UDC 371.3
DOI: 10.52534/msu-pp1.2024.46

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The entrepreneurial revolution in science research and education

Article's History:
Received: 29.10.2023
Revised: 25.02.2024
Accepted: 27.03.2024

Suggested Citation:
Halma, M. (2024). The entrepreneurial revolution in science research and education. *Scientific Bulletin of Mukachevo State University. Series "Pedagogy and Psychology"*, 10(1), 46-55. doi: 10.52534/msu-pp1.2024.46.

Abstract. There are significant challenges in both student and researcher engagement in both education and research, and one contributing factor is the lack of autonomy that each person experiences. This work charts a new path, whereby students and researchers are free to pursue their own interests, and the role of the teacher or university is to support and guide them. This article is a narrative review examined the challenges faced by the educational industry and how they can be remedied through student led, entrepreneurial education, which can take place online. This article examines the impacts of learner autonomy and present alternative apprenticeship models which can be performed inexpensively and produce value independent of the education itself. Apprenticeship, self-directed and project-based pedagogy provides pupils with the skills that they need to succeed in the modern world, differing importantly from standard education, where the relevance to employers is decreasing. While currently, scientific institutions face a crisis of innovation and a related crisis of public trust, entrepreneurial education provides a means of addressing these related problems. These changes have implications at the institutional level, as well as for the relationship between science and society. During budgetary crises, these changes present ways to provide an improved educational experience at lower cost. Overall, entrepreneurial education may be an effective and cost-effective way to perform research and to train pupils for the skills needed in the 21st century. The work provides a roadmap to how existing educational institutions can adapt to the sea change underway with online education, as well as advise new entrants on best practices

Keywords: entrepreneurship in education; science education; scientific research environment; pedagogy; project-based education

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INTRODUCTION

One purpose of education is to prepare the graduate to achieve a greater level of success, productivity, and achievement than they otherwise would without the education. This research explores the current trends in education away from traditional degree-granting universities towards learner directed, "entrepreneurial" education. This research provides a practical guide for how learning institutions can incorporate greater learner autonomy in education and research, and the value of an entrepreneurial outlook to scientific research and education.

The value for the cost of a university education has increasingly come into question, evidenced by decreases in undergraduate enrolment since their peak in 2010 (National Center for Education Statistics, 2022). Enrolments in 2021 were 15% lower than in 2010, and the trend of decline predates the coronavirus pandemic. Additionally, the importance of a college degree is declining; the percentage of US adults who view a college degree as "very important" fell from 70% in 2013 to 51% in 2019, and this decline is most pronounced in young adults (Marken, 2019).

Simultaneously, fewer jobs require college degrees. In the USA, the percentage of jobs requiring a college degree declined from 51% in 2017 to 44% in 2021 (Levanon, 2022). Importantly, the university is increasingly becoming unaffordable, owing to tuition increases; in inflation adjusted dollars, total average undergraduate tuition, including fees, room, and board has increased 175% from $10,097 (2021/22 dollars) in 1980 to $27,764 in 2020 (Digest of Education Statistics, 2023). Likewise, the debt burden for students increases; half of student borrowers still owe at least $20,000 after entering school 20 years ago (Hanson, 2023).

Students are increasingly getting a poor return on investment for the time, money, and energy that they spend on a university degree (Bleemer *et al.*, 2021). As tuition increases, the earning potential of a degree is decreasing, furthermore, lower cost alternatives are entering, including online education, which can often achieve significant price improvements compared to the price of an in-person education (Chirikov *et al.*, 2020). With these factors coming into play, universities must innovate to stay relevant. The current value provision of universities provides several value streams: The education itself, the degree credential, and the university experience, including networking opportunities. The value of education is being competed downwards, with lower cost or even free resources offering the exact same content (Haleem *et al.*, 2022). While many of the other resources do not have the strong credentialing function, increasingly employers are valuing online certifications and competence testing as opposed to a degree (Carnevale *et al.*, 2020). During the Covid-19 pandemic, this issue of the value of a university degree was exacerbated as many universities closed their in-person classes, offering online classes only, which while similar in format and value to many online alternatives, remained at the same price as their in-person offerings before the pandemic (Chakraborty *et al.*, 2021). Many people took issue with this, pointing out that while online-only represents a significant degradation in the quality of education, it was not accompanied by a significant decrease in price. Presently, the market for higher education is typically thought to be restricted to universities, and due to the large demand of students for education and the limited supply of universities, in terms of lecturers, buildings and resources, prices have gone up (Bleemer *et al.*, 2021). Furthermore, the barriers to starting an accredited, degree granting university keep market entrants out. New entrants face the challenge of reputational development, which typically requires five years at minimum. Regulatory forces exist which advantage the currently established players.

