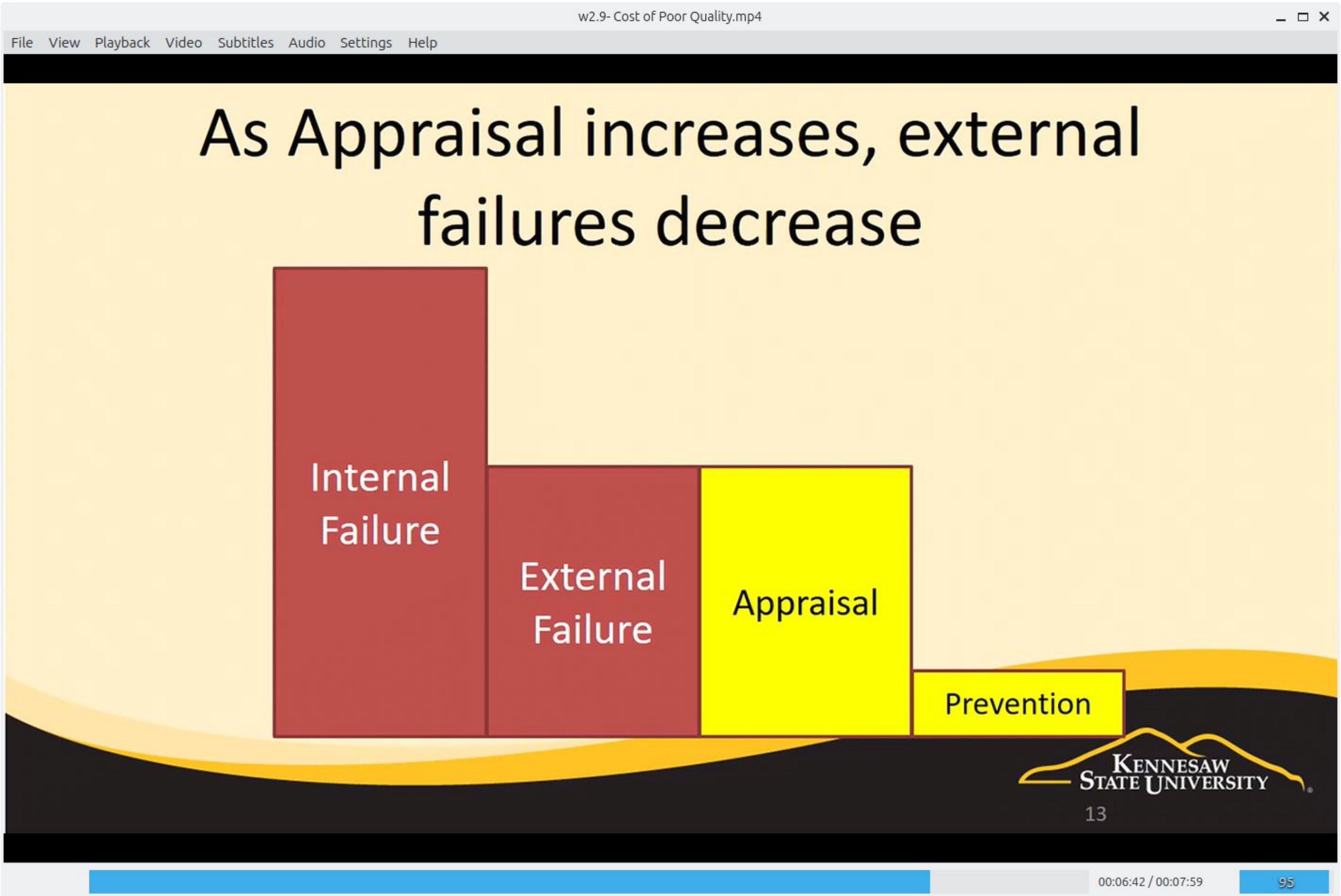
Organizations beginning quality systems
External Failure
Internal Failure
Appraisal
Prevention
KENNESAW STATE UNIVERSITY
12
00:06:20 / 00:07:59
95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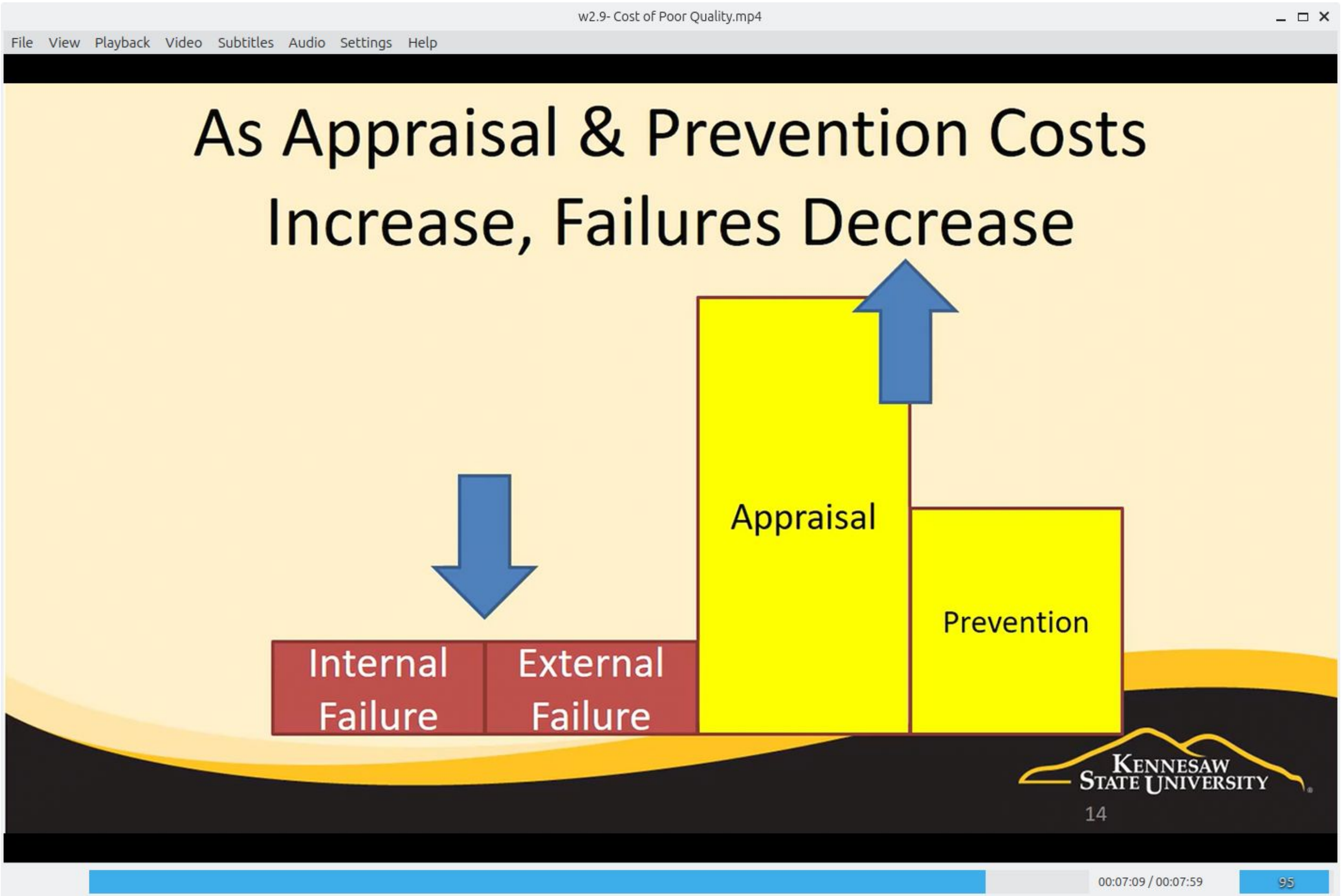
As Appraisal increases, external failures decrease
Internal Failure
External Failure
Appraisal
Prevention
KENNESAW STATE UNIVERSITY
13
00:06:42 / 00:07:59
95


