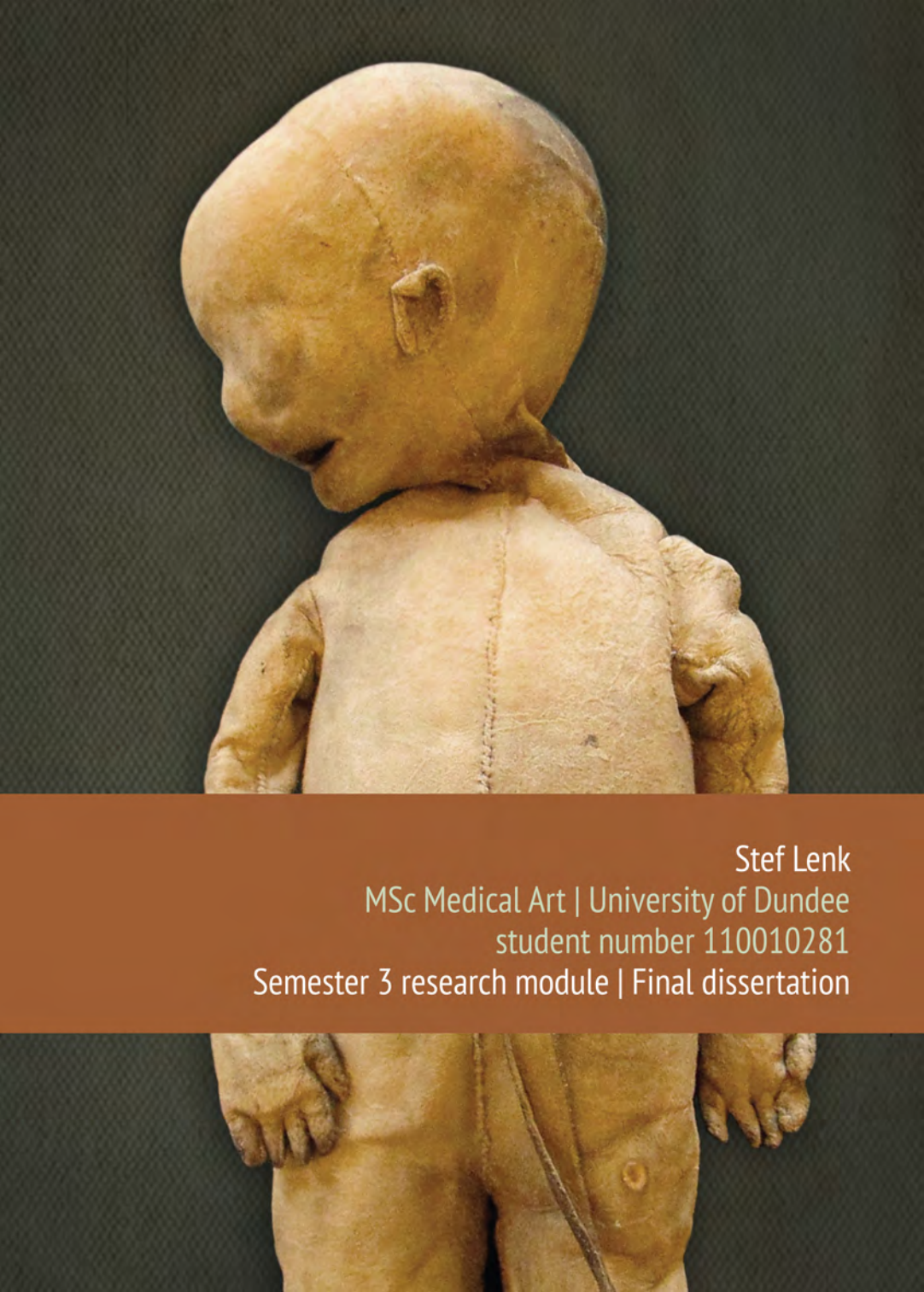

Stef Lenk
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Semester 3 research module | Final dissertation

Among the more extraordinary pieces of the collection at the Royal College of Physicians of Edinburgh are two small and mysterious stuffed leather dolls, delicately hand sewn and housed in boxes of new mahogany, handmade specifically to hold them by the College joiner years ago.

Little is known about the dolls, their origin, or how the RCPE came to acquire them. It is safe to say they were used as obstetric teaching models, similar or identical to those used by Doctor William Smellie, one of the most prominent obstetricians of the 18th century.

At first glance, their lack of anatomical accuracy makes them seem of little use to medical instruction of any sort. Through CT scanning, however, it was discovered that the dolls, stuffed with horsehair-like material and supported by wireframes, also contain genuine human neonatal crania...

No portion of the work referred to in this thesis has been submitted in support of an application for another degree or qualification of this or any other university, or institute of learning. The research presented in this thesis is my own, including any mistakes, unless otherwise stated.

Two Obstetric Dolls and Doctor Smellie's Mechanical Labour Device

TABLE OF CONTENTS

ABSTRACT

This practice-based research project to augment the display of two 18th century obstetric dolls is meant as a public education tool which could be exhibited either online, physically or both at the Royal College of Physicians in Edinburgh. The primary element is a visual rendering and 3D animation of the dolls; the originals are made of leather, horsehair (or similar material), wireframes, and contain neonatal crania with mandibles likely constructed of (animal) bone. The digital exhibit displays both the inside and outside of their forms.

A history of midwifery, obstetrics, and William Smellie's contributions to both fields are described, particularly Smellie's teachings using obstetric dolls and how these models have been further developed and incorporated into modern day training. Museums, medical museums, and the ethics of exhibiting human remains are discussed, as well as the benefits of integrating related materials including websites and 3D animation in order to improve knowledge transfer and the overall viewing experience of the public.

A summary of the methodology used to digitally re-create the dolls is explained in some detail, as well as considerations taken into account when putting together the public information website. Finally, two test groups, one public and one of experts in the fields of obstetrics, midwifery, medicine, and/or museum/curatorial work, were given a survey to evaluate all the exhibit materials. The results of these surveys are discussed, to ascertain areas of success in the project and areas needing improvement.

INTRODUCTION

It was important at the outset of this study to consider how best to address the dolls in order to contribute something significant to their exhibiting. This brings up several concerns: although the dolls exist in their entirety they have become separated from the birthing model with which they would have originally been associated. Their exact origin or how they came to be at the Royal College of Physicians of Edinburgh (RCPE) is unclear. They contain neonatal human remains, raising potential ethical concerns over their exhibition. The only clue to their significance is the historical context of similar objects used in simulated childbirth scenarios around the 18th century.

It becomes evident that without a context the dolls themselves offer little practical knowledge or educational benefit to the viewer. There are no extant images of the woman-machine that would have originally accompanied the dolls; only written descriptions by Smellie's contemporaries and students remain. As a result, it is only through contextualizing this material in a visually arresting fashion that viewers have the chance to engage further with the dolls, or develop a further interest in them.

Working under the theory presented by the RCPE that the dolls might well have belonged to Smellie, significant considerations include: With what was Smellie concerned when constructing his dolls (in terms of practical, social and political context), and what made them efficient tools of education in midwifery?

Some background is given into socio-political conditions of the time and how they influenced the shift from traditional midwifery practice to that which was taught by Smellie and others. The dolls themselves are introduced, and a description and explanation is given as to how they were conceived, used, and judged by Smellie's contemporaries and students. Mention is made of both similar and modern-day obstetric models.

Exhibition factors in medical and other museums are looked at, followed by a review of the ethics of exhibiting human remains, and the pros and cons of using 3D and multimedia technology in a museum context.

The 3D animation exhibits both the dolls' internal and external structures, and substantiates the opportunity to exhibit the dolls online, making them available to a wider public. Drawings have been rendered to illustrate the pertinent anatomy, and photos of the handwork details of the dolls' structures supplements what the 3D animation does not make clear.

The accompanying website adds to the animation with additional information and resources for viewers, similar to what one would find in a traditional museum context. It explains how the dolls were used; at what time and by whom, and how they have contributed to further developments in obstetric simulation devices for modern-day medical education.

The results of evaluation of the animation and website by a test group of sixty-four people, ranging from members of the public to midwives, anatomists, and museum curators are discussed, as well as how this type of practice-based research could be improved, further developed, or applied to other objects for exhibition purposes.

background

THE BEGINNINGS OF MIDWIFERY AND OBSTETRICS

In ancient history, very little attention was given to the discrepancy between male and female physiognomy in medical practice. Childbirth was the only circumstance acknowledged as exclusive to females, and even that received little professional attention. (King, 2007)

Throughout the middle ages, the rising power of religion tended to stifle original thinking, which impeded much scientific and medical progress. (Rhodes, 1994) The clergy had a monopoly on knowledge and controlled most forms of education. Galen (129 AD – 200 AD) introduced the notion that childbirth was due to the mother's muscular contraction expelling the child, rather than the foetus forcing itself out of the birth canal. Not until the 5th century in Greece, however, did teachings appear explicating a branch of medicine geared specifically towards women, in the texts of the *Hippocratic Corpus* (King, 2007)

Little information about the specifics of childbirth techniques and knowledge exists for the period between the 5th and the 15th century. In terms of social mores, the birthing chamber was the woman's place, strictly off limits to men. So much so, that in 1552 a "*Dr. Wertt of Hamburg … entered a lying-in room dressed as a woman so that he could observe what happened. He was burned at the stake for such impropriety*." (Rhodes, 1994, p.15) There is much research to show that childbirth was primarily in the hands of midwives, who had no formal schooling and were mostly illiterate. (Rhodes, 1994)

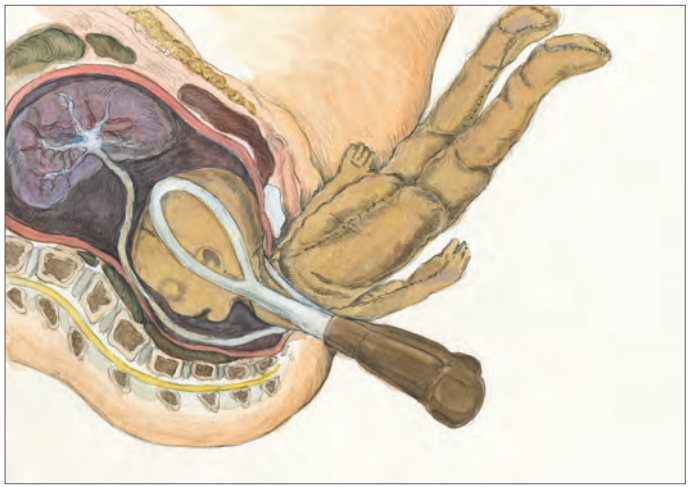
Birth stools were frequently used for delivery; These were chairs with reclining backs and a large hole cut out of the seat. The midwife would squat or sit on the floor in front of the mother, to receive the baby and the placenta into her lap. If labour was prolonged it was common to loosen the garments of the mother and then lift her by her armpits and let her fall as heavily as possible as if to shake the baby out of the vagina. (Rhodes, 1994) An alternative was to tie the

woman to a ladder and then lift it up and bang it down on the floor several times. (Rhodes, 1994) Tools did not exist at this time to aid in childbirth, making delivery an experience based on female knowledge, intuition and tactility, but also one fraught with medical risk.

In 1515, the first (of what was to become widely circulated) obstetric textbook appeared in Germany, entitled *Der Schwangern Frauen und Hebamen Rosengarten*. Translated into English as *Rosegarden for Pregnant Women and Midwives* (Green, 2009), it has been suggested that this textbook was responsible for the rising tension between doctors and midwifes, as men who had hitherto been barred from attending childbirths now had access to this knowledge via the printed page. (Drife, 2002)

The 16th century saw several more developments, notably the founding by French military surgeon Ambroise Paré of a school for midwives in Paris (Drife, 2002) and the appearance of Israel Sprach's *Gynaeciorum Libri (The Books of Gynaecology)*, which would serve as a later resource for William Smellie, one of history's most prominent gynaecologists and men-midwives. (King, 2007)

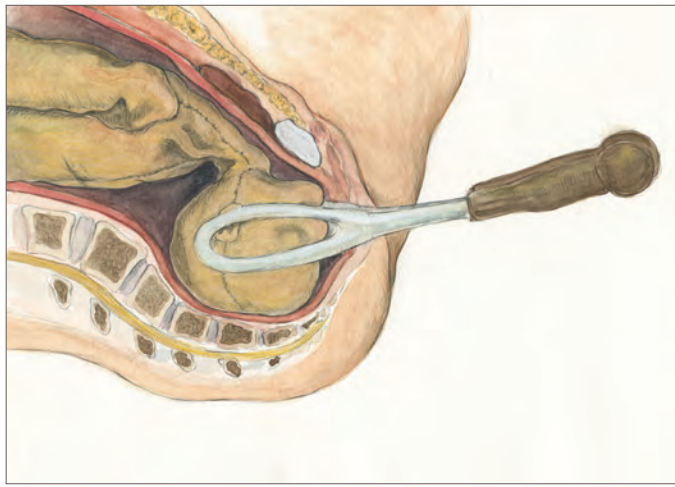
THE ORIGIN OF THE OBSTETRIC FORCEPS



Although there is not surviving pictoral evidence of the 'machines' used to birth the obstetric dolls, the anatomy is made clear in Smellie's drawings on the subject, reinterpreted here to illustrate different difficulties encountered during childbirth. (above) breech presentation at delivery

Because the RCPE obstetric dolls were used to educate medical practitioners in childbirth techniques most often involving the use of obstetrical forceps, an explanation of the tool and its influence on the matter is in order.

It is not certain which of the Chamberlen brothers invented the forceps, a tool that would change the course of midwifery forever, but would also remain a closely guarded secret until the 18th century. In 1569, William Chamberlen and his family first came to England, fleeing religious persecution in France. Chamberlen was a Huguenot surgeon, and his two sons (Peter the Elder and Peter the Younger) followed in his steps, becoming barber surgeons and subsequently well-known practitioners of midwifery. It is supposed by Aveling (1882), that Peter the Elder developed the device, which allows for greater force in extracting the neonate from the birth canal than grip with the hand alone. The tool was conceived at a time when the disease rickets was particularly widespread,

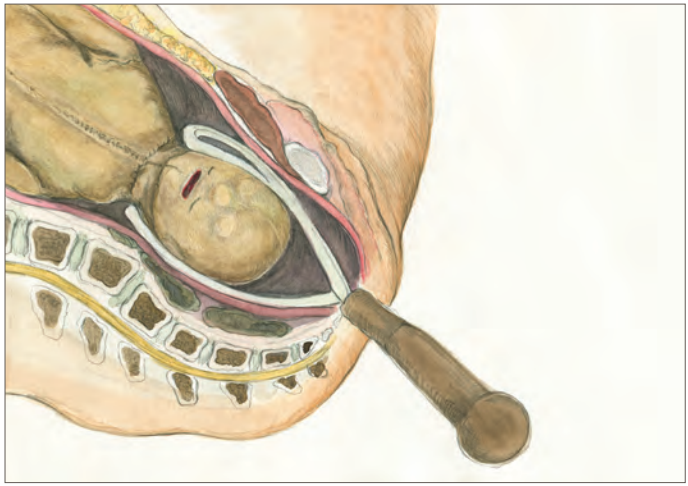


face presentation at delivery

causing pelvic deformity that greatly obstructed delivery of the foetus; it was a major cause of the extremely high infant mortality rate at the time. (Dunn, 1999)

In order to profit exclusively from its use, the Chamberlens kept this invention undisclosed to other practitioners, as well as to expecting mothers who enlisted their services. According to Graham: (1950)

> "[The Chamberlens] *are said to have arrived at the house of the woman to be delivered in a special carriage. They were accompanied by a huge wooden box adorned with gilded carvings. It always took two of them to carry the box and everyone was led to believe that it contained some massive and highly complicated machine. The labouring woman was blindfolded lest she should see the "secret." Only the Chamberlens were allowed in the locked lying-in room, from which the terrified relatives heard peculiar noises, ringing bells, and other sinister sounds as the "secret" went to work.*" (Dunn, 1999, p.232)



occipito-posterior presentation at delivery

In 1670 Peter's eldest son Hugh, who is also said to have practiced midwifery, visited Paris, hoping to sell the secret of the family forceps to the French government. He was not successful in his venture, but returned to London with a copy of Mauriceau's 1668 text, *Observations sur la Grossesse et l'Accouchement,* which he translated and published in England in 1672 under the title of *The Accomplish't Midwife*. In the foreword of his translation, Hugh made vague reference to the family secret, although the actual forceps remained a mystery.

The first appearance of obstetric forceps very similar to those of the Chamberlens' only came into general use after Edmund Chapman had made public Chamberlen's design in 1733 (after Hugh Chamberlen's death) and William Gifford's further modifications to the tool had been published in 1734. (Dunn, 1999)

William Smellie would take these early forceps designs and improve them significantly with such features as the 'English lock' and the pelvic curve, which are still incorporated in modern-day forceps.

