Technology as a Catalyst for Change: Engaging Audiences in the 21st Century

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Abstract

- This session showcases how 3D printing technology can be used to construct flutes that retain their traditional characteristics, but with 21st-century appeal that engages today’s audiences.
- It features a demonstration of the 3D-printed flutes and the system that created them.
- Works to be performed for the demonstration:
  - *Fantasie in D–dur*, Georg Philipp Telemann
  - *Fantasie in e–moll*, Georg Philipp Telemann
Overview of flute making and the role of technology

Methodology used to create a flute using 3D printing technology
  ◦ Hardware and software

Advantages of 3D printing technology

Disadvantages of 3D printing technology

Demonstration of 3D printed flute prototypes as compared with handmade Baroque flutes

Audience feedback

Questions
Overview of Flute Making and the Role of Technology

- From Wikipedia, “Organology (from Greek: ὄργανον – organon, "instrument" and λόγος – logos, "study") is the science of musical instruments and their classification. It embraces study of instruments' history, instruments used in different cultures, technical aspects of how instruments produce sound, and musical instrument classification. There is a degree of overlap between organology, ethnomusicology, (being subsets of musicology) and the branch of the acoustics devoted to musical instruments.
- American Musical Instrument Society and The Galpin Society
Major Changes in Flutes Over Time

- Materials – wood, metal, bone, ivory, crystal, gold, platinum, composite materials
- Pitches: a=392 to a=440 and even higher
- Holes versus keys – and why
- Conical versus cylindrical bore
- Sizes – families/consorts of flutes
- Role in ensembles and in society as a whole
- Designs and “new” inventions
- Playing conventions and styles
- Held to the right side versus held to the left side (or even held in front of the player)
Complete Bone Flutes from China

May be the oldest playable, multi-note instruments. Between 7,000 and 9,000 years old. Fragments of approximately 30 other flutes also found. Made from wing-bones of red-crowned cranes.
Sheep bone with 3 holes on one side. Approximately 6,000 years old.
Also from Wales: A Medieval Flute

Made of deer bone and decorated – making it very rare and probably designed for an important person. Approximately 700 years old.
The renaissance flute, used in Europe from roughly 1500 to 1650 and later, was designed to blend well; it was often played with other flutes in a consort, or perhaps with voices or other soft instruments.
Note how this flute was apparently held either to the right or to the left side of the musician. It also came in several sizes (bass, tenor, descant) to form a consort.
Renaissance Flute in Ensembles
A revolution in flute making took place in the second half of the 17th century. The instrument emerged as the Baroque flute with significant modifications, including a conical bore, the addition of a key for the right-hand little finger and a more ornate body in several pieces. It was now fully chromatic and better suited for a role as a soloist.
The four-piece construction also allowed for a *corps de rechange*. This term means that several interchangeable upper center joints were provided and it allowed the flute to be played at different pitches.
Original baroque and classical flutes were often provided with *corps de rechange* of from three to seven interchangeable center joints. Usually the difference in length between consecutive joints was about 5mm. This makes a difference of about 5 Hz in the pitch.
Baroque Flute Iconography
He is known to have composed 121 flute sonatas, four flute concertos, a "Symphony" in G major, a March in E flat major, various arias and an overture to "Il Re pastore."
He had music rooms in all of his palaces and perhaps played as often as five times per day! (In other words, we have no excuses about why we have not practiced or completed our homework assignments.)
His Flutes

Flute on Left – Made by J.J. Quantz, in Library of Congress Dayton C. Miller Flute Collection
Theobald Boehm (1794–1881) was a goldsmith, engineer and musician (both performer and composer). He pursued and made contributions in all these fields. In the late 1820s, he (with Rudolph Greve) manufactured fine simple system instruments with eight or nine keys. About twenty years later (1847), we find him making all-metal flutes of a very different nature.
Boehm is Responsible for Many Innovations in Flutes
And Today’s Flute
But You Still Have Choices!

- Wood, silver, gold, plastic/composite
- Plated or solid metal
- Closed or open holes (French style)
- Wall diameter (.018 is a heavy wall to give a darker sound)
- In-line or off-set G
- C or B foot
- Extra trill keys
- Machine-made or handmade parts and processes
- Pitch – now a=442 is favored for a slightly brighter sound
- And now, flutes created using 3D printing technology!
How is a 3D printed flute made?

- Make precise measurements of an existing flute
- Take lots of Photos
How is a 3D printed flute made?

- Make some sketches
Model in 3D program

- Used Autodesk Maya
  - Other programs can be more accurate
- Imported photos and sketches
- Set up a measuring system to be able to build on a precise grid—millimeters
- Scale reference photos to the grid
Use of coordinate system
Build the model

- Polygon models
  - ~7500 quads
- Built from simple shapes
- Keep as simple as possible
- Needs to be **waterproof**
- Clean up model, check for problems
- Can introduce design modifications
Scale models
MakerWare

- Software for printer
- Slices the model
- Sends info to printer
MakerBot

- Uses PLA plastic
- Can adjust many factors
  - Thickness of walls
- Extrudes a filament at 0.2 mm
- Lays down a raft and supports
- Print time varied from 2 hours to 22 hours
1 hour to print this piece
Results
Post-Production

- Need to clean up surfaces
- Remove rafts and supports
- Smooth out irregularities
- Use x-acto, dremel tool
Clean-up
Results

- Positive:
  - Easy to design and create
  - Easy to scale
  - Easy to print

- Negative
  - Not as accurate as we would like
    - tolerances
  - Some distortion in shape
Advantages of 3D Printing

- Complete control over the design
- Ease of scalability and modification
- The ability to make a series of prototypes
- Hardware that can quickly output the final product
- Can quickly think of other designs and other ways to build than traditional manufacturing
- Provides a good template for traditional builders
- Can be transferred to a lathe or CNC machine
Disadvantages of 3D Printing

- The hardware has a significant impact on the quality of the output
- The materials currently available may not be "musical" enough
- It is easy for people to dismiss this technology, but having the digital model is so important because you can make modifications
An additive versus subtractive process (as in hand-made flutes, where you carve away/bore out what you don’t want from the wood)

- Difficulty of accounting for the air space
- The conical bore for Baroque flutes
- The size, shape and position of the holes (finger holes as well as the embouchure hole)
- The joints and pieces (must fit snugly to avoid air escaping)
- The construction of the key
Recommendations

- Use CAD software for higher accuracy
- Use more precise printer
- Investigate other materials
- Test various thicknesses for best musical quality
3D Printing of Other Instruments

- **3D-Printed Guitar**
Legal Issues with 3D Printing


Demonstration and Audience Feedback

- Handmade, traditional Baroque flutes
  - Maker information
- Flutes created using 3D printing technology
  - Description of flutes
- Pieces to be performed for demonstration
  - *Fantasie in D–dur*, Georg Philipp Telemann
  - *Fantasie in e–moll*, Georg Philipp Telemann
- Audience feedback – consider the viability and musicality
Any Questions?

Thank you for attending our presentation!
Sara and Albert