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1 **Institutional and technological barriers to the use of open educational resources**
2 **(OERs) in physiology and medical education**

3

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5

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8

9 Abbreviated title: Barriers to OER use in physiology education

10

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16

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18 writing of the manuscript. CH carried out data collection and analysis.

19

20 **Abstract**

21 Open educational resources (OERs) are becoming increasingly common as a tool in
22 education, particularly in medical and biomedical education. However, three key
23 barriers have been identified to their use: (i) lack of awareness of OERs, (ii) lack of
24 motivation to use OERs, and (iii) lack of training in the use of OERs. Here, we explore
25 these three barriers with teachers of medical and biomedical science to establish how
26 best to enhance the use of OERs to improve pedagogical outcomes. An online survey
27 was completed by 209 educators, many of whom (68.4%) reported using OERs in their
28 teaching, and almost all (99.5%) showing awareness of at least one OER. Results
29 suggest that key problems that prevent educators from adopting OERs in their teaching
30 include suitability for particular classes, time, and copyright. Most (81.8%) educators
31 were somewhat, very, or extremely comfortable with OERs so there is no innate
32 motivational barrier to adoption. A lack of training was reported by 13.9% of
33 respondents, and 40% of respondents stated that there was little or no support from
34 their institutions. OER users were no more comfortable with technology or better
35 supported by departments, but tended to be aware of a greater number of sources of
36 OERs. Our study illustrates key opportunities for the expansion of OER use in
37 physiology and medical teaching: increased breadth of awareness, increased
38 institutional support (including time, training, and copyright support), and greater
39 sharing of diverse OERs to suit the range of teaching challenges faced by staff in
40 different subdisciplines.

41

42 **Keywords:** blended learning, open educational resource, medicine, physiology,
43 pedagogy, online, technology.

44 **Introduction**

45 Higher education globally is going through a period of rapid, innovative and
46 revolutionary change, with a shift from the educator as the sole provider of knowledge
47 and information to a collaborative partnership between staff and students to provide an
48 exceptional student education experience (1). Many universities and colleges now
49 describe their educational approach within a blended learning framework, recognising
50 the benefits of flexible learning, deeper learning, collaboration, social learning and
51 enhanced employability afforded by this approach. Examples include offering students
52 opportunities to enrich their face-to-face learning through use of in-class technologies,
53 online resources and interactive materials. Furthermore, many UK universities have
54 invested significantly in policy, training, and infrastructure to realise this strategic aim,
55 including use of virtual learning environments, event capture systems, technology
56 equipped learning spaces, simulations / virtual experiments, mobile voting solutions
57 and a wide range of multimedia resources. These institutional changes have been
58 accompanied by pedagogical changes such as an increase in the use of a flipped
59 classroom approach, where students are provided with online learning resources (e.g.
60 recorded lectures, computer simulations, interactive quizzes) and use contact time with
61 staff to consolidate learning (9). This has been facilitated by the rise of the internet,
62 Web 2.0 technologies, virtual learning environments, open educational resources,
63 MOOCs and other internet-based educational solutions.

64

65 The term open educational resource (OER) was first introduced in 2000 in a UNSECO
66 conference, and the generally accepted definition is “digitised materials offered freely
67 and openly for educators, students and self-learners to use and reuse for teaching,
68 learning and research” (28). This definition broadly includes learning content, software
69 which can enable the use of learning content and open intellectual property licences,
70 which together lead to the democratisation of learning resources. Rather than spending

71 significant time producing educational materials, often with limited resources, educators
72 can now draw on a significant pool of high-quality, freely available open educational
73 and open access resources that can be found online (e.g. the Osmosis library of
74 medical OERs, 12). Large meta-analyses have demonstrated that the incorporation of
75 such technologies into student education enhances learning outcomes (2). Blended
76 learning approaches have been shown to be effective in enhancing learning within
77 clinical training (25) and the use of OERs is also widespread as students move into
78 clinical practice, with almost all residents and program directors using a combination of
79 wikis, e-textbooks, and podcasts (23). Specific randomised controlled trials have shown
80 that online resources such as virtual patients (17) and surgery simulators (10) produce
81 significant improvements in learning.