WILLIAM SMELLIE

William Smellie (1697-1763) is one of the most prominent figures in the development of obstetric and midwifery practice. As well as being responsible for the introduction of and the further development of midwifery forceps in the UK, he founded the institution of midwifery instruction in London. In his *Treatise on the Theory and Practise of Midwifery* (1752) he was the first to describe the mechanism of normal labour, the rotation of the occipito-posterior positioned head, and his application of the forceps to the head in breech deliveries (O'Dowd, 1994), all aspects of which have stood the test of time in the development of techniques of successful childbirth. He is also the one who initiated obstetric teaching with simulated models in the UK.

Having started out as an apothecary and a surgeon, Smellie began his practice in Lanark in 1720. As a surgeon his techniques included craniotomy and turning the child in the womb to reach a better position from which to achieve delivery, but this usually was when the child was already deceased. In 1733 Smellie gained his first professional qualification, becoming a member of the Faculty of Physicians of Glasgow. It was at this time information was published on the use of obstetrical forceps by Edmund Chapman.

Smellie made a visit to Paris in 1739, where he watched M Grégoire at the Hotel Dieu teaching the application of the forceps to man-midwives using a manmade female model, and learned to use a model pelvis to demonstrate delivery positions.

He brought this innovation back with him to London and by 1741 he had begun teaching with his own version of dolls and 'machine'. His advertisement in the London Evening Post of 1st June that year read:

> *'on Monday 14 June, at 5pm, will begin a course of lectures on the theory and practise of midwifery, at 11am for women, and 3pm for men, by Mr. Smellie, at his house in the New Court,*

Dr Graham Wait

A

TREATISE

ON THE

Theory and Practice

OF

MIDWIFERY.

By W. SMELLIE, M.D.

LONDON:

Printed for D. WILSON, at Plato's Head, near Round-Court, in the Strand.

MDCCLII.

formerly the Key and Garter Tavern, over against St. Albans Street, Pall Mall.' (Rhodes, p.43)

His courses were part of a marked revolution in medical education by which lectures were given privately and were open to anyone who could pay to take them. There were no prior requisites for attending. The courses were more practice-based than the Oxbridge medical education model (King, 2007). A 12-lecture course normally lasted two weeks and cost two guineas plus an extra guinea for attending a labour. (King, 2007)

The core element of Smellie's courses was the 'machines', made from real women's bones and dressed in clothing (to preserve their purity), which gave birth to doll-babies. He would get a student-volunteer to deliver the doll while he shifted the levers to imitate the actions of the maternal abdomen. (Blackwell, 2001) He discussed as a part of his lectures the six non-naturals and then gave a series of case histories to illustrate their role in obstetrics. (King, 2007)

Over a 10 year period Smellie gave 280 courses, involving 900 students, in the management of over 1000 labours (Roberts, 2010) It is important to note that Smellie also taught women, although separately from men. (Drife, 2002)

Smellie's 'machine' and others of the time represent the humble beginning of the obstetric simulation model, also known as a partial-task trainer, modern variations of which are still used today in obstetrics training.

(page 19) portrait of William Smellie | courtesy of The Wellcome Library, London
(facing page) | original frontispiece for William Smellie's 1752
"A Treatise on the Theory and Practise of Midwifery" | Courtesy of RCPE

THE RISE OF THE MAN-MIDWIFE
class structure, politics and social implications

In the 1500s medical education was controlled, in London at least, not by the universities, but by the guilds of Barbers, Surgeons, and Apothecaries. In the mid-17th century, English class structure began to change, which heavily influenced the structure of the medical industry, and after 1780 the rise of an industrial bourgeoisie was well on its way. (Frank, 1976)

Although physicians, surgeons and apothecaries had their own innate caste structure, all medical practitioners were members of an affluent class. In order to justify their high fees, it became more necessary to present themselves not just as vocational practitioners, but ones with the seemingly magical ability to intervene with the course of nature in restoring health to the afflicted individual. (Jewson, 1974)

This demand resulted in medical innovators keeping their discoveries exclusive to private practice rather than sharing them with professional rivals, which would have benefitted the public but of course potentially cut down on business. Jewson points out that "*The free exchange of information among medical practitioners and investigators was impossible as long as clients, rather than professional colleagues, held control over the distribution of rewards in the career system.*" (Jewson, 1974)

Although Smellie made his forceps publicly accessible, reproducing drawings of them and sharing the technology widely, there are no extant drawings of the accompanying female model. Bonnie Blackwell surmises in her article "*Tristram Shandy and the theatre of the mechanical mother*" that Smellie sidestepped publishing detailing on his birthing machine to give himself a monopoly in midwifery courses. (Blackwell, 2001)

Smellie's training including forceps and models would result in a new sort of practitioner called the man-midwife. An increasing number of these men-midwifes entered into vocational competition with the traditional female midwife, trained by apprenticeship, licensed by the church, and typically

present at home births. Men-midwives were predominantly medically qualified and had forceps and other tools at the ready when summoned to aid with delivery. The difficult tension between both parties proved disadvantageous for expectant mothers. Traditional midwives were on occasion hesitant to admit failure and call in a medical practitioner, while medical practitioners, who would often accuse their female counterparts of using outdated ancient practices, were known to blame midwives in instances of fatality to which they had been summoned due to medical complications, saying that they had been invited too late in the labour process to save the patient and/or child. (Allotey, 2011)

The rise of men-midwifery generated socio-political implications as well: Women of the upper classes would attempt to set themselves apart from the lower classes by employing costly surgeon/man-midwives, and lower-class pregnant women would in turn employ a man-midwife to attempt to match up socially. Man-midwifery as a result became a lucrative venture, particularly as extra income for doctors and surgeons already in practice. (Alottey, 2011)

This is also the subject of a prominent letter of dissent against Smellie by fellow medical practitioner William Douglas in 1748, in which he points out that open admission to his course meant potentially anyone (not just medical practitioners) could become a midwife, creating of course potential problems of incompetency within the practising world.

It has been suggested that at this time in history childbirth in Europe and the UK metamorphosed from a physiologically natural and manageable phenomenon into a female pathology of sorts: unnatural, unmanageable, and frequently exploited by doctors as a surgical event for their own profit. With male-midwifes on the scene, birthing children was no longer a vocation; it had become a professional privilege. (Blackwell, 2001)

the obstetric ‘phantoms’

THE PHILOSOPHY OF THE 'MACHINE' AND THE EMERGENCE OF OBSTETRIC SIMULATION DOLLS

Becoming influential in the 17th Century and onwards was Descartes' philosophical notion that the body and mind are separate entities. As a corollary of this, body and soul became academically divorced from each other, opening up the body itself to further scientific investigation. (Ehrenreich and English, 1973)

It is possible that the onset of industrialization also held sway over prevailing theories, creating a metaphor of the 'body-as-machine', and the woman consequently as mere 'reproductive machine'. Smellie noted himself in *A Treatise on the Theory and Practice of Midwifery* how his success unfolded when he '*began to consider the whole [process of assisted birth] in a mechanical view, and reduce the extraction of the child to the rules of moving bodies in different directions*' (Smellie, 1762, p.252)

Smellie felt that: "*In order to acquire a more perfect idea of the art, [the male midwife] ought to perform with his own hands upon proper machines, contrived to convey a just notion of all the difficulties to be met with in every kind of labour; by which means he will learn how to use the forceps and crotchets with more dexterity, be accustomed to the turning of children, and consequently, be more capable of acquitting himself in troublesome cases*." (Smellie, 1756 p.44)

One must also keep in mind that with the prevailing societal norm at the time ever extolling the virtues of propriety, the use of dolls and machines in place of actual patients preserved women's purity, while maximizing the possibility for 'live' demonstrations to those learning midwifery.

INFLUENCES IN THE DEVELOPMENT OF THE DOLLS

Professor Urs Boschung cites Georg Heinrich Langsdorf and C.E. Daniels as sources for specifically published research on the history of simulator doll models used in obstetrics up until the first half of the 19th century. Earliest findings indicate that already in 1715, Swedish Accoucheur Johan van Hoorne used some sort of 'phantom' in his weekly midwife training seminars:

> *"I preserved the Genitalia (Geburts-Glieder), and the bones (Beine) which form the pelvis, and also the flesh… and (also) made a stuffed child with limbs out of very thin and delicate leather, with which I showed the midwifes all operations, and especially the turning of the foetus in the womb."* (Translated from German by Stef Lenk, Boschung, 1981, p60)

There were two previous models that possibly serve as partial prototype and inspiration for Smellie's machines: The first, originated in France by M Gregoire at the Hotel Dieu in Paris, was an open work basket-weave (corset and hoop skirt) construction with leather pouches put inside, whale-bone stays to represent organs, and levers in the abdominal cavity. The operation would squeeze handles at the back of the model to give the mechanical sense of the actions of the womb during a contraction. In place of the womb a glass

(above) Similar obstetric phantom of the time (Italy, 1701-1800). Housed at the Wellcome Trust in London. (copyright Wellcome Trust Science and Society Picture Library

carafe was used, although it is said that Gregoire used real foetuses in his birthing lessons. (Blackwell, 2001)

Between 1740 and 1760 French midwife Louise du Coudray manufactured hundreds of her birthing mannequins to teach midwifery, first in Paris and then to over 4000 midwifes in the countryside of France. Her models were of soft sponge built on human pelvic bones with linen dolls, as well as clear and red fluids that recalled the glass veins and arteries of the model of blood circulation between foetus and mother. (King, 2007) Two of these models still survive at the Musée Flaubert in Rouen, France. (Musées en Haute-Normandie, [n.d]) and pictures of them can be seen online at http://www.musees-haute-normandie.fr/objet.php3?lang=en&idrub=72

DOCTOR SMELLIE'S MECHANICAL LABOUR DEVICE

It was upon his return from Paris in 1739 that Smellie began creating his own woman models out of real pelves with ligaments, muscles and skin in artificial materials, and used cloth dolls to simulate the foetus. The aim was to '*exactly imitate real women and children*' (King, 2007, p.133), different machines being used for different problems that the man-midwife may encounter. The womb was also represented by a glass carafe turned upside down, with a leather doll squeezed inside in configurations matching different possible breech births. Smellie's students and successors praised the dolls because they meant that "*every material circumstance might be laid open to the naked Eye*" (King, 2007, p.133)

Not everyone was in favour of Smellie's machines, however. Obstetrician William Douglas, a contemporary of Smellie, ridiculed Smellie's machines, saying:

> *"A Machine is used by most Masters, to give an Idea to their Pupils, in order to prepare them for operating upon the natural Subject; the nearer to Nature their Apparatus is, the more preferable; every good Master should use a natural Foetus in his Machine, as that is in some Measure Nature itself, and*

by it the Position of the Child, a very essential Part, is learnt; Instead of a Child, you make use of little stuffed Babies, which have rather amused, than instructed, your Pupils in the natural Members of a Child…" (Douglas, 1748, p.19)

He points out that the use of stuffed dolls to mimic the child does not accommodate the need of students to learn delivery through the sense of touch alone. This limitation was something not lost on Smellie, who dedicates the third lecture of his midwifery course to touch, and who notes in his texts that all these aids alone were not supposed to be sufficient to teach midwifery; students were also expected to attend 'real labours'. (King, 2007)

The construction of later obstetric machines would also address the significance of touch as a crucial learning factor. The models created by Friedrich Benjamin Osiander in 1794 in the Academy for Accouchement in Göttingen, were used during teaching in conjunction with real children's remains. He stated:

"… the artificial dolls are a pointless toy in this exercise; this because what is of primary importance is to be able to feel without the benefit of sight, a practice which could never be successfully learnt with artificial dolls." (Translated from the German by Stef Lenk; Boschung ,1981, p.61)

To return to Smellie's machines, Douglas also criticizes the glass carafe used for the womb; He explains that Smellie's lessons grant no genuine experience of the scenario, due to the ability of the student during his courses to *'[peep] over the Os Pubis and thro' Mr. Lambe's Glass Matrix'* (Douglas, 1748, p.21) (referring to the glass 'uterus', something which of course would not be possible in a real-life scenario.)

In comparing the machines with their predecessors, Douglas points out that Smellie's machines are "*covered with a kind of Silk, in Imitation of her Skin, and appears in her Buff; here she has the Addition of Shoes, Stockings, and the Common Apparel of Women, but of what Use are these to the Learner? The Pelvis of the French, is of natural Bones, as well as his, and as to the Cuticle, Ligaments, Muscles,*

and Contents of the Abdomen, they are only fit to amuse Midwives, and young Apothecaries, that don't understand any thing of Anatomy; but not worth the Notice of an Artist." (Douglas, 1748, p.25)

Regardless, the syllabus to Smellie's course shows that the 'Machines' were in regular use, alongside his own texts, drawings, and '*wet and dry Preparations, and other artificial Contrivances*' (King, 2007, p.133) to add to the accuracy of what was shown to the students. He also developed artificial wombs with hinges, some also with glass windows.

By 1747 Smellie had three machines, with six 'artificial children'. He continued to develop the dolls, one for example with a head that separated from the body so that he could demonstrate the difficult situation in which the head remained in the uterus after the rest of the body of a deceased child had been extracted with instruments. (King, 2007)

(facing page) frontispiece of the pamphlet with William Douglas's famed attack against William Smellie in 1748 | courtesy of RCPE

A LETTER TO Dr. *SMELLIE.*

SHEWING

The IMPROPRIETY of his New-invented

WOODEN FORCEPS;

AS ALSO,

The ABSURDITY of his METHOD

Of *Teaching* and *Practising*

MIDWIFRY.

By WILLIAM DOUGLAS, M. D.
Physician to his Royal Highness the Prince of Wales's *Household, and Man-midwife.*

Decipimur Specie recti.——— HOR.

LONDON:
Printed for J. ROBERTS in *Warwick Lane.* 1748.

(Price Sixpence.)

ONWARDS INTO THE 21st CENTURY

Not dealt with in this study is the further development of obstetric simulation models following those created by Smellie. Boschung refers to subsequent models by Johann Christian Stark and Friedrich Benjamin Osiander in the 18th and 19th centuries, which were further appropriated by later teachers of obstetrics and midwifery.

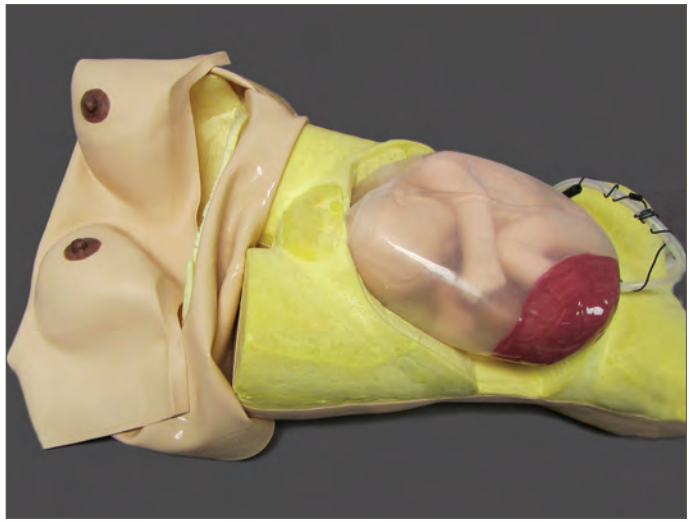
High fidelity simulation entered the health-care industry in the late 1980s. Since 1980, health-care disciplines have been taking steps towards incorporating simulation into training, evaluation and credentialing programs (Gardner, 2007) Modern 'machines' are anatomically correct female mannequins with the capacity to simulate some aspects of labour. Some mannequin mothers can be programmed to vomit as well as verbalize pain and anxiety. Equipped with a motor in its stomach, the machine is able to 'birth' an accompanying mannequin child and placenta.

There are a great many different varieties of modern obstetric training models, providing different levels of capability. Companies such as Anatomical Model, Adam-Rouilly, and Gaumard are but a few examples of manufacturers. Pamela R. Jeffries et al. and Roxane Gardner both offer comprehensive surveys of contemporary simulator types and clinical simulations for teaching midwifery and obstetrics. (Jeffries, 2009 & Gardner, 2007)

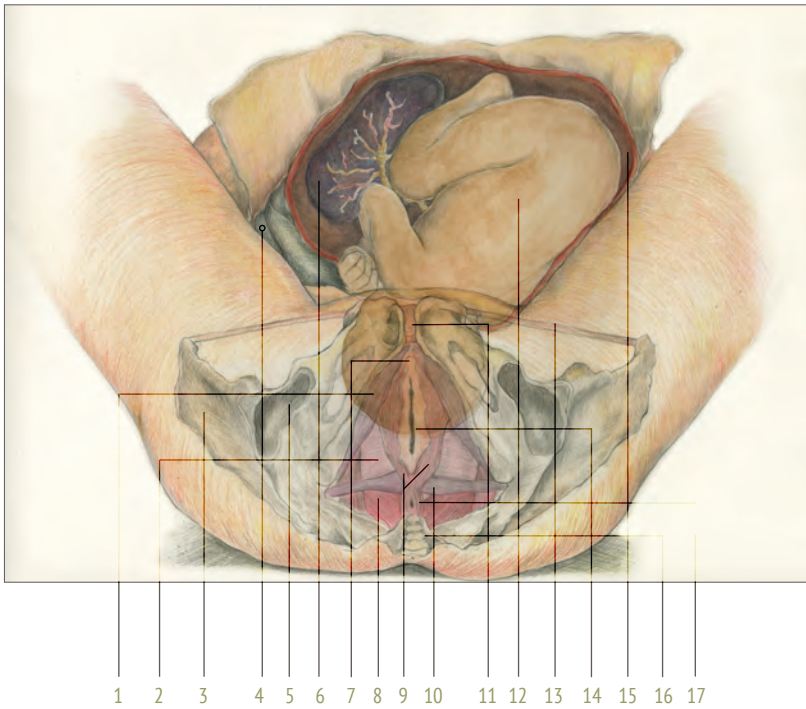
Proponents of these technologies claim that birth simulators improve students' confidence, time-management, leadership and critical thinking' (Nall, 2012). They help to identify clinical error, reduce clinical risk, and improve clinical outcomes.

