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Microelectronic Technology, AI and Academic Dishonesty: An Agile Engineering Approach

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Abstract*—With general computing technology being easily accessible to any individual, concerns arise when academic testing is implemented. These concerns include the potential effect on academic integrity, veracity and tenability, through the act of cheating. Mobile phones are as common as textbooks in the classroom. Microcomputers the size of a fingernail, with the ability to compute, display, and output information to a user are no longer an assumptive prognostication of an outdated science fiction reader. COVID-19 brought with it a shift to remote, online learning, both in high schools and colleges, where acts of academic dishonesty abounded. There is a dire need to address the issue of cheating in academia, especially those facets of academia conducted remotely. Students who cheat may be unprepared for college-level coursework or lack true disciplinary skills needed to enter the workforce. The result is that colleges and universities may need to increase spending to better monitor testing, as well as enhance remedial services to students who enter college unprepared. Increased cost remedies may be passed on to future students through increased tuition costs. This paper provides a review of the topic of technology and its role in academic cheating, in addition to concise conclusions for the educator. Special attention is given to the current and future possibility of microelectronic technology being used in deceitful academic acts. In addition, based on the results of the literature survey conducted for this work, recommendations for future research in this area are discussed at length. Educators face a seeming dichotomy: persist in traditional anti-cheating educational structures, advancing anti-cheating technology and jurisprudence; or, embrace technological progress and encourage the cooperative use of student technology in learning. Finally, we propose incorporating Agile approaches in education as a potential solution.

I. Introduction

At the 2022 Sinquefield Cup chess tournament, Magnus Carlsen, the number one chess grandmaster in the world, lost to the number forty-nine grandmaster, Hans Niemann. The upset was so extraordinary, Carlsen accused Niemann of cheating. Whether the accusation is true or not is not the purview of this article; but the implications are of interest. Cheating in professional chess has occurred in the past, although methods of detecting player electronic aids exist. Because of the 2022 Sinquefield Cup incident, numerous theories about potential cheating technologies have been proposed, the most popular of which involves a vibrating device inserted into the anus that is capable of relaying chess moves from a remote computer [1]. Although seemingly outlandish, the possibility is not improbable. Contact lenses with integrated circuits, which could be repurposed to aid cheating, have been proposed as early as 2008 [2]. Computerized contact lenses have been used in many projects: eyeball tear glucose monitoring [3] and measuring intraocular pressure [4]. Mojo Vision has developed a very powerful, general-purpose augmented reality contact lens as of 2021 [5]. State-of-the-art techniques for constructing soft contact lenses with wireless circuits embedded in them are well under way [6]. Visual prostheses, or smart bionic eyes, are a subject of recent discussion [7].

Clearly, modern technology has the potential to be used in cheating, academically oriented or otherwise. This potential will likely only increase as microelectronics become more available to the public. Mobile phones are exceedingly common personal devices, with 95.5% of high school students owning one [8]. In the classroom, they are the objects most utilized for cheating [9]. Because of the ubiquity of wireless networks, modern cellphones provide functionality beyond simple Short Messaging Services (SMS), through many social apps.

There are various methods of academic cheating, including techniques inside and outside the classroom. The use of paper-mill websites (sites in which anonymous authors can be paid to produce academic papers) was found to have increased 200% from 1997 to 1998 [10]. Students have also been found using their cellphones to communicate with one another during proctored exams (sometimes by sending images) and to listen to recorded notes in their headphones, in addition to using their calculators to store formulas, among numerous other clever strategies [11]. In a 2003 review of the topic, Dehn summarizes by stating that "… technology and other cultural factors may be synergizing to produce the perfect storm of increasing academic dishonesty" [12].

With the advent of COVID-19, which persisted for nearly three years, many high school and college students completed major portions of their degrees without stepping into the classroom. The incidence of academic cheating increased without the mitigating factor of physically attending classes [13]. A 2021 paper presented clear evidence of online, non-proctored advanced placement examination cheating, with examination terms for calculus, literature and physics arising in Google search trends in time with the beginning of the examination period [14]. The paper continues, drawing a distinct corollary with the cheating rampant in online chess communities, saying that: "If we can learn anything from online chess, then the message is very clear: online cheating will only get much worse and schools and universities will have their first-hand experience in Fall 2020. While online chess websites are private ventures and can ban any player for any reason, schools and universities will have a much more difficult task to provide clear evidence