82

83 However, rather than this being a liberating experience for the educator, the shift in role
84 from the “sage on the stage” to the “guide at the side” (15) brings with it a series of
85 barriers or issues. Educators may have a lack of awareness of these tools and
86 technologies, or lack the infrastructure or support to implement blended learning
87 techniques into their programmes (first order barriers, 8). Medical students and faculty
88 have been shown to use a wide array of resources, but often of variable quality which
89 suggests that 1st order barriers may act through a lack of awareness of high quality
90 resources, rather than resources per se (3). Second-order barriers occur when the
91 educator may have the opportunity to engage with blended learning (i.e. there are no
92 significant first-order barriers) but lacks the motivation to do so and therefore chooses
93 not to. Often, this is a result of a lack of trust in the pedagogical effectiveness of
94 blended learning or a personal dislike of technology (8). Finally, third-order barriers
95 occur when the educator wishes to use blended learning but lacks the experience or
96 knowledge to implement it effectively (27). Often these three barriers act together to

97 create a complex set of issues that have held-back the transformative potential of the
98 new technologies (22).

99

100 This study takes two complementary approaches to the issue of the use of OERs in
101 medical and biomedical education. We consider OERs separately to other blended
102 learning approaches as they involve a distinct set of challenges around openness vs
103 copyright, producers vs consumers of resources, and the rapidly growing body of
104 OERs with little or no control over quality. In this study, we report on a survey of
105 educators which seeks to evaluate the first-, second- and third-order barriers as
106 described above to identify barriers and opportunities for the application of OERs in
107 medical and biomedical higher education teaching.

108

109 **Methods**

110 A survey was carried out online between 01 February 2016 and 04 March 2016 of
111 educators involved in the teaching of physiology and medicine at colleges and
112 universities. The survey was designed to investigate the presence and prevalence of
113 different barriers to the use of OERs, as outlined above. Participants were recruited
114 through professional networks, personal contacts, and social media. Specific questions
115 then focused on the following key areas:

- 116 (i) First order barriers (awareness): familiarity with technology (computers,
117 smartphones, tablets, technology in general, and open educational
118 resources) and awareness of sources of open educational resource,
119 (ii) Second order barriers (motivation): behaviour around OERs (creation,
120 sharing, modification), attitudes to the link between OERs and student
121 engagement, and willingness to pay for OERs.

122 (iii) Third order barriers (opportunity): reasons for not using OERs, support for
123 OERs are departmental, faculty, and institutional level, and whether
124 students expected supplementary e-resources.

125

126 The survey collected information specific to participants on (i) location of the institution
127 to evaluate geographical variation in use of OERs; (ii) percentage of your time spend
128 on teaching, research, or administration; (iii) percentage of time spent teaching medical
129 or dental students, physiology students, medical/biomedical science students, or health
130 science students; and (iv) participants' view of the development of pedagogy in their
131 field. Questions were validated through discussions with colleagues at the University of
132 Leeds who provided qualitative feedback to ensure that wording was clear.

133

134 **Results**

135 *Survey respondents*

136 A total of 209 completed the survey, predominantly based in North America (n=94) and
137 Europe (n=73), with other respondents from Australasia (n=11), Africa (n=6), Asia
138 (n=4) and South America (n=2), and 17 respondents did not state their location.

139 Participants were involved in teaching a variety of undergraduate programmes,
140 including medicine/dentistry (n=97), physiology (n=97), biomedical sciences (excluding
141 health sciences, n=114), and health sciences (e.g. nursing, occupational therapy,
142 physiotherapy; n=102).

143

144 *1st Order Barriers – Awareness of OERs*

145 Out of 209 participants, 143 (68.4%) reported using OERs during their teaching. Of
146 those 143, 40 participants reported creating their own OERs, and 28 then went on to
147 share their OERs with other educators. Awareness of at least one OER was almost
148 universal, with only one respondent reporting that they were unfamiliar with any of the

149 options presented (Figure 1). On the other hand, 23 participants listed a total of 24
150 additional resources with which they were familiar and which were not in our predefined
151 list suggesting that there is far greater breadth of awareness than is reflected in the
152 data. Hence we can conclude that awareness of OERs per se is not a reasonable
153 barrier to their use in teaching. However, we received a number of free text comments
154 to the effect that there were difficulties in identifying *relevant* OERs, or that the time
155 taken to browse and check existing resources was simply greater than the time needed
156 to create resources *de novo*.