Here, new entrants have the advantage of providing online education, which obviates many of the capital-intensive costs of setting up a learning institution. Furthermore, e-learning increases accessibility, as classes can take students from anywhere in the world, so long as that person has at least transient access to the internet (Valverde-Berrocoso *et al.*, 2020). Current primary and secondary education provides the government funded school as the main option, and private school is out of reach financially for many people. However, much of the educational needs can be supplemented by online courses, which can be delivered at low cost. If necessary, one can also, while keeping fixed costs low, rent out venues or rooms in order to teach classes, or the education can be given in the owned spaces (dwellings or businesses) of the teachers, pupils (in the case of adult education) or their parents (in the case of primary or secondary education). While the shift away from a physical campus is important for keeping fixed costs low, the educational institution may choose to create a physical campus as they grow in numbers and resources. Importantly, the shift towards online education allows competitors to enter the market and significantly lower capital requirements. Lowering capital requirements allows for new entrants to provide an online experience and compete with incumbent education.

This article presents a narrative review examining the challenges faced by educational institutions by competitors in online education, as well as the relatively lower value of a university degree in this new environment. This study aimed to investigate how educational institutions can adapt to the growing scepticism of students and employers about the value of a university degree, and how education can adapt to this environment. The study used the methods of analysis, synthesis, generalization, and systematization. A search was conducted for sources in international databases, such as Scopus, related to project-based education, student engagement in research, etc. The 64 most relevant ones were selected, and this paper was written on their basis. This article then examines examples of schools enabling greater learner autonomy and presents alternative apprenticeship models which can be done with low capital requirements and their learner outcomes, presenting a qualitative comparison between entrepreneurial education and standard education. The article then discusses the implications of this educational model for science and the education sector.

EDUCATIONAL TRENDS: SELF EDUCATION AND MICRO-CREDENTIALS

Increasingly, parents are embracing homeschooling, unschooling and alternative pedagogies including Montessori (Lillard & Else-Quest, 2006) and Waldorf schools (Stehlik, 2019). The growth in these alternative forms of education displays a general dissatisfaction with the quality of children's education. Many high school graduates lack basic literacy, numeracy, critical thinking, and reasoning, and often need to take remedial classes when they reach university (Gorzycki *et al.*, 2016). Enforcement of standards for education requires more effort than merely passing students, and the educational quality suffers. Though a lagging measure, the value of a degree lowers, as it takes some time for the current crop of students to fully penetrate the job market to reflect their education upon their employers and peers. Grade inflation has been an issue, as pupils and their parents increasingly see education as a product that one purchases, and not a process that one must take active ownership in (Johnson *et al.*, 2006). The consumer model also motivates a passive approach to education by the students, where they study merely to achieve the end of graduation. Many researchers, parents, and educators have showcased the importance of learner directed education, as this provides the passion and self-direction to learn something (Brookfield, 2009; Lee *et al*., 2016). When students learn what they are interested in, discipline and self-direction take care of themselves. Here the role of the teacher becomes less like a singular authority transmitting information unidirectionally, but a coach in dialogue with the students to help them to discover their proclivities, gifts, interests, as well as the possible value that they can provide others (van Nieuwerburgh & Barr, 2017; Beard & Wilson, 2018). Combining these attributes with the willingness of people to pay for the skill produces the Japanese concept of "Ikagai", which is the intersection between one's interests, abilities, an unmet or underserved want in the world, and people's willingness to pay for the work that the pupil does (Kumano, 2018).