However the more true-to-life the simulations become, the more chance there is of perpetuating the presentation of birth as always predictable, controllable, and as a pathology where birthing women are only passive patients (Nall, 2012). Medical anthropologists are concerned that the use of birth simulators reinforces the worrisome conviction that science and technology and the importance of institutions and machines prevail over the natural process of what is a purely physiological phenomenon (Nall, 2012) .

modern obstetric training model (outside and inside views) manufactured by Adam Rouilly courtesy of Professor Jean Ker, Clinical Skills Centre, University of Dundee | photos by Stef Lenk



machines as models
the anatomy of childbirth



THE GRAVID UTERUS

1. ischiocavernosus muscle
2. urogenital diaphragm
3. pelvis
4. small intestine
5. acetabulum (femoral joint)
6. placenta
7. clitoris
8. levator anii muscles
9. bulbospongiosus muscles
10. superior transverse perineal muscle
11. symphisis pubis
12. fetus
13. sacrotuberous ligament
14. vagina
15. uterus
16. coccyx
17. external sphincter muscle

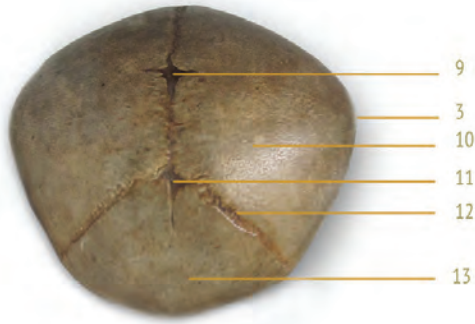
The size of the neonatal skull relative to that of the female pelvis (specimens courtesy of CAHID, University of Dundee)

THE NEONATAL SKULL

One of the primary benefits of being able to train with anatomically correct birth models is the opportunity to attempt different types of birth scenarios without endangering either mother or child. In order to illustrate this, photographic images and illustrations were created to be included in the website. Specimens of the neonatal skull and a female human pelvis were borrowed from the Scheuer Collection and the osteology collection, provided by the Centre for Anatomy and Human Identification at the University of Dundee.

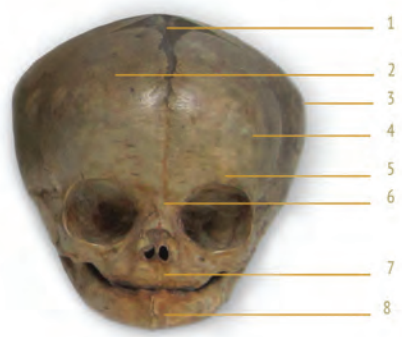
Anatomically, both halves of the pelvis are joined anteriorly at the pubic symphisis, a fibrocartilaginous (a mixture of fibrous tissue and cartilaginous tissues) joint that keeps the pelvis steady. During pregnancy, the symphysis pubis widens an average of 2-3 mm from the usual 4-5mm gap. The average gap is about 7.7mm. This widening of the pelvic ring helps facilitate the delivery of baby. (CARTA, [n.d])

lateral view

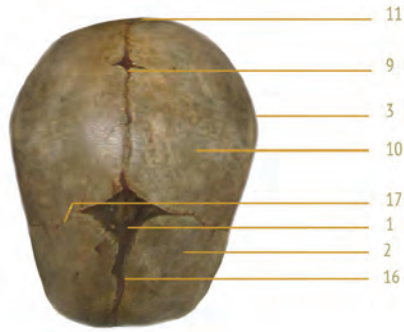


posterior view

One of the most obvious advantages to using a real neonatal skull in the obstetric dolls is the ability to imitate its pliancy when passing through the birth canal. The movement of the skull beneath the leather of the doll during a simulated taught delivery would have been as close an imitation of the real-life scenario as is possible, in a simulated situation. Photographic images of the anatomy of the neonatal skull were included on the website, along with a simple explanation of fontanelles: membranous areas that have not yet ossified in the developing cranial vault of the neonate. It is due to the fontanelles that the diameter of the skull can decrease slightly on its journey through the birth canal and can withstand increased intracranial pressure during delivery. (Jones, 2012)



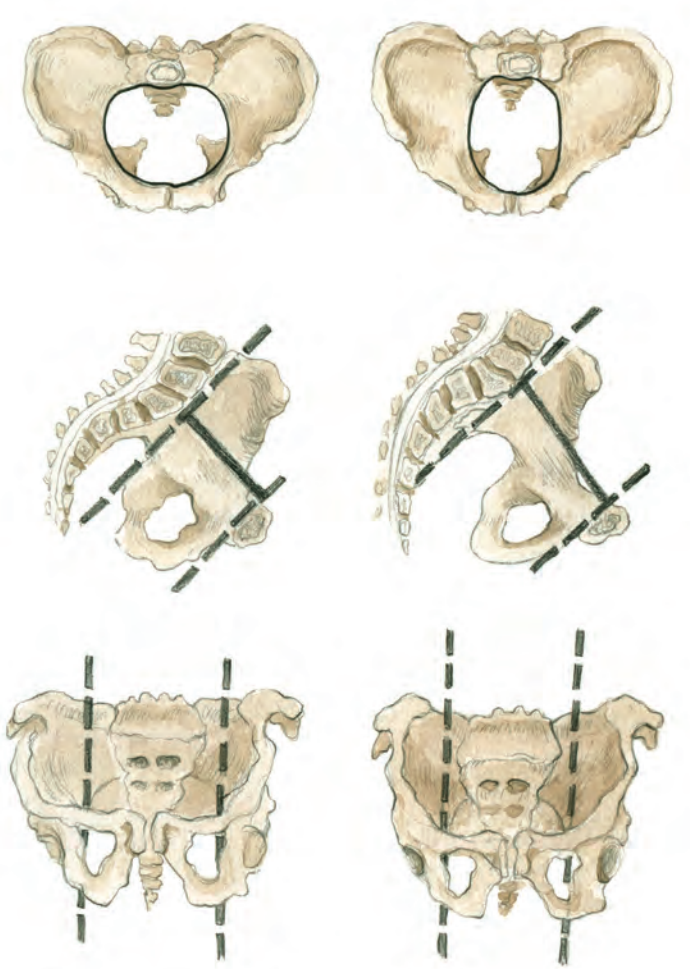
anterior view



superior view

1. anterior fontanelle
2. frontal bone
3. parietal eminence
4. frontal eminence
5. orbital ridge
6. glabella
7. maxilla
8. mentum
9. sagittal suture
10. parietal bone
11. posterior fontanelle
12. lambdoidal suture
13. occipital bone
14. temporal suture
15. temporal bone
16. frontal suture
17. coronal suture

(neonatal skull specimens courtesy of the Scheuer collection, University of Dundee)

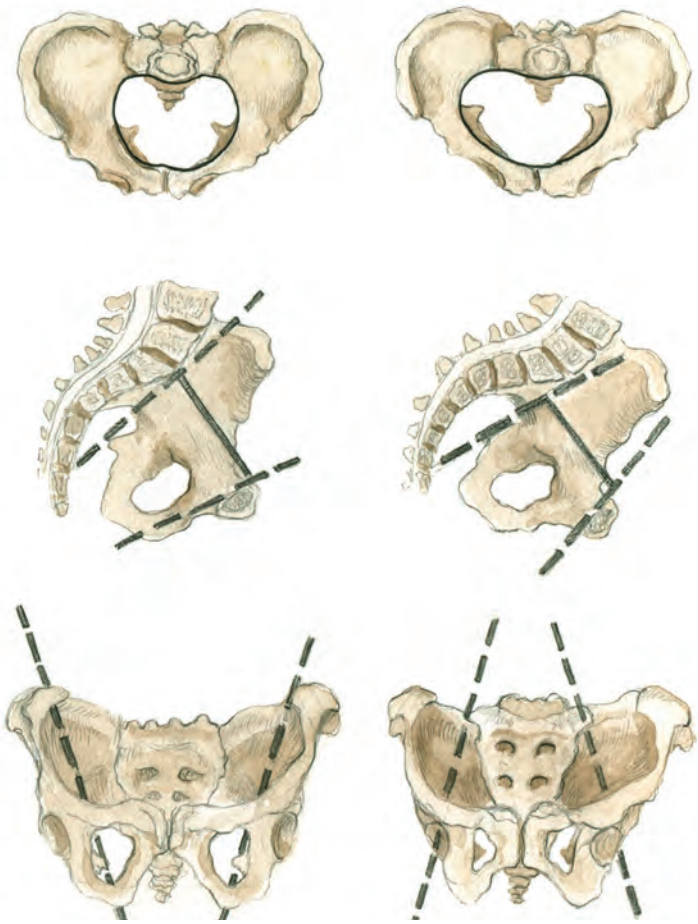


gynaecoid anthropoid

THE FEMALE PELVIS

Illustrations were made of the different types and shapes of female pelves, another primary concern during childbirth that teaching with the dolls would have made very clear.

diagrams by Stef Lenk, drawn after Hanretty, 2010



android platypelloid

There are four main types of pelvis (above spread from left to right) the gynaecoid, anthropoid, android and platypelloid. The directional lines in the diagrams indicate potential difficulties encountered in the delivery of the foetal head, due to shape and size of passage through the birth canal.

exhibiting the dolls

THE MEDICAL MUSEUM

Medical museums were built into all medical schools and many hospitals in the 19th century and were a prominent part of the medical education process until the mid-20th century. They served three purposes: preservation, education, and commemoration. Primarily an educational tool, medical museums provided specimens for students to recognize the effects of different pathologies on parts of the human anatomy. They also provided a historical chronicle of the development of medicine, through exhibited tools, drawings, wax and plaster models, as well as documentation. Preserved materials (wet specimens in alcohol and later formaldehyde solutions, dried specimens, and specimens injected with wax or other substances to demonstrate venous, arterial, and lymphatic systems) were used for teaching at a time when opportunities for human dissection were scarce (McLeary, 2000).

These museums were the 'real-life' object equivalent of libraries, though far more valuable, inasmuch as the information they provided was three-dimensional. Also, anatomical specimens were real and direct proof of the effects of pathologies and different attempts and methods at medical cures. (McLeary, 2000)

The medical museum no longer plays as prominent a role in medical educational facilities or curricula, mainly due to modern day technology and the popularity and accessibility of the Internet and digital resources. Access to the materials once prominent in museums is often limited to practitioners in the field or academics who have been granted special permissions for research purposes.

But although our understanding of anatomy has changed very little over the past few centuries, the pathologies we have come into contact with, including complications during childbirth, are continually evolving, as are the techniques we use to deal with them. The contents of these museums are still very much relevant. How best to disseminate that knowledge to the public and practitioners in the field, as well as to prevent these objects from becoming obsolete, does bear further scrutiny.

MUSEUM AS EDUCATIONAL ENTERTAINMENT

It is important to acknowledge that most museums today share a vocabulary (if not also a physical location) with entertainment. Museum visits could all too easily be grouped together as mere tourist attractions along with carnivals, sideshows, and other popular diversions. This is not strictly a modern phenomenon: in her 'Anatomists and Entrepreneurs in Early Eighteenth century London", Anita Guerrini argued that waxworks and machines representing the body were part of the culture of fairs and curiosities, in which science and street performance overlapped not only to spread information, but also to instil a sense of wonder to viewers. (Guerrini, 2004)

It is very important not to undervalue the contents of museums, whose objects are concrete markers of our history (in contrast with representations of objects, or written descriptions of objects, both of which are one step removed from reality.) Through their collections, museums have a great potential to educate, and through that to influence our quality of living and our understanding of ourselves as human beings.

The practice of learning through objects, however, is not as simple as just putting them out on display for the world to see. This because, although in the museum "*our attention is drawn to the object by the use of several framing devices: the plinth, the glass case, the spotlight…* [these devices] *invite us to look at the object. They don't… tell us what to look for in the object.*" (Giebelhausen, 2006, [n/a]).

Without context or prior expertise, the uninformed viewer has no starting point for understanding the significance of an object, and the knowledge gained from seeing the object has very little potential to educate. Through research and accompanying texts, posters, explanations, and modern interactive media, there are ever more avenues for recreating the relevant context that gives objects their significance.

In summary, it is the curator/researcher's job to create a narrative of sorts, to grant the audience access to the 'life' surrounding the object. This can be challenging, for, as S. Alberti

states in 'Objects and the Museum': "*Objects themselves are mute… and many museum things have insufficient associated literature and provenance details to sustain an in-depth study* "(Alberti, 2005, p37)

Igor Kopytoff suggests that the recording of a history of an object is not so unlike the recording of a history of a person. The same questions can be asked: where did the object come from? What were the important events involving the object? What was the socio-political climate at the time of the object's existence, and at what point and why (if at all) did the object lose relevance/become obsolete? (Alberti, 2005) In answering these questions, a narrative about the object begins to develop, providing the context necessary to accurately present the object for educational purposes. Personal interpretations and projections made upon objects by researchers and experts dealing with these questions must also be taken into account when presenting results of research, and/or putting objects on display.

photo by Stef Lenk | specimens courtesy of Scheuer Collection and University of Dundee

ROYAL COLLEGE OF PHYSICIANS OF EDINBURGH

Established in 1681, the Royal College of Physicians of Edinburgh (RCPE) was founded by physicians meeting in each other's homes to discuss the ways in which standards in medicine could be improved. Although the RCPE mandate makes no mention of the Library or the various artefacts they hold (Donaldson, 2012), the RCPE does have an extensive library and archival collection.

Because the RCPE has no official exhibit space, much of their non-print holdings find their way to the public via their website. There is a link on the RCPE homepage to online exhibitions of objects initially linked to educational symposia. The Sibbald Library Project (named after Robert Sibbald, one of two founding members of the College) is an undertaking aimed at increasing public access to RCPE's collection.

In spring 2009 Wellcome Trust Research Resources funded a report on the RCPE archive. The report praised the quality and condition of the archive but indicated that a lot of the collections were effectively invisible due to the lack of information available on the contents. As a result of this, the College put in a bid for Wellcome funding to improve cataloguing standards and was awarded a grant in June 2010. (RCPE, 2012)

The project is using Calmview (Calm for short) allowing fully web-enabled access to the collections that have been catalogued so far, with more to follow as the project develops. Calmview is a user-customized windows-based collection management system designed for online showcasing for museums and galleries in a public-friendly format. Calm manages object entry, loans in and depositor records, multi-media object cataloguing, location and movement records, conservation, and of course internet/intranet access. (Axiell, 2012)

Some interesting items also have come to light in the process, which the RCPE intends to highlight via College Collections Showcase, linked to the College's homepage. (RCPE, 2012)

THE ETHICS OF EXHIBITING HUMAN REMAINS

The human neo-natal crania inside the dolls raise the question of exhibiting human remains, which would inevitably be an issue in planning public presentation of the dolls.

The way people interact with death through human remains has changed over time. Sledzik and Barbian, referring to the mentality towards death in the 17th and 18th century, cite from Frank Gonzalez-Crussi's 1995 book *Suspended Animation: Six Essays on the Preservation of Bodily Parts:*

> *"…past generations were able to establish a certain communion with the dead, a certain intimate commerce that seems no longer possible….Death was not, as in our days, a spectral, terrifying image whose presence must not be evoked in polite conversation. It was a harrowing but concrete everyday reality. Consequently, the realm of the dead and the ambiance of the living were not cleft from each other as they are now, but closely adjoined to each other."* (Gonzalez, Crussi, 1995, p.86, as cited by Sledzik and Barbian, 2001)

Today, apart from medical professionals, people have very little contact with human remains except in the saddest of circumstances (illness and loss of loved ones, news footage from world disasters) The association, therefore, is rarely a happy one, and one that is the root of considerations when displaying anatomical specimens in a museum or online environment.

Nevertheless, Skedzik and Barbian write about the fundamental ethics of exhibiting human remains: "*Museums, as the stewards of history, have a commitment to maintain biological materials. Denying the visitor access to these materials denies them knowledge of themselves.*" (Sledzik and Barbian, 2001, p.26)

With the exception of the Royal College of Surgeons' Hunterian Museum, British anatomy museums that were open to the public in the 19th century are now (unlike in

Italy, Germany and Switzerland) for medical personnel only (Andersen, 2012). And yet, as pointed out by Y. Michael Barilan, of the three key components of exhibiting the human body or parts thereof—personal story, authenticity and demonstrativeness of a marvel, authentic anatomical exhibits are endowed not only with authenticity, but the innate presentation of a marvel. (Barilan, 2005) That this material should be denied to the public seems unethical in and of itself.