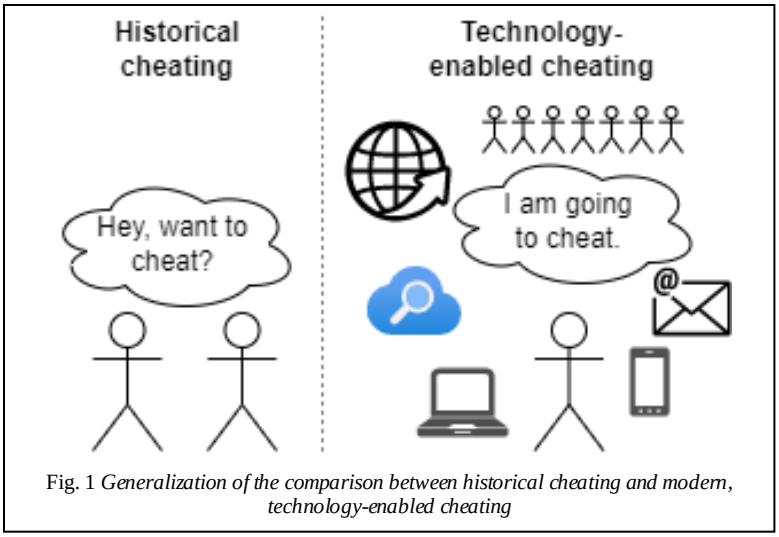

Fig. 1 *Generalization of the comparison between historical cheating and modern, technology-enabled cheating*

that proves students' cheating" [14]. They go on to state that cheating in online examinations should literally be *expected*, not as a possibility, but as an inevitability.

Recent advances in the field of artificial intelligence (AI), natural language processing (NLP), allow for entire bodies of technical text to be generated with simple natural language prompts. OpenAI's Generative Pre-trained Transformer (GPT) models and the open-source Bidirectional Encoder Representations from Transformers (BERT) models are subjects of feverish discussion in both the scientific and layman community, as early as 2017 [15]. The use of large-scale, transformer-based models has been evidenced as a potential threat to the education community, where students can use them to generate text assignments, and even code files [16, 17]. In a January 2023 paper, compellingly titled "*ChatGPT: Bullshit Spewer or the End of Traditional Assessments in Higher Education?*", the authors discuss the threat of ChatGPT to academic professionals and provide recommendations to them in the face of the growing expansion of powerful natural language models. They conclude with the following: "… we believe that major changes to traditional higher education assessments such as essays and online exams are in order to address the existence of increasingly powerful AI, unless universities want to be akin to driving schools that teach [horse riding]" [18].

This paper does not long consider language models that can be used to write student assignments; it is mentioned as an area of tangential concern to educators. The primary focus of this paper is on physical microtechnology that may be used for in-classroom acts of academic dishonesty, such as during an examination.

There is obviously a dire need to address the issue of cheating in academia, especially those facets of academia that are not conducted face-to-face. Yet, even face-to-face academics suffer from the possibility of illegitimate behavior [11]. No matter the venue in which cheating occurs, for colleges the effects could be costly. Students who cheat may be unprepared for college-level coursework or lack true disciplinary skills needed to enter the workforce. The result is that colleges and universities may need to increase spending to better monitor testing, as well as enhance remedial services to students who enter college unprepared. Enhancing remedial education programs may not be viable, as programs to prepare students for college-level work are coming under more scrutiny [19]. Costly remedies may be passed on to future students through increased tuition costs.

This paper provides a review of the topic of technology and its role in academic cheating, in addition to providing concise conclusions for the educator. Special attention is given to the current and future possibility of microelectronic technology being used in deceitful academic acts. Section 2 provides a brief overview of background terminology, including a terse summary of the history of academic cheating research. Section 3 describes the technique of the literature review. Section 4 contains the literature review itself. Section 5 presents the author's discussion and conclusions.

II. Background

A. A Succint History of Cheating Research

A summary of historical cheating research is necessary to demonstrate the perennial nature of academic cheating. In a few words: cheating in academia is long-standing.

An early book on educational psychology, published in 1928, presents empirical observations of cheating, focusing specifically on school-age children. The authors consider several factors potentiating acts of deception in the classroom,

including genetic predisposition through familial inheritance, the relationship between teacher and students, attendance at church, intelligence, socio-economic status, racial group membership, and even frequency of attendance at motion picture showings. The authors finally conclude with this general statement: "Honesty appears to be a congeries of specialized acts which are closely tied up with particular features of the situation in which deception is a possibility, and is apparently not greatly dependent on any general ideal or trait of honesty. Motives for cheating, lying, and stealing are highly complex, and are specialized just as are the acts of deception. The most common extraneous motive is the desire to do well in class." [20].

In 1964, Bowers reviewed the general forms of academic dishonesty and incipient strategies for curbing them that were mostly social or judicial in nature, including student honor codes [21]. It is a telling comparison between Bowers' suggestions and the complicated, technical lists of strategies to stop academic dishonesty in more modern papers (see Section V for a discussion of this).

