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Research Article

First Step to Scaling Innovation at the National Level in the U.S.: Economic Costs and Savings for Free First Year of National University Education

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Abstract

Objective: Open source technological development has proven that innovation scales with the population of well-educated participants. Thus, to increase national innovation the number of citizens that acquire university educations should be maximized. An approach to this challenge is to offer free university education with open-source virtual classes. To quantify potential savings the objective of this study investigates the viability of offering free first year of university education in the U.S.

Methods: This study calculates total savings per year after accounting for the investments on a first-year education nationally.

Results: The results found that development costs for 16 courses needed to make the transition to sophomore year possible for most of American university students and to ensure they are maintained indefinitely with an endowment is $160 million. To proctor the exams twice a year a block grant to each high school in the U.S. would be $6,400 and the total proctoring cost would be about $171 million. Together conservatively to serve all high school graduating seniors the total cost is $331 million, which is far less than 1% of the U.S. Department of Education annual budget. Savings, again conservatively only counting current American university students on tuition alone would be $46.3 billion/year and as the students could live at home, they would save an additional $17.4 billion/year. The savings minus the costs to provide openly accessible free freshman year of education for the entire U.S. public is $63.4 billion annually.

Conclusion: This approach would increase the university-educated population and increase national innovation rates, but future work is needed.

Keywords: education, university, innovation, economics, national strategic advantage https://doi.org/10.53964/mem.2025001

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1 INTRODUCTION

For several decades now the software industry has demonstrated a novel method of technical development that drives rapid innovation by harnessing the concept of free and open-source software (FOSS)[1]. FOSS is software that is released under a license that enables anyone and everyone to use, copy, study, and change it. Not only is everyone allowed to use it, but the software also is accompanied by source code, which is freely accessible so that everyone can change it. User-developers are encouraged to voluntarily improve the design of the code itself in exchange for the requirement that their adaptations must be re-shared with the same license[2]. Software released with a FOSS license thus establishes a gift economy[3], which has been very well established to create rapid innovation[4,5]. Free and open-source innovation is based on widely used FOSS licenses[6], which have consistently[7] proven to be massively successful[8]. For those outside of the software industry, it is important to understand just how ubiquitous FOSS has become. It is now the dominant method of technical development in the whole software industry. Overall 90% of cloud servers run open-source operating systems[9] such as major companies such as Amazon, GE, Google, Facebook, Netflix, Tesla, Sony, X, Yahoo as well as NASA, CERN and most universities. Both the New York and London Stock Exchanges run on FOSS[10]. More than 90% of the Fortune Global 500, which includes both technology-based companies like IBM, Cisco and Intel, but also major brick-and-mortar retailers like Wal-Mart and even fast food retailers like McDonalds[11]. At this point every supercomputer on the planet runs on open-source operating systems[12]. Open-source now has the vast majority (over 84%) of the global smartphone market[13]. Similarly, the relatively new market of the Internet of things (IOT) is already over 80% run on FOSS[14]. Lastly, artificial intelligence (AI) also is built on an open-source foundation[15,16] as more than half of academic articles on machine learning depend on open-source[17]. Take for example, the open source TensorFlow from Google[18], which is a major contributor to rapid innovation in the AI space[19]. The free open-source innovation cycle is so rapid that The Guardian reported on a Google engineer leak: "Open-source models are faster, more customizable, more private, and pound-for-pound more capable"[20]. FOSS is simply superior because it was able to innovate faster than proprietary models.

The real secret of FOSS innovation, however, is what Eric Raymond called Linus' Law, which state "many eyes make all bugs shallow", that is based on the idea that a diverse set of technically-qualified perspectives improves the quality of a software product[4]. Linus' Law can be applied to any technological innovation arena, but it does demand technically-qualified eyes. The current best practice for obtaining the technical prowess needed to navigate the knowledge economy is a university education[21,22]. Thus, any nation wishing to accelerate innovation would seek to maximize their well-educated population by getting as many students into university as possible. Many nations already use the approach of providing free (or nearly free) university education primarily in Europe (e.g. Norway, France, Germany, Denmark, Sweden, Norway and Finland, for example). This approach challenges the United States of America's historical and now eroding lead as the top "innovation nation"[23]. Historically, America's goals and that of aspiring students was aligned: an American university education has been a consistent method for providing economic mobility[24]. This, unfortunately, has been challenged as university tuition in the U.S. has increased far faster rate than inflation[25-27]. Counter intuitively, the cost of college ballooned even as faculty salaries and faculty to student ratio have remained flat and even decreased[28]. Ballooning tuition is due primarily to both an increase in the number of administrators and their salaries[29,30]. There are now three times as many administrators as there are faculty (on a per student basis) at leading U.S. universities[31]. In order to pay administrators who objectively are overpaid[32], the relative price of university education now forces many students to take on debt sparking a crisis[33]. Although a university education is still a wise investment for an economically secure future[34], high tuition costs have made it more illusive for America's working class[35]. Often the only way for working class students to afford college is to take on debt. This debt has expanded to unprecedented levels and now Americans owe $1.75 trillion in federal government ($1.62 trillion) and private student loan debt combined[36].