It is important to evaluate the difference between potential viewers of human remains. The medical professional is not only accustomed to seeing such objects, which can be psychologically unsettling, they are interested in the 'findings' presented by such material, disassociated from the life of the person it once belonged to. Indeed, "*Medical doctors are the only professionals who enjoy widespread social permit to dissect the body and to behold it, while ignoring the person*." (Barilan, 2005, p.11)

The public, not having the privilege of precise knowledge of what they are seeing, are more inclined to need and want a background, a story, and a general context for the object in order to understand it. Visitors can view everything from human hairballs to foetal specimens with abnormalities displayed in glass bottles. Ethical measures need to be taken to allay the potential disgust and associations with mortality that may repel an uninformed viewer, or the possible diminution of objects to 'freak show' material. One way to do this is to prohibit as much as possible a disregard for the person to whom the remains belonged, or at the very least (should that knowledge not be available), some historical context for that person.

Proponents of these displays at the museum maintain that the initial disgust that many viewers feel is essential to the viewing experience, causing visitors to react strongly and then look closer at what is really at hand. In their article "From Privates to Presidents," Barbian and Sledzik advocate that viewers should "*think beyond the disgust and aversion to the inner meaning of both the beauty and complexity of the human body and the person who left it for us to examine*." (Sledzik and Barbian, 2001, p.22)

The International Council of Museums (ICOM) specifically addresses the display of human remains, stating that they should be "*displayed in a manner consistent with professional standards and, where known, [should take] into account the interests and beliefs of members of the community, ethnic or religious groups from whom the objects originated. They must be presented with great tact and respect for the feelings of human dignity held by all people*." (ICOM, 2006, p.8)

The Department for Culture, Media and Sport in the UK believes that:

> *"Human remains should be displayed only if the museum believes that it makes a material contribution to a particular interpretation; and that contribution could not be made equally effectively in another way. Displays should always be accompanied by sufficient explanatory material"* (DCMS, 2005, p.20)

The Wellcome Trust also has a policy on public display of human remains: They consider

> *"…that there is a strong educational value and high level of public interest in displays featuring human remains. … Careful thought will always [have] been given to the reasons for and context in which remains are displayed."* (Wellcome Trust, [n.d])

It is these guidelines that give strength to the notion that the two RCPE obstetric dolls would be well served by an accompanying 'digital dissection' when exhibiting them.

THE DIGITAL DEMOCRATIZATION OF KNOWLEDGE | Computers in an Exhibition Context

The benefit of museums has always been that they offer objects themselves to the viewer, in three dimensions, in their real and unmistakable form. This is something books, pictures, and texts cannot offer, with their two-dimensional formats of visual representations and/or written interpretations of objects.

Modern technology, including products of the Internet and 3D software programs, presents a helpful intermediary. With these technologies we are able to replicate objects in three dimensions, sometimes with a remarkable similarity to the originals, allowing viewers to see the objects without potentially damaging them, which is inevitable when rare and/or irreplaceable items are on public display or handled by many.

3D digital representation also offers a sort of psychological buffer when dealing with sensitive materials such as human remains. Seeing a *representation* of human remains offers a shield of sorts, from the potential psychological impact that real cadaveric remains present.

In terms of the accessibility of objects, modern developments in the medical industry have taken us even further into the hitherto unseen elements of things; Through CT scanning and x-ray technology, we are able to see inside people and objects in a non-invasive way. This maximizes our ability to understand both the inner and outer life of an object, and to pass this knowledge on to others.

Websites democratize access to this information. In the case of this project, the creation of a website puts the obstetric dolls into historical and practical context, and the digital replication of the external and internal structures of the dolls means the extant human remains can be represented in an ethical way, whilst preserving the objects themselves. The audience has a chance to examine them from all angles, including the internal structures of the wireframe and the neo-natal crania sewn into them.

This accessibility also provides museums with a new way of proving their relevance in an increasingly mobile and financially limited world. Today's museums' need for financial support is in competition with things as varied as online films, downloads, and e-books, many of which are more enticing to the public because they cost little and are easily accessible. Internet resources also offer the appeal of interactivity (the mere act of clicking on links to access further information etc. is proof of this). When people are engaged with something through interaction, they maintain an active role in the process of learning, (Cairncross, 2001) and a greater potential exists for them to create a personal significance between the objects and themselves. Through the Internet, the object is no longer separated from the viewer via glass boxes or boundary lines. The object becomes a personal experience.

FURTHER BENEFITS OF MULTIMEDIA IN EXHIBITION MATERIALS

Studies have proven that people retain information in different ways: Richard Riding provides an extensive analysis of these cognitive styles in his 1997 "On the Nature of Cognitive Style". In summary, some prefer learning through audio media, some through visual; some represent information better verbally, and others prefer written text.

Multimedia, of which websites offer the most inclusivity, enables curators and designers to use different elements to convey information congruently, including audio, video, visual imagery, and text. Users also have their own control over said information: they can engage with the material at a time, place and speed convenient to them, and through hyperlinks they can navigate specifically to areas of the subject that are of most interest to them.

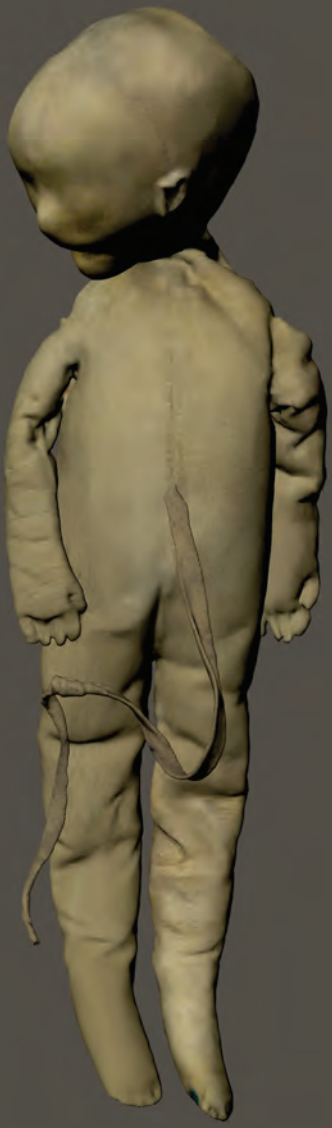
Cairncross and Mannion's 2001 article "Interactive Multimedia and Learning: Realizing the Benefits" is a survey of studies that have been done into human-computer interaction, learning theory, and developing guidelines for design of screen layout, particularly with images and text. Considerations in creating interactive multimedia involve moving the emphasis

from learning as strictly reproducing knowledge to learning as transforming knowledge. They cite Mayes's argument that most important research findings from cognitive psychology include learning as a by-product of understanding, and that understanding is best achieved through performing tasks. (Cairncross & Mannion, 2001) In this context, tasks are defined as interacting with the material.

In terms of limitations of the medium:

> *"if potential problems, such as memory overload, divided attention and disorientation are to be prevented, then human psychological limitations, such as memory, perception and attention must be considered when designing interfaces. "* (ibid, p.158)

It is also beneficial to acknowledge the daily environment and its influence on potential viewers. The surfeit of dynamic video and audio material confronting most westerners in perpetuity through exposure to television, advertising, and film suggests that the use of similar media can provide a familiarity of sorts, increasing engagement and enjoyment of exhibit material more efficiently than static data.



methodology
animation and website

doll one

doll two

Photos by Stef Lenk
Dolls courtesy of the RCPE

doll one

doll two
Xray data of the dolls courtesy of the RCPE

ABOUT THE DOLLS

Upon commencing the project, it was explained by Professor Ian Donaldson of the Royal College of Physicians of Edinburgh that it is unknown as to how the dolls came to be in their possession, but that they are either similar or identical to those used by obstetric practitioner William Smellie, who was famous for using such models to teach male-midwifery in the 1800s.

CT scans of both of the dolls had been produced on a Toshiba Aquilon One 320 slice clinical scanner at the Clinical Research Imaging Centre (CRIC) at Edinburgh University (Murchison, 2012). A high definition protocol was used for scanning, and the dolls were scanned at .5mm thickness with intervals of 5mm in a helical mode (as opposed to a volume mode). The image kernel was FC8 (Hendry, 2012)

The CT data for the smaller doll (doll one) was incomplete, so the feet were rescanned at RCPE using a Polymes Fastscan Scorpion handheld 3D digital laser scanner. This data was cleaned up in the same way as the CT data and then imported and joined with the digital image to the rest of the doll.

The dolls are both 48 cm long. Doll one is approximately 14cm wide and doll two approximately 17cm wide, and both are hand-sewn out of a tan-coloured leather. X-rays (made by the radiology department of the Royal Infirmary of Edinburgh for RCPE), revealed the presence of neonatal crania, as well as folded packing material of some sort in the orbits of each doll. The dolls bodies' are filled with horsehair or a similar material, as well as wireframes at their cores. Dr. Suzanne Duce of the University of Dundee verified this information by examining the CT data through the software program Amira: because the image signal comes from dense solid objects, metal appears very bright (almost white) in the digital data, and air appears very black. Hair provides an image signal, and denser hair even more signal (aka more white in the image) (Duce, 2012)

Each doll has its own distinguishing characteristics. The cranium of doll one is broken beneath the leather (shards

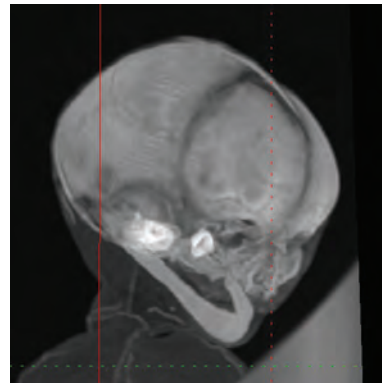
appear in the digital data that are still embedded in the stuffing within the cranium), making it possible that the cranium was damaged whilst the doll was being used in obstetric training. It also has an inflexible twist in the neck area, so that the head faces consistently to the left.

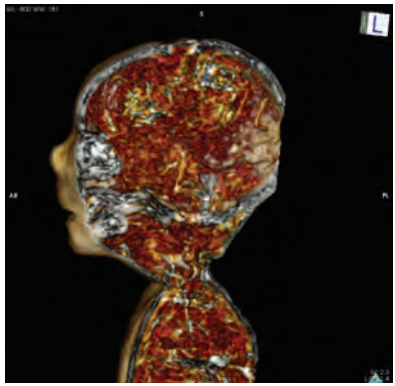
Doll two has small marks in the maxilla area faintly reminiscent of a moustache, and red fabric has been sewn into the mouth area.

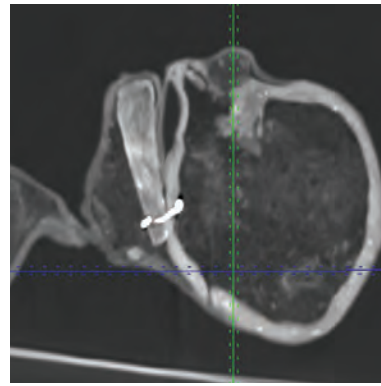
The mandibles are not genuine human mandibles, but are carved out of (animal) bone or similar material and appended to the crania before being sewn into the dolls. It is not exactly clear out of what they are constructed. Professor Sue Black of the Centre For Anatomy and Human Identification at University of Dundee states that "*one of [the mandibles] is made out of several parts because you can see the join lines [and it] is not uniform because there is the appearance of a cortex. But it is very dense in the centre and not really like bone at all.*" (Black, 2012)

(above) rescanning the feet of doll one at RCPE | photo by Professor IML Donaldson

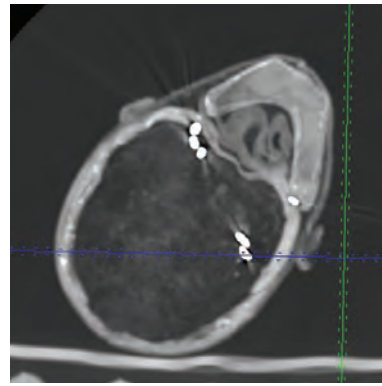
(above) initial CT scanning of the dolls photo courtesy of Prof. IML Donaldson and RCPE







(above) Osirix is a DICOM image processing software, similar to Amira, for Mac platform computers. Opening the dolls data in Osirix resulted in different views of the inner construction of the dolls, including the above, which clearly illustrates both the horsehair-like material used to pack the crania, and the paper-like material used to augment the facial features of the dolls.
(right, top to bottom) Amira image analysis of mandibles of the dolls (top and middle) doll one and (bottom right) doll two



THE DIGITAL DATA

The CT data was imported into a software program called Amira ® (version 5.4.2), software used for visualizing, manipulating and understanding life science and bio-medical data. It was broken down into orthoslices: 841 slices for doll one (smaller than doll two probably due to the missing feet) at a voxel size of .342x.342x.5, and 1020 slices for doll two at a voxel size of .366x.366.x.05 .

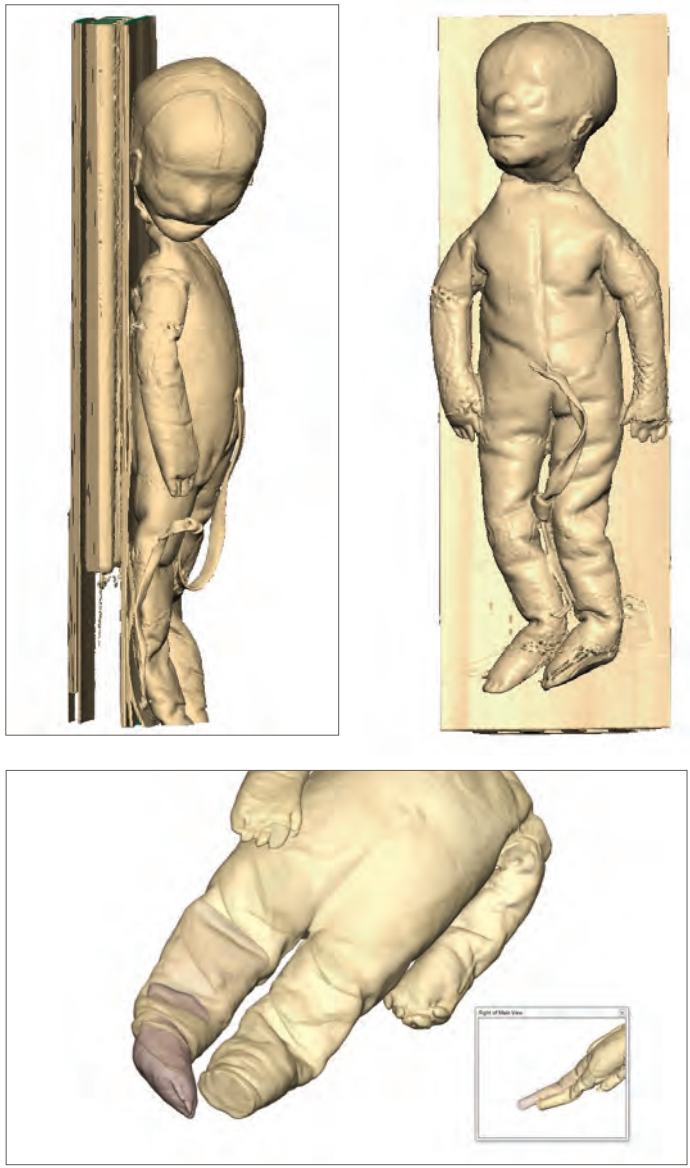
Isosurfaces were then made of the imported data to view the different internal structures of the dolls. The results were six STL files, one for each of the skulls, one for each of the dolls' bodies, and one for each of the constituent wireframes holding the dolls' structures in place.

These files were all brought into the software program Freeform (version 11) to clean up residual artifacts from the CT data, to clarify details on the models, and to reduce file size where possible in order to expedite file processing in Maya at a later stage. Freeform is a 3D output system allowing the practitioner to work with virtual clay, using a haptic arm device to 'touch' and manipulate the surface of the object.

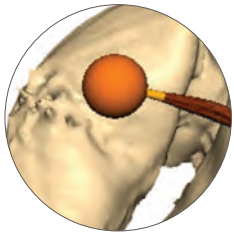
First the artefacts surrounding the objects were selected and deleted. This included the platforms on which the dolls lay during scanning, as well as random digital information occasionally scanned by the CT machinery, but not a part of the objects themselves.

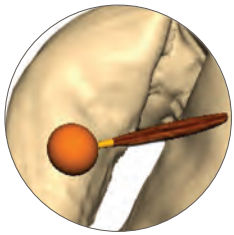
Digital carving tools and the smooth tool were then used to clean up residue left by deleted data, and to ensure the shape of the dolls, skulls and wireframes was as true to their original form as possible.

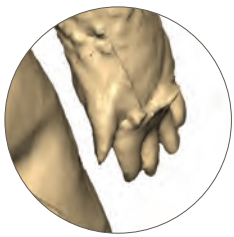
In the case of doll one, data from the digitally re-scanned feet was also cleaned up and imported into the corresponding Freeform file, at which point the feet were appended onto the body of the doll.