A 1998 review of empirical cheating research provides several insights into the factors influencing collegiate cheating [22]. Below are presented some of the findings:

- *Males generally cheat more, though the difference was reported as diminishing over time*
- *Lower G.P.A. students cheat more*
- *Business major students cheat more than others*
- *Personal moral/ethical guidelines affect cheating propensity and feelings about cheating*
- *More surveillance corresponded with less cheating*
- *Observing others cheating, knowing friends who cheat, and sitting next to friends significantly affected cheating*

The authors of the paper provide a warning against the common thought often averred, that cheating is increasing. They indicate the inaccuracy of previous metrics for quantitatively measuring cheating. They state also that: "The amount of unflattering attention the popular press gives to the studies reporting high percentage levels of collegiate cheating could lead many students to the conclusion that they must cheat just to keep up with their peers… if students accept the notion that everyone in their culture (i.e., college) cheats, they will be more likely to engage in this behavior" [22].

A 2006 effort provides a review of cheating psychology and extends it with two empirical studies on college students, in which ethics and personality factors are measured in response to various cheating activities [23]. They present a list of 24 unethical behaviors using information technology. Students surveyed were tasked with rating the perceived severity of the 24 behaviors. The behavior rated as most severe by both studied groups of students was "Buying a paper online and submitting it as your own".

It is not the intent of this review to fully consider the psychological aspects of cheating. Cheating is assumed to be an inevitability in academia. The interested reader should investigate *Psychology of Academic Cheating*, by Anderman and Murdock [24]. Henceforth, this paper will consider only the technical aspects of technology, especially microtechnology, employed in acts of academic dishonesty.

B. Remote Learning and Academic Cheating

This section presents a brief consideration on the phenomenon of remote learning (online- or e-learning) and academic cheating. It is included because with COVID-19 came a nearly universal shift to e-learning. As will be discussed below, academic cheating during COVID-19 was very common [13]. With e-learning, students consistently use their mobile phones, tablets, laptops, desktop computers, and other common household technology, to do their homework, projects, and even quizzes and tests; and this affords them more opportunities to cheat. Though much of the technology used in remote learning is not exactly microtechnology (e.g., the desktop computer), it is important to highlight the obvious role of technology-aided cheating in remote learning.

"Technology is fast becoming the new frontier both facilitating cheating behavior and at the same time blurring the bounds and definitions of what constitutes cheating. With the increased move to online learning sparked by necessity through the COVID-19 pandemic, the need for a more in-depth understanding of collegiate cheating using high-tech methods has quickly become a required component of course preparation…" [25].

A fundamental form online cheating can take is for someone other than the registered student to complete exams or assignments. In order to decrease online cheating, research work has been done in the digital authentication of online students, involving facial recognition software [26].

A potential future method, though very complex, that could be used in online cheating to thwart facial recognition software, is facial modification software, such as deepfakes (deep learning fakes). An old method of cheating in large, in-person classrooms is when a student pays a person to take the exam for them [27]. Assuming the teacher does not know the student's face, this method is effective. The same method can be employed in online cheating, especially if

exams are not proctored. If exams are proctored, and there is a worry about the educator detecting the wrong student taking the test, it is possible that students could employ face filters (which are prevalent on mobile apps) or deepfake software to make their face look like the real student, even on live camera. Replicable methods for detecting deepfakes exist [28].

As discussed in several early papers on technology-aided cheating, the use of paid paper mill websites to produce student papers is common [10]. Research has been conducted on the topic of *contract cheating*, or the act of paying others to do coursework. A 2022 literature review asserts that this method of cheating has become rampant because of COVID-19 and the attendant shift to online classes [29].

An interesting extension of this is the use of deep learning AI algorithms to automatically generate natural language text artifacts. Since around 2018, there is significant discussion on the social and ethical implications of AI-generated content, e.g., images, videos, books and even invention patents [30, 31]. AI has been proven capable of writing scientific papers, though initial human input is needed [32]. A 2019 review reports on automatic article generators (AAGs), including their use in producing entire books and forging scientific publications [16]. Carmichael and Weiss present a forward-looking paper regarding ML cheating in academia, encouraging educators to find and employ *better* ML to combat ML-enabled contract cheating services [33]. Also discussed earlier is the meteorically popular rise of large-scale, transformer-based models (e.g., GPT and BERT) into academia, which is becoming a predominant concern in specific disciplines, and for which there are currently few reliable tools available to detect its use [17, 18].

C. Microelectronic Technology and Cheating

It is necessary to distinguish between common technology used in cheating (e.g., a desktop computer running another web browser during an online examination) and microelectronic technology, hereafter referred to as ***microtechnology***. A definition is provided here for the purpose of establishing a shared understanding.

According to Merriam-Webster, microelectronics is defined as "a branch of electronics that deals with the miniaturization of electronic circuits and components" [34], and microtechnology is defined as "technology on a small or microscopic scale" [35]. These definitions are general, so some specificity is necessary to understand the use of microtechnology in academic cheating.

Microtechnology, in the context of academic cheating, includes any technology that can be hidden on or inside the body; or obscured by some part of the body or an extension of it (e.g., clothing, a chair). Some examples of microtechnology are the common cellphone and wireless earbuds. Further, it is asserted that microtechnology includes nanotechnology, which is invisible to the human eye. Nanobots are an example of nanotechnology frequently employed in biomedical applications [36]. Though no instance of nanotechnology employed in cheating was located during this survey, it remains a future possibility for researchers to investigate.