Is it possible to provide quality university education at low costs and without forcing students into lifelong debt? One way would be to offer free university education with open-source virtual classes and textbooks. Setting up an entire free online university is challenging and complex, but the potential savings could be substantial. To quantify those potential savings this study investigates the viability of offering the first year of university education for free to the entire U.S. population. Specifically, this study calculates: i) the cost for a standard freshmen class curricula including lectures and auto-graded homework and textbooks for these classes, ii) cost to provide national testing to prove knowledge acquisition, iii) the total savings per year after accounting for the investments on a first-year education nationally. The total economic viability of the approach is determined. The results are discussed, limitations identified,

Table 1. Selected MIT Freshmen Year Courses

Course	MIT Course	Link to Representative OpenCourseware
Calculus 1 and 2	Calculus I: 18.01 Calculus II: 18.02	https://ocw.mit.edu/courses/18-01sc-single-variable-calculus-fall-2010/
Physics 1 and 2	Physics I: 8.01 Physics II: 8.02	https://ocw.mit.edu/courses/8-01sc-classical-mechanics-fall-2016/
Chemistry 1 and 2	Chemistry: 5.111 Chemistry: 5.112	https://ocw.mit.edu/courses/5-111sc-principles-of-chemical-science-fall-2014/
Biology 1 and 2	Biology: 7.012 Biology: 7.013	https://ocw.mit.edu/courses/7-012-introduction-to-biology-fall-2004/
American History 1 and 2	American History to 1865: 21H.101 American History Since 1865: 21H.102	https://ocw.mit.edu/courses/21h-101-american-history-to-1865-fall-2010/
Art History	Introduction to Art History: 4.601	https://ocw.mit.edu/courses/4-601-introduction-to-art-history-fall-2018/
Psychology	Social Psychology: 9.70	https://ocw.mit.edu/courses/9-70-social-psychology-spring-2013/
Anthropology	Introduction to Anthropology: 21A.00	https://ocw.mit.edu/courses/21a-00-introduction-to-anthropology-spring-2022/
Philosophy	Problems of Philosophy: 24.00	https://ocw.mit.edu/courses/24-00-problems-of-philosophy-fall-2019/
Ancient Philosophy	Ancient Philosophy: 24.200	https://ocw.mit.edu/courses/24-200-ancient-philosophy-fall-2004/
Introduction to Media Studies	Introduction to Media Studies: 21L.015	https://ocw.mit.edu/courses/21l-015-introduction-to-media-studies-fall-2003/

and conclusions are drawn about the potential of offering a first year of university education for free for all Americans.

2 METHODS

To estimate the cost of developing a first-year national curriculum it stands to reason that the best curriculum would be targeted. Massachusetts Institute of Technology (MIT) was thus selected as a template because it is generally regarded as one of the top universities in both the U.S. and the world. Currently, MIT is ranked #1 by QS Top Universities[37].

All MIT undergraduates must complete the university's General Institute Requirements (GIRs)[38], which consist of: 6 science courses, 4 communication-intensive courses, 8 humanities, arts and social sciences (HASS) courses, labs, physical education and restricted courses. As it is assumed students will take this first year online and then go to a traditional university for the last three years they can take labs, PE, communication and restricted courses there. The list of classes that would well prepare students following their freshmen year MIT[39] was collected and is show in Table 1. In general, MIT Open Courseware classes have lecture videos, problem sets and solutions, exams and solutions and lecture notes. Some also have recitation videos and simulations. The courses selected for Table 1 were chosen to be easily transferrable to any other university so the virtual year would be counted towards any degree.

