The True Cost of Field Education is a Barrier to Diversifying Geosciences

Antoinette Abeyta

Math and Science Division, University of New Mexico-Gallup, 705 Gurley Ave, Gallup, NM, 87301, USA.
Email: abeytaant@unm.edu
Twitter: @variolax

Anjali M. Fernandes

Department of Earth and Environmental Sciences, Denison University, 100 West College Street, Granville, OH, 43023, USA.
Email: anjali.fernandes@denison.edu'
Twitter: @climbing_ripple

Robert C. Mahon

Department of Earth and Environmental Sciences, University of New Orleans, 2000 Lakeshore Drive, New Orleans, LA 70148, USA.
Email: rcmahon@uno.edu
Twitter: @RobertCMahon

Travis Swanson

Department of Geology and Geography, Georgia Southern University, P.O. Box 8149, Statesboro, GA, 30460, USA.
Email: tswanson@georgiasouthern.edu
Twitter: @traviseswanson

The True Cost of Field Education is a Barrier to Diversifying Geosciences

*Antoinette Abeyta[1]
Anjali M. Fernandes[2]
Robert C. Mahon[3]
Travis Swanson[4]
[1.] Math and Science Division, University of New Mexico-Gallup, 705 Gurley Ave, Gallup, NM, 87301, USA
[2.] Department of Earth and Environmental Sciences, Denison University, 100 West College Street, Granville, OH, 43023, USA
[3.] Department of Earth and Environmental Sciences, University of New Orleans, 2000 Lakeshore Drive, New Orleans, LA 70148
[4.] Department of Geology and Geography, Georgia Southern University, P.O. Box 8149, Statesboro, GA, 30460, USA

**Corresponding Author: Antoinette Abeyta, Math and Science Division, University of New Mexico-Gallup, Gallup, New Mexico, USA, E-mail: abeytaant@unm.edu*

Fieldwork is considered critical to developing technical skills in geoscience education, and typical undergraduate degrees require >30 days in the field. Tuition costs of enrolling in field camp are acknowledged as a barrier to participation in geosciences; however, the cost of participation in field activities may also include the cost of personal field gear (hiking boots, backpacks, etc.), travel, lost wages, and dependent care. To neutralize impacts of systemic bias on the future geoscience workforce, it is imperative that we (a) examine how the cost of field work presents barriers to participation, and (b) intentionally direct financial resources towards dismantling these barriers. We show that the financial burden associated with a week-long field endeavor, excluding potential tuition costs and including personal field gear, domestic air travel, lodging, dependent care and lost wages range from 1271 to 2,007 U.S. dollars (USD), and can be as large as 6,262 USD. This sum is likely to be out of reach for individuals from low-income groups, and represents a fundamental barrier to diversifying participation in our field. Budgets for inclusive field research and education must account for and accommodate these financial challenges to broader participation.

Earth is home to many diverse communities and cultural heritages. If we aspire to generate innovative and equitable scientific solutions to current and future environmental problems, the workforce that drives progress in geosciences must be equally diverse [1]. The geosciences, however, have persistently maintained the lowest rates of ethnic and racial diversity among all STEM fields [2]. Less than 9% of all students enrolled in geoscience graduate programs in the U.S. are from historically excluded groups (Black, Latinx, Native American) [3]. Identifying and removing the barriers that limit participation in geosciences is of paramount importance and is critical to achieving our vision of a diverse geoscience workforce.

Direct observations of Earth's natural phenomena are foundational in geosciences [4], emphasizing the importance of field education. A bachelor's degree in geoscience typically

requires 30 to 60 days of field experience [5]. For many individuals, field experiences provide the first opportunity to apply theoretical and practical concepts learned in the classroom. Coupling visits to novel locations with the shared thrill of discovery among peers, field experiences can be transformative, educationally enriching, and community building endeavors for junior scientists. The powerful impact of shared field experiences is reflected in the geoscience identity; participation in fieldwork is often seen as a rite of passage that underpins membership in the geoscience community. The depth and range of the technical skills developed during field experiences (e.g., educational field trips, field camp, field-based research and/or internships) is used to qualify their educational background [6]. Yet, research that addresses how the costs related to participating in field experiences may constitute barriers to participation and success is relatively scarce.