This model allows students to reach an optimal vocation for themselves. Courses are imposed on students through standardized curricula. The justification is that students need to take a variety of course requirements in order to provide a well-rounded education. While the student has some say in the courses that they take, they choose from the options presented to them, and are passive agents in a static course structure. Often, a justification presented for faculty designing curricula is that if the students were to decide, they would just make things extremely easy for themselves. While this may hold for the cases in which students are not engaged in course content, when there is alignment between the skills taught and the student's interest, students often go well beyond what would be the mere requirement for passing, or even passing with honours, in a standard class. However, some balance and guidance from a teacher/coach is important. While some students have a clear and definitive idea what their interests are and what their learning journey will look like, many pupils do not know their interests or may know their interests but have not mapped out a learning journey (Bjørke & Mordal Moen, 2020). This process of interesting discovery occurs by pupils exploring topics that they are curious about. If they are not curious about anything, they can notice this, or, with the agreement of the pupil, the teacher can suggest topics for them to investigate, based on the coach's assessment of the pupil's aptitudes and interests. With interest comes greater exploration, and the teacher/coach can be extremely helpful here in charting a learning path together with the pupil. Increasingly, the availability of information means that the teacher is less in this provider role of transmitting information, for this has both limited utilities, and their efforts are better directed towards coaching the pupil in following their own interests. This need not be restricted to any way to learn more, including reading books, watching educational videos, attending courses (online and in person), workshops and seminars, and taking an apprenticeship with someone practising the skill at a higher level. Here, the environment becomes more entrepreneurial. On the demand side, pupils are choosing their own education and designing their own "curriculum" and incorporating multiple different formats, as opposed to being restricted to the standard pedagogical mode of a classroom (Sorgman & Parkison, 2008). On the supply side, advanced practitioners and teachers can design workshops and charge fees for these. Group workshops often produce more favourable economics and can also have the advantage of the pupils teaching each other and being able to participate in exercises. Smaller workshops or class sizes can also be beneficial, as it allows a deep dive into a skill set which may not be reached in a classroom with other pupils. Practitioner-teachers may eschew at least a portion of monetary remuneration by requesting help from the pupil, who can both help with some less advanced aspects of the business while learning. Here, as long as there is communication and agreement, both parties' benefit. In some cases, the coach or a third party may wish to be at the table when the arrangement is made, to ensure that the arrangement is fair for both parties. Apprenticing does require effort on the part of the mentor, and continuation and enthusiastic participation requires that the arrangement be a win-win for both parties.

There are numerous benefits to an apprenticeship model and project-based learning over traditional education (Muehlemann & Wolter, 2014; Wolter & Mühlemann, 2015; Kokotsaki *et al*., 2016). Students graduate with very practical skills that are already in demand in the marketplace, otherwise the apprenticeship mentor would not be employed. The pupil may continue to collaborate with the mentor for some time afterwards, until they feel confident and have enough resources to begin on their own. This emancipation is the ideal outcome to come from education, where the former pupil now has learned everything, they need to know to pursue their craft, as well as be paid for it enough to continue and to invest in the furthering of their education. Furthermore, the former pupil can now take on apprentices, which is especially valuable to someone starting out. While they may be less senior than some people, pupils learn the business at the early stage, which is the stage that they are entering. As the mentor rises in stature and competency, he may wish to mentor more advanced pupils, and will differentiate in important ways from the other practitioners in his industry. This differentiation means that the mentor can then teach her own method, as she has achieved a level of mastery where her expertise is respected. The practitioner can then begin creating educational products, and these can reach far more people than a one-on-one mentorship arrangement can. Furthermore, these products intended for a broader audience may introduce interested people to the craft. This view of education fundamentally values sharing of knowledge. Many people selling educational products online have very high-quality free content, which they can fund through monetizing higher touch products. This allows people the guidance they seek in executing their plans.

ENTREPRENEURSHIP IN RESEARCH: STUDENTS AT THE FRONTIER

While the intersection of entrepreneurship and scientific research typically is associated with the valorization of the scientific work, it is worth fostering an entrepreneurial orientation for scientists to be more capable at self-directing their own research. There is a transition where an early career researcher goes from as a PhD student or postdoc to an early faculty position where they are expected to fund themselves and define their own project. Here, scientists often find that the skills they previously learned, do not prepare them for this transition (Haubenstock, n.d.).