157

158 *2nd Order Barriers – Motivation to use OERs*

159 If only 0.5% of educators are unfamiliar with OERs then why do 31.6% of educators not
160 use them? Our data suggest that there are three main problems that prevent educators
161 from adopting OERs in their teaching, including (i) the utility of OERs in their particular
162 classes, (ii) a lack of time to modify teaching to incorporate OERs, and (iii) a concern
163 about the copyright implications of using third party resources (Figure 2A). It is likely
164 that these three are linked: the lack of time available to educators means that they are
165 simultaneously unable to spend the effort to adhere to copyright legislation or seek out
166 those resources which are most appropriate to their particular teaching needs. The
167 significance of these logistical problems is emphasised by the data showing that most
168 (171/209, or 81.8%) educators were somewhat, very, or extremely comfortable with
169 OERs (Figure 2B). Hence there is no innate motivational barrier to adoption – the lack
170 of motivation stems from a lack of opportunity.

171

172 *3rd Order Barriers – Skills and training in OER use*

173 The fourth reason for not using OERs given by participants was that they were not sure
174 how to incorporate OERs into their teaching (Figure 2A). This 3rd order barrier was
175 reported by 29 (13.9%) of respondents and is likely to be related to other barriers, as a

176 lack of awareness of pedagogical applications for OERs may also reduce educators'
177 capacity to identify suitable OERs or understand efficient methods for the incorporation
178 of those resources into teaching. What is also worth noting is that many educators
179 reported limited support from their institutions in the creation and use of OERs.
180 Specifically, educators received no support or very little support from 49.8 % of
181 departments (n=104), 45.9% of faculties (n=96), and 40.7% of institutions (n=85). The
182 reduction in support at higher administrative levels might indicate a lack of overarching
183 support from senior management for the provision of OERs which could also be a
184 cause of limited time that staff have available for pedagogical innovation.

185

186 *Correlates of OER use*

187 Having demonstrated that all three orders of barriers exist to different extents, are there
188 any differences between OER users and OER non-users that might help identify
189 potential interventions to enhance the adoption of OERs more widely? T-tests showed
190 that there was no significant difference between users and non-users in the degree of
191 comfort with technology ($t=-1.025$, $p=0.307$) or the level of departmental support
192 available ($t=-0.717$, $p=0.475$). However, there was a significant difference between
193 OER users and OER non-users in the extent of knowledge about OERs ($t=-3.983$,
194 $p<0.001$) with OER users aware of 4.47 (± 0.15 SE) OERs compared to non-users who
195 were aware of 3.45 (± 0.20 SE) resources. These results suggest that, while there is
196 widespread knowledge about OERs per se, there is an additional benefit to greater
197 familiarity with the resources that is associated with increased rates of use.

198

199 **Discussion**

200 This study has shown that there is no single barrier to the increased usage of OERs in
201 physiology and medical physiology education, instead there are multiple, interlinked
202 barriers. Limited usage by educators is not due to a lack of awareness of the existence

203 of OERs per-se but difficulties in discovering relevant OERs, determining how best to
204 incorporate them into existing teaching, and the time-inefficiencies of discovery,
205 checking suitability and academic content. There is also conflicting evidence of the
206 educational benefits of OERs and limited Institutional support for their creation or
207 utilisation.

208

209 **Educational benefits**

210 Two thirds of respondents to this survey utilise OERs in their teaching. Whilst this is a
211 clear majority, it is likely that other physiology educators are only going to follow suit
212 and introduce OERs into their teaching if clear educational benefits or learning gains
213 can be demonstrated. Whilst student self-reported perceptions of learning gain
214 achieved through engagement with OERs are clear (6, 24), evidence of actual learning
215 gain, as determined by assessment outcomes, is lacking. OERs improve student
216 assessment outcomes when compared to control groups who have no access to the
217 resource or materials (4, 21) however there is no difference in assessment
218 performance when compared to students who receive the materials in a different
219 format or mechanism (5). Whilst OERs don't necessarily promote learning gain,
220 appropriately utilised, they have other educational benefits, for example developing
221 laboratory (20) or problem-solving skills (7) which should be highlighted to educators
222 and articulated to students.