The typical student will have 8 classes in the first year. Table 1 shows 16 courses (c) to be developed to provide students with some basic selection to start.

The cost to develop online university courses ranges significantly. It could go from zero (e.g. MIT Courseware already exists and is good) to commercial online course hosting ($200 to $10,000)[40]. The cost of an online course can be more than an in person course depending on how it is done[41]. Similarly textbook authors rarely make significant money in royalties with the lions-share of the profits going to the publishers[42]. One approach to ensuring that a top-quality professor would be working on the course and maintain it indefinitely would be to offer a contest for an endowed professorship. The results of a survey study of university professors in the U.S. show that a super majority (86.7%) of faculty respondents indicated willingness to accept an open source-endowed professorship, where all of their intellectual output would be put in the public domain[43]. Remarkably 27.5% of responding professors declared that no additional economic compensation would be needed for them to accept the terms of an OS-endowed professorship[43]. Thus, the sensitivity for the costs to create a national curriculum goes to zero on the low end as nearly a quarter of American faculty members could be expected to provide their pre-developed courses for the prestige and require no funding. There maybe an even greater opportunity to develop these courses for free if academics outside of the U.S. are considered as well (e.g., Canadian professors had similar responses to the open source endowed professorship survey[44]).

To remain conservative and to make a national level quality textbook, course, and have quality problem sets one would want a top-tier academic working on it and thus it is assumed that it would need to be funded. An average MIT professor makes between $128,000 to $393,000 per year (average $250,000)[45]. To make this prestigious as well as to ensure the funds to hire staff, webserver, etc. $500,000 will be used as the assumption for the draw rate/year/course to fund one professor and appropriate staff to maintain one course of high quality (e.g. self-correcting problem sets). This assumption is extremely conservative as the vast majority of university courses are developed for substantially less. For example, commercially it costs ($200 to $10,000)[40] and this is also the range of what adjuncts are paid to teach a course ($3,556 on average)[46]. Purchasing new technical infrastructure to host the courses is unnecessary. First, the vast majority of universities already have this infrastructure internally, but professors that publish their course in MIT Courseware often leverage external commercial systems (e.g., using YouTube or Vimeo to host the videos or using Github or Gitlab to host the course notes as well as version tracking and issue/error correction). Similarly, there are several zero cost options that would provide hosting like Wikiversity supported by the Wikimedia Foundation (a non-profit dedicated to providing the infrastructure for free knowledge) or the Open Science Framework, which is supported by the Center for Open Science (a non-profit technology organization).

This funding would also allow for quality assurance and all the conventional practices at universities would be maintained. For example, the free textbooks would be peer-reviewed by multiple disciplinary specialists, which is the same for conventional textbooks.

To fund this development and maintenance forever, it is assumed an endowment mechanism is used. MIT currently has a $24.6 billion endowment and earned 8.9%[47]. If it is assumed that the winning university for a course would receive a sustainable 5% return on the endowment, a similarly conservative assumption, $10 million of endowment (E_c) would be needed per course, which could be offered to the universities with zero overhead (an average of 52% would be lost[48] if normal university overheads were applied, but they will profit from the invested endowment as normally the draw rate on the return from the endowment is much less that the actual return and the centralized administration captures the difference).

The cost of developing and maintaining the freshmen year nationally, C_F, would thus be:

$$C_F = E_c \times c \text{ [USD]} \quad (1)$$

where E_c is endowment to create course and c is the number of courses. There are also costs associated with providing the course including maintenance of course, online offering, and proctoring.

The other major costs associated with administering the course is offering exams and grading. The grading could be done with a high stakes end of semester test in each class to be administered electronically as part of the online course. This cost would already be handled by the course development and could work the same way as the problem sets. To ensure that cheating was minimized the exams would be proctored by high school teachers in high schools on the weekend at the end of each semester, twice per year. A high school teacher would need to check U.S. government issued photo IDs and watch as the students that wanted to take the test (and thus get the credit for the course) while making use of computers already at high schools. The number of high school students in the U.S. graduating per year is about 3.93 million, g[49]. To be conservative it can be assumed that all graduating seniors would attempt to take their first year of university for free while living at home and working (or while completing their senior year of high school). There are 26,727 high schools (s) in the U.S. including public and private[50]. Home schooled students could take the tests at their local public school. If it is assumed that each course has a proctor per exam, a 2.5h exam and that high school staff would need to work a half day (4h) to open the school, ensure wifi access, etc. High school teachers make on average $27/h[51]. If it is assumed that the high schools are each offered $50/h ($h$) for their staff, each high school would make a small block grant to proctor per year:

$$p = h \times 2 \times 4 \times c \text{ [USD]} \quad (2)$$

where h is the hourly wage of high school staff and c is the number of courses. The total cost for proctoring would thus be:

$$C_{p/y} = p \times s \text{ [USD/year]} \quad (3)$$

where p is the grant size to a high school to proctor the tests per year and s is the number of high schools. Although the costs were calculated if all high school seniors chose to pursue a university education, the savings will be based on assuming only those that normally would go to university would use the program. Thus, to determine the savings the number of university freshmen is 2.34 million freshmen enrolled in a college, f[52]. The average college tuition is $43,505 ($t_{private}$) for private, $24,513 for public (out of state) and $11,011 for public (instate) (t_{public})[53]. Roughly 27% of university students attend private universities[54]. Again, being conservative if it is assumed that all public students would only avoid instate tuition. The conservative tuition savings would be:

$$s_t = f \times 0.27 \times t_{private} + f \times (1 - 0.27) \times t_{public} \text{ [USD/year]} \quad (4)$$

where f is the number of university freshmen in the U.S. and t is the average tuition at public universities. In addition, it would be assumed that the freshmen students would continue to live at home and thus not need to pay for room at the universities. The average cost of a dorm room, d, at a four-year college was $7,456 in 2022-2023[55]. The conservative board savings are thus:

$$s_d = d \times f \text{ [USD/year]} \quad (5)$$

where d is the average cost of a dorm room and f is the number of university freshmen in the U.S. The overall conservative savings would be:

$$s_{con} = s_t + s_d \text{ [USD/year]} \quad (6)$$

where s_t is tuition savings and s_d is the savings on dorm costs. For the non-conservative best case the savings would replace *f* in equation 4 and 5 with *g*.

3 RESULTS

Using Equation (1), the cost to develop the 16 courses shown in Table 1 and ensure they are maintained indefinitely using an endowment for the winning universities is $160 million. The block grant to each high school in the U.S. would be $6,400 (Equation (2)) and the total proctoring cost would be about $171 million (Equation (3)). Together the total cost is $331 million. For context the U.S. Department of Education (DOE) budget is over $240 billion in 2024[56] so the investment would be far less than 1% of all DOE spending.

Savings for American university students on tuition alone would be $46.3 billion per year by Equation (4). Thus, the savings on board is another $17.4 billion annually from Equation (5). This brings the overall savings to over $63.7 billion USD annually. The savings minus the costs to provide openly accessible free freshman year of education for the entire U.S. public is $63.4 billion dollars. The overall savings would accrue to the university students and their parents and be geographically distributed throughout the country. If the project was successful and increased enrollment in universities to maximize the well-educated to drive U.S. innovation, in the best case all 3.93 million high school graduating seniors, the savings would eclipse over $106 billion dollars annually.

Previous work has investigated the costs and savings of massive open online courses (MOOCs)[57,58]. For example Casement concluded in 2013 that optimism about online learning reducing the price of college is premature as most virtual courses equals or exceeds the charge for traditional ones[41]. Based on the results of this study, his results are no longer accurate for the limited selection of courses and approach used here.

This approach uses a tiny fraction of the current DOE budget to eliminate the costs of the first year of university education for the entire nation. All students that successfully passed the exam would be able enter conventional universities for their final 3 years of a bachelor's degree having all of their online credits transfer.

4 DISCUSSION

4.1 Limitations of Approach

This approach has several limitations. First, this approach does not provide a full complement of the numerous courses (usually several 100) available at most U.S. universities. It has no discussion, no communication, no labs, no field work, no interaction with peers or faculty and no physical education. It is thus lacking in many of the positive attributes of a conventional university education that make them such effective educational tools. It is thus expected that it will not be as effective as conventional university and that wealthier students will instead still choose to attend a brick-and-mortar school despite the costs. Many students do not like online learning[59,60]. Most students would prefer in person vs online learning and most students would tend to want to avoid classes where their entire mark was on a single high-stakes exam. Some less-affluent students may not have easy access to computers and the Internet[61] (about 8% of Americans do not have internet access[62]) and so may also not be serviced well by this model. In addition, some students will not have the necessary self-control to make self-paced learning with the free national online freshmen curriculum effective. These students may fail the exams or learn too poorly to finish their degrees even if they do pass the exams (similar to the current roughly 2/3rds do not graduate in six years after starting their 4-year degrees[63]).

