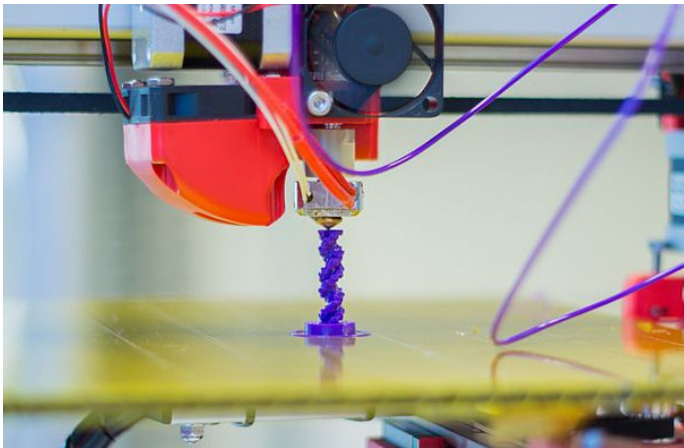


The printed prosthesis revolution

EXERCISE 1a Describe the pictures below.



© Jonathan Juursema, [CC BY-SA 3.0](#), via [Wikimedia Commons](#)



© Intel Free Press, [CC BY-SA 2.0](#), via [Wikimedia Commons](#)

1b What else do you know about the technology shown in the photos?

EXERCISE 2 Now read only the **headline** and the **first sentences of the paragraphs** (marked in **bold**). What do you learn about...

- a) Joe and Chris Oxenbury?
- b) the organization e-NABLE?
- c) the 3D-printed prostheses?

STUDY TIP The first sentence of a paragraph is also known as the **topic sentence**. Topic sentences summarize the content of the paragraph. Just reading the first sentences of each paragraph can give you a good idea what a text is about.

EXERCISE 3a Now read the full text. What is your first impression: Is the author's attitude towards the new technology positive or negative?

3b Decide whether the following aspects are described as positive (= an advantage / chance) or negative (= a disadvantage / limitation) in the text. Also, indicate the line(s) where the information can be found, and give reasons for your choice.

	p	n	in line(s)
a) Example: Price of traditional prostheses	<input type="checkbox"/>	x	9-11
b) Price of 3D-printed prostheses	<input type="checkbox"/>	<input type="checkbox"/>	
c) Usability of the 3D-printed hands	<input type="checkbox"/>	<input type="checkbox"/>	
d) Weight of material	<input type="checkbox"/>	<input type="checkbox"/>	
e) Durability of material	<input type="checkbox"/>	<input type="checkbox"/>	
f) Quality in comparison with medical prostheses	<input type="checkbox"/>	<input type="checkbox"/>	
g) Designs being shared online	<input type="checkbox"/>	<input type="checkbox"/>	
h) Building prostheses that are less functional for general purposes	<input type="checkbox"/>	<input type="checkbox"/>	
i) Possible use in low-income and post-war countries	<input type="checkbox"/>	<input type="checkbox"/>	
j) Looks/design of 3D-printed prostheses	<input type="checkbox"/>	<input type="checkbox"/>	

Example: *The price of traditional prosthesis is very high, so some patients (or their parents) can't afford them. So this is a disadvantage of traditional prostheses.*

3c Was your first impression from **EXERCISE 3a** correct?

The printed prosthesis revolution

Could open-source 3D printing revolutionise children's prostheses? Fathima Simjee reports. | 18 May 2015

First published here: <https://mosaicscience.com/story/printed-prosthesis-revolution/>, CC BY 4.0.

1 Joe Oxenbury was born without a left hand. "It was a glitch," says his father, Chris. "That's what the doctors told us. His hand just didn't grow when he was in the womb."

5 When Joe was eight years old, Chris organised a fundraising campaign to buy his son a £2,000 prosthetic hand. But children can quickly outgrow their prosthetic limbs – hands need to be updated as often as every nine months to ensure they fit correctly. At that cost, Chris wouldn't have been able to provide Joe with a replacement as often as he would need.

10 Then, in 2014, Chris read about an organisation called [e-NABLE](#), a 5000-strong international group of 3D-printing enthusiasts. Using open-source prosthetic designs, these volunteers print and assemble prosthetic hands and arms costing as little as £40. Those wanting a prosthesis send through photos, measurements and other specifications. The organisation then matches recipients with volunteers.