Enrollment in field camp can cost around 4,000 USD or more, and is now a recognized barrier to participation in geosciences [7,5,8,9]. Excluding tuition costs, other financial burdens associated with field work can pose additional barriers. To our knowledge, a published quantitative assessment of these financial burdens does not yet exist. Furthermore, objective data to assess how these burdens impact the persistence and retention of students in geosciences is largely absent.

In this study, the "hidden" financial costs of participation are systematically quantified. Items included in this analysis are: (1) the cost of adequate field gear, (2) the cost of domestic travel to field sites, (3) loss of wages, and (4) the cost of dependent care. The analysis was conducted for a five-day field experience that includes domestic travel within that five-day interval. The range of costs are presented as the 25th and 75th percentiles of the assembled datasets, as well as the maximum estimated expense for each category. The 25th and 75th percentiles represent the most likely range of costs incurred. Importantly, this analysis was conducted before the coronavirus pandemic in 2019.

A. The cost of personal field gear

Inadequate field gear can present significant health and safety risks to participants [10], but adequate personal field gear and protective equipment (e.g., sturdy hiking boots) is costly. Fieldwork budgets do not normally include individual field equipment as a cost; instead, budgets are typically constructed with the assumption that participants already own the gear needed to conduct field work safely [11]. As numerous studies have shown, the cost of adequate outdoor gear is a barrier to participation in outdoor activities, particularly for minoritized groups [12–14]. Therefore, the basic field gear needs (e.g., sturdy boots, wool socks, backpack, rain gear, etc.) are less likely to already be owned by students from underrepresented groups. For this study, estimated costs of essential personal field gear included a field pack, a pair of hiking boots, a raincoat, a set of fast drying pants, a pair of wool socks, a pair of work gloves, a water bottle, a hat, a notebook, a hand lens, pencils, markers, sunscreen, and a personal first aid kit.

If the individual were to purchase just one of each item, the most likely range of this initial investment would be 243 to 630 USD, with a maximum estimate of 2,526 USD (Figure 1). For a five-day field experience, we deemed that the minimum necessary gear would include 2 pairs of

pants and 3 pairs of socks. The range of costs in this estimate varied from 303 to 758 USD, with a maximum estimate of 3,226 USD.