223

224 **Student acceptance of OERs**

225 Whilst there is a significant increase in the use of e-learning, virtual learning
226 environments, semi and flipped classroom approaches in higher education, students
227 still prefer face to face instruction (13). They are becoming increasingly consumerist in
228 their approach to their education. Their acceptance of the use of OERs in courses
229 depends on the benefits being clearly articulated or evident. OERs should be user

230 friendly, requiring minimal computer knowledge or skills (14), time-efficient in promoting
231 learning in comparison to more traditional methods (11, 18), and integrated
232 appropriately within the course. They are best utilised either in conjunction with more
233 traditional learning methods or as supplementary learning resources (26). There are
234 also financial benefits. Many students can spend large amounts of money on books
235 related to their course, with some unable to afford recommended course materials.
236 Thus, an increased use of OERs by educators can particularly be of benefit to learners
237 from less financially secure backgrounds within developed countries and also learners
238 from developing countries (16).

239

240 **Increased creation, sharing and adoption of OERs**

241 An increased adoption and use of OERs by educators is only going to come about if
242 the community works together to overcome the barriers identified in this study:
243 discovery; ability to incorporate into existing teaching; academic content checking. The
244 process has to start with OER creators designing their resources with sharing and re-
245 use in mind rather than creating them primarily for use in their own teaching and then
246 sharing as a secondary outcome. Resources have to be in a format or duration so they
247 can easily be incorporated into existing teaching (e.g. short podcasts rather than entire
248 lecture presentations), accompanied by a clear set of learning outcomes, appropriate
249 support materials and guidance for colleagues on their use to facilitate this. Full author
250 details and affiliations will provide provenance and negate the need for academic
251 content checks. The latter will promote their excellence in student education, the
252 Institutional “Brand”, reducing Institutional barriers. However, many will still remain
253 including institutional concerns about sharing educational intellectual property with
254 competitor Institutions or alternatively, using a competitor institutions educational
255 resources and the negative impression this may give to students, or the substantial
256 academic and financial resources required to create excellent OERs. Funding for large

257 scale OER projects and repositories has also become an issue, limiting further growth
258 on this area. In the UK, government funding for the UK open educational resources
259 (UKOER) programme (19) ceased in 2012, with Jorum, the UKs principal OER
260 repository closing, after 13 years in existence, in September 2016. As evidenced in
261 this survey, many other excellent OER repositories which hold physiology OERs
262 remain, with colleagues aware of their existence. However, these have required
263 substantial resource for their creation and on-going development and therefore the
264 continued support of individual organisations e.g. the American Physiological Society
265 for LifeSciTRC, its repository of physiology OERs is essential. Others, for example
266 OeRBITAL and the UK Royal Society of Biology's OER repository have been lost or
267 have stagnated when funding ceased.

268

269 As part of our contribution to this goal of sustained, online repositories for OERs, we
270 have created an online repository to complement those already in existence. The
271 Repository of Physiology E-resources (ROPE, [http://www.fbs-
272 wp.leeds.ac.uk/repository/rope/](http://www.fbs-wp.leeds.ac.uk/repository/rope/)) is hosted at the University of Leeds and currently
273 contains >150 resources including images, slides, apps, animations, and videos. Since
274 the Jorum resource has closed down, ROPE was established to mirror as many of the
275 physiology resources from that site as possible. We welcome submission of materials
276 to be hosted on the repository and hope that ROPE can be an important companion
277 site to other online repositories in the future by adding to the resilience of online
278 platforms for OERs.

279

280 **Conclusion**

281 OERs can form an important part of a blended learning approach to higher education
282 teaching, but OER use varies widely among educators in medical and physiological
283 fields. We find little evidence for barriers related to awareness or training, but many

284 respondents highlighted the time needed to find, modify, and incorporate suitable
285 OERs into individualised teaching practice while adhering to copyright laws as a
286 deterrent to the use of OERs. Use of OERs did not vary with the self-evaluated skill
287 with technology, nor with support from institutions, but educators did use OERs more if
288 they were aware of a greater range of resources. Our results suggest that OER use
289 may be enhanced through two main actions: (i) by the ongoing curation of a variety of
290 high quality and flexible resources that can be incorporated into specific teaching
291 cases, and (ii) through greater institutional support to provide the time and resource to
292 incorporate OERs into the wider pedagogical landscape in an appropriate manner.

293

294 **Ethics**

295 This project has ethical approval from the University of Leeds Faculty Of Biological
296 Science Ethical Review Committee (ref: BIOSCI 13-001).