15 "When you get a 3D printer, once the novelty of printing keyrings and trinkets has worn off, you immediately want to do something useful with it," says James Holmes-Siedle, a London-based architect and the Enable volunteer who made Joe his first 3D-printed hand.

20 Anyone with a 3D printer can take part, although volunteers are asked to print and assemble a test hand as a show of their commitment and capability to build one. Recipients, however, have to display a certain amount of movement in their wrists or elbows to qualify, since the functionality of the prosthesis very much depends on it. A prosthetic hand, for example, is activated by wrist movement: rotating the wrist forward to open and backward to close.

25 When Joe's 3D-printed hand arrived in the post, "within four or five minutes he was picking up oranges and all sorts of things," says Chris. Joe can now grip a bat with both hands to play rounders at school.

30 Joe's prosthetic hand is currently with Holmes-Siedle for repairs owing to wear and tear. Holmes-Siedle sees this as a positive sign – it's being well used – but it also highlights a limitation: durability. Many volunteers print in polylactic acid, a plastic-like material, which makes the prostheses light enough to attach to the body with a Velcro strap but means they aren't strong enough to hold larger weights or sustain heavy impacts.

35 "The technology is great, but the material is not durable enough [to withstand] normal life," says Dr Abdo Haider, Lead Consultant Prosthetist at The London Prosthetic Centre. Haider uses 3D printing to make prototypes of new prosthetic designs.

50 Holmes-Siedle stresses that his creations aren't meant to be full-blown medical prostheses. "They are not prosthetics in the traditional sense. A prosthetist will meet the end client, make moulds, and take very detailed measurements and assessments. We try to be careful about expectations, because that is not what we're doing."

55 What they can do is help kids like Joe, who may have to wait until they are older to suit more costly prostheses. "Because children grow so fast, there might be periods of time when they don't have constant access to new prosthetics, and this is intended to fill that gap," says Holmes-Siedle.

60 One exciting thing about 3D-printed prostheses is that the designs are all freely available open source and constantly evolving. Holmes-Siedle is particularly interested in tensioning, and the fishing wire that acts as tendons in the prosthetic hands. He made some changes to the basic design of Joe's hand and within minutes of sharing his new designs online, other volunteers around the world were printing, testing and giving feedback on the adjustment. He's now working on a new revision based on what he's learned.

70 Some Enable volunteers are even experimenting with prostheses that are less functional for general purposes but great at one particular thing. "Let's say you want to ride a bike," explains Holmes-Siedle. "It's actually quite difficult to do that with a hand-based product, but it's easy to have a different [gripping] device on the end that will allow the child to do that."

75 Tony McGarry of the National Centre for Prosthetics and Orthotics at the University of Strathclyde in Glasgow believes 3D printing also has a lot of potential for low-income and postwar countries where the need for prostheses is rarely met: "There are millions of people who will never get prosthetics, and maybe some day down the line 3D printing might help to address this."

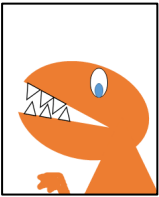
80 But perhaps the biggest effect is on children's self-esteem. The ease and speed of the process mean that it's easy to design a bespoke prosthesis, different from the usual flesh colours. The first hand Holmes-Siedle made was for a young boy named Charlie, who requested a superhero-themed design. Charlie was later approached by two older boys in the park: "They said 'Wow, we wish we could have an arm as cool as that!'" Holmes-Siedle's newest client, a girl, has requested a rainbow theme. Joe went for a steampunk design.

85 As for Chris, he simply hopes that one day he and Joe will be able to make a hand together: "What I want to do in the future is raise money for myself to get a 3D printer, [and] to give somebody the feeling we had when we opened that box with the hand in it. If I could give that feeling to somebody, it would be amazing."

EXERCISE 4a Read the comments on the article below and tick which person mentions the following arguments (sometimes, more than one person mentions one argument.)

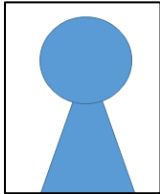
	dino32	alex.1998	mbpenguin	n	t
a) material is not robust enough	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
b) product may be dangerous for patients	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c) material is bad for the environment	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
d) reduces power of medical device companies	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
e) liability in case of damage is unclear	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
f) prostheses for people who usually wouldn't get any	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
g) prostheses improve when more people are involved	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

4b Tick if the argument is new (n) or if it has already been mentioned in the text (t).