Overall, however it is expected that some fraction of the U.S. university population will choose to attend the free national online university. It will serve those that do have the appropriate self-control, but perhaps not the finances to fund a university. It will also appeal to students trying to minimize their university debt (as U.S. students are now in over $1.7 trillion in debt)[64]. It is important to recall that despite these drawbacks, this approach is meant only to provide the baseline for students to fulfill the requirements to move into their sophomore year without paying any tuition or extra board fees for their first year.

There are also logistical challenges that would need to be addressed to implement this in the U.S. These include setting up the initial endowment contest, evaluating entries, administrating the endowments, ensuring continuity when a professor retires, change jobs or dies. There are also many efficiencies that could be gained - e.g. grouping exams together to have proctoring be less expensive. It may also be possible to group testing centers within a city to do multiple smaller school's students in the same testing location. Having multiple versions of the same course, which would increase investment costs, might also prove to be useful for increasing the university educated population even further.

The largest logistical challenge would be handling the potential scaling issues. Many adults have not finished their university education even if they started it (46% of women have at least a bachelor's degree and only 36% of men have a university degree[65]). Thus, more than half of the population may want to participate in the program. For the initial year of the program, it would thus be recommended that it only be open to senior high school students for the testing. To maximize the number of adults with this education, however it would be ideal to expand it to anyone that wanted to take the tests. Scheduling software would need to be written and adapted to optimize the number of proctors at each high school.

Overall, having this as an option would be highly probable to increase the U.S. university population, it would capture some lower income intelligent students that are being missed by the current system. Using online education to scale science, technology, engineering, and mathematics (STEM) learning has already proven effective at lower costs in other countries (e.g. Russia)[66]. Having a U.S. government backed English entire first year university curriculum would also be valuable for providing education to drive sustainable development throughout the world. This as well as the economic savings for U.S. student population is a secondary benefit. The main advantage for the U.S. government is that with this increase in educated people in the U.S. the innovation rate would be expected to increase[67].

4.2 Limitations of Study and Future Work

The estimates made in the methods section were all meant to be conservative in terms of both costs (estimate high) and savings (estimate low), and thus the total net savings may be a substantial underestimate. How to calculate the additional economic activity for the presumed higher percentage of highly-educated American is also an area that need substantially more investigation. From the model proposed, with relatively modest investments of even $10 million per course eventually all university education could be replicated with high value modules. Future work could also investigate more sophisticated methods of online learning - e.g. self-correcting tutorials that learn and adapt with the student, virtual labs and simulations could all also be developed to add more depth to the curriculum in the future. Substantial future work is needed to determine how much these costs would be and what the savings would be if they were implemented. Developing a method to expand this to the other three years of university education and potentially graduate school are also left for future work. Future work is also needed in interviewing or surveying to determine how students would feel about trading in conventional education for a free federal first year education course.

4.3 Potential Negative Consequences

The implementation of this program would likely be highly disruptive to many colleges and universities throughout the U.S. Several studies have considered how MOOCs in general would be disruptive[68-70], as this would be universal and government sponsored it would be expected to be even more disruptive. With the forthcoming demographic time bomb (2026 on there will be a continuous drop of potential people of traditional college age)[71] this could help accelerate the loss of colleges and universities[72]. Already some have claimed that in 15 years half of U.S. universities could be bankrupt[73]. This could have several negative consequences. First, it would tend to reduce the number of local colleges or universities available for students. This would make living at home during university more challenging and tend to concentrate students at the larger universities with again larger classes sizes and lack of classroom interaction. Having so many universities, which tend to be major employers in their communities, close down would also have major economic impacts especially for university towns. Perhaps most importantly, it would further undercut academics themselves. In an era of fake news, academia still provides some measure of reliable truth despite it being eroded by special interests on many sides of the political spectrum. Although it can be argued that professors have hardly lived up to what Chomsky called the 'responsibility of the intellectual'[74], there are at least some still attempting to point out inconvenient truths to the powerful even if many have failed[75]. It should be pointed out that the majority of faculty have ceded control of academia[30,76]. The free automation of the first year of teaching could provide a slippery slope to completely eliminate the role of public intellectuals that would be a substantive loss for the country. Far more work is needed to probe the ethical consequences of this approach and how to manage it to maximize social benefit for the nation.