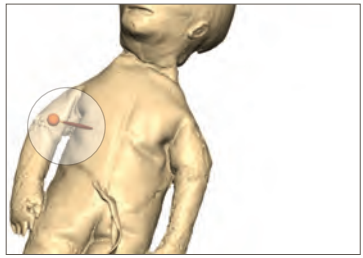


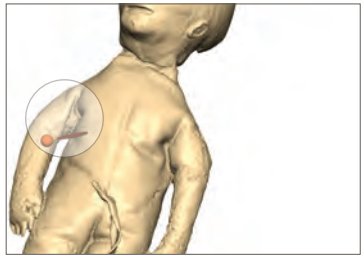
(top) original CT data for (l) doll one and (r) doll two
(bottom) Appending of doll one's feet from 3D digital scan data

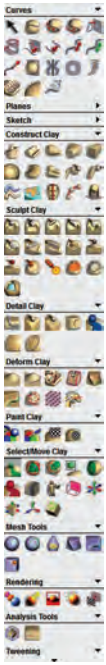




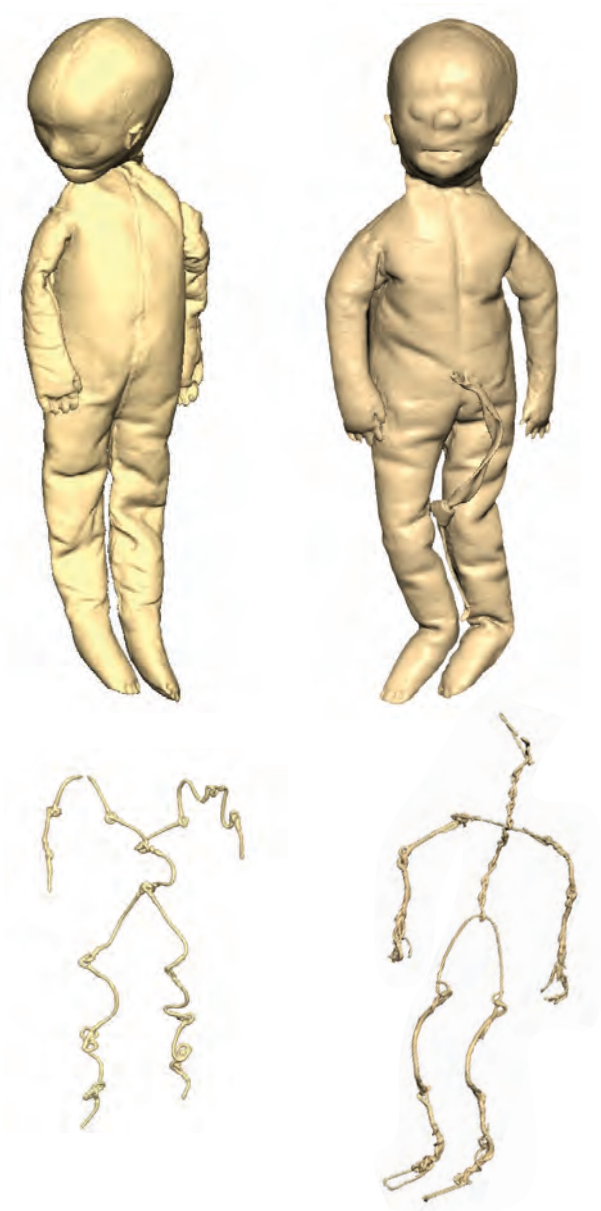








(top two rows) full screen and closeups of smooth tool in Freeform
(above) closeups of cornroll sculpting tool in Freeform
(far right bottom) freeform toolbar
(right) doll two with CT platform selected (in green) for deletion



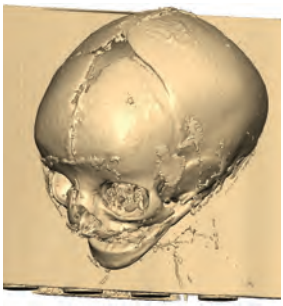
Both dolls and their wireframes after cleanup in Freeform. (l) doll one (r) doll two

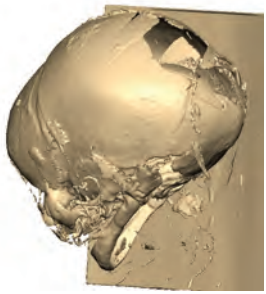
THE SKULLS
Extra CT data from the Scheuer Collection

The skulls needed additional processing in order to be ready for 3D rendering. Doll one's skull is broken; this presumably happened after it was sewn into the form, as the shards show up in the CT data embedded in the stuffing in the cranium of the doll. Doll two's cranium surface was barely discernable in the CT data, possibly because of similar density of the dried leather to the bone, making it difficult to discern the leather 'skin' in the head area from the actual cranium. The CT data also had some areas of weakness (i.e. little extant visual data due to the bone being very thin), which needed to be digitally corrected to render specific features of the skull discernible.

It was decided that the most efficient way to create useable visual representations of the skulls for the 3D animation was to superimpose better quality CT data of neonatal crania on the RCPE dolls to create reliable visual composites to be used in the animation.

Two skulls were selected from the Scheuer neonatal collection at the College of Life Sciences at the University of Dundee, and CT data for both of them was acquired. Data was chosen that reflected the dolls' crania as closely as possibly, so that form and facial construction would match. Doll two's corresponding skull had visible dentition within the tooth crypts: Dr. Craig Cunningham stated that "*this is normal[;] it is likely that with*





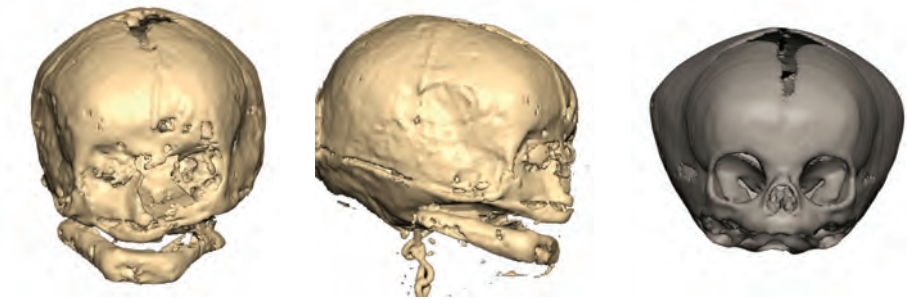
higher resolution you would have been able to visualise these teeth in the obstetric dolls as well." (Cunningham, 2012) He also verified that this dentition is not present in all neonates, which explains why tooth crypts are not visible in the data belonging to doll one.

The data of the two Scheuer skulls was brought into Amira and isosurfaces created and saved as STL files (as explained previously) before being brought into Freeform to aid in the digital correction process for the dolls' crania.

They were then superimposed onto the doll crania, and scaled and tugged to match. The priority was to keep as much of the original information from the RCPE data as possible, while still being able to illustrate with anatomical precision what neonatal skulls inside the dolls would look like.

In the case of doll one, extraneous data from the Scheuer skull was deleted to make the composite. In the case of doll two, fundamental detail of the anterior of the cranium was missing, and so for the purposes of exhibition and explication the Scheuer cranium was modified to as close an approximation of the doll cranium as possible, and this image was used to proceed with the 3D rendering. The mandibles from the RCPE data were joined to the composite skulls before bringing the files into the next stage of visual reconstruction.

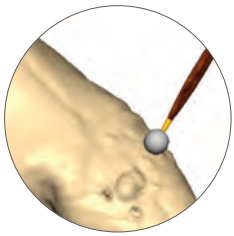
(l and c) digital skull data of dolls skulls before cleanup in Freeform and (r) CT data (cleaned up) of Scheuer specimens | (opposite page) doll one (below) doll two

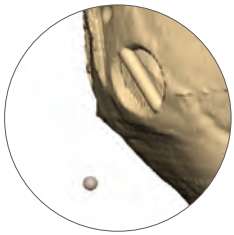


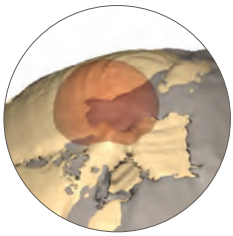
(right) Superimposition of the Scheuer crania onto the dolls crania:

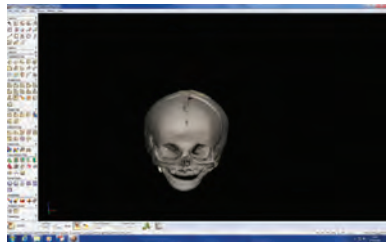
Doll one: original data in grey, Scheuer data in tan
Doll two: original data in tan, Scheuer data in grey

(below) Detail images of (top) toothpaste fill tool, (middle) create clay tool, and (bottom) tug tool in Freeform.

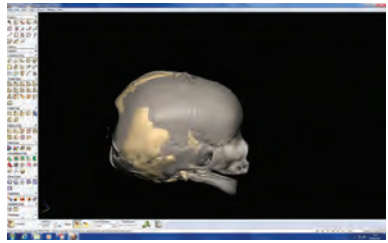




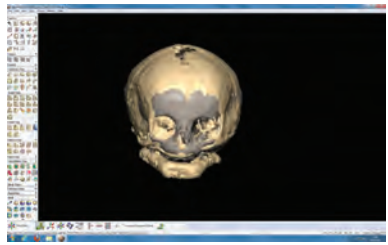




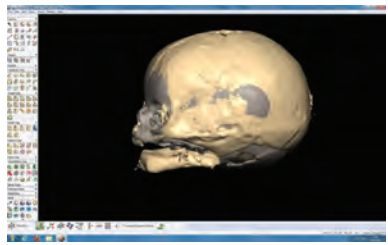
doll one



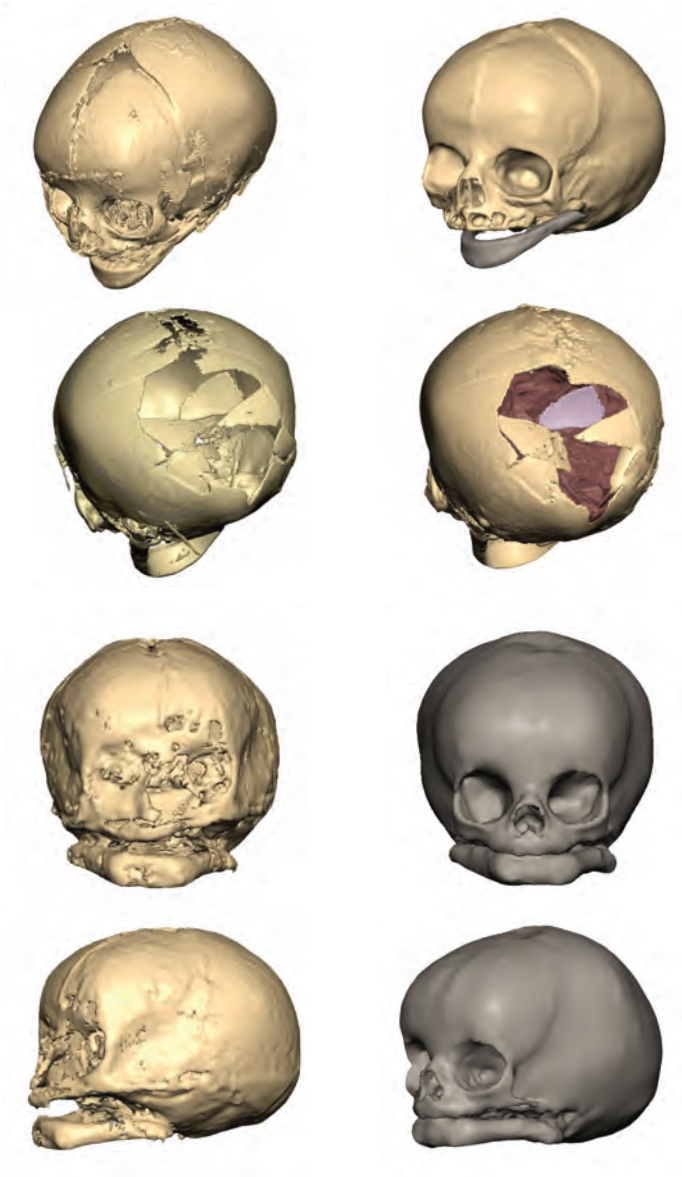
doll one



doll two



doll two



comparison between original CT data and final composites before being imported into Maya (top to bottom) doll one (front and back) and doll two (front and side)

TEXTURING THE MODELS

Upon completion of the digital 'clean-up', the freeform files were then imported into Autodesk Maya, a 3D digital modelling, simulation, compositing and animation program.

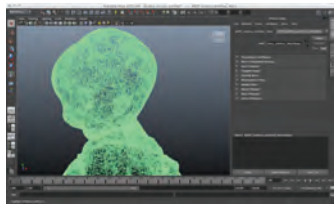
The initial stage for all components of the dolls was a preparatory one of reducing polygonal geometry that had been exported by Freeform, in order to make the files a workable size. This was done by using the mesh—reduce command in the polygons submenu of the program. This function joins minute geometrical faces into larger ones, reducing the overall number of faces and hence the size and complexity of the file, which can interfere with the texturing and animation process.

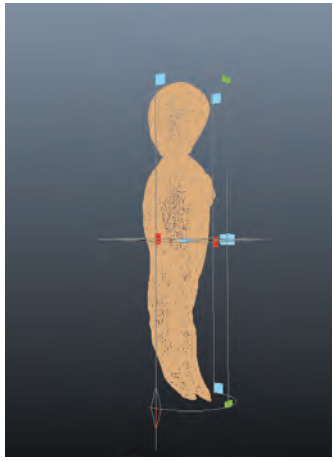
The dolls were then UV mapped in order to be textured. UV mapping is a process by which the geometry of the objects is basically 'unfolded' into a two-dimensional map, which can then be exported into different software (in this case Mudbox and Photoshop) to be painted on and textured. Texturing is a term applying to visual components that re-create the surface of an object in a realistic fashion. In this instance, details such as the texture of the leather, the seams of the dolls, and distinguishing characteristics and marks were visually compiled to create a composite that accurately reproduced the real objects digitally.

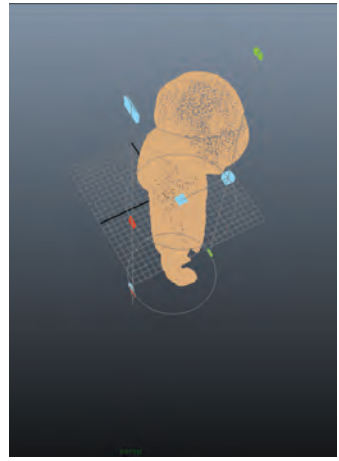
Upon completion of the texture map, the file (with its 2D coordinates now 'painted over' with visual information) is re-imported back into Maya and applied to the three-dimensional doll; the two-dimensional coordinates correspond spatially to the three dimensional coordinates from which they were originally translated.

UV MAPPING

There are several methods for UV mapping and texturing, many of them hindered by the fact that CT scan data such as that created from the dolls is infinitely more complex and geometry-rich than most models made specifically for Maya texturing and animation. The digital information when

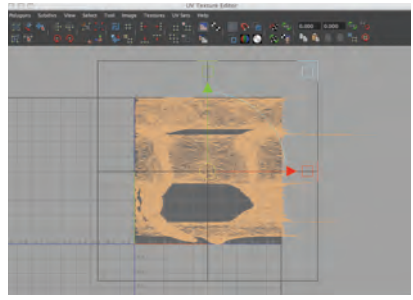






(top) reducing geometry of the dolls in Maya (l) before and (r) after

(middle) cylindrical UV mapping in Maya (doll one)



(above) the resulting 'unfolded' UV map of the entire doll, shown in the Maya UV editor window, before exporting to zBrush.

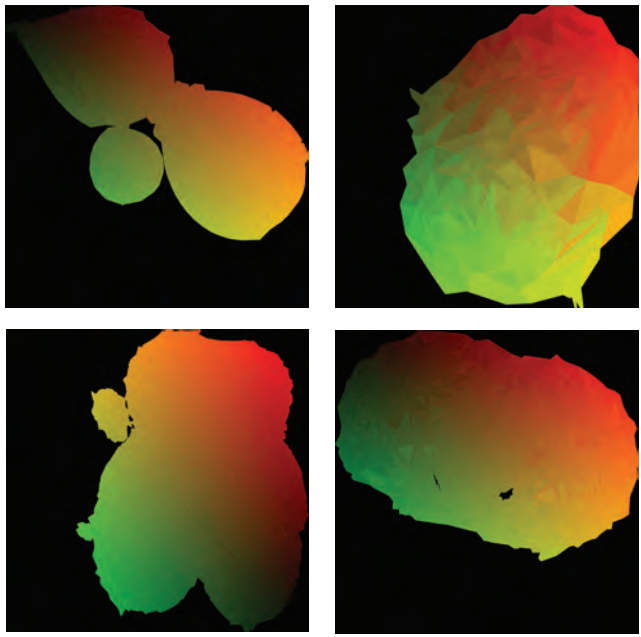
'unfolded' becomes incomprehensible and therefore not easily textured with any accuracy.