dino32

"I'm not saying we shouldn't use 3D-printed prostheses at all, but I'm against volunteers printing them. A prosthesis is, after all, a medical product that needs to be tried and tested to make sure it is safe – and from what it says about the durability of the material, I have my doubts about that! What happens if a child gets hurt using the prosthesis? Who would pay for the child's hospital bills? It would be better if medical device companies invested in the technology and started producing affordable (temporary) alternatives themselves."



alex.1998

"I see your point. However, in my view, the fact that volunteers can print them at home is what makes these prostheses so revolutionary. It means that medical device companies cannot dictate prices anymore and that a larger number of people can contribute – which drives innovation. In a way, 3D printing takes the Web 2.0 to the next level. In the past, only a few select people had the ability spread their opinion, but today, everybody cannot only access knowledge, but also make their voice heard. In the same way, 3D printing makes the production of goods much more democratic."



mbpenguin

"I agree that the e-NABLE project is great for people who wouldn't have access to prostheses otherwise. Nevertheless, before 3D printed prostheses can be a true alternative to traditional ones, some issues will have to be resolved. I think the material used in 3D printing is the biggest drawback. The plastic used (PLA) is not only too fragile for the purpose, but may also take years to decompose. In my eyes, a technology that relies so heavily on plastic does not have a future."

4c Read the three comments again and find expressions that have a similar meaning as the following words and phrases.

- a) I understand what you mean. _____
- b) In my opinion ... 1. _____
- 2. _____
- c) However, ... _____
- d) disadvantage _____
- e) I'm not sure I believe that. _____
- f) I share the view _____
- g) I do not claim that ... _____
- h) In a sense, ... _____

EXERCISE 5 Write your own comment (100-200 words) on the question “Could open-source 3D printing revolutionise children’s prostheses?” You can reply to the text itself and/or to the comments. The following guiding questions can help you:

- Look again at the advantages and disadvantages from **EXERCISES 3a** and **5b**. Which do you find the most important? Say why.
- Can you think of additional advantages or disadvantages that have not been mentioned yet? Explain.
- Are there other/better solutions to the problem (i.e. patients not having access to affordable prostheses) than volunteers 3D-printing prostheses?
- Do you have any ideas how either the technology or the e-NABLE production process might change / be improved in the future?

Giving one’s opinion	Referring back to certain aspects in the text	Advantages and disadvantages
<ul style="list-style-type: none"> ▪ In my <i>view / opinion / eyes</i>, ... ▪ Personally, I <i>think / believe</i> ... ▪ I’m <i>against / for</i> ... ▪ I (seriously) doubt that ... ▪ I (strongly) (dis)agree with the view that ... 	<ul style="list-style-type: none"> ▪ From what it says about ..., I think that ... ▪ Regarding ..., I have to say that ... ▪ As to ..., I think ... 	<ul style="list-style-type: none"> ▪ ... is a big <i>disadvantage / drawback / downside</i>. ▪ ... is a <i>major advantage / plus / benefit</i>. ▪ Another <i>argument for/against</i> ... is that ... ▪ <i>On the downside</i>, ...
Making suggestions	Conceding	Making a point
<ul style="list-style-type: none"> ▪ It would be better if ... ▪ ... could be an alternative solution. ▪ Why don’t we ... instead? 	<ul style="list-style-type: none"> ▪ I’m not saying that ..., but ... ▪ I see your point. However, ... ▪ I agree that ... Nevertheless ... ▪ It’s true that ..., but on the other hand, ... 	<ul style="list-style-type: none"> ▪ ... is not only useful, but also ... ▪ What I find most impressive is that ... ▪ ... may not be perfect, but it does have the advantage ...

EXERCISE 6 Construct the missing words from the syllables. The letters in the yellow cells form a solution word.

One letter: i ▪ l
 Two letters: af ▪ as ▪ be ▪ de ▪ du ▪ el ▪ es ▪ ra ▪ ro ▪ ty ▪ us
 Three letters: ble (2x) ▪ cro ▪ don ▪ ~~he~~ ▪ nov ▪ sem ▪ sis ▪ ten ▪ the ▪ Vel
 Four letters: abil ▪ able ▪ ford ▪ ~~frag~~ ▪ pros ▪ vice ▪ tate ▪ teem ▪ wire
 Five letters: spoke