297

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304

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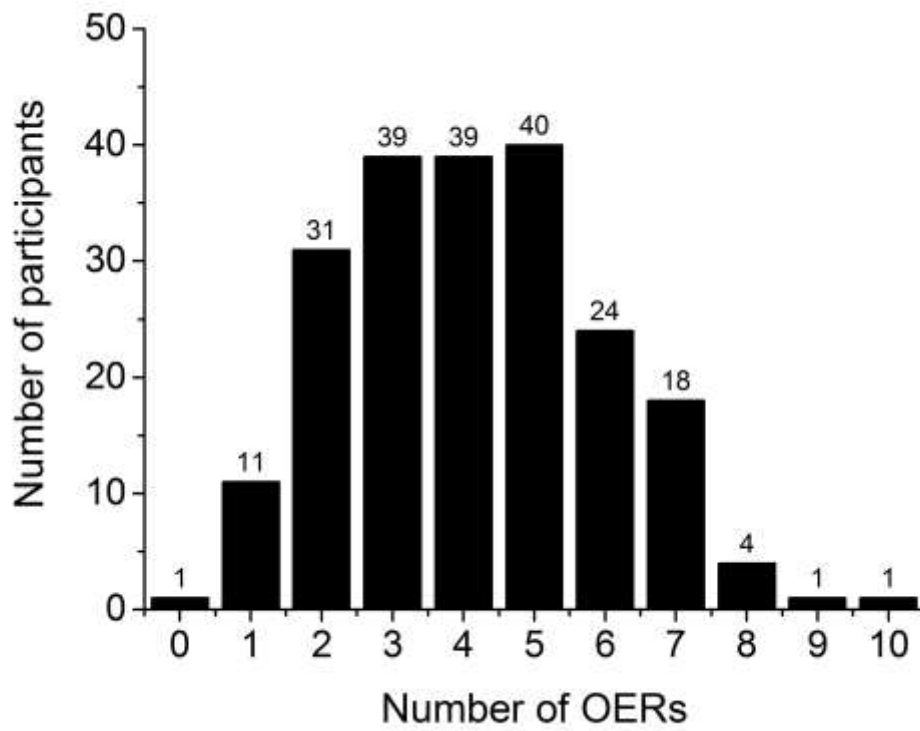
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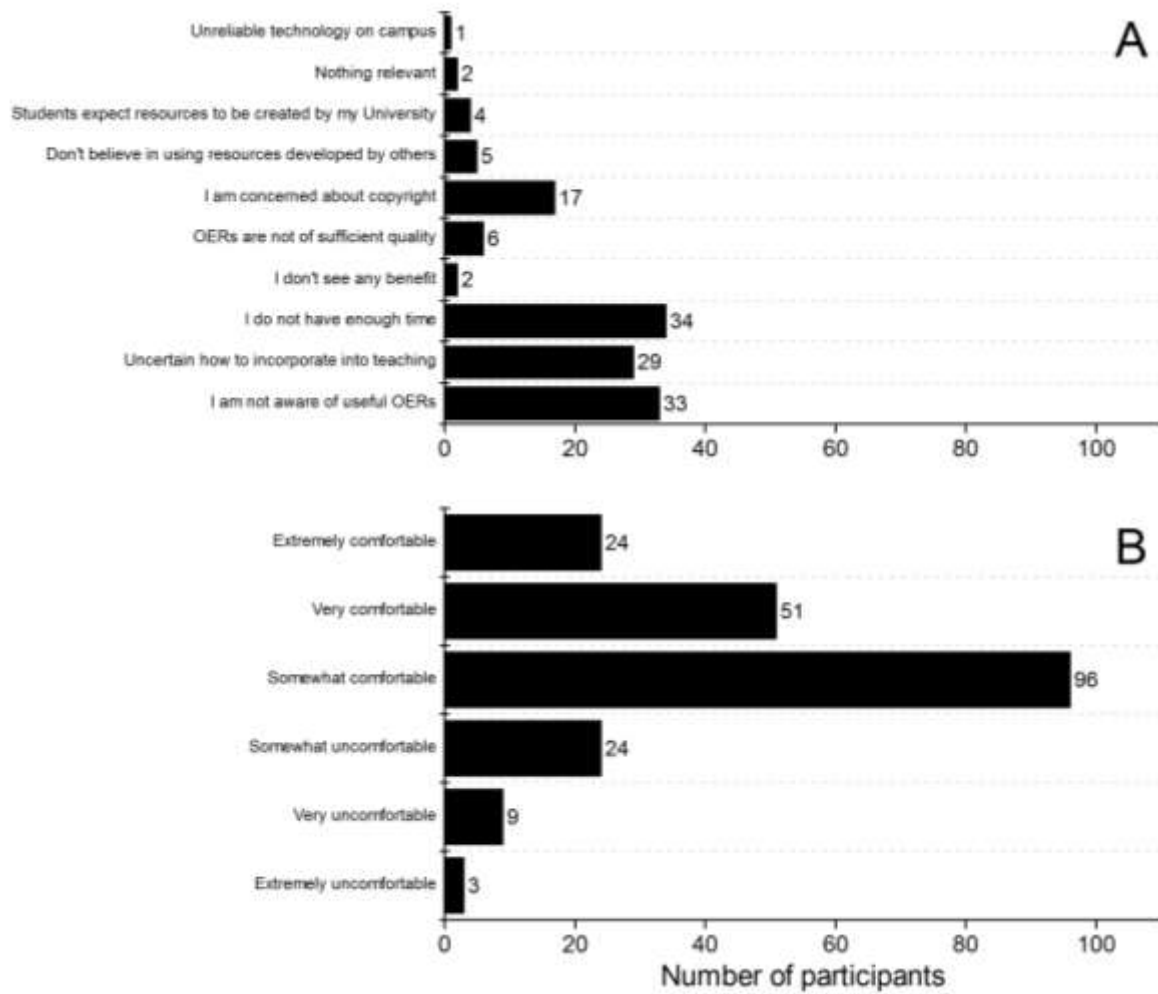
377 **Figures**