5 CONCLUSIONS

This study provided a model to radically reduce the cost of university education nationwide, where a select number of courses would be developed by some of America's best professors. The professor would be ensured continual funding using $10m/course endowments that would be given to the top universities in a contest to prepare the learning materials. Previous research showed that more than 80% of professors in the U.S. would be willing to accept such an endowed chair. Sixteen of the standard first year classes for one of the nation's top universities needed to make the transition to sophomore year possible for most of American university students. The investment cost for this as well as to ensure they are maintained indefinitely with an endowment is $160 million. To proctor the exams twice a year a block grants could be arranged for each high school in the U.S. and would amount to $6,400 annually. This means a total proctoring cost would be about $171 million annually. Together to serve all high school graduating seniors the total cost is $331 million. This estimate, although far less than 1% of the U.S. DOE annual budget, is a conservative overestimate. Savings, again conservatively only consider current American university students. The savings on tuition alone would be $46.3 billion annually and as the students could live at home, they would also save an additional $17.4 billion annually. The savings minus the costs to provide openly accessible free freshman year of education for the entire U.S. public is $63.4 billion annually. Although these economic savings are substantial, the most important result of this approach is that it would be expected to increase the university-educated population and thus increase national innovation rates. Future work is needed to quantify the increases in education and innovation as well as to optimize the approach and find ways to minimize any adverse consequences. Finally, the economic benefits at the national level for the increased innovation should be quantified.

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Conflicts of Interest
The authors declared no conflict of interest.

Data Availability
All data generated or analyzed during this study are included in this published article.

Author Contribution
Pearce JM wrote this article.

Abbreviation List
AI, Artificial intelligence
DOE, Department of Education
FOSS, Free and open-source software
GIRs, General Institute Requirements
HASS, Humanities, arts and social sciences
IOT, Internet of things
MIT, Massachusetts Institute of Technology
MOOCs, Massive open online courses
STEM, Science, technology, engineering, and mathematics
U.S., United States