w2.9- Cost of Poor Quality.mp4
File View Playback Video Subtitles Audio Settings Help
As Appraisal & Prevention Costs Increase, Failures Decrease
Appraisal
Prevention
Internal Failure
External Failure
Kennesaw State University
14
00:07:09 / 00:07:59
95

💰 Cost of Quality (COQ)

The **Cost of Quality (COQ)** concept, dating back to the work of Joseph Juran, defines the difference between the actual cost of a product or service and what the cost would be if there were **no possibility of defects or failure.**

While fewer than 10% of companies tracked these costs as of 2009, measuring COQ is crucial for identifying improvement opportunities.

4️⃣ Four Classifications of Quality Costs

Quality costs are traditionally grouped into four categories, divided between the **Costs of Poor Quality (Failure Costs)** and the **Costs of Good Quality (Appraisal and Prevention Costs)**.

I. Costs of Poor Quality (Failure Costs)

Classification	Timing	Description and Examples
External Failure Costs	**After** the product/service reaches the customer.	**The most expensive costs.** Includes customer complaints/dissatisfaction, loss of market share, penalties from customers, warranty costs, scrap, repair, and massive costs/reputational damage from product recalls.
Internal Failure Costs	**Before** the product/service reaches the customer.	Still expensive, but better than external failure. Includes the expense of sorting good from bad, retesting, **rework, scrap**, changing design or methods, and experiencing **lower yield** (FPY/RTY).

II. Costs of Good Quality (Control Costs)

Classification	Timing	Description and Examples
Appraisal Costs	Incurred in efforts to **detect errors or defects.**	Includes the cost of inspection (personnel, equipment maintenance, and time) for incoming, in-process, and final inspection/tests. Catching a problem early minimizes investment losses.
Prevention Costs	Incurred to **prevent errors or defects** from occurring in the first place.	Often **one-time** costs. Includes money spent on capability studies, process control, training, and Lean tools like **mistake-proofing** (Poka-Yoke) and visual management.

📉 The Evolution of the Optimal Quality View

The relationship between control costs (prevention/appraisal) and failure costs dictates the total cost of quality, but the view on the "optimal" quality level has changed.

View	Optimal Quality Level	Total Cost Curve	Rationale
Traditional View	**Less than 100%**	U-shaped	Suggests that failure costs decline as prevention/appraisal costs rise, but at some intersection point, the **total cost will begin to rise**, meaning 100% quality costs too much.
Modern View	**100% Good Quality**	Continually declining	Suggests that total costs continue to **decline until perfect quality is reached**, making 100% good quality the optimum goal.

Quality System Maturity

As an organization matures in its quality journey, the mix of these costs shifts:

1. **Beginning Stage:** High **External Failure Costs** are likely the reason the system was started.
2. **Developing Stage:** The company increases **Appraisal Costs** (inspection). This drives external failures down, but often increases **Internal Failure Costs** (as defects are now caught internally). This is considered an improvement.
3. **Mature Stage:** The company increases spending on **Prevention Costs.** A robust system of prevention and appraisal drives both **Internal and External Failure Costs down.** Eventually, the company may even be able to reduce the scope of inspection, lowering Appraisal Costs.