All forms of microtechnology employed in cheating must necessarily perform the same function of transmitting desired information to the cheater; whether by means of a visual screen, an auditory signal, a vibrating code, or some other meaningful input to one of the human senses that is interpretable.

III. Literature Review

In surveying the research landscape, it was possible to extricate and make explicit a simple taxonomy of academic cheating. Three types of cheating were identified (see Fig. 2). The first type of cheating, traditional classroom cheating, is cheating in the typical academic classroom, with an educator present. The second type, online classroom cheating, is cheating outside of the traditional classroom, but in an online classroom, during a "live" assignment, such as an exam, that may or not be proctored by an educator. The last type, out-of-classroom cheating, involves the use of resources, technology or other individuals to produce "forged" or plagiarized assignments, such as written papers or homework done cooperatively that were assigned individually; or by paying or using an entity to produce it. This taxonomy corresponds loosely with the two traditional types of academic dishonesty, exam cheating and plagiarism, where the former takes place within the classroom and the latter takes place outside of the classroom [23].

Out-of-classroom academic cheating generally does not benefit from the use of microtechnology, because no educators are observing the students, and students therefore have no need to labor in disguising their acts of cheating. Microtechnology can still be used in cheating outside of the classroom, however; for instance, a student could use their cellphone to text a friend in their dorm room requesting answers to a homework problem.

Traditional and online classroom education see the explicit, active use of microtechnology in cheating because dishonest acts must be concealed around educators, and smaller devices are more easily concealed. Online cheating presents a special challenge to educators, because of the difficulty in detecting and assessing dishonest acts. "… cheating should be expected in the online examination, with the reason being very intuitive: the instructor can observe cheating evidence in the face-to-face examination, but there is only indirect cheating evidence in the online examination" [14].

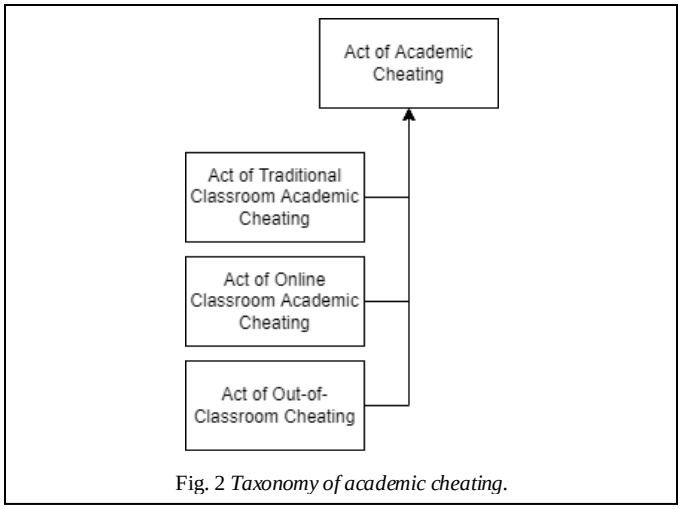

Fig. 2 *Taxonomy of academic cheating.*

D. Method of Review

This review is not systematic, per the guidelines provided by Kitchenham [37]. It is a general review of the topic's synthesized literature. Reviewed literature was found by way of entering the following search phrases into Google Scholar:

- *Technology and cheating*
- *Online learning cheating*
- *COVID cheating*

The word *cheating* was replaced with the following synonyms and synonym phrases in additional searches:

- *Unethical academic behavior*
- *Academic dishonesty*
- *Academic deceit*

Additional sources were found by following some of the sources of the reviewed literature, in a technique referred to as snowballing [38]. Moreover, by proposing the literature review, an answer to a very forward-looking, predictive question was sought:

- *What is the possibility of entire degrees being obtained illegitimately using information technology?*

E. Cheating and Microtechnology

Bachore presents a summary of microtechnologies and their application in academic cheating, in addition to methods for detecting and preventing such acts [11].

- Cellphone: messaging someone in or out of class for answers during an exam, either by text or with photos
  - Detect/prevent by prohibiting cellphones
- Calculator: typing notes and formulas into calculator prior to an exam
  - Detect/prevent by prohibiting personal calculators, or by supplying them to students
- MP3 player: listening to recorded notes or lectures with earphones hidden under hair or hand
  - Detect/prevent by preventing MP3 devices

A 2011 paper presents a summary of traditional and technological methods of cheating in higher education [39]. Below are given the methods using technology.