References
[1] Wasserman AI. How the Internet transformed the software industry. *J Internet Serv Appl*, 2011; 2: 11-22.[DOI]
[2] Lakhani KR, Von Hippel E. How open source software works: "Free" user-to-user assistance. In: Produktentwicklung mit virtuellen Communities: Kundenwünsche erfahren und Innovationen realisieren. Gabler Verlag: Wiesbaden, Germany, 2004.
[3] Zeitlyn D. Gift economies in the development of open source software: anthropological reflections. *Res Policy*, 2003; 32: 1287-1291.[DOI]
[4] Raymond E. The cathedral and the bazaar. *Know Technol Policy*, 1999; 12: 23-49.[DOI]
[5] Herstatt C, Ehls D. Open source innovation: the phenomenon, participant's behaviour, business implications. Routledge: New York, USA, 2015.
[6] Comino S, Manenti FM, Parisi ML. From planning to mature: On the success of open source projects. *Res Policy*, 2007; 36: 1575-1586.[DOI]
[7] Lee SYT, Kim HW, Gupta S. Measuring open source software success. *Omega*, 2009; 37: 426-438.[DOI]
[8] Weber S. The Success of Open Source. Harvard University Press: Cambridge, USA, 2005.
[9] FAIR rackspace. Cloud Computing with Linux | Realise the True Potential & Value. Accessed 4 July 2023. Available at:[Web]
[10] Kumar S. 25 Big Companies and Devices Running on GNU/Linux. Accessed 20 November 2024. Available at:[Web]
[11] Parloef R. How Linux Conquered the Fortune 500. Accessed 4 July 2023. Available at:[Web]
[12] Vaughan-Nichols S. Supercomputers: All Linux, all the time. Accessed 4 July 2023. Available at:[Web]
[13] IDC. Smartphone Market Insights. Accessed 4 July 2023. Available at:[Web]
[14] IoT Developer Survey 2019. Accessed 23 July 2022. Available at:[Web]
[15] Langenkamp M, Yue DN. How open source machine learning software shapes AI. In: Proceedings of the 2022 AAAI/ACM Conference on AI, Ethics, and Society. Association for Computing Machinery. New York, USA, 19-21 May, 2022.[DOI]
[16] Gibney E. Open-source language AI challenges big tech's models. *Nature*, 2022; 606: 850-851.[DOI]
[17] Engler A. Five ways that Open Source Software shapes AI policy, Brookings. Accessed 19 July 2023. Available at:[Web]
[18] Dean J. Tensor Flow - Google's latest machine learning system, open sourced for everyone. Accessed 19 July 2023. Available at:[Web]
[19] Mewald C. The Golden Age of Open Source in AI Is Coming to an End, Medium. Accessed 19 July 2023. Available at:[Web]
[20] Milmo D. Google engineer warns it could lose out to open-source technology in AI race. Accessed 28 July 2023. Available at:[Web]
[21] Amidon DM. Innovation Strategy for the Knowledge Economy. Routledge: London, UK, 2009.
[22] Davenport P. UNIVERSITIES AND THE KNOWLEDGE ECONOMY. Accessed 20 November 2024. Available at:[Web]
[23] Kao J. Innovation Nation: How America Is Losing Its Innovation Edge, Why It Matters, and What We Can Do to Get It Back. Simon and Schuster: New York, USA, 2007.
[24] Haskins R, Holzer HJ, Lerman R. Promoting Economic Mobility by Increasing Postsecondary Education. Accessed 20 November 2024. Available at:[Web]
[25] Smart JC (Ed.). Higher Education: Handbook of Theory and Research. Springer Dordrecht: Berlin, Germany, 2005.[DOI]
[26] Bundick B, Pollard E. The Rise and Fall of College Tuition Inflation. *Econ Rev*, 2019; 104: 1-19.[DOI]
[27] Akers B. A New Approach for Curbing College Tuition Inflation. Report. Accessed 20 November 2024. Available at:[Web]
[28] Rhoades G. College tuition increases and faculty labor costs. Available at:[Web]
[29] Leslie LL, Rhoades G. Rising Administrative Costs. Accessed 20 November 2024. Available at:[Web]
[30] Ginsberg B. The Fall of the Faculty. Oxford University Press: New York, USA, 2011.
[31] Weinstein P. Administrative Bloat At U.S. Colleges Is