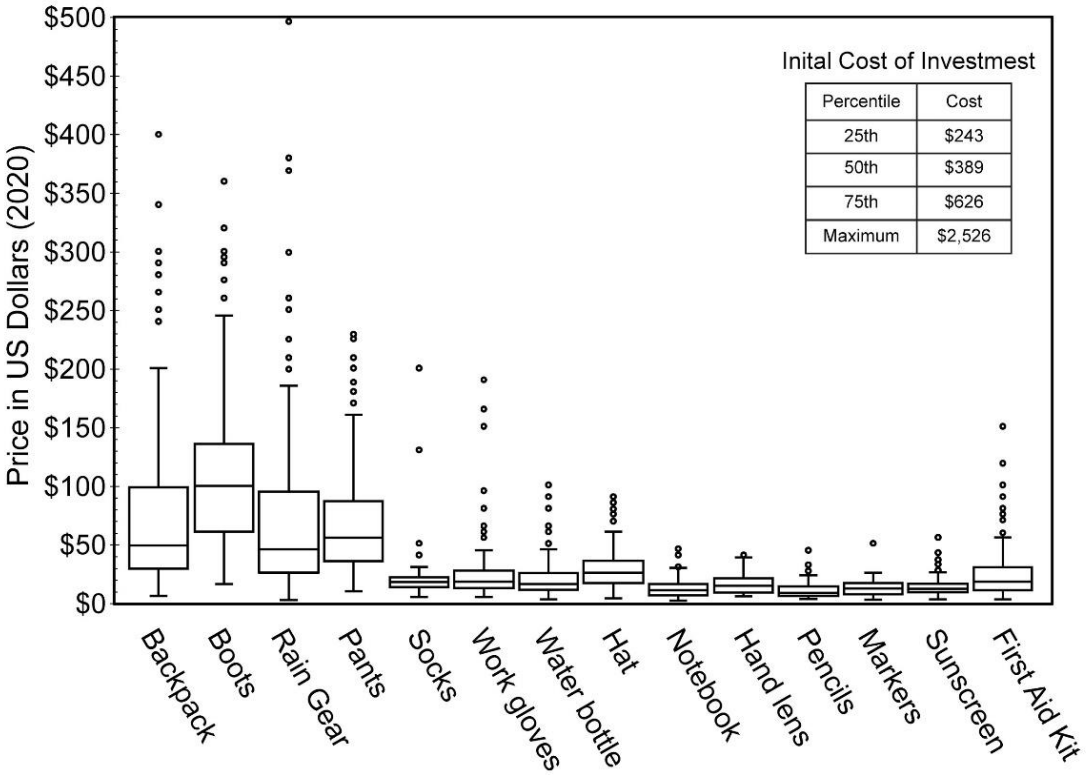

Figure 1: Distribution of costs of essential field gear. Dots represent values outside of 2 standard deviations.

As consumer products can be marketed differently to women and men, we examined the results to see if there is a price difference between women's and men's gear. Apart from socks, which had a similar range and price distribution, all gendered items (boots, rain gear, pants, and work gloves) showed a statistical difference in price. The cumulative difference between women's and men's gear ranges from 43 to 135 USD more, with a maximum estimate of 172 USD; meaning women on average will spend more than their male counterparts for their field gear (Figure 2).

As students progress in their geoscience careers and accumulate field gear, this cost will decrease over time. However, it is important to note that students will also need to maintain, repair, and replace their gear over time. These estimates do not include gear for field work at sites that require specialized preparation (e.g., sub-zero temperatures, wading, or swimming in water, etc.) and does not include specialized sizes or adaptive clothing for special needs.