a) Something that breaks easily is ... b) self-confidence = self-... c) something that can be used instead of shoe laces: ... d) not too expensive = ... e) to put together = to f) long-lasting, robust = g) a replacement for a missing limb: ... h) Phones and tables are mobile ...s. i) custom-made = ... j) It connects muscles and bones. k) Ease of use = ... l) A thread made of metal: ... m) Something new and special is a ...	<table border="1" style="margin: auto; border-collapse: collapse;"> <tr> <td style="background-color: yellow;">f</td> <td style="background-color: yellow;">r₁</td> <td style="background-color: yellow;">a</td> <td style="background-color: yellow;">g</td> <td style="background-color: yellow;">i</td> <td style="background-color: yellow;">l</td> <td style="background-color: yellow;">e</td> </tr> <tr> <td style="background-color: yellow;">2</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td style="background-color: yellow;">3</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td style="background-color: yellow;">4</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> <td style="background-color: yellow;">5</td> <td></td> </tr> <tr> <td style="background-color: yellow;">6</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td></td> <td style="background-color: yellow;">7</td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td></td> <td style="background-color: yellow;">8</td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td style="background-color: yellow;">9</td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td style="background-color: yellow;">10</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td style="background-color: yellow;">11</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td style="background-color: yellow;">12</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td style="background-color: yellow;">13</td> </tr> </table>	f	r ₁	a	g	i	l	e	2							3									4										5		6										7							8								9					10							11							12											13
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The solution word is: r _2_ _3_ _4_ _5_ _6_ _7_ _8_ _9_ _10_ _11_ _12_ _13_

Vocabulary list

to assemble	zusammensetzen, montieren
affordable	erschwinglich, bezahlbar
bespoke	maßgeschneidert
to decompose	zerfallen, sich abbauen
device	Gerät
down the line	bis zum Ende
some day down the line	irgendwann in der Zukunft
durable	haltbar, langlebig
ease	Einfachheit
ease of use	Benutzerfreundlichkeit
full-blown	komplett, völlig
fundraising	Mittelbeschaffung
fragile	zerbrechlich
to evolve	sich entwickeln
functional	funktionsfähig; praktisch
functionality	Funktionalität; Funktionsweise
glitch	(kleinere) Störung, Panne, Defekt
impact	Aufprall; Auswirkung
innovation	Innovation, Neuerung
limb	Körperglied
limitation	Einschränkung
measurement	Maße
medical device company	Medizintechnik-Unternehmen
mould	(Guss- / Press-)Form
novelty	Neuartigkeit
open source	adj. <i>computer program whose code is public and can be edited by anybody</i>
potential	Potential
prosthesis	Prothese
qualify	in Frage kommen
revolutionary	revolutionär
to rely on	angewiesen sein auf; sich verlassen auf
to rotate	rotieren, drehen
rounders	Schlagball
self-esteem	Selbstbewusstsein
specification	Spezifikation, Angabe
to sustain	aushalten
tendon	Sehne
usability	Nutzerfreundlichkeit
Velcro	Klettverschluss
wear and tear	Abnutzung
wire	Draht
to withstand	aushalten
womb	Mutterleib
wrist	Handgelenk

Sources

Text: Simjee, Fathima. "The Printed Prosthesis Revolution." *Mosaic Science*, 18 May 2015, mosaicscience.com/story/printed-prosthesis-revolution/.

Images:

- 3D printer: Jonathan Juursema, [CC BY-SA 3.0](https://creativecommons.org/licenses/by-sa/3.0/), via Wikimedia Commons:
https://commons.wikimedia.org/wiki/File:Felix_3D_Printer_-_Printing_Head.JPG
- Hand prosthesis: Intel Free Press, [CC BY-SA 2.0](https://creativecommons.org/licenses/by-sa/2.0/), via Wikimedia Commons:
[https://commons.wikimedia.org/wiki/File:3d_printed_hand_\(15642062429\).jpg?uselang=de](https://commons.wikimedia.org/wiki/File:3d_printed_hand_(15642062429).jpg?uselang=de)

Answer key

EXERCISE 1

- a. The picture on the left shows a 3D printer which is printing an object. The picture on the right shows a prosthetic hand. It is made of plastic and wires. The wires probably act as tendons and allow the wearer to open and close his/her prosthetic hand.
- b. 3D printing is a production technique. The printer creates a 3D object from a digital model. Different materials can be used; traditionally, it is associated with plastic, but today there are also 3D printers for other materials (metal, ceramics, etc.).

EXERCISE 2 Now read only the **headline** and the **first sentences of the paragraphs** (marked in **bold**). What do you learn about...