Skyrocketing. Accessed 20 November 2024. Available at:[Web]
[32] Pearce J. Are you overpaying your academic executive team? A method for detecting unmerited academic executive compensation. *Tert Educ Manag*, 2016; 22: 189-201.[DOI]
[33] Carlson SM. The US student loan debt crisis: State crime or state-produced harm?. *J White Collar Corp Crime*, 2020; 1: 140-152.[DOI]
[34] Reddick CG, Ponomariov B. The effects of institutional factors on the return on investment of a university education in the United States of America. *Qual High Educ*, 2024; 30: 185-199.[DOI]
[35] Schueckler C. Can I afford college? High tuition costs squeeze out middle-class students like me. Accessed 20 November 2024. Available at:[Web]
[36] Hanson M. Student Loan Debt Crisis. Available at:[Web]
[37] QS TOP UNIVERSITIES. Massachusetts Institute of Technology (MIT). Accessed 21 November 2024. Available at:[Web]
[38] MIT Office of the First Year. General Institute Requirements (GIRs). Accessed 22 November 2024. Available at:[Web]
[39] MIT Office of the First Year. Typical First-Year Schedule. Accessed 23 November 2024. Available at:[Web]
[40] Cavalheiro V. How Much Does It Cost To Create an Online Course? Accessed 24 November 2024. Available at:[Web]
[41] Casement W. Will Online Learning Lower the Price of College? Accessed 24 November 2024. Available at:[Web]
[42] Lepionka ME. Writing and Developing Your College Textbook: A Comprehensive Guide to Textbook Authorship and Higher Education Publishing. Atlantic Path Pub: Gloucester, USA, 2008.
[43] Pearce JM, Pascaris AS, Schelly C. Professors want to share: preliminary survey results on establishing open-source-endowed professorships. *SN Soc Sci*, 2022; 2: 203.[DOI]
[44] Pearce JM, Tiwari S, Pascaris AS et al. Canadian professors' views on establishing open source endowed professorships. *Cogent Educ*, 2022; 9: 2122255.[DOI]
[45] Indeed. Professor yearly salaries in Cambridge, MA at Massachusetts Institute of Technology. Accessed 24 November 2024. Available at:[Web]
[46] Wilson J. The Typical U.S. College Professor Makes $3,556 Per Course. Accessed 5 December 2024. Available at:[Web]
[47] MIT News. MIT releases financials and endowment figures for 2024. Accessed 24 November 2024. Available at:[Web]
[48] KAISER J. NIH plan to reduce overhead payments draws fir. Accessed 24 November 2024. Available at:[Web]
[49] Smith CP. High School Graduation Trends in the Years Ahead. Accessed 24 November 2024. Available at:[Web]
[50] Winograd G. How Many Schools in the US (2024 Updated Data). Accessed 24 November 2024. Available at:[Web]
[51] ZipRecruiter. High School Teacher Salary. Accessed 24 November 2024. Available at:[Web]
[52] Alonso J. 'A Very Promising Sign'. Accessed 24 November 2024. Available at:[Web]
[53] Wood S. See the Average College Tuition in 2024-2025. Accessed 24 November 2024. Available at:[Web]
[54] Statista. U.S. college enrollment and forecast 1965-2031. Accessed 24 November 2024. Available at:[Web]
[55] de Visé D. Two roommates. A communal bathroom. Why are college dorm costs so high? Accessed 24 November 2024. Available at:[Web]
[56] USAspending. Department of Education (ED). Accessed 24 November 2024. Available at:[Web]
[57] Hall R. For a political economy of massive open online courses. *Learn Media Technol*, 2015; 40: 265-286.[DOI]
[58] Belawati T. Open education, open education resources, and Massive Open Online Courses. Accessed 24 November 2024. Available at:[Web]
[59] O'neill DK, Sai TH. Why not? Examining college students' reasons for avoiding an online course. *High Educ*, 2014; 68: 1-14.[DOI]
[60] Fetzner M. What Do Unsuccessful Online Students Want Us to Know? *J Asynchronous Learn Netw*, 2013; 17: 13-27.[DOI]
[61] Kahin B, Keller J. Public Access to the Internet. MIT Press: Cambridge, UK, 1995.
[62] Scholl J. Millions of Americans Still Don't Have Internet at Home, U.S. Census Data Says. Accessed 24 November 2024. Available at:[Web]
[63] National Center for Education Statistics. The NCES Fast Facts Tool provides quick answers to many education questions. Accessed 24 November 2024. Available at:[Web]
[64] CFR.org. What Should the U.S. Do About Rising Student Loan Debt? Accessed 24 November 2024. Available at:[Web]
[65] Schaeffer K. 10 facts about today's college graduates. Accessed 24 November 2024. Available at:[Web]
[66] Chirikov I, Semenova T, Maloshonok N et al. Online education platforms scale college STEM instruction with equivalent learning outcomes at lower cost. *Sci Adv*, 2020; 6: eaay5324.[DOI]
[67] Nambisan S, Sawhney MS. The Global Brain: Your Roadmap for Innovating Faster and Smarter in a Networked World. Pearson Prentice Hall: Harlow, UK, 2007.
[68] King E, Alperstein N. Best Practices in Online Program Development: Teaching and Learning in Higher Education. Routledge: New York, USA, 2014.
[69] Savelli S. Massive Online Open Courses: Towards Openness. *DigitCult-Sci J Digit Cult*, 2016; 1: 49-66.
[70] Jirgensons M. Educating the Future with Disruptive e-Learning Solutions. *Int Conf Comput Supp Educ*, 2014; 2: 65-70.[DOI]
[71] Amesite. Navigating the Impending Demographic Downturn: The Higher Education Time Bomb Post-2026. Accessed 24 November 2024. Available at:[Web]
[72] Moody J. A Look Back at College Closures and Mergers. Accessed 24 November 2024. Available at:[Web]
[73] Suster M. In 15 Years From Now Half of US Universities May Be in Bankruptcy. My Surprise Discussion with @ClayChristensen. Accessed 24 November 2024. Available at:[Web]
[74] Chomsky N. The Responsibility of Intellectuals. The New Press: New York, USA, 2017.
[75] Allott N, Knight C, Smith N et al. The Responsibility of Intellectuals: Reflections by Noam Chomsky and others after 50 years. UCL Press: London, UK, 2019.
[76] Donoghue F. The Last Professors: The Corporate University and the Fate of the Humanities, With a New Introduction. Fordham Univ Press: New York, USA, 2018.