Beginning a lab is like starting a business, and the management is similar. One must deal with hiring and managing people, spending money, and keeping the venture profitable, while negotiating with the institution, suppliers, and generating support for research. While some researchers do not wish to learn this, some stay as postdocs, preferring the other factors be covered by their lab head. However, this limits their effectiveness as well as their own personal and professional growth. While some may wish to stay where they are due to understandable factors, many postdocs feel dissatisfied in the long term, feeling they have not reached their potential, and that their compensation is too low. It should be said that many postdocs have achieved an elevated level of technical skill, and it may be their most effective position to continue doing this. However, innovation can occur here as well. For example, at an elevated level of competency, they can see if they can automate the process or teach others in the process. Putting out educational products is a way for a laboratory to provide value to the wider community, as well as to provide a source of incoming revenue. Communicating with the public is also necessary; scientists are often implored to become "science communicators" and speak to the public, but public engagement in science events and discourse is limited (Weingart & Guenther, 2016). About half of scientists have some contact with journalists, and 47% of scientists disseminate their research through social media (Pew Research Center, 2015). Still, given the tenuous relationship between scientists and the public, these efforts do not engage the public sufficiently (Intemann, 2023). Achieving a challenge-skills balance, as pointed out by Mihaly Csikszentmihalyi's book Flow in one's efforts, is necessary for one to grow in one's field (Csikszentmihalyi, 1990). While someone who is taking on a new challenge may feel inadequate to face the challenge, at least at first, they do not feel disengaged or like they are stagnating. If the challenge-skills balance is chosen well, then they will experience rapid growth and learning, and at some point, they can look back at having conquered the challenge of learning a new skill.

Universities and granting agencies can support their academics by granting them autonomy in choosing which research directions to take (Jabrane, 2022; Niemczyk & Rónay, 2023). Granting agencies may wish to define a project, and that is fine. By granting autonomy, trust in the capabilities of the researcher is communicated, and the researcher has the confidence they need to take on large challenges. On the other side, academics who do not rise to the challenge should be removed, as they both squander resources and set a poor and highly contagious example to their peers and students (van Mook *et al*., 2010). Institutions of teaching and research must prioritize excellence and communicate clearly that mediocrity is not allowed so long as one carries this affiliation. With this, genuine excellence can develop in institutions, as the culture pushes people to be greater, rather than the culture of mediocrity exemplified by bureaucracies and most clearly showcased in coffee mugs which say things like "I can't wait for the weekend". Mediocre employees must be removed; they should first be given the choice to step up, though this is a gesture, as those truly willing would take the first steps themselves. If a member of the faculty feels they need help to achieve mastery, this can be answered, so long as the impetus and onus lies with the faculty member. Nobody is trying to hold onto a hiring, when there is an obvious misalignment. Academics need to be free to apply for grants and to initiate interesting projects, capable of reaching out to unconventional funding sources, and communicating through the public via multiple channels. The university can highlight examples of excellence in research, communication, and practice, and invite those with demonstrable excellence to share their knowledge.

Regarding self-development, the university currently focuses almost entirely on mental aspects. While lately there are some initiatives towards mental health, these are focused on coping strategies and do not provide an authentic experience of mastery and growth. Physical exercise should be emphasized, and the university should not sell unhealthy food on its campus, as these empirically undermine learning and health. The easiest way to adopt change is in the cafeterias, which serve as a centralized location to serve students and staff. This food should be of high quality, organic, and unhealthy food, such as soft drinks, should not be available (Hakim & Meissen, 2013). Ideally, the food should be grown locally, if not right on campus as part of practical education in agriculture, horticulture, gardening, animal husbandry and culinary arts (Ratcliffe *et al*., 2011). To not engender passivity, the students' union may take charge of the cafeteria to ensure that the requisite functions for service are fulfilled, including cleaning (Singapore Introduces Daily Cleaning Duties for Students, 2016). Students are free to organize it how they wish, but they are responsible for its operation. In this model, all parts of the day can serve as educational opportunities, and practical skills are important to learn. Cooking is one of the most important skills that anyone can have, as home cooking is associated with greater health outcomes and can provide a satisfying social experience and way to connect with others. Training students to fund their own research and manage their labs is an essential element which is absent from their education currently, which emphasizes technical skills. Often, technical people believe that these skills are "beneath" them in some way, as evidenced by their designation as "soft skills". Communication and people skills are vital to having an impact beyond being a technically competent individual. Additionally, educational experience should teach the attributes of taking responsibility, of being self-directed, and of intelligent risk taking. Boldness is reprioritized in schools, which reward obedience, penalize collaboration, maintain that there is one correct answer and approach, and punish mistakes (Table 1).