- d) Joe and Chris Oxenbury?
Joe is a boy who was born without a left hand. Thanks to the organization e-NABLE, he now has a 3D printed prosthesis. Chris is his father.
- e) the organization e-NABLE?
They are a group of about 5,000 volunteers who use their own 3D printers to make prostheses.
- f) the 3D-printed prostheses?
cheap, brittle material, good for people who otherwise would not have access to a prosthesis, open source designs

EXERCISE 3a/c The author points out some weaknesses (the material is not durable enough and they are not as good as a traditional prostheses), but there are far more advantages and chances (low cost, ease of use, open source design, experimentation with new types of prostheses, use for low-income and post-war countries, effect on children's self-esteem).

3b	p	n	in line(s)
a) Example: Price of traditional prostheses	<input type="checkbox"/>	x	9-11
b) Price of 3D-printed prostheses <i>They only cost £40, which is a great advantage for the patients.</i>	x	<input type="checkbox"/>	13-15
c) Usability of the 3D-printed hands <i>Joe learned how to use the hand within minutes.</i>	x	<input type="checkbox"/>	32-34
d) Weight of material <i>The material is light, so it is easy to attach and wear.</i>	x	<input type="checkbox"/>	40-41
e) Durability of material <i>The material breaks to easily and has to be repaired often.</i>	<input type="checkbox"/>	x	43-45
f) Quality in comparison with medical prostheses <i>The 3D printed prostheses aren't a real replacement for medical prostheses, which are made by experts.</i>	<input type="checkbox"/>	x	50-53
g) Designs being shared online <i>Sharing the designs helps the volunteers improve them because everybody can give feedback.</i>	x	<input type="checkbox"/>	65-69
h) Building prostheses that are less functional for general purposes <i>These prostheses allow children to do things that would be difficult with a normal prosthesis (such as riding a bike).</i>	x	<input type="checkbox"/>	71-73
i) Possible use in post-war and low-income countries <i>The text says that there people in these countries need a lot of prostheses, but rarely get them – 3D printing could be a solution.</i>	x	<input type="checkbox"/>	80-82
j) Looks/design of 3D-printed prostheses <i>The children can choose their own designs, so the prostheses even look cool.</i>	x	<input type="checkbox"/>	

EXERCISE 4a / 4b Read the comments on the article below and tick which person mentions the following arguments (sometimes, more than one person mentions one argument.)

	dino32	alex.1998	mbpenguin	n	t
a) material is not robust enough	x	<input type="checkbox"/>	x	<input type="checkbox"/>	x
b) product may be dangerous for patients	x	<input type="checkbox"/>	<input type="checkbox"/>	x	<input type="checkbox"/>
c) material is bad for the environment	<input type="checkbox"/>	<input type="checkbox"/>	x	x	<input type="checkbox"/>
d) reduces power of medical companies	<input type="checkbox"/>	x	<input type="checkbox"/>	x	<input type="checkbox"/>
e) liability in case of damage is unclear	x	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
f) prostheses for people who usually wouldn't get any	<input type="checkbox"/>	<input type="checkbox"/>	x	<input type="checkbox"/>	x
g) prostheses improve when more people are involved	<input type="checkbox"/>	x	<input type="checkbox"/>	<input type="checkbox"/>	x

4c Read the three comments again and find expressions that have a similar meaning as the following words and phrases.

i) I understand what you mean.	I see your point.
j) In my opinion ...	1. in my view 2. in my eyes
k) However, ...	Nevertheless, ...
l) disadvantage	drawback
m) I'm not sure I believe that.	I have my doubts about that.
n) I share the opinion	I agree
o) I do not claim that ...	I'm not saying that ...
p) In a sense, ...	In a way, ...

EXERCISE 5 Individual answer

EXERCISE 6

a) Something that breaks easily is ...	f	r	a	g	i	l	e			
b) self-confidence = self-...	e	s	t	e	e	m				
c) something that can be used instead of shoe laces	v	e	l	c	r	o				
d) not too expensive	a	f	f	o	r	d	a	b	l	e
e) to put together	a	s	s	e	m	b	l	e		
f) long-lasting, robust	d	u	r	a	b	l	e			
g) a replacement for a missing limb	p	r	o	s	t	h	e	s	i	s
h) Phones and tables are mobile ...s.	d	e	v	i	c	e				
i) custom-made	b	e	s	p	o	k	e			
j) It connects muscles and bones.	t	e	n	d	o	n				
k) Ease of use	u	s	a	b	i	l	i	t	y	
l) A thread made of metal	w	i	r	e						
m) Something new and special is a ...	n	o	v	e	l	t	y			

Solution word: revolutionary