Before beginning, the umbilical cords of the dolls were selected and saved as separate objects. This was done to make the geometry of the dolls less complex. The umbilical cords were later UV mapped and textured in an identical process to that which follows, and reimported and regrouped with the dolls' bodies.

For the dolls' bodies a cylindrical UV map was generated for each, and these maps then exported into the digital modelling/ texturing program zBrush. A plug-in entitled UV master was used to take the extant UV maps and re-model their geometry to be compatible for direct texture editing.

The zBrush UV maps were reimported into Maya, inverted so that they were on the correct axis for placement, and then exported into Mudbox, also an Autodesk program, used

The UV maps as modified by zBrush's UV master plug-in: doll two (clockwise from left) umbilical cord, mandible, body, and cranium



primarily for high-res digital sculpting, texture painting, and displacement. The interface for Mudbox is very similar to Maya, but it is used primarily for working on the surface of objects, and offers paint tools such as airbrush, clone, dodge, burn, and others similar to Adobe Photoshop, a 2D photo manipulation program.

PHOTO STENCILLING

In preparation for the Mudbox process, two hundred and fifty four digital photos had been taken of both dolls collectively with a Canon SX210 IS digital camera, to be used as reference material in the texturing process. Out of these photos, images that had the least shadow and the most detail, clarity and accuracy of features were chosen and brought into Photoshop, where they were colour corrected to match each other as closely as possible. Tools used were levels and curves to modify colour luminosity (levels of blacks, whites and greys within the colour), and colour balance to modify hue and saturation.

The resulting photos were then collaged as closely as possible in Photoshop to recreate a hypothetically 'unfolded' version of the doll. This was done to have a visual preview of potential inconsistencies at the joining seams of the photos, when applied to the 3D objects.

These photo collages, as well as colour-corrected close-ups of defining features of the dolls were imported into Mudbox as stencils. Stencils were then interchangeably digitally impressed onto the 3D surface using the stencil brush tool. The object was slowly rotated until the entire surface of the doll was stenciled with the corresponding details found in the two dimensional photographs. Inconsistencies of colour as well as visible seams were corrected using the clone tool, which selects closely situated pixels and echoes their values overtop of the selected area needing correction.

Once the objects had been fully stenciled, the resulting file was once again exported as a TIF file. This was opened in Photoshop for final colour correction and cloning inconsistencies, and was then applied to the doll in Maya, as a texture attachment to a basic lambert shader. Because the file

was created corresponding directly to the 3D UV map of the object, the features were automatically grafted into correct position on their corresponding 3D surface.

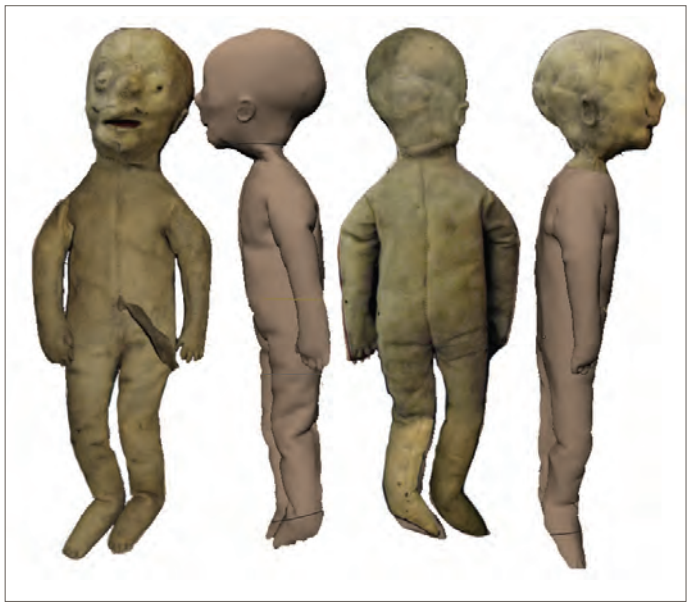
An identical process was followed for the skulls. Cylindrical UV maps were made in Maya, re-modelled in zBrush, imported to Mudbox (via Maya) and then stenciled with photo reference of the Scheuer crania, which had been used in originally creating a 3D composite of the doll cranium.

The mandibles of both dolls were textured separately using a lambert shader attached with a Photoshop file of a generic bone texture. This was done to ensure they would not be confused with the same osteological material of the neonatal crania.

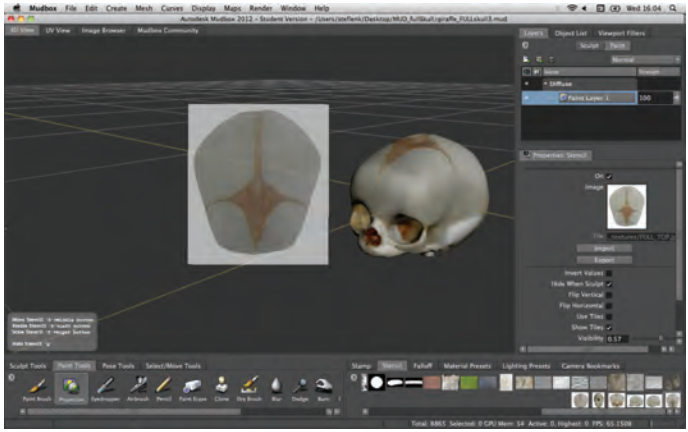
The wireframes were coloured with a blinn shader, chosen for its luminescence, to reflect the surface of metal. A rusty brown colour was chosen to aesthetically echo the probable age and state of the wire. It should however be stated that there is no evidence as to what kind of metal was used for the wireframes, and the colour chosen for the animation should not be assumed to be empirically correct.

After texturing each element of each doll, all elements were re-imported and positioned in relation to each other in Maya. They were then grouped in terms of what would be visible/moving at any given point in the animation. The leather and the umbilical cord formed one group, and the cranium, mandible and wireframe formed the second group (one for each separate doll)


(above) photo-reference material for texturing
(l) before colour correction (r) after colour correction
(the drastic difference in colour between different shots of the dolls is due to different lighting conditions at the times the photos were taken. Consistent lighting would improve results greatly in future endeavours of this sort)

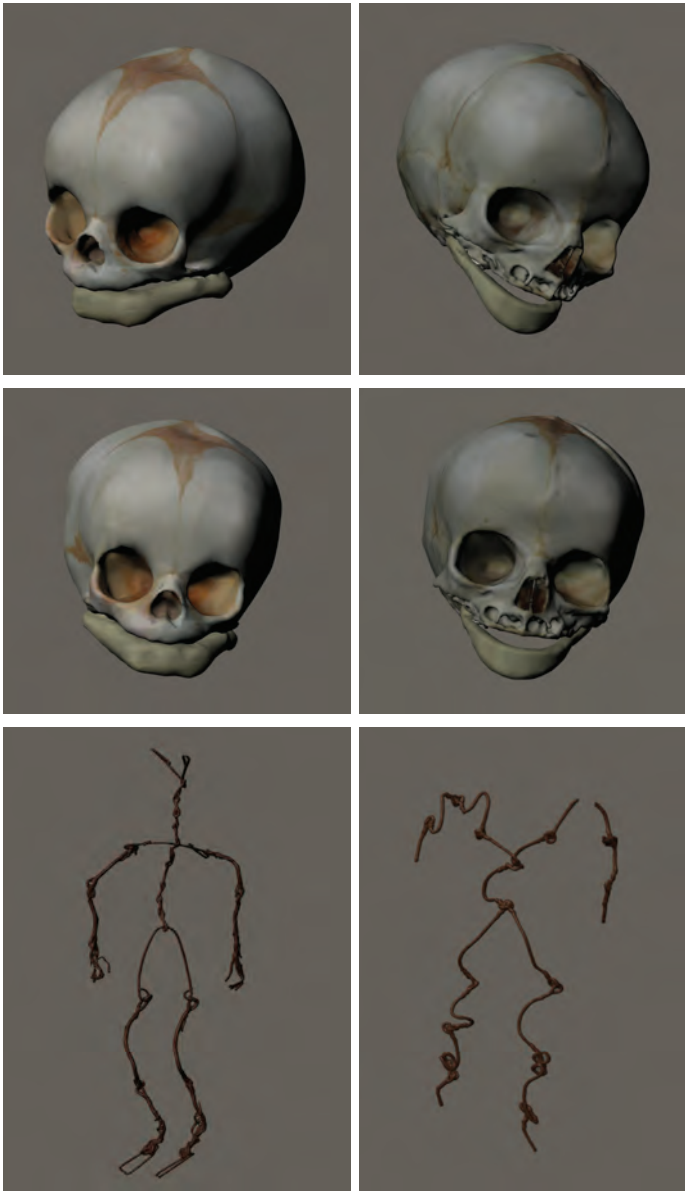


The hypothetical preliminary 'unfolding' of the doll in Photoshop
Screenshots were taken of the digital doll figures in Maya and brought into Photoshop, where colour corrected photos were superimposed on them. Doing some of this collaging in a 2D program was more time-efficient than bringing all materials immediately into Mudbox to superimpose on the 3D surface. The image of the digital doll was deleted before bringing the textures into Mudbox for stencilling.



(above) Mudbox interface and stencilling process : the original reference photo is placed over the digital object and a 'stencilling brush' is used to impress it onto its 3D surface.

(above) The resulting TIF texture file for the body and cranium of doll two, exported from Mudbox. Note the similarity in overall shape between the texture file and the initial zBrush file of the same (p.74)



(above) skulls and wireframes at final digital textured stage (l) doll two (r) doll one

(above) dolls at their final digital textured stage (l) doll two (r) doll one

ANIMATION

The animation was created by setting up a camera in Maya, and positioning it to centre the dolls and capture the entire rotation and as much detail as possible of their surfaces. The animation timeline was set to 1240 frames, and then divided into two halves (with the dolls rotating once to 360° to exhibit their outer surfaces and a second 360° rotation to exhibit the inner contents beneath the leather). The dolls were moved in the frame in different stages of rotation, and key frames (images defining the starting and ending point of a transition) were set at intervals on the timeline to record these movements and ensure a smooth transition.

The same process was followed for the opacity changes in the second half of the animation. Opacity levels were decreased on selected frames in the leather grouping for each doll. Key frames were set to mark this opacity change, for which Maya automatically creates transitions when rendering the frames in their entirety. The animation was then batch rendered in Maya. Set at 2560x1540 screen resolution (to maximize quality of detail), the result was an output of 1240 IFF files, saved as 72dpi images.

These files were then imported as an image sequence into Adobe AfterEffects, a motion graphics software, where the black background from Maya was changed to a dark brown for aesthetic compatibility with the website. The film was then directly rendered as a full resolution /24 frames per second QuickTime movie. Stretch settings were set at 1520x768 with aspect ratio locked, to be better optimized for website viewing, and 150pixels were cropped from both the left and right sides, to get rid of dead visual space on either side of the dolls.

The final .mov file was compressed using Zencoder, in order to reduce file size and make it possible to embed the animation on the website.

(above) The AfterEffects interface with imported IFF files from Maya

THE WEBSITE CONTENT AND DESIGN CONSIDERATIONS

Usability researchers have discovered that contrary to traditional readers, web users tend to read in quick, short bursts. The use of lots of visuals to break up text and illustrate key points is therefore extremely effective in holding attention and drawing readers in to different aspects of content on the site. (Dotmarketing, [n.d])

Dotmarketing, a firm building websites for higher and continuing education institutions, associations and foundations points out that while traditional academic writing follows a pyramid style—laying a foundation using sources and research to work from a hypothesis to conclusion, the web tends to follow what is known as an 'inverted pyramid' style, borrowed from journalism. In this format, the most important information is presented first, followed by additional supporting detail. This allows readers to read only as far on any given page as they need to to get the amount of information that they require or that interests them, and then move on via hyperlinks. (Dotmarketing, [n.d], p.5)

It putting together the text for the website, background research was edited and condensed, and conscientiously simplified to be less academic and therefore potentially less condescending to the intended public. Each page was limited to 400 words or under, so as not to overwhelm the public with information; external links and references were also provided in the site to direct those interested towards further resources for learning.

Pages were designed to have titles and text placed consistently, and the use of external links allowed for maximizing information availability where permissions limitations prohibited the re-publishing of relevant imagery.

The website for the Royal College of Physicians of Edinburgh (owners of the dolls) (http://www.rcpe.ac.uk/) was taken into consideration, and earth-toned colours chosen for the website text and titles to compliment those of the RCPE site. Other websites considered include the Hunterian Museum in London and the Royal College of Surgeons (http://www.rcseng.ac.uk/museums/museums#), as well as examples from the Calmview collection management system for online showcasing exhibits from museums and galleries. (http://www.axiell.co.uk/calmview)

PT Sans Narrow, a simple sans-serif font, was chosen for the primary typeface because of its high legibility in website interfaces. It is an open source font accessible through Google Fonts, an online resource allowing the web designer to implement code granting constant access to a large number of open-source fonts. Using Google Fonts allows the designer to look beyond default browser fonts when designing a web page, which allows for more original design and custom choices corresponding to the given website's material.

The font Nauert was used for the titling on the home page and the masthead of the site, for its reminiscence of the more ornate and sophisticated look of fonts used around the 18th century.

In terms of content, a basic history and chronology of obstetrics and midwifery contextualized the dolls in history and practise. Images of the associated anatomy were created to clarify what

a teacher of man-midwifery would have been confronted with, and how the dolls were helpful in this regard. Different types of pelves, as well as the characteristics of the neo-natal skull, were explained in the context of their significance to the child birthing process. Although there is no extant information of the female 'machine' Doctor Smellie would have used in conjunction with the dolls, reference was given to similar machines, as well as external links to one that very likely served as a strong influence for his own construction of the same.

Photos of the dolls themselves were included to give the broadest showcase of their characteristics and to fill in any informational gaps the animation may have left out. The process of digitally re-rendering the skull was included, to ensure that the public would not be misled by the details in the animation that were not part of the original CT data provided of the dolls construction.

A page with ensuing developments of obstetric trainers, was included to show the public how the dolls provided a fundamental basis for designing simulated models, which have developed along with modern technology into far more sophisticated simulations.

Finally, further resources and reading were provided on a bibliography page on the site, for those interested in learning more about the materials.

(Note: After receiving feedback from the survey group, technical changes and corrections were also made to the original website (located at http://steflenk.com/OBSTETRICdolls/index.html) to improve its usability, navigability, and aesthetic appearance. For screenshots of website pages please refer to appendix 1)

project evaluation

EVALUATION SURVEY | public and expert

Upon completion of the website, artwork, and animation, the material was made open to a survey group of public individuals and experts in the fields of medicine, anatomy, obstetrics, midwifery, and/or museum curatorial work. Survey participants were asked to scroll, click and read through the website at their own discretion and to watch the animation of the dolls, and afterwards to evaluate the materials via the survey. The materials were made available 31 July and survey results were accepted until 4 August.

Participants were recruited predominantly via email and Facebook. Emails were also sent to the Centre for Anatomy and Human Identification specifically, and the website information was posted on their Facebook page. Along with the website URL (http://steflenk.com/OBSTETRICdolls/index.html) a preliminary survey link was provided with an information and consent form. Outlined in the form was the time commitment necessary to participate, the option to skip questions, and the option to withdraw participation or information at any time during or after the survey process. Also addressed were confidentiality, privacy and anonymity concerns, and the secure mode of storage for all data collected. At the bottom of the page was a button with a link to the survey. It was clearly explained that clicking on the survey link pre-supposed an agreement to participate, in place of a signature. The consent form could be printed and saved at participants' discretion, and email contact details were given for any further queries or concerns about the project.

Members of the public who were approached had no prior knowledge of the subject matter. There were no restrictions on age, sex, gender, or education level; only basic literacy and a layman's understanding of the questionnaire and material were necessary to take part. The goal was to have the educational and aesthetic worth of the project evaluated objectively, by people who could potentially be exposed to such work in a museum setting, and to record any particular merits or weaknesses of the work.

The expert sampling had to have some contextual understanding of the material, whether it be via a medical or anatomical background, one in obstetrics or midwivery, or background in curatorial or museum work. These qualifications were to establish some faction of critique from those already exposed to related or similarly contextualized material. The preliminary information sheet/consent forms were identical, except for the link, which led either to the expert survey or the public one. The questions for the expert survey were almost identical to those on the public survey, but included also reference to the anatomical accuracy of the neonatal crania, and the success (or failure) of the work to appropriately address the sensitivity of the material (given the ethical issues surrounding the exhibiting of human remains).

QUESTIONNAIRE, RESULTS, AND DISCUSSION

The questionnaire consisted predominantly of multiple choice questions (see tables page 90-93) A sample size of ten people from each category had been planned: the results showed that 37 members of the public and 27 experts viewed and interacted with the website. There were 16 questions in the public survey, and 19 questions in the expert survey, although results showed that 10 members of the public did not answer the last eight questions (possibly due to their location on a subsequent webpage).

91.9% of the public and 88.9% of experts visited each section of the website, and 72.1% of the public and 81.5% of the experts spent five minutes or more on it. 81.1% of the public and 88.9% of experts watched the entire animation.

THE WEBSITE

Of most significance in terms of practical evaluation was with what browser and on what computer platform (Mac or PC) viewers saw the site, as the defaults of different browsers can result in substantial differences in how the website appears on screen.