- Mobile phone: messaging others, using applications, reading notes, using a web browser
- Calculator: pre-loading notes
- MP3 player: listening to recordings or looking at images/videos
- Wireless receiver: whispering into a microphone, where a student outside the hall can look up the answer and provide it by speaking back
- PDA: similar to the mobile phone
- Invisible ink pen: notes are written on the skin or some other article; when no one is looking, the corresponding light is shone, revealing the notes
- Wrist watch: similar to the mobile phone

- Label maker/printer: a water or soda bottle is purchased, the label removed, and a label printed to look identical, but filled with notes, is placed on the bottle

In a 2021 paper, the same authors provide insight into the psychological aspects of cheating in higher education [25]. They also provide several forms of cheating, gathered by querying students. Their list is similar to that found in Bachore's paper [11], with the addition of a few clever techniques.

- Smartphone: putting cheatsheets on phone lockscreen for quick access
- Smartwatch: setting text reminders to repeat notes in 5-10 minute intervals

A 2008 paper presents a list of cheating microtechnologies similar to that in [39], with the addition of an interesting object called a SoundBug [40].

- SoundBug: a small speaker developed by FeONIC that can turn a flat, resonant surface (such as a table or binder) into a panel speaker; although the sound is audible to anyone near it, its novelty can help to disguise it from educators; further, the volume can be set so low that only a person placing their ear against the resonant surface can hear it

A 2021 survey of real students in higher education found several innovative cheating techniques, including some using technology [41].

- Calculator: pre-loading notes
- Smart watch: displaying notes on the screen
- UV ink pen: hiding notes and revealing them
- Cell phone: messaging, using notes or the Internet

Some of these microtechnologies are rather simple, and most of them are commonplace items for students. They are effective devices of cheating, or can be made to be effective through clever modifications (e.g., smartphone lockscreen notes), as surveyed, and remain as such because of their ubiquity.

F. Revisiting the Definition of Microtechnology

Technology, in a more general sense, does not necessarily include only electronic items. In the context of human history, the skill of weaving cloth is a considerable technology, arguably a microtechnology. A 2021 review presents several very innovative techniques employed by student cheaters in the same year, including the use of a handkerchief with written notes on it that could be pulled out when notes were needed; and if an instructor placed suspicion on the object, the student could simply wipe their brow as if they had been sweating [41]. The surveyed students reported great success with this technique.

Again, in a broader historical sense, this is clearly a use of microtechnology-aided cheating, but for the scope of this paper, only electronic or computerized microtechnologies are considered at length.

IV. Discussion

It is clear that technology-aided academic cheating, including those acts of academic dishonesty performed with microtechnology, are common, past, present, and certainly future. Educators must face this issue in the traditional classroom and in other modes of education, like remote e-learning.

As several studies have shown, the incidence of academic cheating in online learning is much higher than with in-person learning, because of the lack of a face-to-face, proctored environment [14, 42]. "Methods of cheating have become ever more sophisticated and hard to detect. Increasing miniaturization of technology along with increased information storage will undoubtedly lead to increases in cheating" [39]. Moreover, as Moore's law states, the price of manufacturing electronic circuits has consistently decreased since the 1960s, making access to microelectronics ever easier for consumers [43]. Some predicted, possible future cheating microtechnologies are given in Table I.

This being said, it is necessary to be cognizant of different expert opinions about the prevalence of cheating. Some, like Crown and Spiller, have stated that the consistent, mainstream assumption that student cheating is rampant may make students feel like they must cheat in order to keep up with their peers, thus inflating the issue [22].

A. Detecting Acts of Cheating

It seems that the most certain way of preventing students from utilizing microtechnology in academic cheating is to deprive them of the chance to do so. One way to curb technology-aided cheating is to implement technological solutions in response. It is evident that, in the papers reviewed, the strategies proposed to curb acts of academic dishonesty exist in a symbiotic relationship with acts of academic dishonesty themselves; in a word: such methods are attempting to

"fight fire with fire". In addition to several practical, non-technical approaches [39], several cutting-edge technologies have been proposed to battle academic cheaters.

Table I. Potential Future Cheating Microtechnologies

Microtechnology	**Method**
Computerized contact lens	Displaying information from an outside source viewing the video stream; potential for AI problem solving or Internet connection (see Mojo Vision [5])
Bionic eye	Similar use to the computerized contact lens [7]
Electroceuticals	Small devices implanted into the body that stimulate nerves and tissue through small electrical pulses; currently it is used for therapeutic reasons (e.g., for brain injuries), but there is potential for use in inputting information to wearers [44]
Bone-conduction headphones	Can be passed off as a hearing aid, or hidden under long hair; used by listening to recorded lectures or notes, possibly receiving a wireless transmission
Facial modification software	Bypassing facial recognition when entering a classroom with CCTV cameras, or used during online examinations, to take an exam for another student (deep fakes)
Smart glasses	Displaying information, sending video stream to an outside source; potential for AI problem solving or Internet connection
Radio/telegram transmitter	Hidden in the pants leg, entire sentences can be sent in Morse code by tapping a finger on the transmitter; a student outside the classroom can respond accordingly
Tattoos	Tattoos on the skin could be inked with small notes that could be read; without prior screening, tattooed students could use their body as a notebook
Mask microphones	Viable because of COVID-19 and mask-wearing; microphones exist that cover the face and allow the wearer to speak into them without being heard by nearby people (normally used for private phone calls in public settings); someone on the receiving end could return answers to a hidden earbud
Light signal transmission	Students in the same classroom could communicate using Morse code with small electronic devices containing lights attached to a button; some cheap digital watches allow the wearer to light the screen for nighttime use, and at certain angles, the light is visible from several feet