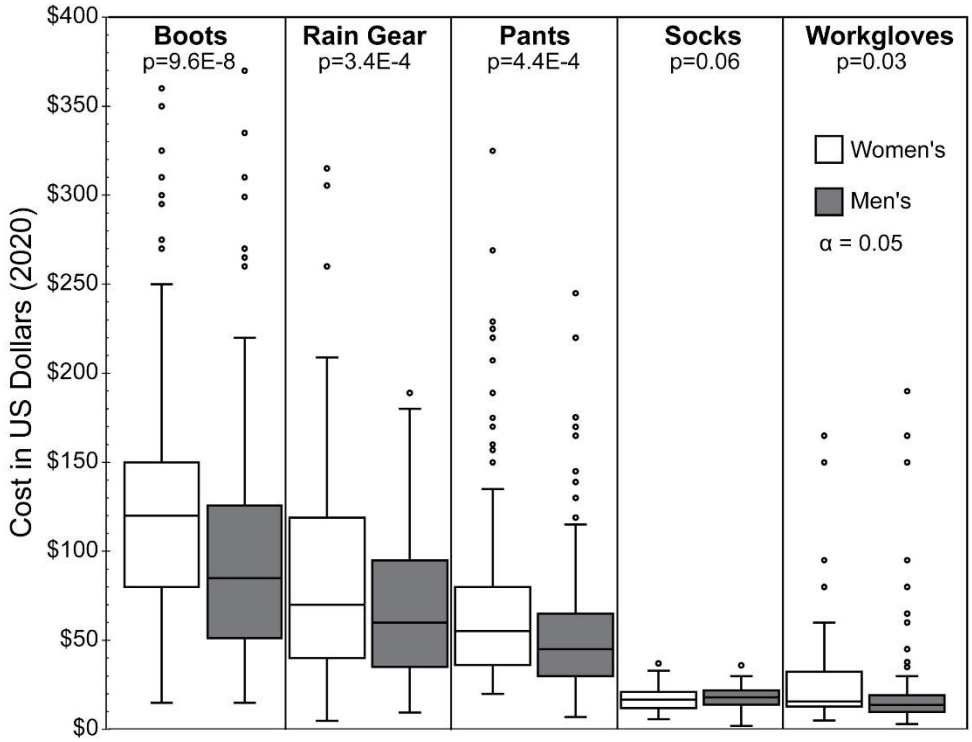

Figure 2: Price difference of gendered field gear items, women's gear is shown in white and men's gear is shown in grey. Dots represent values outside of 2 standard deviations. All items, with the exception of socks, show statistically significant differences at a level of α = 0.05.

B. The cost of domestic travel to field sites

Domestic flights for a five-day trip varied from 381 to 477 USD, with a maximum estimate of 938 USD; lodging varied from 275 to 368 USD, with a maximum estimate of 2,140 USD (Figure 3). The combined cost related to travel ranges from 656 to 844 USD Individuals can choose to reduce costs by sharing lodging arrangements; however, this practice has been shown to introduce safety risks associated with sexual misconduct [15]. This estimate is based on US citizens traveling domestically. Additional costs related to the acquisition of passports and visas, as well as airfare and lodging, will be required for international travel. International students who have travel limitations will incur additional financial burdens.

C. Wage losses

An estimated 80 percent of undergraduate students work while enrolled in classes [16]. Overlapping fieldwork and employment schedules can create financial stress and negatively impact student productivity and wellbeing [17]. Extended amounts of time away from their employment will have direct impacts on students' financial obligations (e.g. rent).

For this work, the loss of wages are calculated by using US federal and state minimum wage laws, and are therefore the lowest compensation possible. The calculated loss of wages varied from 174 to 252 USD, with a maximum estimate of 360 USD (Figure 3). In 2017, women on average earned 82% of what men earned; women of color earned as little as 55% [18]. Women,

and especially women of color, would therefore have to work more hours on average to recover the income that is equivalent to that lost by their peers who are men [18].

D. Costs associated with dependent care

Travel for fieldwork commonly means that students must make arrangements for dependent care. As dependent care expenses are not typically considered in the costs of participation, the associated financial burden can become particularly acute for low-income students and their families [19]. Subject to availability, which varies with time of the year, lead time, geography, employment factors, flexibility, quality, and cost, suitable dependent care options may not be available for students [20]; therefore, fieldwork will also not be an option for them.

Dependent care cost is estimated to range from 98 to 127 USD, with a maximum estimate of 246 USD (Figure 3). These calculations were based on a single dependent child under the age of 6 during standard hours (Monday to Friday, 8 AM to 5 PM), and does not account for care outside of standard hours; implicit in this calculation is the assumption that the student has a support network for unregulated, unpaid child-care outside of standard hours. This estimate also does not account for specialized care for dependents with special needs, infants, multiple dependents, and elders. Despite efforts and improvements in gender equity and inclusion in the workforce, women are impacted disproportionately by dependent care obligations [21]. Although dependent care will often not be an issue for the average college student in the U.S.A., it will inordinately impact individuals from non-traditional backgrounds [22].

In summary, the cumulative costs associated with participating in a five-day field experience range from 1271 to 2,007 USD; our estimates yield costs as high as 6,262 USD.

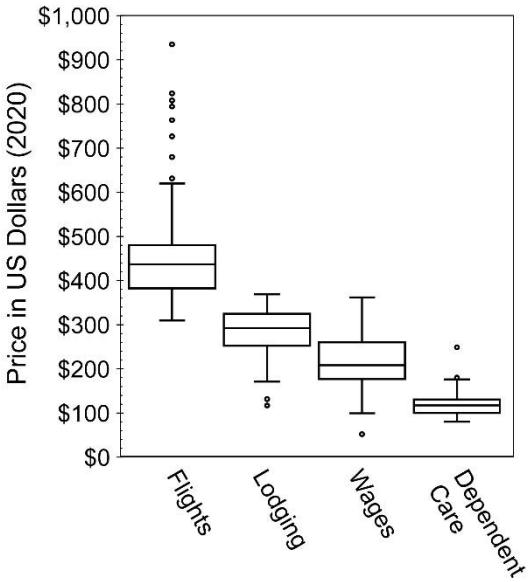

Figure 3: Distribution of costs associated with travel, lodging, loss of wages and dependent care. Dots denote observations outside of 2 standard deviations.