Table 1. Differences between science as currently practised and entrepreneurial science

Science as practised	Entrepreneurial science
Obedience	Respectful challenge
Risk aversion	Risk taking
Mono-disciplinary	Multidisciplinary
Individual	Collaborative
Scarcity	Abundance
One correct approach	Multiple approaches
Teacher as authority	Teacher as mentor
One-way communication	Dialogue
Mistakes are to be avoided	Mistakes are learning opportunities
Mediocrity	Excellence/mastery
Rewarding meekness	Rewarding valiant attempts
No standards	High yet achievable standards
Implicit denigration of student capabilities	Believing students can achieve more
Sees duty as measuring and sorting static capabilities	Sees duty as growing dynamic student potential
Education detached from real world	Education for the real world
Highest possible achievement: perfect grade	Unlimited upward potential
Prescribed	Self-directed
Learning toward narrow test	Learning towards project application
Intangible, largely forgotten outcomes	Tangible outcome
Teacher does not practice subject	Subject teacher is practitioner
Fixed mindset	Growth mindset

Source: author's original work

The many differences in approaches between entrepreneurial education and standard education are highlighted in Table 1. Self-directed and project-based learning create significant positive benefits on academic achievement for the pupils in these programs (Zhang & Ma, 2023). The ethos of traditional schooling has been suitable for industrial production; however, it fails to teach the skills and mindsets for success in today's world. One of these most important orientations is for pupils to take initiative and responsibility for their own learning, which will often mean signing up for a course or mentorship opportunity. It is even possible for self-directed pupils to advance the frontier of a field. Student capabilities, which are underestimated and underutilized in current school systems, can be better developed by incorporating entrepreneurial elements in education.

SCIENCE IN THE REAL WORLD: THE INTERFACE OF SCIENCE WITH THE PUBLIC

Scientists need to leave the ivory tower and interface with the world to gain support for their research (Halma & Guetzkow, 2023). The public is no longer willing to support nameless research and vague research agendas. The future will require researchers to actively sell the public on their research and to gain funding through voluntary provision of funds, and not government grants which are assumed endless. Lower levels of infrastructure costs motivate "zero-based" thinking in science, meaning that scientists are never guaranteed a continuation of their position. While the project should be contracted out and funded in advance ideally, and the researcher should have time, if they are not making progress, it will become apparent as the deadlines pass without the accompanying milestones. In this case, they may either come back for more support, lower the scale of their project, or possibly abandon it altogether. Investors from the public must also perform due diligence on projects and people, and a percentage will fail. This also enables a shift away from institution-supported narratives, which has come to the fore when official pronouncements about coronavirus and the response, were demonstrably wrong, while amateurs made accurate predictions and assessments that are still being confirmed today (Shir-Raz *et al*., 2022; Halma & Guetzkow, 2023).

Entrepreneurship relies less on the opinions of experts, and the market is the final judge of success. The non-entrepreneur looks at the economy and assumes all the roles have been filled already, where the entrepreneur finds and creates a role for herself. This is a fundamental difference, and while the latter is less secure, there is far more potential value in people pursuing their own research directions, instead of making incremental improvements suggested by an expert. This is echoed by research showing that as fields become more established, they also become less disruptive (Park *et al.*, 2023). Given this finding, researchers emphasize creativity training in science (Yanai & Lercher, 2023). Informal and hobbyist science, termed "Night Science" by Francois Jacob, is more interdisciplinary (Jacob, 1995). In several publications, interdisciplinary science is associated with greater impact than its monodisciplinary counterparts, as long as the fields are sufficiently proximal (Yegros-Yegros *et al.*, 2015). Innovation is occurring in the world of bits, while innovation in the world of atoms still faces many challenges. While technology has putatively improved, improvements in real services have not manifested. For example, as medical spending increases, there is not a concomitant increase in population health quality (Tanne, 2023). Despite the tendency for technological development to drive down costs over time, people are increasingly struggling to pay for necessities (Gooding, 2022). One would imagine that with improvements in digital dissemination of lessons, as well as freely available tools and lectures, the cost of education could see decreases, or the quality could see significant improvements. Despite newer technologies, a large scale, 20-year survey from 1988 to 2008 found no significant improvement in undergraduate scientific literacy over the time period (Impey *et al.*, 2011). Several thinkers such as B. Masters & P. Thiel (2014) have postulated that society is currently in a state marked by lower levels of innovation, which echoes other observations of declining rates of innovation (Huebner, 2005). Parallel observations in economics show declining American business dynamism (Akcigit & Ates, 2021).