A 2022 literature review presents a comprehensive list of video camera and machine learning (ML) techniques used to detect student cheating in the classroom [45]. A 2021 paper provides a review of AI-based proctoring systems [46]. Curran, Middleton and Doherty (2011) also provide several methods of detecting and preventing academic cheating.

- Signal jamming devices (jammers): prevent wireless equipment from transmitting or receiving signals
- Faraday cage: metal is integrated into the walls of a building, blocking wireless signals from going in or out
- Signal detection devices: partially fulfill the function of a jammer without the legal/ethical concern of blocking signals
- CCTV cameras: visually detecting students cheating and scaring potential cheaters to not do so
- No calculators: calculators not allowed in the exam room; they are provided by the educators
- Metal detectors: entrance and exit into the exam room occurs through these, detecting prohibited microelectronics

Assuming future higher education programs will continue assigning students work and then evaluating them with quizzes and tests, naturally, some questions need to be answered explicitly to ensure that students are actually achieving their learning goals and obtaining their degrees legitimately:

- *How can students be surveyed, scanned or physically investigated to find forbidden microtechnology?*
- *How can students' out-of-classroom activities be monitored and restricted to prevent cheating (e.g., online resources, paying others to do assignments)?*

An answer to the first question may be found in Curran, Middleton and Doherty's paper, which presents practical, in-classroom techniques for cheating detection [39], in combination with Radwan, Abachy and Al-Araji's paper, which provides a summary of ML-based cheating detection systems [45].

This second question is particularly important to ask of classes or programs where evaluation occurs on a paper or project basis (e.g., dissertation papers). How can educators ensure that students are not using online resources to have their papers written for them? VPNs and browsers like Tor can obscure a student's IP address, thus allowing them to escape oversight from their academic institution [47]. And, further, answers to these questions spawn an important ethical concern:

- *What ethical principles would student technology observance potentially violate?*

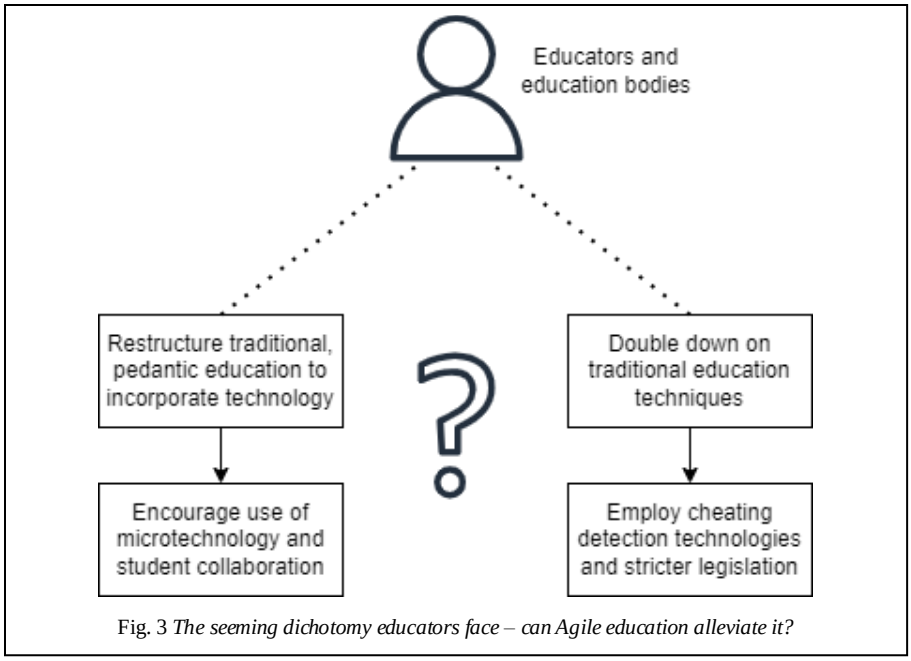

Fig. 3 *The seeming dichotomy educators face – can Agile education alleviate it?*

As an answer to this question, Coghlan, Miller and Paterson discuss the ethics of Online Proctoring (OP) software for remote examinations. Performing a literature review of the subject considering COVID-19, they present a list of ethical principles and their implications for OP exam technology [48].