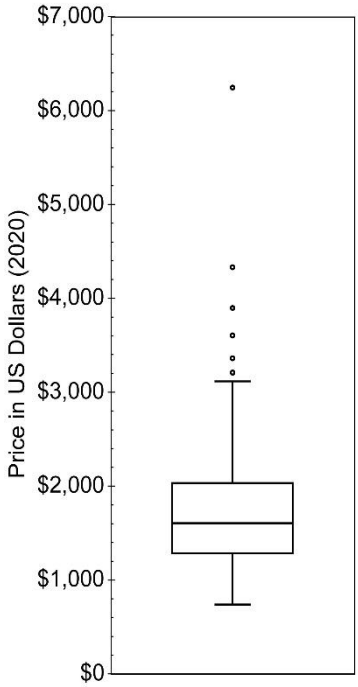

Figure 4: Distribution of costs associated with a week long field exercise, including field gear, travel, lodging, loss of wages and dependent care. Dots denote observations outside of 2 standard deviations.

Conclusions

The expense of field education has been noted as a potential barrier to participation in geosciences; however, thus far, the primary focus of cost-assessments has been on the cost of conducting the science or the costs associated with tuition and fees. In the geosciences, we have historically neglected to account for and accommodate the financial costs associated with field activities, and the potential barriers to diverse participation that lie therein. In this work, four major barriers have been identified that make access to field education challenging: (1) cost of personal field gear, (2) costs associated with travel and lodging, (3) loss of wages, and (4) costs of dependent care. All geoscience students need to have the financial and social capital to surmount at least one of these challenges (i.e., field gear); students from historically disadvantaged backgrounds (e.g. low-income groups, first-generation college students, historically excluded racial and ethnic groups, women, etc.) may need to overcome one or more of these financial challenges to participate in field experiences. These unacknowledged financial burdens perpetuate systemic bias against students who do not possess the necessary social and financial capital; ultimately they contribute to the persistently low rates of representation of racial and ethnic minorities in geosciences. The information in this study is essential for educators, field team leaders and principal investigators designing budgets for inclusive field research or education in geoscience; accommodating these costs in research and education budgets would be a first step towards eliminating barriers to diverse participation. At the administrative level, the budgets for inclusive research and/or required educational field experiences ***must*** account for the financial needs of individual student participants.

Unless we acknowledge and accommodate the costs of field work in research and education budgets, geosciences will continue to be a field in which only the financially and socially privileged can thrive.

Acknowledgements

Funding for this work was provided by the National Science Foundation, Award number 2005439 and 1855209. We thank the student participants and scientists who participated in the 2019 Bonnet Carre field campaign for sharing their experiences and challenges to participation.

Methods

The costs associated with a five-day field experience trip which requires domestic travel were estimated for field experience lasting one work week (a total of 5 days and 4 nights, including 3 work days in the field). In this scenario, students worked in moderate temperatures and high humidity outside New Orleans, Louisiana, U.S.A., and were required to dig trenches, sample and describe deposits, as well as work on a boat to collect cores and grab samples of flood deposits from Lake Pontchartrain.

The cost of field gear and travel were estimated using up to six major online retailers for each item (e.g., gear, flights, hotel bookings). Search results were sorted by "best match" or "featured" according to the retailers' algorithms (typically the default search settings). Research into typical consumer search behaviors (e.g., the average number of pages a consumer visits, the average time they spend on a website, and the average time spent making a purchasing decision) has shown that the first few pages (roughly 40-50 items displayed) is what most consumers use to inform their purchases of products, goods, and services online [23–26]. In our experience, the displayed items that were ranked lower than 40th on the list were no longer relevant to the search criteria. Therefore, the prices associated with the first 40 related items in the search were recorded.