This would suggest that there is a declining rate of valorization from science, or that the current valorization of science has a lower impact on people's lives. One potential counter to this trend is the adoption of lean startup methodologies in science (Yordanova, 2022). In the example of life sciences, it is estimated that 85% of research funds are wasted, which amounts to an estimated $200 billion USD in the USA in 2010 (Chalmers & Glasziou, 2009; Macleod *et al.*, 2014). Even optimistic estimates making the case for science find a startlingly low return on investment for publicly funded research and development; estimates for the level of National Institutes of Health funding to produce a single patent range from $4.3 million to $40 million (Kalutkiewicz & Ehman, 2014; Azoulay *et al.*, 2019). Within academic economics literature, the value of public investment in research and development (R&D) is equivocal, despite this being the primary justification for the public funding of research (Toole, 2012; Yin *et al.*, 2022). In the USA, the current research funding environment emerges out of the Vannevar Bush era, which prioritized funding both applied and basic science, and importantly, established science as a permanent institution under governmental aegis (Miri, 2021). This established a permanent role for the government to guide the technological development of the nation and an associated bureaucracy to enable research deemed in the public interest. While the current funding system possesses some market mechanisms such as funding competitions, still, the system possesses characteristics of central planning, with all the attendant inefficiencies that that carries (Stringham, 2001).

This discussion of wide-scale inefficiencies calls for entrepreneurial science to be instantiated not only at the level of the individual scientist, but that it permeates the current systems for scientific knowledge production. Little literature exists on the explicit comparison between public funding models for science vs. private funding models, though the analogy of industrial R&D exists. The association between private R&D expenditures and the number of patents is positive, while there is no association between governmental R&D expenditures and the number of patents (Paula & Silva, 2021). The major difference between private and governmental R&D is that private R&D is constrained by the need for the firm to be profitable, which usually leads to them addressing a consumer need. Levels of private R&D funding are disciplined by the market, whereas governmental R&D investment has a less pressing need to address a consumer need and is more insulated from market forces. This work suggests that the introduction of market mechanisms into research can increase the level of innovation, as parametrized by the number of patents issued. Increasingly, scientists are asked to weigh in on issues which affect the public without being accountable to the public. For example, during the Covid-19 pandemic, views dissenting from public policy were denounced as anti-science (Bozeman, 2022; Shir-Raz *et al.*, 2022; Harambam & Voss, 2023). While some suppositions from the opposition were outlandish, others gained credibility, such as the possible laboratory origin of Covid-19, the equivocal effectiveness of masks (Jefferson *et al.*, 2023), and the dangers associated with mRNA vaccination (Piché-Renaud *et al.*, 2023; Looi, 2023). Surveys show the public desires a greater level of transparency and accountability in scientific research (Funk, 2021).

Science which interfaces with the public and public (i.e. market) needs is more likely to produce a novel and useful innovation, which may be a patent. Insulation of science from public engagement and market discipline is deleterious to the institution of science, as it can breed both distrust from the public, or irrelevance, as exemplified by the negligible contribution of governmental R&D to the patent productivity of a nation (Paula & Silva, 2021; Halma & Guetzkow, 2023). A current source of tension between science and the public is the perception that research and education are squandering limited funds, and scientists are in turn "insulated" from the same market that most people live in. This critique is not baseless, as much of scientific research is of dubious value, given its low citation rate. It is important that, if science is to depend on public funds, that it ultimately be accountable by public audit into the value of the research and the allocation of resources. In a healthy and mutual beneficial relationship between science and the public; the public believes that it is receiving an adequate return on investment through the value generated by scientific research, and valuable work by scientists is adequately supported. A restoration of scientific accountability to the public pays great dividends for social cohesion, and market mechanisms enable limited resources to be allocated towards scientific projects. Institutional science has relied on large public subsidies, and the value of public investment is controversial. Science needs to be oriented towards providing value.