378

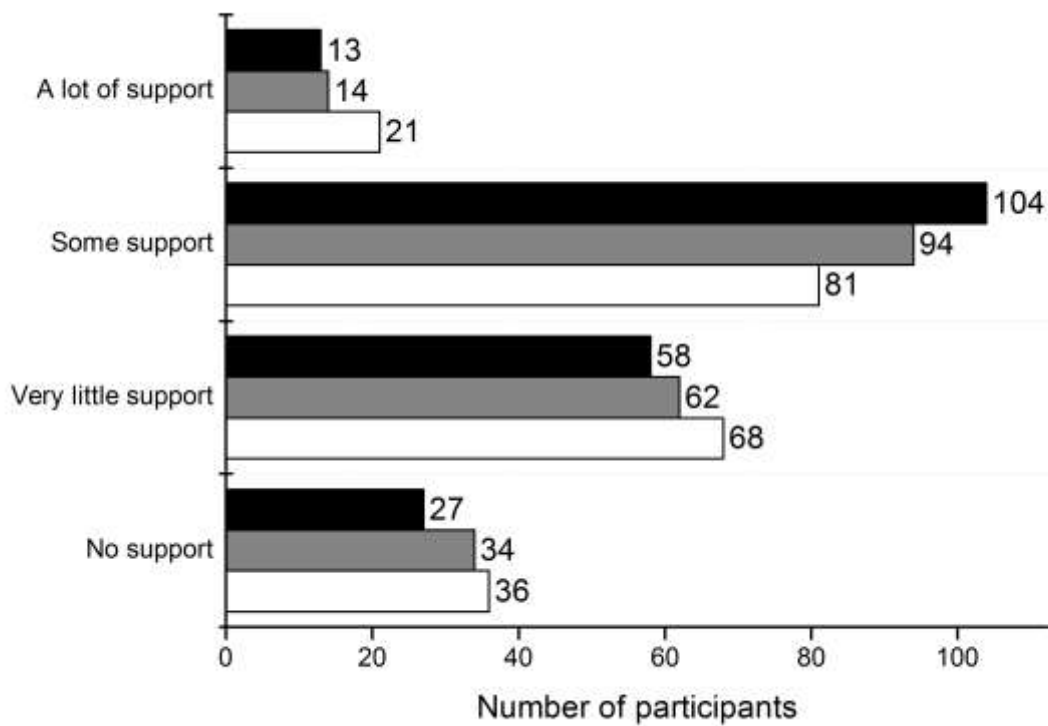
379 Figure 1: First order barriers to the use of open educational resources (OERs),

380 expressed as the number of OERs of which participants reported being aware.



381

382 Figure 2: Second order barriers to the use of technology expressed in terms of (A)
 383 specific issues with the implementation of online educational resources (OERs), and
 384 (B) self-rated confidence in using OERs.



385

386 Figure 3: Third order barriers to the use of open educational resources in terms of
 387 support at institutional (black), faculty (grey), and departmental (white) level.