Tracking online activity and prior search histories typically alter the prices displayed; this phenomenon is known as dynamic pricing. To account for this, each search was conducted after web browser history was cleared and a private browsing mode was used [27,28]. Dynamic pricing is usually set by prior search history and proprietary algorithm variations. As a result, collecting data on consumer price distributions poses a challenge. There are always slight variations in the price customers paid for an item [27]. Although the scope of this research is limited to assessing the scale of cost associated with participating in a field activity, we acknowledge that the nuances of proprietary internet algorithms and pricing may result in slight variability in the final estimate reached by different individuals with distinct browsing histories.

All prices associated with each item were used to estimate the range of costs associated with that specific item. The 25th and 75th percentiles were used to bracket the estimated range of costs, as these represent the most likely cost incurred. These values were then totaled to compute the range of costs associated with a field experience and estimate the financial investment required from students.

Personal field gear: Items that were sold in sets of multiples were calculated by individual price per item and recorded in its place. Consumer products available are often marketed differently to men and women, mainly by altering minor aspects of the products such as cut, size variability, and color. Pricing of gendered items were compared, to assess whether men and women pay significantly different amounts [29]. The following gear had gender-related differences in pricing: hiking boots, rain coats, fast drying pants, wool socks, and work gloves. Three separate searches were conducted on each of these gear items: (1) a genderless search, (2) a search for women's gear, and (3) a search for men's gear. For example, when looking for data on hiking boots, three searches were performed – "hiking boots", "women's hiking boots", and "men's hiking boots".

Cost of out of state travel: Cost analyses associated with domestic travel were performed for airfare and lodging. Airfare and lodging estimates were determined by searching four major online travel booking agencies, 6 weeks ahead of the date of the search. A scenario in which students travelled from New Mexico, Ohio, and Georgia, USA, to New Orleans, Louisiana, USA, was used for airfare data. The price of the first top matches for airfare and travel bookings were recorded.

Lost wages: The United States' federal and state minimum wage laws (2020) were used to estimate the cost of lost wages. An 8 hour workday was assumed while calculating the estimated loss of wages.

Dependent care: The average cost of childcare by state was used to compute a cost per week varying by state, and then to predict the range of costs associated with organizing childcare to attend a field trip [30]. This analysis was carried out for dependent care for a single child under the age of 6, under typical child care conditions. These values could potentially be significantly larger as this approach does not account for special accommodations, price differences in adult dependent care, and availability of dependent care outside standard hours.

References

1. Medin, D. L. & Lee, C. D. Diversity makes better science. *APS Obs.* **25**, (2012).
2. Bernard, R. E. & Cooperdock, E. H. G. No progress on diversity in 40 years. *Nat. Geosci.* **11**, 292–295 (2018).
3. Trapani, J. & Hale, K. *Higher Education in Science and Engineering | NSF - National Science Foundation*. (2019).
4. Petcovic, H. L., Stokes, A. & Caulkins, J. L. Geoscientists' perceptions of the value of undergraduate field education. *GSA Today* **24**, 4–10 (2014).
5. Giles, S., Jackson, C. & Stephen, N. Barriers to fieldwork in undergraduate geoscience degrees. *Nature Reviews Earth & Environment* **1**, 77–78 (2020).
6. Wilson, C. *Status of the geoscience workforce 2016*. (American Geosciences Institute,

2016).