- Fairness
- Transparency
- Non-maleficence
- Privacy
- Respect for autonomy
- Accountability
- Academic integrity
- Liberty and trust

They also provide actionable insight for educators involved in e-learning. "[In] deciding whether or not to adopt [OP technologies], educational institutions also need to have the right systems in place to remain accountable for such choices… before the technology is utilized, staff and students should be consulted and adequately informed about the impacts and the capabilities of selected OP technologies. For example… how cheating is determined and privacy affected. Information addressing key questions about OP technologies should be readily available." [48].

B. An Agile Response to the Academic Cheating Problem

There are several ways to address online and microtechnology-aided cheating in the classroom. As discussed in the previous section, educators could implement technological solutions, but this is not a tenable position, and amounts to what may become a technological arms race between students and educators. Judicial or technological constructs employed to detect or prevent cheating are not the only potential solution. Higher education could be restructured so that microtechnology use would not be seen by students as a means of illicit academic progression, but as an academic tool. In one view, it seems that the attempts of educators in stopping the use of microtechnology in academic cheating is a losing position, as the prevalence of microtechnologies have grown exponentially in recent years. Some have presented a similar sentiment: "For many years, education has centered on the concept of individual students working on problems alone, memorizing some random facts, and then regurgitating the information to the teacher in the form of a test. Teachers did not spend much time teaching students how to effectively use collaboration as a means of solving problems… many teachers would view collaboration as cheating… So maybe it is time to rethink the idea of cheating… If companies are seeking employees who can collaborate and use technology, then educators should teach students the ethical use of collaboration and technology in order to promote their success in the future." [49].

An example of this sentiment employed in real-world education is the Agile engineering paradigm, which resulted from a software engineering group's divergence from the traditional, documentation-oriented software engineering

methods of the past, to a more responsive, customer-oriented method [50]. Utilized often in the software engineering industry as a method of delivering products, Agile development is also becoming more common as a tool for software engineering education, by allowing students to work in cooperative product development groups [51].

Table II. Mapping Agile Values to the Classroom [52]

Agile Value	**Agile Education Value**
Individuals and interactions over process and tools	Students over traditional processes and tools
Working software over comprehensive documentation	Working projects over comprehensive documentation
Customer collaboration over contract negotiation	Student and instructor collaboration over rigid course syllabi
Responding to change over following a plan	Responding to feedback rather than following a plan

As a case in point, consider a course in higher education in which the educator assigns students a written paper as an assignment. In the traditional mode of teaching, students may cheat by paying someone else to write their paper, possibly through a paper mill website, or by using AI to generate it. Unless the teacher is very careful, this act of cheating may go unnoticed. Now, assume the same teacher employed an Agile method of education, and required the students to adhere to Agile principles on every assignment, including their papers. Every class day, the teacher might ask students during the daily standup meeting to describe what they have been working on, what obstacles they have encountered and their current plans for their assignment(s). Cheating students would struggle to answer questions about a paper they did not write, and the teacher would be more easily alerted to deceptive acts. Therefore, Agile education could increase student accountability, and perhaps deter cheating.

Additionally, the rising use of large-scale, transformer-based models in daily life is apparent: students have and will use them during the course of their education [16]. It may be possible, however, to ameliorate this seeming dilemma. Students could be required to use GPT or BERT for particular assignments, where they must then edit, revise and annotate the automatically generated assignment through their own effort, showing, with references or sound reasoning, how the model arrived to this answer, as these language models suffer from inaccuracies and the tendency to submit falsehoods that "sound right" [18]. This novel approach would give students the opportunity to use the language models as a basis for general understanding, much like a student-professor relationship engenders, whereafter they must apply their own cognizance to the structuring and understanding of the general concepts laid forth.

V. Conclusion

In performing this review, the authors must state that, while research on microtechnology-aided cheating techniques is plentiful and useful to educators, more emphasis must be placed on research regarding AI-aided cheating. AI is a rapidly expanding field, with its constructs ever more available to individuals, enabled by the omnipresence of capable computational engines like cellphones and laptops. Automatic Article Generators (AAGs) have been used in the past to produce scientific articles and even entire books [16, 33].

Some potential future cheating microtechnologies are given in Table I. These are purely theoretical illicit uses, but the technologies in the table find practical use in modern life. Perhaps the most interesting microtechnology is the computerized contact lens that can display a screen only visible to the wearer. The company Mojo Vision has produced a working product as of 2021 [5]. Coupled with the recent advances in ML natural language processing (e.g., GPT and BERT) [15], and the speed of network communications, such a device could be immensely powerful for the student engaging in acts of academic dishonesty (see Fig. 4). Optical character recognition (OCR) is a long-researched task of machine learning computer vision [53], and could be used together with large-scale, transformer-based models like GPT and BERT to form a cohesive cheating system for in-classroom students.