CONCLUSIONS

Higher education is currently in the midst of a crisis of legitimacy, with its student/customer base less willing to pay the premium prices associated with university education. Increasing competition from online course providers, and improvements in online course quality, challenge the effective monopoly that universities have exerted on specialized knowledge and training. Online education is usually much more affordable, and often free, making it accessible across the world. These knowledge dissemination methods are likely to expand access for low income people, while established universities suffer from bloat in their expenditures. Increasingly, training will be learner directed and project based, as several lines of evidence demonstrate that these techniques manifest improvements in the student experience. Similar trends exist in primary and secondary education, as interest rekindles in homeschooling and alternative forms of education, such as Waldorf or Montessori schools.

Empowering the entrepreneur in each scientist is an important and vital task with wide-ranging implications. It is also possible, requiring a new school system, which has been made far more tractable through advances in online education delivery. Once certification and accreditation are made robust, alternatives will be able to compete against existing schools; both in terms of the educational experience and the subsequent value of the diploma. Employability and value of the credential in the marketplace will eventually come to favour the higher value credential, which will be the current alternative, given some time to grow and demonstrate its value. Science currently faces a crisis in legitimacy, as a sceptical and wary public are less trusting of institutionalized science. The means to address this is through public-interfacing science, which also has significant correlates with the entrepreneurial need to interface with market opinion. While scientists have a duty to remain in integrity, which means not merely telling the public what they want to hear, they should be open to presenting their science and recommendations for the public. Instilling an entrepreneurial ethos in science is important to keep it grounded in pragmatism, and will make for more efficacious use of limited research funds. The adoption of a more entrepreneurial mindset in science will provide many knock-on benefits in the trust between the public and scientists, while removing unnecessary expenditures forms the public purse, as these sectors will surely see a contraction. Entrepreneurial education is not only future-proof, but it welcomes the future by creating it. Further research requires discovery of efficient implementation, and the factors which predispose pupils, as well as educators, towards success in a more entrepreneurial educational environment. While metrics such as income, skill level, and grades can measure student progress, research on the impacts of differences in implementation can be better understood. For example, there may be cultural differences by geography, such as the urban/rural divide, which can influence the success of such a system. Additionally, further work can be performed to adapt the curriculum and teaching approach to a skill set specifically. In conclusion, entrepreneurial approaches to education are potentially transformative, and obviate many of the societal crises affecting science and education. Entrepreneurial focuses on education can potentially improve the pupil experience and increase the quality of their education. These approaches should be explored for any educator who values the experience of their pupils.

ACKNOWLEDGEMENTS

This work is for those renegades who have been part of this movement without even realizing it, and those who still dream.

CONFLICT OF INTEREST

The study's author, Matthew Thomas J. Halma, declares no conflicts of interest.

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Підприємницька революція в наукових дослідженнях та освіті

Анотація. Існують значні проблеми із залученням студентів та дослідників як до навчання, так і до наукових досліджень, і один з факторів, що призводять до такої ситуації, це брак автономії, з яким стикається кожна людина. Ця робота окреслює новий шлях, на якому студенти та дослідники можуть вільно розвивати власні інтереси, а роль викладача або університету полягає в тому, щоб підтримувати й направляти їх. Ця стаття – наративний огляд, у якому розглядалися виклики, з якими стикається освітня галузь і те, як їх можна вирішити за допомогою підприємницької освіти під керівництвом студентів, яка може реалізуватися в режимі онлайн. У статті вивчено наслідки автономії учнів і представлено альтернативні моделі навчання, які можуть бути реалізовані недорого і бути корисними незалежно від самого освітнього процесу. Учнівство, самокерована та проектна педагогіка надає учням навички, необхідні для досягнення успіху в сучасному світі, суттєво відрізняючись від стандартної освіти, актуальність якої для роботодавців знижується. Тоді як наукові установи стикаються з кризою інновацій та пов'язаною з нею кризою суспільної довіри, підприємницька освіта є засобом вирішення цих проблем. Ці зміни мають наслідки на інституційному рівні, а також для відносин між наукою та суспільством. Під час бюджетних криз, як правило, відбувається скорочення обсягів фінансування підприємницької освіти. Робота надає дорожню карту того, як навчальні заклади можуть адаптуватися до кардинальних змін, що відбуваються з онлайн-освітою, а також консультує нових абітурієнтів щодо найкращих практик

Ключові слова: підприємництво в освіті; природничо-наукова освіта; науково-дослідницьке середовище; педагогіка; проєктна освіта