SURVEY RESULTS

The surveys for both groups were conducted via surveymonkey.com, and results were calculated as percentages for each question individually. All questions asked are shown in the following four tables, except for the two comment questions, asking participants why they felt the material would be suitable for a museum/educational setting, and how they felt the material could be improved.

		not at all	somewhat	moderate	very	extremely
How user-friendly and navigable was the website?	public	0	0	5.4%	54.1%	40.5%
	experts	0	0	11.1%	66.7%	22.2%
		not at all	somewhat	moderate	very	extremely
Was the information provided by the website well organized?	public	0	0	8.1%	54.1%	37.8%
	experts	0	0	7.4%	77.8%	14.8%
		yes	no			
Did you visit each section of the website?	public	91.9%	8.1%			
	experts	88.9%	11.1%			
		0-2 min	2-5 mins	5-10 mins	more	
Please indicate how much time you spent on the website/animation.	public	5.4%	13.5%	51.4%	20.7%	
	experts	7.4%	11.1%	55.6%	25.9%	
		yes	no			
Did you watch the animation from beginning to end?	public	81.1%	18.9%			
	experts	88.9%	11.1%			

		not enough	useful	over-whelming		
Aesthetically, how did you find the level of animation?	public	8.3%	77.8%	13.9%		
	experts	0%	92.3%	7.7%		
		not at all	somewhat	moderate	very	extremely
Was the website and animation aesthetically pleasing?	public	0	2.8%	16.07%	58.3%	22.2%
	experts	0	3.7%	14.8%	70.4%	11.1%
		not at all	somewhat	moderate	very	extremely
Was the information provided by the website comprehensible?	public	0	0	14.8%	55.6%	29.6%
	experts	0	0	14.8%	74.1%	11.1%
		not at all	somewhat	moderate	very	extremely
Did you feel the information on the website contextualized the dolls historically?	public	0	3.7%	11.1%	37%	48.1%
	experts	0	0	25.9%	59.3%	14.8%
		not enough	useful	over-whelming		
How informative was the animation in visually describing the dolls and how they are built?	public	3.7%	81.5%	14.8%		
	experts	3.7%	85.2%	11.1%		
		not at all	somewhat	moderate	very	extremely
Were the other visuals on the website helpful in understanding the material?	public	0	3.7%	11.1%	66.7%	18.5%
	experts	0	0	25.9%	59.3%	14.8%

		not at all	somewhat	moderate	very	extremely
Would the accompanying visuals have provided sufficient information without the animation?	public	3.75	22.2%	55.6%	18.5%	0
	experts	7.4%	33.3%	33.3%	22.2%	3.7%
*How significant did you find the animation in contributing to knowledge of the subject?	public	3.7%	3.7%	33.3%	48.1%	11.1%
		yes	no			
Would the animation/ website, be a welcome addition in a museum or educational setting?	public	96.3%	3.7%	(participants were also provided with a comment box to explain why)		
	experts	100%	0			
		not at all	somewhat	moderate	very	extremely
** Were the dolls' crania in the animation anatomically accurate?	experts	0	0	23.1%	61.5%	15.4%
		yes	no			
** Were aspects of the research noticeably absent?	experts	3.7%	96.3%			
		not at all	somewhat	moderate	very	extremely
** Did you feel the materials were appropriate, given the ethical issues surrounding the exhibiting of human remains?	experts	0	11.1%	22.2%	59.3%	7.4%

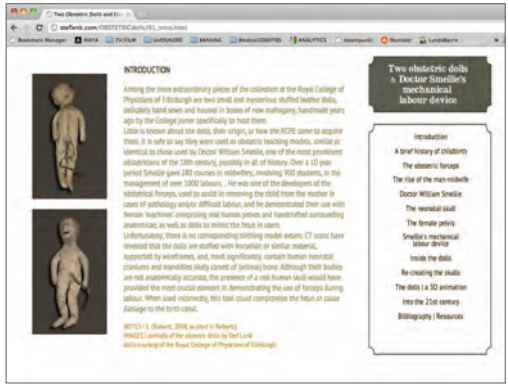
* only asked of public participants | ** only asked of expert participants

As a precaution the website was evaluated in five browsers on a Mac computer via Dreamweaver (the application in which the code was written) before being made public. Possible faults and inconsistencies in Safari, Chrome, Internet Explorer, Firefox and Opera were all noted and the code corrected accordingly. A compatibility error report was generated in Dreamweaver, to contend with eventual problems, and a site-wide link check was done to ensure that all materials appeared as programmed. The URL was then viewed by a colleague on a PC computer in all the same browsers, and screenshots of each page compared and the code further corrected.

browser used | expert participants					
	firefox	chrome	safari	IE	other
mac	7.4%	7.4%	33.3%	0%	0%
pc	37%	7.4%	0%	7.4%	0%
browser used | public participants					
mac	13.5%	18.9%	8.1%	2.7%	0%
pc	18.9%	18.9%	0%	13.5%	5.4%

Unfortunately, despite these adjustments, there were further problems detected after the site went public, particularly to do with which *version* of the browser the viewer was running. For example, a preliminary screen shot of how the site looked in Firefox for a Mac showed no problems (see images p.94). When the site was viewed in Firefox on a PC by a member of staff at the University of Erlangen, there were no problems. However, when the site was viewed in Firefox on a different PC by one of the expert participants, follow-up showed that they had not seen the site in the format it was intended. (see images p.94)

In the future it would be a crucial question to ask during evaluation not only on which browser and platform the site had been viewed, but which version of the browser was used.



browser inconsistencies found in website viewing

(top) intro page viewed in Firefox 14.0.1 on a Mac platform,

(middle) in Firefox version 13 on a PC platform

(bottom) Firefox version 11, also on a PC platform.

There were three major technical criticisms of the website aside from browser problems. These were scroll bars and window resizing, legibility (particularly footnotes and picture bylines), and larger images and pop-up windows.

Originally the site had been coded to constrain the browser window to the size of the website at startup, but feedback indicated this was having unexpected repercussions in different browsers, mainly in the inclusion of scroll-bars, which are aesthetically annoying and impractical. (This code has since been removed, although scrollbars are still not consistently hidden, as coded.) Internet Explorer was also inconsistent in terms of results. A member of the public who is a website designer stated that IE had revealed scrollbars on each page, despite extant code to hide all scroll-bars for all browsers. The smaller pop-up windows still have scroll bars in some instances, and not in others, to do again with the browser version. Further research and evaluation is necessary to solve this problem completely.

There was criticism that the size of the footnotes and picture captions was too small to be easily legible, particularly due to the use of a lighter coloured font (light orange). This has since been revised by increasing the font size in the CSS style sheets of each page.

The last issue was to do with popup windows and larger images. There was a strong consensus that all images on the site (not just those of the neonatal skull) should have been scaleable. Also of concern by some were the use of separate pop-up windows for the images which *could* be enlarged, as this format creates disorganization on the viewer's screen when more than one window is opened at a time.

The alternative to separate popup windows is to write Javascript creating popups of larger images within the original browser window, while temporarily graying out the background. The main page beneath reappears when it is clicked on. This is aesthetically preferable, organized and more practical, and was the intention at the outset of building the site. However, popup windows were used instead so that (particularly on the page about the neo-natal skull) the anatomical terms on the main page would remain visually

accessible at the same time as the larger version images of the skull views were open.

A possible solution for this would be to add anatomical terms to each of the skull view images individually, and have these revised images appear in a javascript grayed-out pop-up like the one described above.

Although some found the text on the website too long, others felt it was not overwhelming, and provided a *'reasonable and accessible depth of information that visitors…could decide to use or not"*

THE ANIMATION

Feedback for the animation was predominantly positive:

> *'Showing the skulls within the rotating bodies enhanced the emotional impact of this strange exhibit'*
>
> *'it [was] useful, almost tactile, being able to see the dolls all the way around. This and the reality of the skull were the most significant for me'*
>
> *'[the] next best thing to being able to circle the dolls in a display case, and perhaps better.'*
>
> *'this would be of additional benefit to primarily visual learners, or where visitor's first language may not be that of the dominant group'*
>
> *'although the descriptions and illustrations and photos were descriptive and informative, the animation is a beautiful and quick accurate depiction that truly suggests just how unique the birthing dolls are in relationship to their date of creation and function'*

In terms of improvements, one viewer pointed out that there was no visual cue that the picture of the dolls on the animation page had to be clicked to play (although this

instruction was given textually). A visual 'play' symbol has since been added.

It was suggested that making the animation more interactive (ie. allowing viewers to rotate the doll themselves) would be a plus, and some thought further close-ups of the skulls would have been beneficial. The advantage of being able to see inside the dolls was met with positive feedback, as well as the fact that they needn't be destroyed in order to do it.

Quicktime video was a problem for some; it was however chosen when preparing the animation for the website with preliminary knowledge that Flash is inaccessible for others. The ideal solution would be to provide the animation in both formats.

In terms of anatomical accuracy (which was asked in the experts survey) 23.1% found the crania moderately accurate, 61.5% found it very accurate, and 15.4% found it extremely accurate. 0% of the experts found the crania not accurate.

By far the main criticism of the animation was a lack of contrast between the background and the dolls. This is something that can be hard to guage, given that computer screens can be drastically different in terms of colour calibration (ie, what seems adequately bright and full with contrast on some screens can look quite the opposite on others) Although the feedback in this regard confirms that overall the animation was very dark, making it difficult at times to discern the materials (particularly the wireframes).

This can be corrected by further adjusting levels of saturation and brightness in the photoshop texture files of the dolls, and then re-importing into Maya, and re-rendering the animation from there, or colour-correction in AfterEffects.

Not mentioned by survey participants but also noticed in the animation were areas of texturing missing detail due to problems in the UV mapping process. Research into this has revealed that retopology of the UV maps (reconstructing the maps so the geometry is equally spread across the object) would eradicate this problem.

conclusion

CONCLUSION

The objective of the project was to create a 3D animation of the two 18th century obstetric dolls to be able to show their inside structures, as well as to create a website to offer online accessible visual context for them, including the history of obstetrics, the dolls themselves, and how they have influenced modern developments in obstetric training.

Overall, the website and animation received a positive response from the survey group of both experts and members of the public. Regarding the material as a whole, one viewer stated that "*it offers an innovative and imaginative alternative to the historical information and visuals in traditional museum contexts, which are often 2-dimensional and lack artistic quality. This website and animation demonstrate real flair and imagination for the topic, which wouldn't be communicated the same with the display of mere text and photographs.*"

85.2% of both public and experts found the information on the website comprehensible, and 80.5% public and 81.5% of experts found the material aesthetically pleasing.

With regards to accuracy, the rendition of the crania ranged from moderately to extremely anatomically accurate for 100% of the experts, and 80-85% of the group (81.5% public and 85.2% experts) felt the animation was useful in terms of visually describing the dolls and how they are built. In the experts survey 96.3% of participants stated that there were no noticeable aspects of the research absent, and 88.9% felt that the matter of ethical concerns in surrounding the exhibiting of human remains was moderately to extremely appropriate.

Because the material was created for viewing and accessibility by members of the public, specific attention was paid to creating text and images that would be informed but straightforward. One viewer praised it for being "*succinct … without condescension*". 96.3% of public and 100% of experts agreed that the materials would be a welcome addition in a museum or educational setting. 96.3% of public participants and 100% of experts felt the other visuals

created for and presented on the website were helpful in further under-standing the material.

This positive feedback indicates that creating of 3D animations, concise web-accessible texts and relevant visuals would be a positive addition to museum culture, and work of this sort could apply to any number of different collected specimens both within the medical industry and in the museum industry at large. One suggestion made which would be an excellent idea for taking this particular project further would be an elaboration of the dolls animation to include a view of the dolls head in relation to the female birth canal/pelvis.

More extensive knowledge of website/browser compatibility would greatly aid in creating material that would appear consistently for all viewers. More knowledge on how to create interactive animations would also result in more sophisticated and user-friendly materials.

Although this was not noted in survey feedback, the actual texturing of the dolls could also be greatly improved at the photo reference stage. Due to inconsistent lighting at the different times the dolls were photographed, collaging the texture involved colour correction which sometimes compromised sharpness of detail, and sometimes resulted in a somewhat patchy effect, particularly on the surface of the leather. If shadows and colour consistency did not have to be removed in photoshop, the texturing process would have gone quicker and been way more efficient.

Most of the technical problems can be solved with more research and testing. The affordability and accessibility of publishing the website makes it an appealing option for museums, and offers an interesting and visually engaging venue to showcase the two dolls in the RCPE collection.

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Thanks also to Michel Bestmann for proofreading, cross-checking the website and animation on different browsers and computers, and for helping me solicit participants for the expert survey group, and finally to Vanessa Krout and Goetz Nawroth for proofreading my english translations of german material and correspondence.

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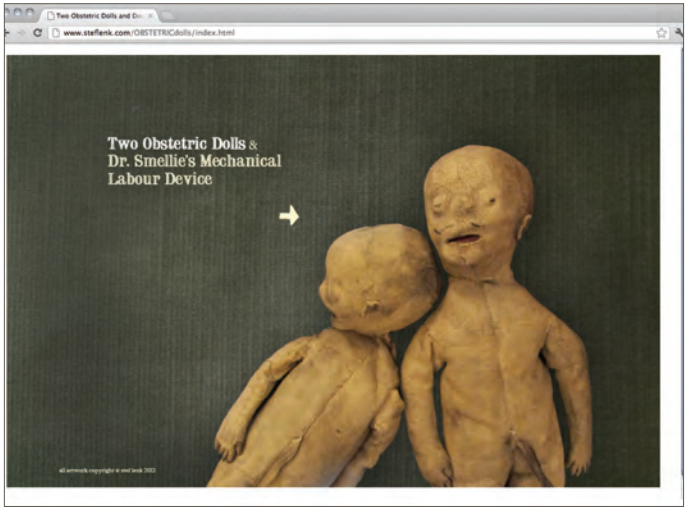
COLLECTIONS

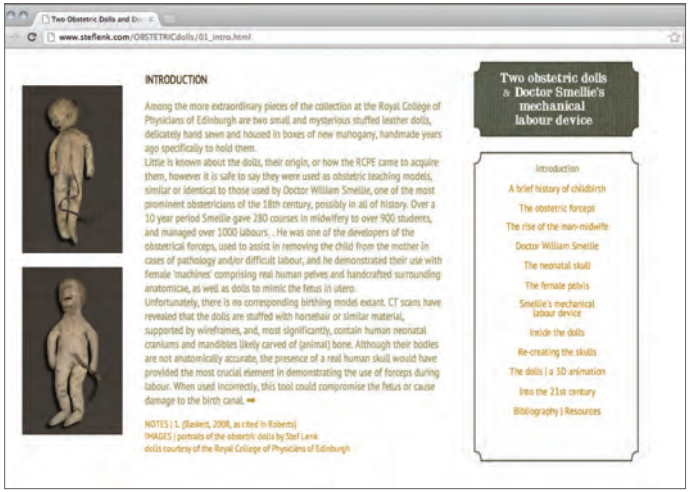
Anatomical Specimens Collection, Dundee, Scotland, School of Life Sciences, University of Dundee

The RCPE Collection, Edinburgh, Scotland, Royal College of Physicians of Edinburgh

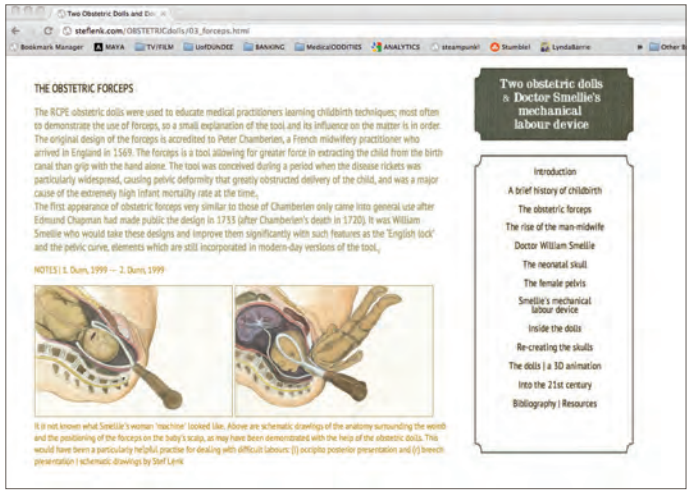
SCHEUER, L , (ongoing) [neo-natal osteological remains] (specimen boxes: SC21, SC180, SC223), Scheuer Collection, Dundee, Scotland, School of Life Sciences