7. Wilson, C. E. Status of the geoscience workforce 2019. (2019).
8. Stokes, A., Feig, A. D., Atchison, C. L. & Gilley, B. Making geoscience fieldwork inclusive and accessible for students with disabilities. *Geosphere* **15**, 1809–1825 (2019).
9. Marshall, A. M., Atchison, C. & Collins, T. Building stronger, more inclusive geoscience learning communities through accessible field experiences. in vol. 2019 ED53E–0886 (2019).
10. Oliveri, S. R. & Bohacs, K. *Field Safety in uncontrolled environments: a process-based guidebook*. (American Association of Petroleum Geologists, 2005).
11. Mallory, M. L. *et al.* Financial costs of conducting science in the Arctic: examples from seabird research. *Arctic Science* **4**, 624–633 (2018).
12. Stanfield, R., Manning, R., Budruk, M. & Floyd, M. Racial discrimination in parks and outdoor recreation: an empirical study. in *In: Peden, John G.; Schuster, Rudy M., comps., eds. Proceedings of the 2005 northeastern recreation research symposium; 2005 April 10-12; Bolton Landing, NY. Gen. Tech. Rep. NE-341. Newtown Square, PA: US Forest Service, Northeastern Research Station: 247-253.* (fs.usda.gov, 2006).
13. Schwartz, A. & Corkery, M. R. Barriers to participation among underrepresented populations in outdoor programs. *Recreational Sports J.* **35**, 130–144 (2011).
14. Metcalf, E. C., Burns, R. C. & Graefe, A. R. Understanding non-traditional forest recreation: the role of constraints and negotiation strategies among racial and ethnic minorities. *Journal of Outdoor Recreation and Tourism* **1-2**, 29–39 (2013).
15. Clancy, K. B. H., Nelson, R. G., Rutherford, J. N. & Hinde, K. Survey of academic field experiences (SAFE): trainees report harassment and assault. *PLoS One* **9**, e102172 (2014).
16. Roksa, J. Differentiation and work: inequality in degree attainment in US higher education. *Higher Education* **61**, 293–308 (2011).

17. Burston, M. A. I work and don't have time for that theory stuff: time poverty and higher education. *Journal of Further and Higher Education* **41**, 516–529 (2017).
18. Graf, N., Brown, A. & Patten, E. The narrowing, but persistent, gender gap in pay. *Pew Research Center, April* **9**, (2018).
19. Henly, J. R. & Lambert, S. Nonstandard work and child-care needs of low-income parents. in *Work, family, health, and well-being , (pp* (ed. Bianchi, S. M.) vol. 583 473–492 (Mahwah, NJ, US, 2005).
20. Sandstrom, H. & Chaudry, A. 'You have to choose your childcare to fit your work: childcare decision-making among low-income working families. *Journal of Children and Poverty* **18**, 89–119 (2012).
21. Kamp Dush, C. M., Yavorsky, J. E. & Schoppe-Sullivan, S. J. What are men doing while women perform extra unpaid labor? Leisure and specialization at the transition to parenthood. *Sex Roles* **78**, 715–730 (2018).
22. Vaccaro, A. & Lovell, C. D. Inspiration from home: Understanding family as key to adult women's self-investment. *Adult Education Quarterly* **60**, 161–176 (2010).
23. Pallant, J. I., Danaher, P. J., Sands, S. J. & Danaher, T. S. An empirical analysis of factors that influence retail website visit types. *Journal of Retailing and Consumer Services* **39**, 62–70 (2017).
24. Moe, W. W. Buying, searching, or browsing: differentiating between online shoppers using in-store navigational clickstream. *J. Consum. Psychol.* **13**, 29–39 (2003).
25. Bhatnagar, A. & Ghose, S. Online information search termination patterns across product categories and consumer demographics. *J. Retail.* **80**, 221–228 (2004).
26. Branco, F., Sun, M. & Villas-Boas, J. M. Optimal search for product information. *Manage. Sci.* **58**, 2037–2056 (2012).
27. Deck, C. A. & Wilson, B. J. Tracking customer search to price discriminate. *Econ. Inq.* **44**, 280–295 (2006).

28. Yang, H. & Ye, L. Search with learning: understanding asymmetric price adjustments. *Rand J. Econ.* **39**, 547–564 (2008).
29. Duesterhaus, M., Grauerholz, L., Weichsel, R. & Guittar, N. A. The cost of doing femininity: gendered disparities in pricing of personal care products and services. *Gender Issues* **28**, 175–191 (2011).
30. Mattingly, M. J., Schaefer, A. P. & Carson, J. A. Child care costs exceed 10 percent of family income for one in four families. (2016).