With the recent advent of these accessible language models, and the shrinking size of microelectronics, different techniques to education and student evaluation must rise to meet the challenge, or educators face the dilemma of unwittingly and consistently evaluating student material that is not their own, but the output of technology. Sorely needed, in parallel with the feverish advancements and publications on microtechnologies and transformer models, are proposals of approaches and techniques for educators and their assignments and evaluations. This, to avoid the stagnant method of just submitting to tradition and assigning essays or code assignments to students, which are easily forged. This is a forward-looking outlook, and indeed it must be, if educators are to continue to properly educate and evaluate the next generation of students that will be using these revolutionary technologies. In this paper, the Agile method of engineering is proposed as having the potential to ameliorate the present and coming ailments of educators.

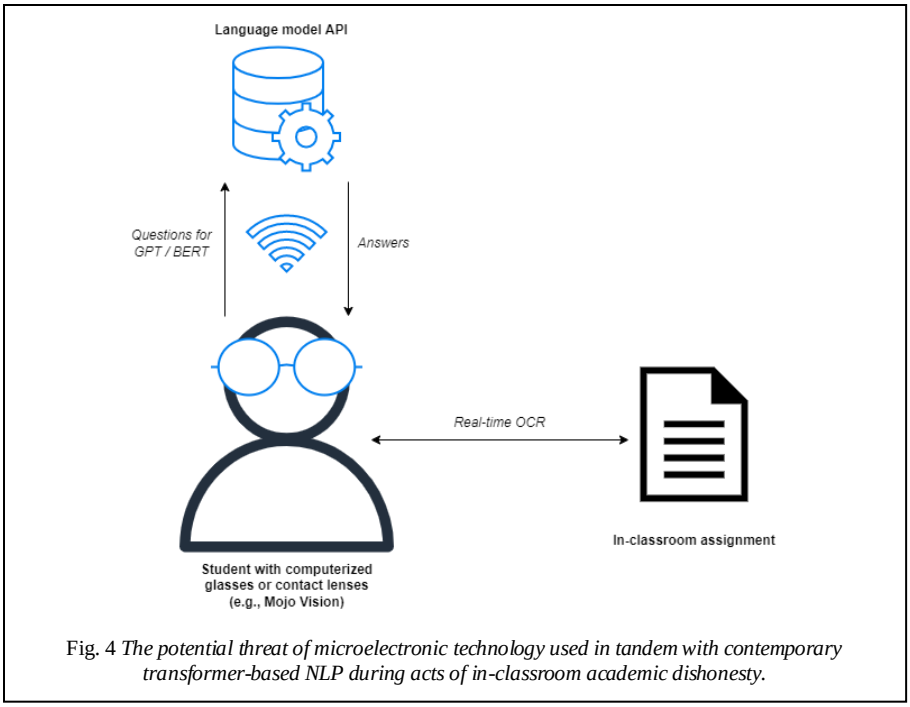

Fig. 4 *The potential threat of microelectronic technology used in tandem with contemporary transformer-based NLP during acts of in-classroom academic dishonesty.*

Agile education, with its focus on product delivery, documented iteration and worker communication, may see appropriate use in the context of stemming acts of academic dishonesty. Other qualitative techniques should be investigated as well. In addition to surveying NLP techniques for identifying AAGs and machine-derived bodies of text, a relevant paper, aptly titled "*Artificial Intelligence is a Tool for Cheating Academic Integrity*", presents six key points for educators faced with rapidly changing technology [16]:

1. Raise educator awareness about these AI tools and their issues, as just having *suspicion* about AAGs can help identify AI-enabled cheating
2. Conduct workshops to inform about AAGs and their output characteristics
3. Teach educators the reasons for plagiarism and give students support by instituting academic policy changes
4. Identify if students understand when they are committing an act of academic dishonesty, as many students do not consider their actions to be violations
5. Give students less opportunity to cheat by assigning tasks difficult for ML to generate, e.g., in-class activities as opposed to literature reviews
6. Employ severe penalties for offenders as a method of deterring future cheaters

In answer to the question, "what is the possibility of entire degrees being obtained illegitimately using information technology?", it is probable. The possibility of a degree being "forged" from start to finish, with acts of academic dishonesty employed consistently throughout the degree process, is entirely possible, especially when contemporary large-scale, transformer-based language models and computerized microtechnologies are considered. But no precise answer can be given to the question without additional research in the area. As such, it is proposed that researchers use this question as guidance on future research, because its answer is important for educators and education bodies. It would no doubt be a goal of immense importance for researchers to quantify, in empirical terms and numbers, the historical, current and future probability of total academic degree forgery in the face of these rapidly expanding technologies. In the future, it remains a distinct possibility that students will utilize the powerful, modern technologies discussed in this paper in acts of academic dishonesty.

This paper provides a review of the topic of microtechnology and its role in academic dishonesty, with the goal of bringing an increase in awareness to educators and education bodies. Educators must be cognizant of the latest advances in technology and how students may utilize them to properly prevent acts of academic dishonesty, both within the classroom and without. In addition to advocating for more research into ML-enabled cheating mechanisms, this paper proposes that the Agile engineering paradigm may alleviate the issues of technology-aided cheating and encourages more researchers to investigate it as an educational framework.

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