APPENDIX 1 | THE WEBSITE





APPENDIX 1 | THE WEBSITE



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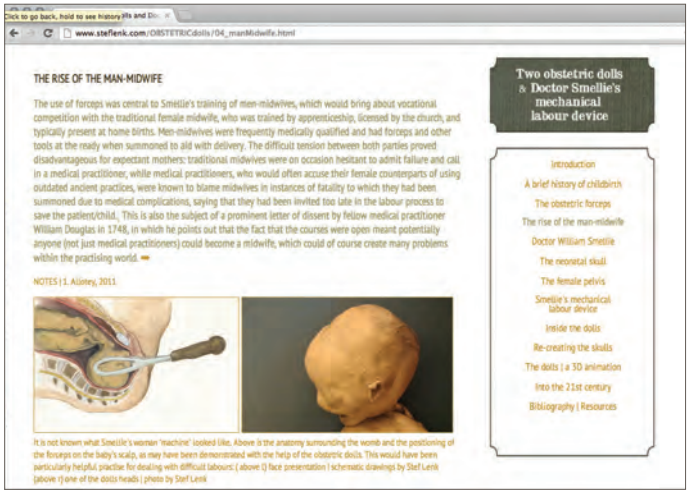


www.steflenk.com/OBSTETRICdolls/04_manMidwife.html

THE RISE OF THE MAN-MIDWIFE

The use of forceps was central to Smellie's training of men-midwives, which would bring about vocational competition with the traditional female midwife, who was trained by apprenticeship, licensed by the church, and typically present at home births. Men-midwives were frequently medically qualified and had forceps and other tools at the ready when summoned to aid with delivery. The difficult tension between both parties proved disadvantageous for expectant mothers: traditional midwives were on occasion hesitant to admit failure and call in a medical practitioner, while medical practitioners, who would often accuse their female counterparts of using outdated ancient practices, were known to blame midwives in instances of fatality to which they had been summoned due to medical complications, saying that they had been invited too late in the labour process to save the patient/child.. This is also the subject of a prominent letter of dissent by fellow medical practitioner William Douglas in 1748, in which he points out that the fact that the courses were open meant potentially anyone (not just medical practitioners) could become a midwife, which could of course create many problems within the practising world. ➡

NOTES | 1. Allitey, 2011

It is not known what Smellie's woman 'machine' looked like. Above is the anatomy surrounding the womb and the positioning of the forceps on the baby's scalp, as may have been demonstrated with the help of the obstetric dolls. This would have been particularly helpful practise for dealing with difficult labours: (above l) face presentation | schematic drawings by Stef Lenk (above r) one of the dolls heads | photo by Stef Lenk

Two obstetric dolls & Doctor Smellie's mechanical labour device

Two Obstetric Dolls and

www.steflenk.com/OBSTETRICdolls/05_Smellie.html

DOCTOR WILLIAM SMELLIE

William Smellie (1697-1763) is responsible for the introduction and the further development of midwifery forceps in the UK, and was also the most well known practitioner of midwifery instruction in London. In his 'Treatise on the Theory and Practice of Midwifery" (1752) he was the first to describe the mechanism of normal labour, the rotation of the baby's head with obstetrical forceps, and his application of the forceps to the head in breech deliveries., many aspects of which are still used today. Smellie is one of the most prominent figures responsible for the initiation of obstetric teaching with simulated models in the UK.

Having started out as an apothecary and a surgeon, Smellie began his practice in Lanark in 1720, later moving to London to take up practice there. In 1733 Smellie became professionally qualified as a member of the Faculty of Physicians of Glasgow. It was at this time information was published by Edmund Chapman on the use of obstetrical forceps.

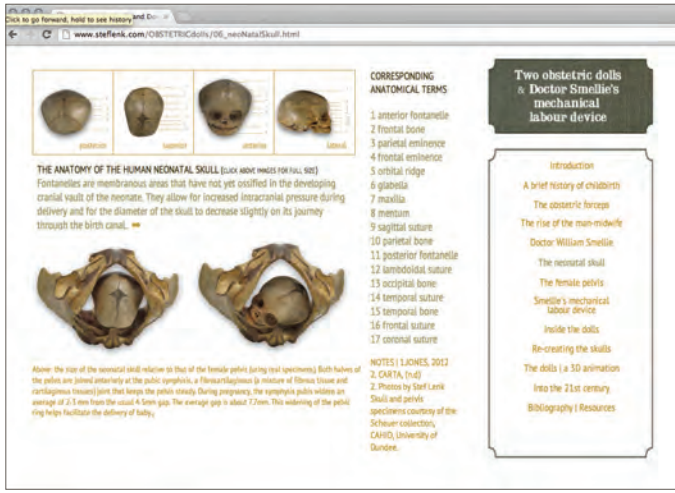
Smellie made a visit to Paris in 1739, where he watched M Grégoire at the Hotel Dieu teaching man-midwives the application of the forceps and demonstrating delivery positions using a manmade female model., He brought this innovation back with him to London and by 1741 he had begun teaching with his own version of dolls and 'machine'. His courses were part of a marked revolution in medical education by which lectures were given privately and were open to anyone who could pay to take them; there were no prior requisites for attending. It is important to note that Smellie also taught women, although separately from men., ➡

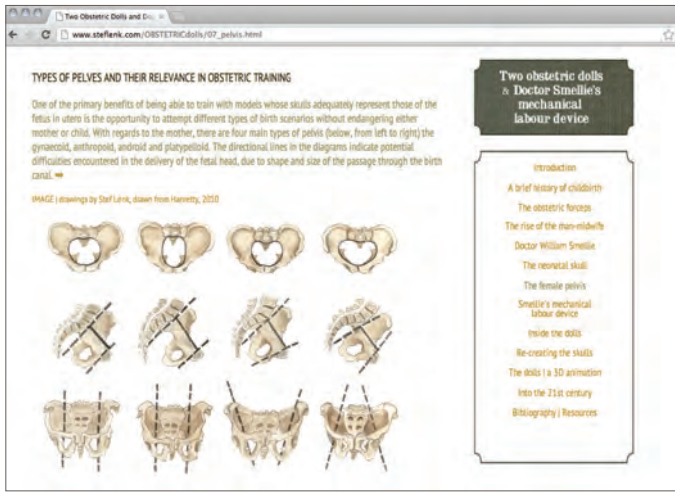
NOTES | 1. O'Dowd, 1994 • 2. King, 2007 • 3. Drife, 2002

IMAGES | (top) portrait of William Smellie courtesy of Wellcome Library, London (bottom) frontispiece to William Smellies "Treatise on the Theory and Practice of Midwifery" courtesy of Royal College of Physicians of Edinburgh

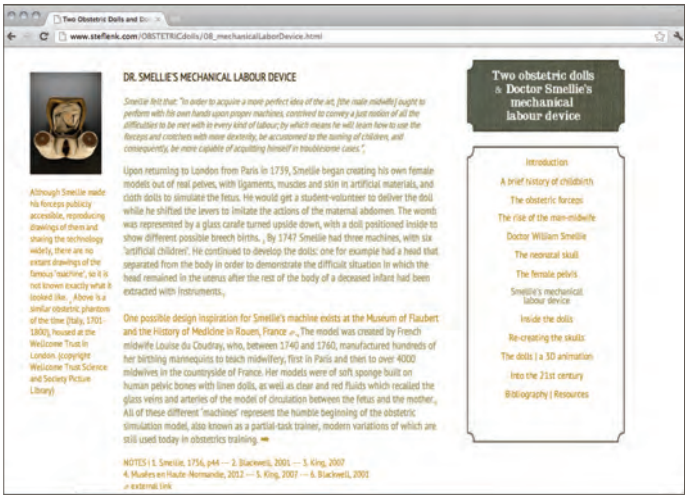
Two obstetric dolls & Doctor Smellie's mechanical labour device

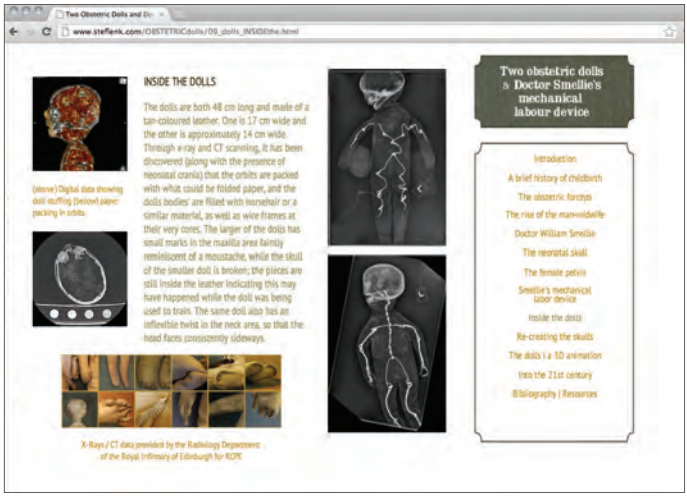
APPENDIX 1 | THE WEBSITE



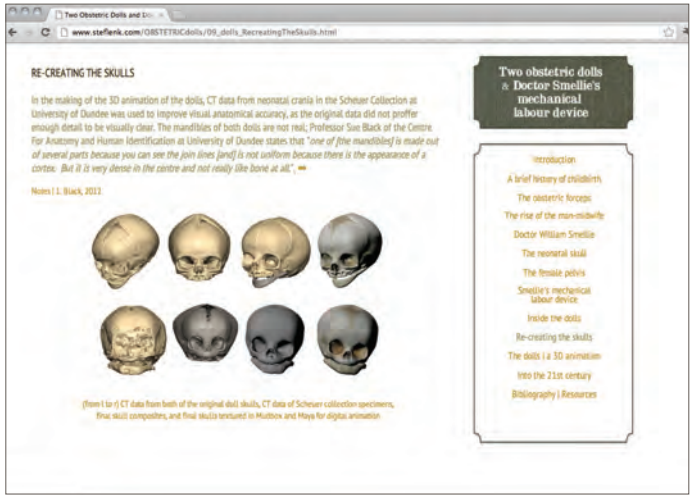


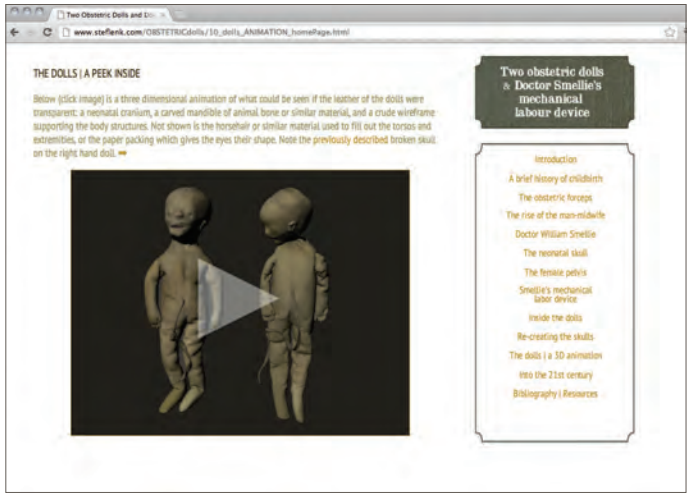
APPENDIX 1 | THE WEBSITE



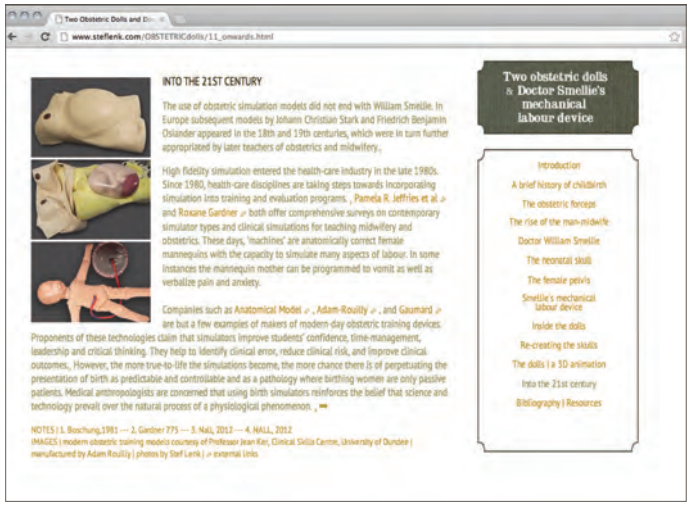


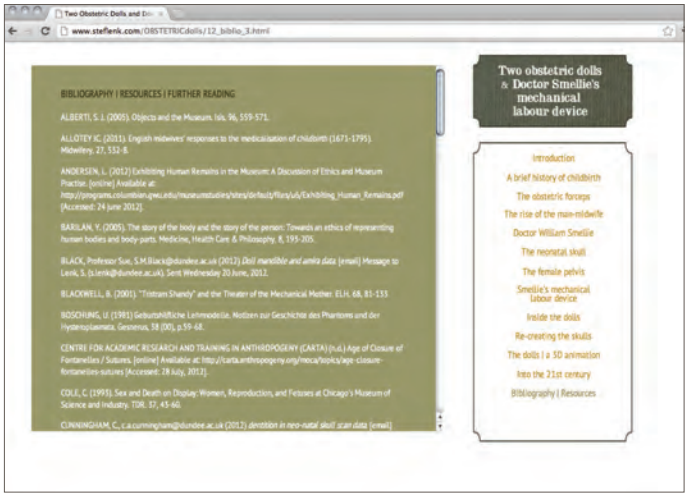
APPENDIX 1 | THE WEBSITE





APPENDIX 1 | THE WEBSITE





Questionnaire | Public

Public information website and 3D animation of 18th century obstetric dolls

Upon completion, please retain one copy and return the other signed to Stef Lenk
s.lenk@dundee.ac.uk | CAHID | College of Life Sciences | University of Dundee | Dundee | DD1 5EH

Please answer the following questions by selecting the answer that best describes your experience.
If you cannot or would rather not answer any of the questions, please leave them blank.
Any additional comments are also welcome, but at your own discretion.
Please use the numbers below to rate your evaluation.

1 = Not at all 2 = Somewhat 3 = Moderately 4 = Very 5 = Extremely

1| How user-friendly and navigable was the website? ☐

2| Was the information provided by the website comprehensible? ☐

3| Was the information provided by the website well organized? ☐

4 | Did you visit each section of the website? ☐

5| Please indicate how much time you spent on the website/animation ☐
1= 0-2 minutes
2= 2-5 minutes
3= 5-10 minutes
4= more than ten minutes)

6| Did you feel the information on the website contextualized the dolls historically? ☐

7| With which browser did you visit the website? ☐
1= firefox
2= safari
3= chrome
4= internet explorer
5=other)

8| How informative was the animation in visually describing the dolls and how they are built? ☐
1=not enough
2=useful
3=overwhelming

9| Did you watch the animation from beginning to end? ☐

10| Aesthetically, how did you find the level of detail in the animations? ☐
1=not enough
2=useful
3=overwhelming

11| Were the other accompanying visuals on the website helpful in understanding the material? ☐

12| Would the accompanying visuals have provided a sufficient understanding of the material without the animation? ☐

13| How significant did you find the animation in contributing to knowledge of the subject? ☐

14| Was the website/animation aesthetically pleasing? ☐

15| Would the animation/website in your opinion, be a welcome addition in a museum/educational setting? Why? ☐

16| What improvements would you suggest for the website/animation?

Questionnaire | Expert

Public information website and 3D animation of 18th century obstetric dolls

Upon completion, please return to Stef Lenk
s.lenk@dundee.ac.uk | CAHID | College of Life Sciences | University of Dundee | Dundee | DD1 5EH

Please answer the following questions by selecting the answer that best describes your experience.
If you cannot or would rather not answer any of the questions, please leave them blank.
Any additional comments are also welcome, but at your own discretion.
Please use the numbers below to rate your evaluation.

1 = Not at all 2 = Somewhat 3 = Moderately 4 = Very 5 = Extremely

What is your field of expertise? **anatomy** ☐ **obstetrics** ☐ **museum / curatorial** ☐

other (please specify) _____

1| How user-friendly and navigable was the website? ☐

2| Was the information provided by the website comprehensible? ☐

3| Was the information provided by the website well organized? ☐

4 | Did you visit each section of the website? ☐

5| Please indicate how much time you spent on the website/animation
1= 0-2 minutes
2= 2-5 minutes
3= 5-10 minutes
4= more than ten minutes) ☐

6| Did you feel the information on the website contextualized the dolls historically? ☐

7| Were the skulls in the animation anatomically accurate? ☐

8| Were questions raised for you as a result of the material provided? ☐

9| Were aspects of the research noticeably absent? ☐

10| With which browser did you visit the website?
1= firefox
2= safari
3= chrome
4= internet explorer
5=other) ☐

11| How informative was the animation in visually describing the dolls and how they are built?
1=not enough
2=useful
3=overwhelming ☐

12| Did you watch the animation from beginning to end? ☐

13| Aesthetically, how did you find the level of detail in the animations?
1=not enough
2=useful
3=overwhelming ☐

14| Did you feel the animation / website appropriately addressed the sensitivity of the material (given the ethical issues surrounding the exhibiting of human remains)? ☐

15| Do you think the animation would be a useful addition to exhibiting the actual dolls? ☐

15| Were the other accompanying visuals on the website helpful in understanding the material? ☐

16| Would the accompanying visuals have provided a sufficient understanding of the material without the animation? ☐

17| How significant did you find the animation in contributing to knowledge of the subject? ☐

18| Was the website/animation aesthetically pleasing? ☐

19| Would the animation/website in your opinion, be a welcome addition in a museum/educational setting? Why? ☐

20| What improvements would you suggest for the website/animation?

LIST OF FIGURES

when not otherwise indicated all artwork, digital screenshots and photography by Stef Lenk